BEST 5 CONFERENCE
Building Enclosure Science & Technology

New Construction or Deep Retrofit?

Roadmap to Build a Case for Deep Retrofit

ZERO ENERGY READY HOME U.S. DEPARTMENT OF ENERGY
EPA WaterSense
EPA Indoor airPLUS QUALIFIED HOMES
ENERGY STAR HOMES
U.S. GREEN BUILDING COUNCIL LEED USGBC

TEAM LINKoln

U.S. DEPARTMENT OF ENERGY RACE TO ZERO STUDENT DESIGN COMPETITION

TEAM INTRODUCTION

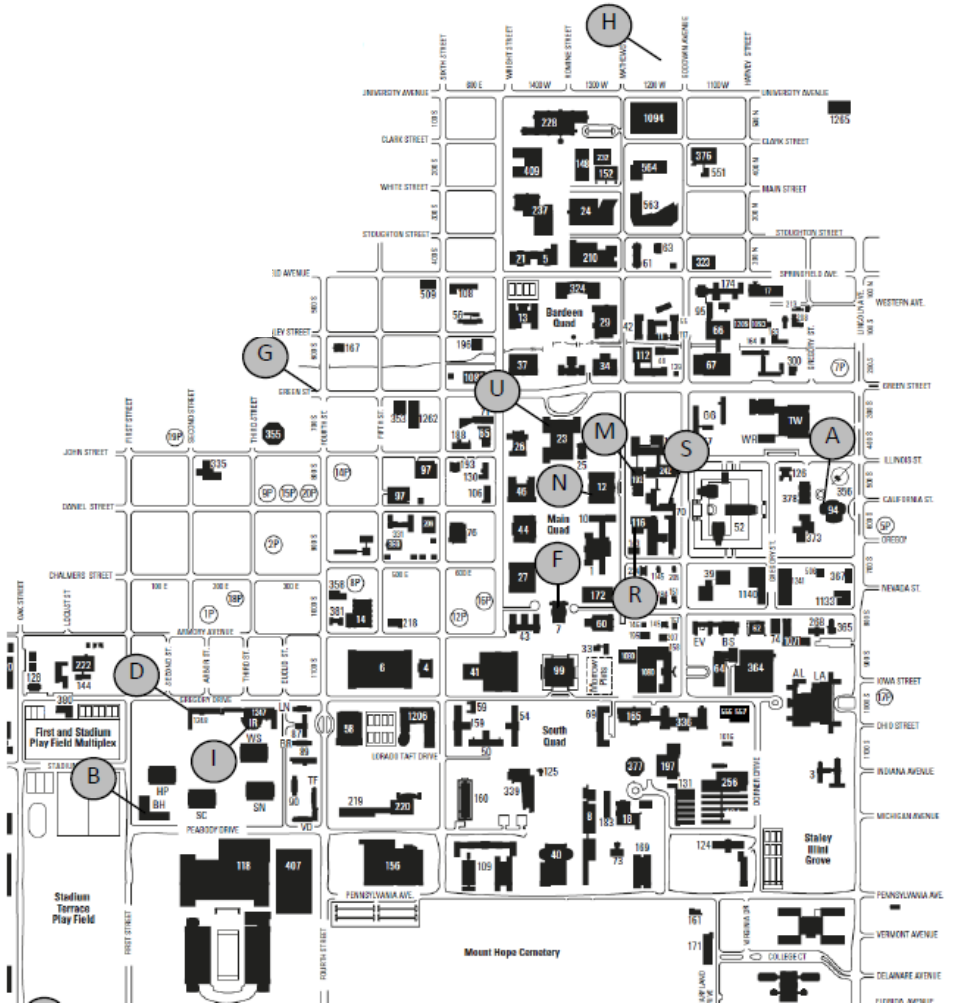
ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

ILLINOIS
SOLAR
DECATHLON

22 students

7 majors

1 university



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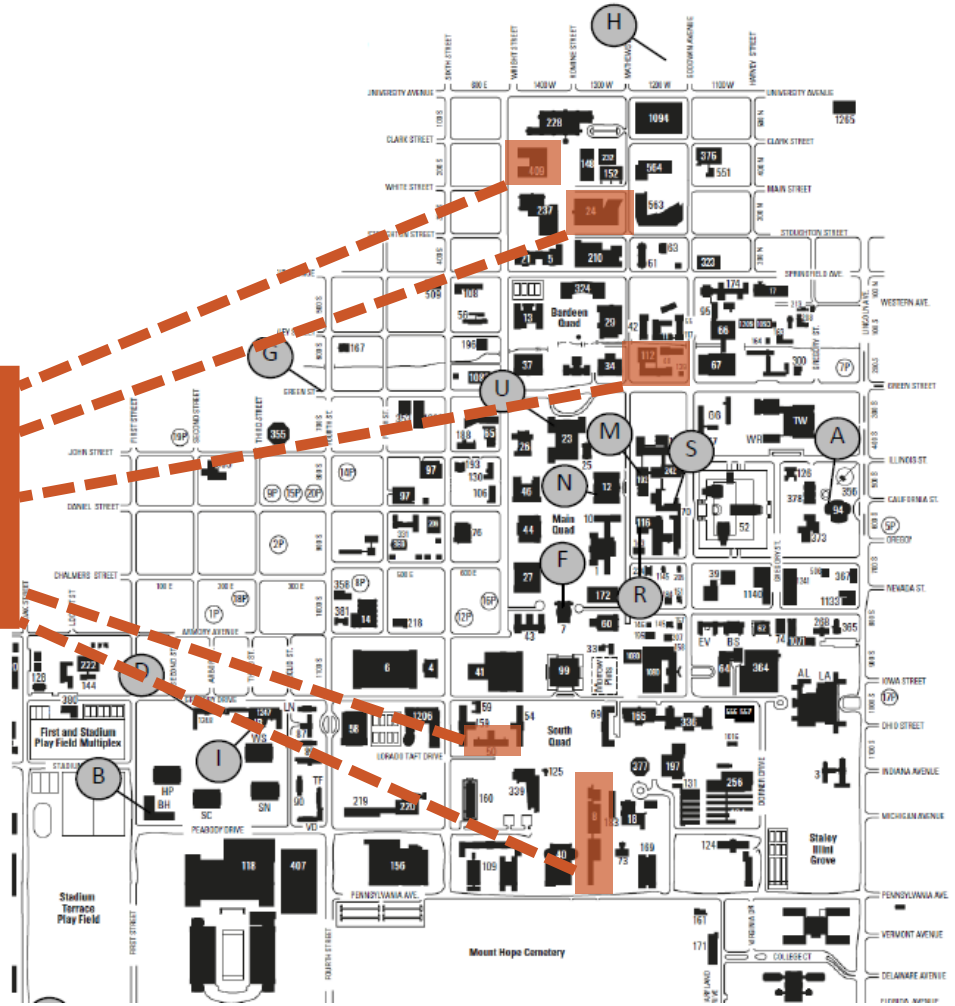

PROJECT SUMMARY

Location: Urbana, IL

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IECC 5A, BA “Cold”

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8 Unit Multifamily Housing Retrofit

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2, 3, and 4 Bedroom Units

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2, 3, and 4 Bedroom Units

Energy Bill: **$308 w/o PV**

$82 w/PV

PROJECT SUMMARY

Location: Urbana, IL

IECC 5A, BA “Cold”

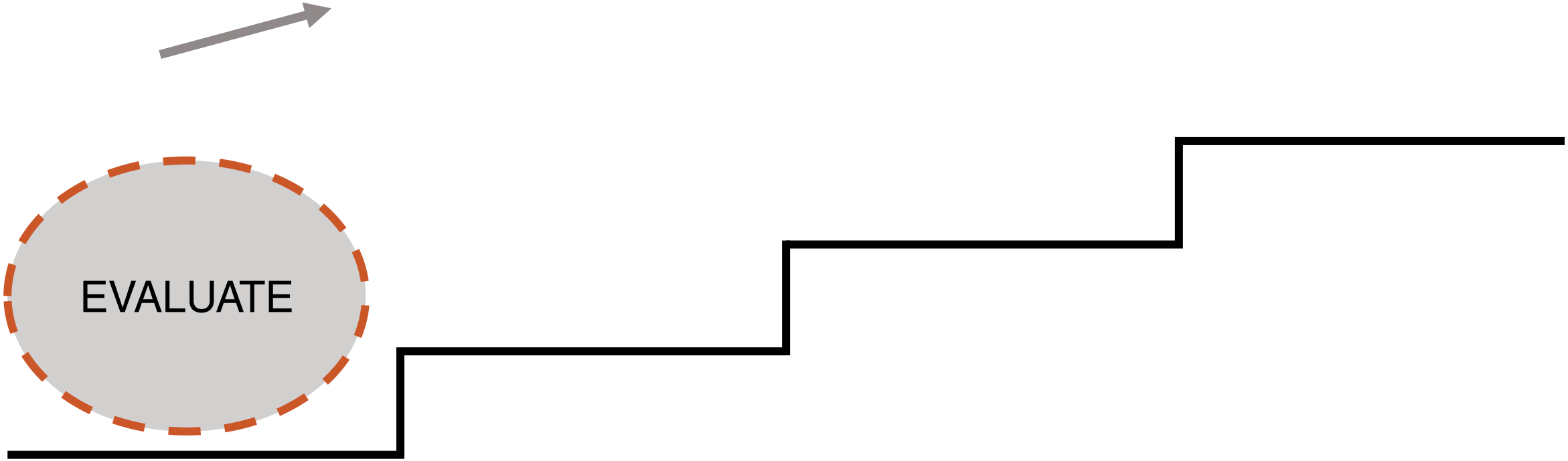
8 Unit Multifamily Housing Retrofit

2, 3, and 4 Bedroom Units

Energy Bill: $308 w/o PV
$82 w/PV

HERS Rating: 35 w/o PV
12 w/PV

DESIGN PROCESS



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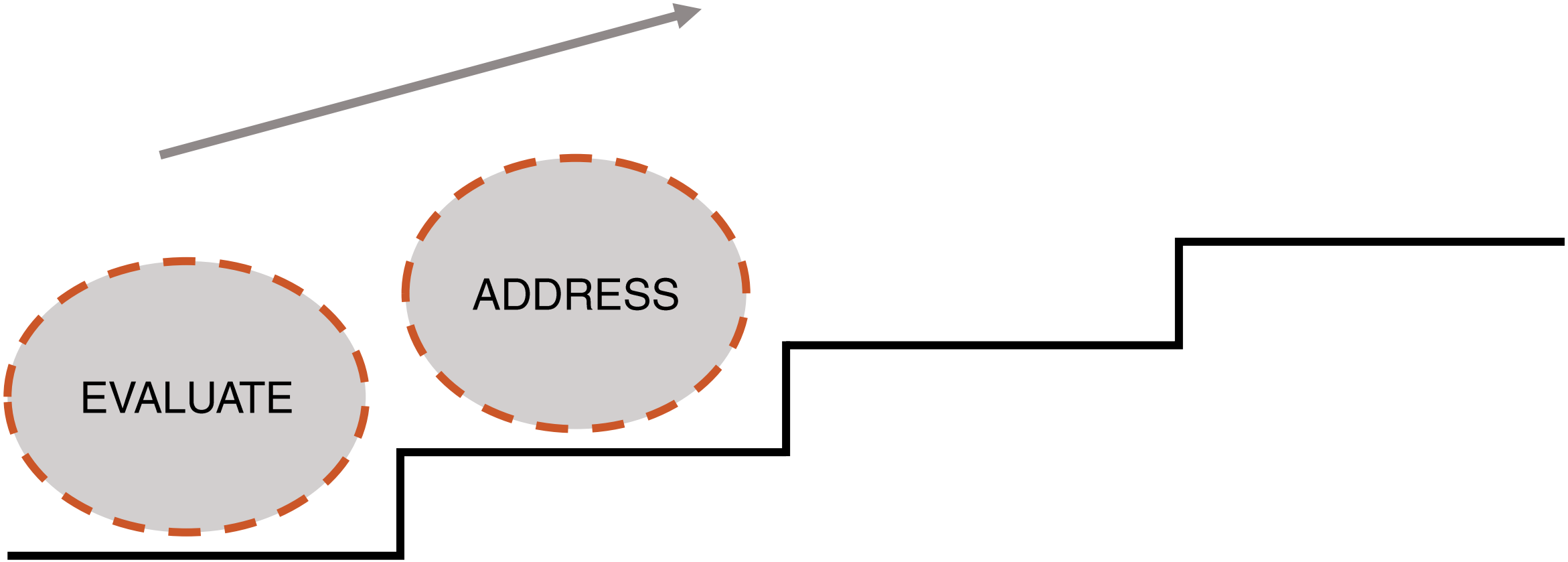

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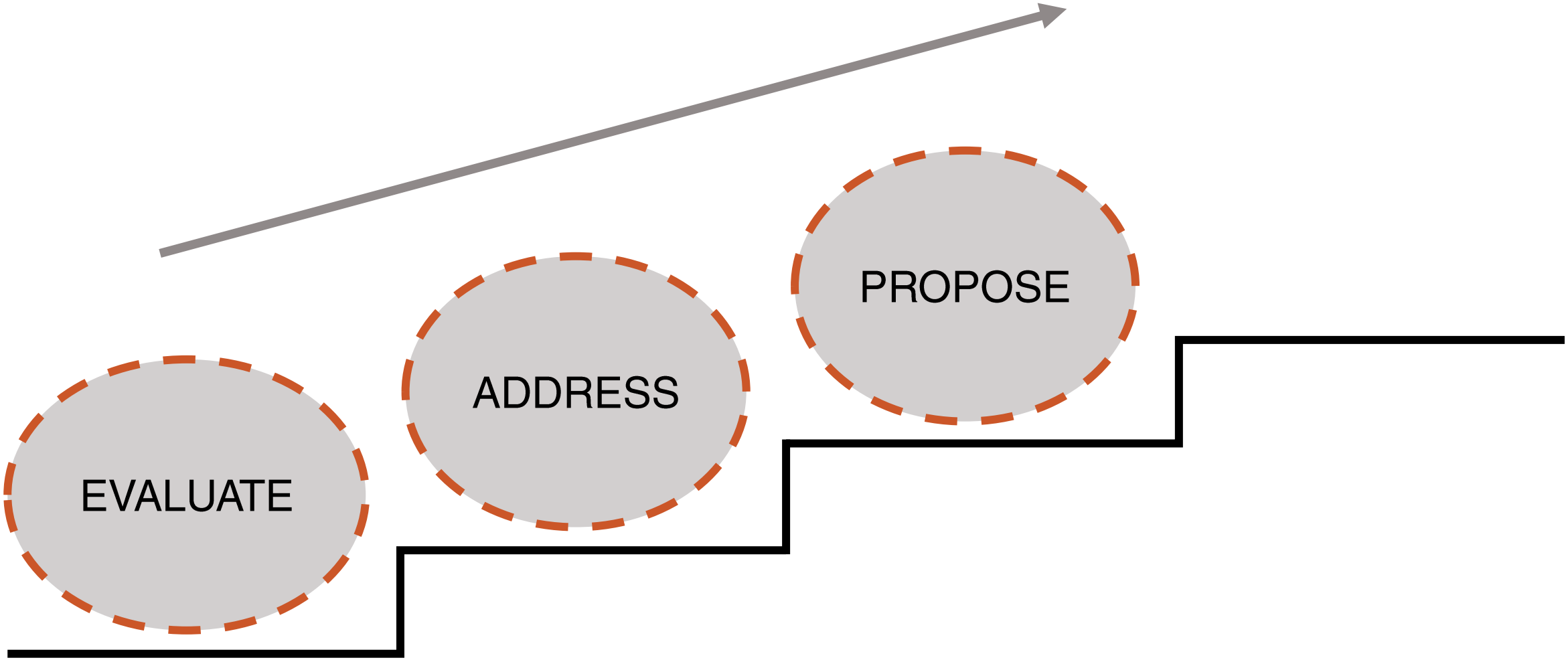

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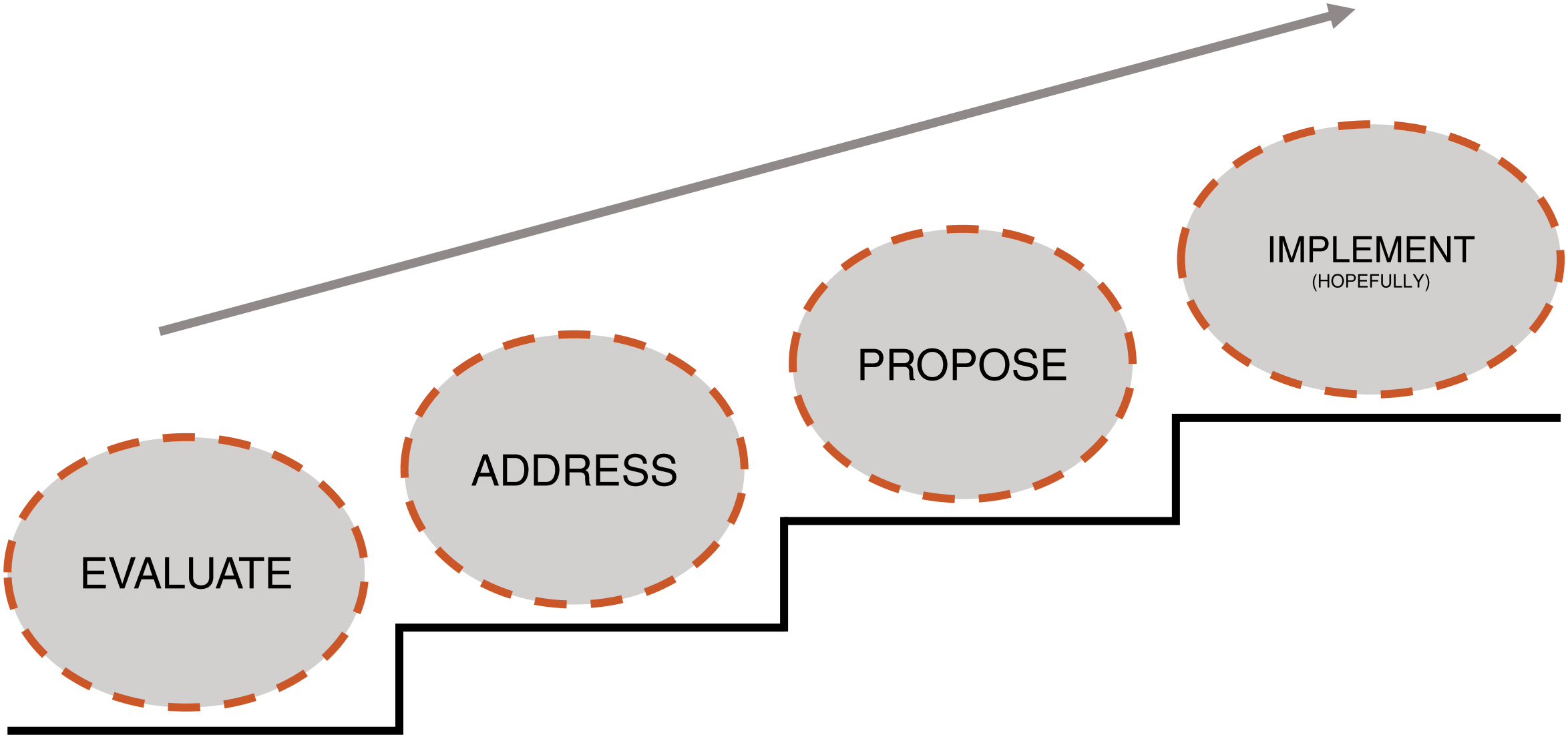
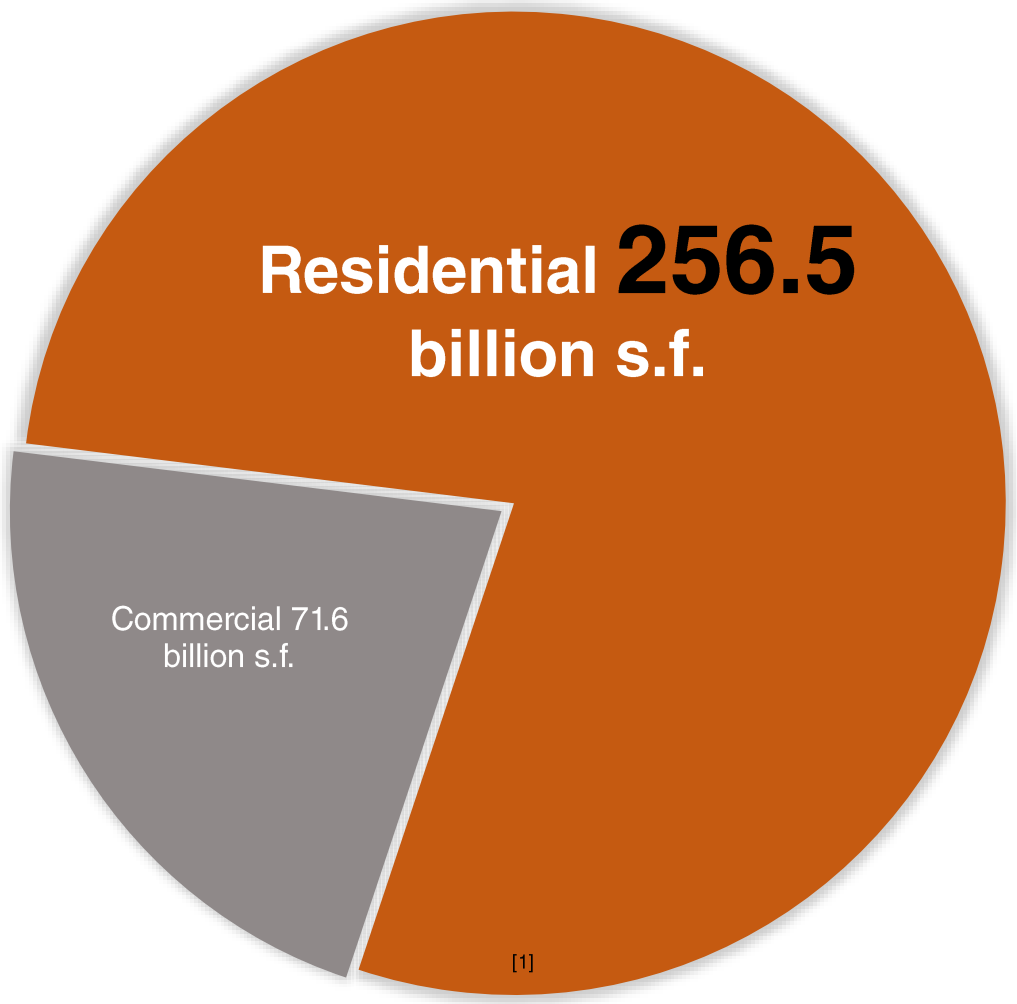


EVALUATE



[1] Preservation Green Lab, *The Greenest Building: Quantifying the Environmental Value of Building Reuse*. Prepared for the National Trust for Historic Preservation, 2011.

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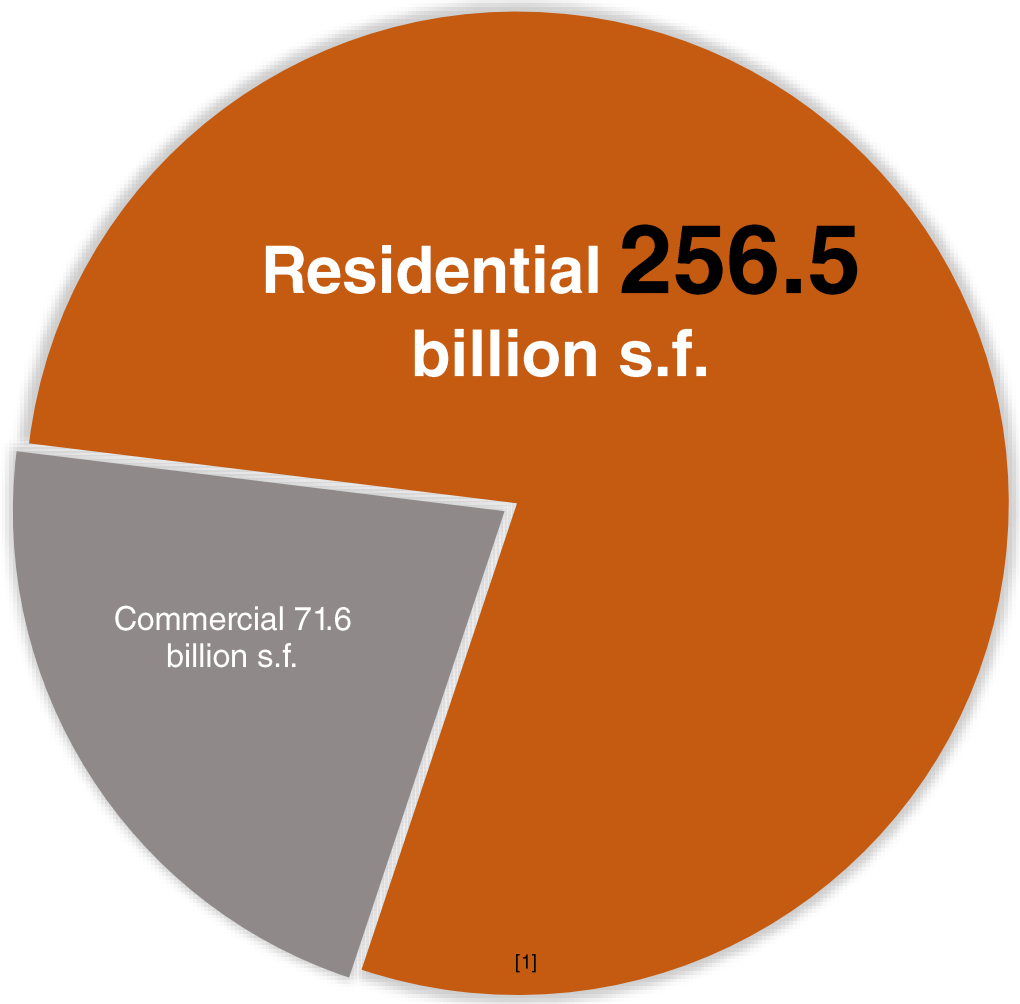

82.0% Single Family Detached
6.1% Single Family Attached
3.3% Apartments buildings with 2-4 unit
2.9% Mobile Homes

5.7% Apartment buildings with 5 or more units =

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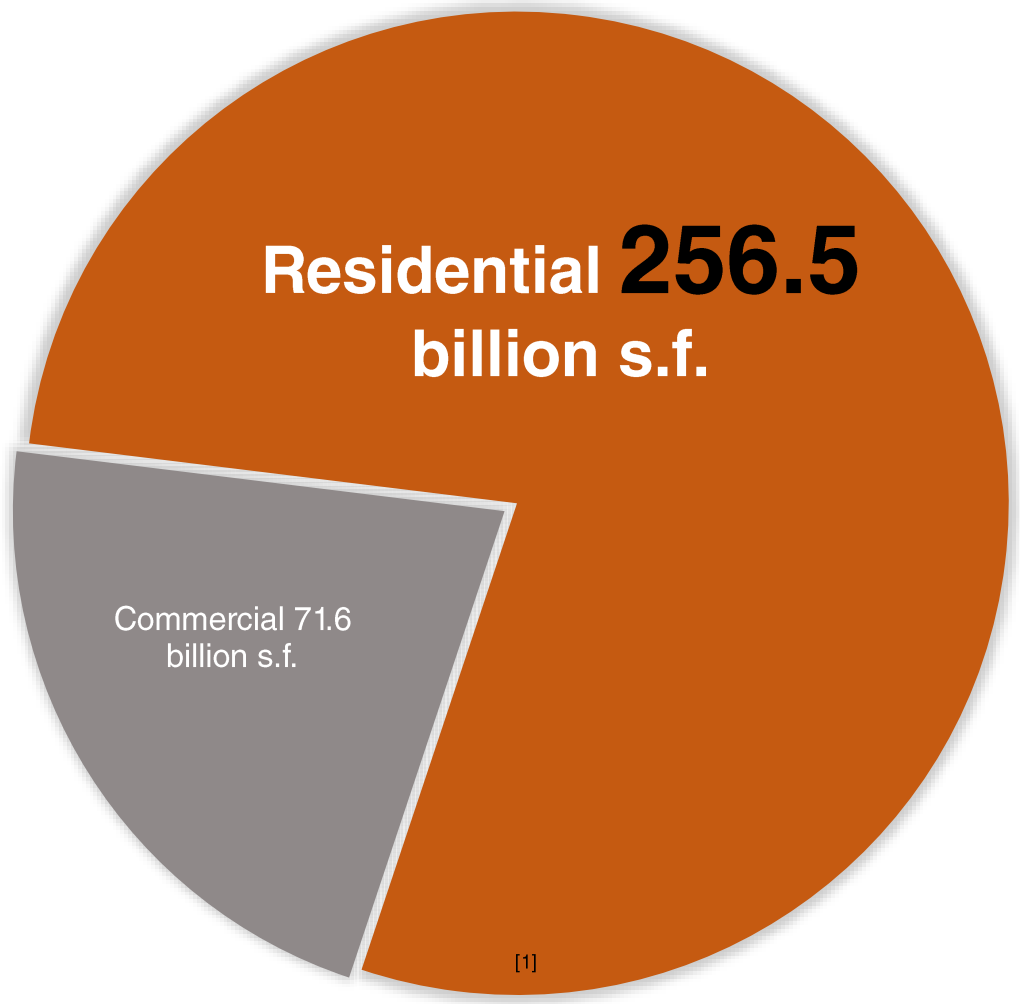

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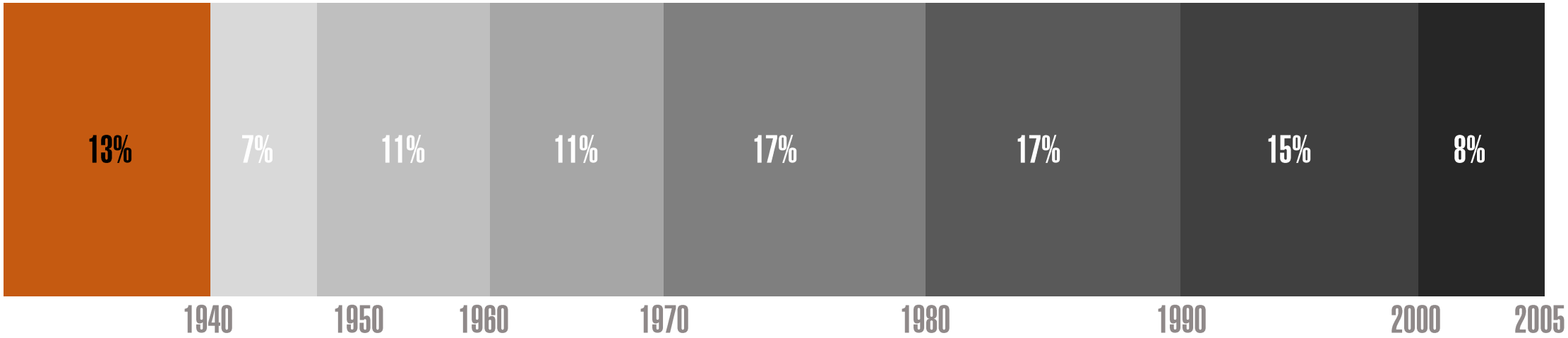
EVALUATE

Age of U.S. Building Stock[1]



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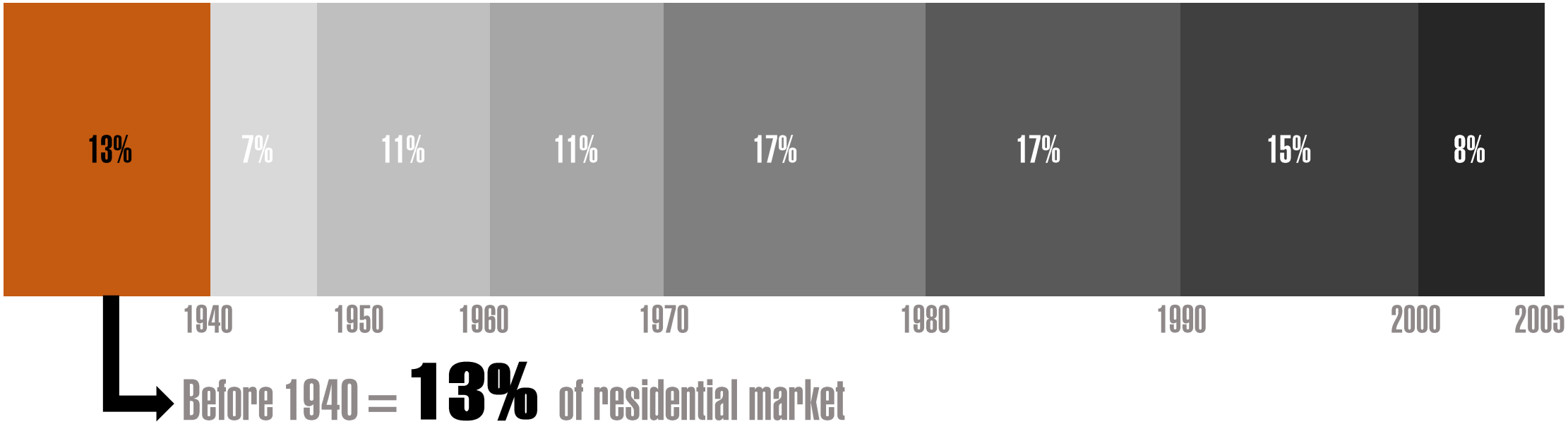

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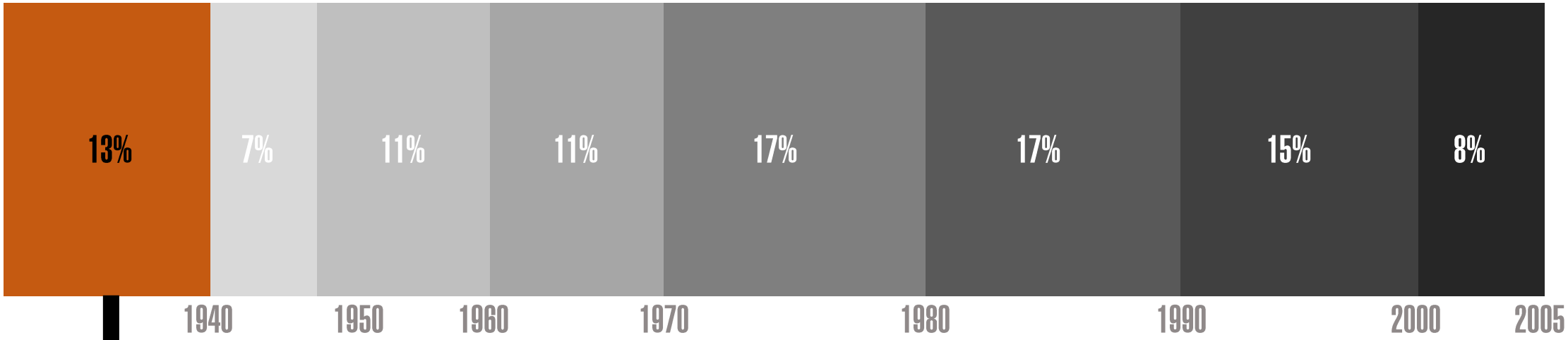

Before 1940 = **13%** of residential market

82 billion s.f. of existing space will be demolished and replaced

between 2005 and 2030[2]

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[2] Arthur C. Nelson, *Toward A New Metropolis: The Opportunity to Rebuild America*. The Brookings Institution Metropolitan Policy Program, 2004.

EVALUATE

Environmental Impacts of Renovation vs. New Construction[1]

Standard Building: -9%

HPB: -12%

Climate Change

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Icons created by Nathan Stang, Eduardo Chang, and yohooo from Noun Project

EVALUATE

Environmental Impacts of Renovation vs. New Construction[1]

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HPB: -12%

Climate Change

Standard Building: -17%

HPB: -20%

Human Health

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Environmental Impacts of Renovation vs. New Construction[1]

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Human Health

Resource Depletion

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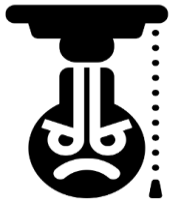

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Ecosystem Quality

Standard Building: -24%

HPB: -28%

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DESIGN GOALS

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SITE LOCATION

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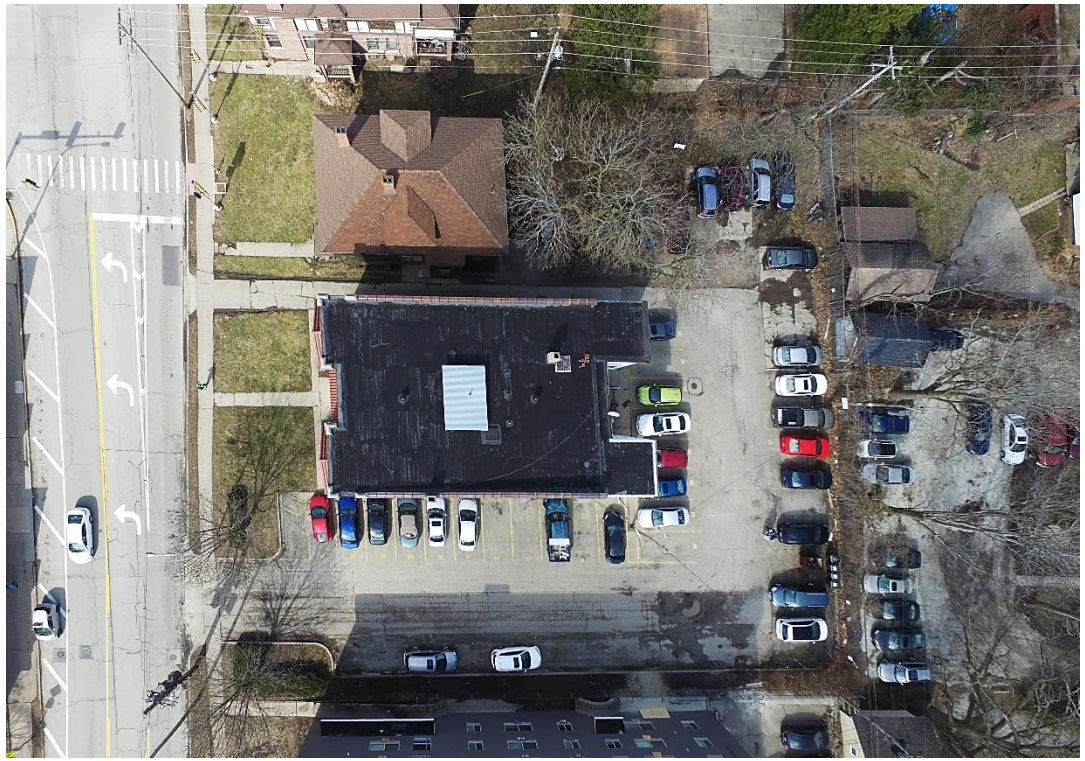
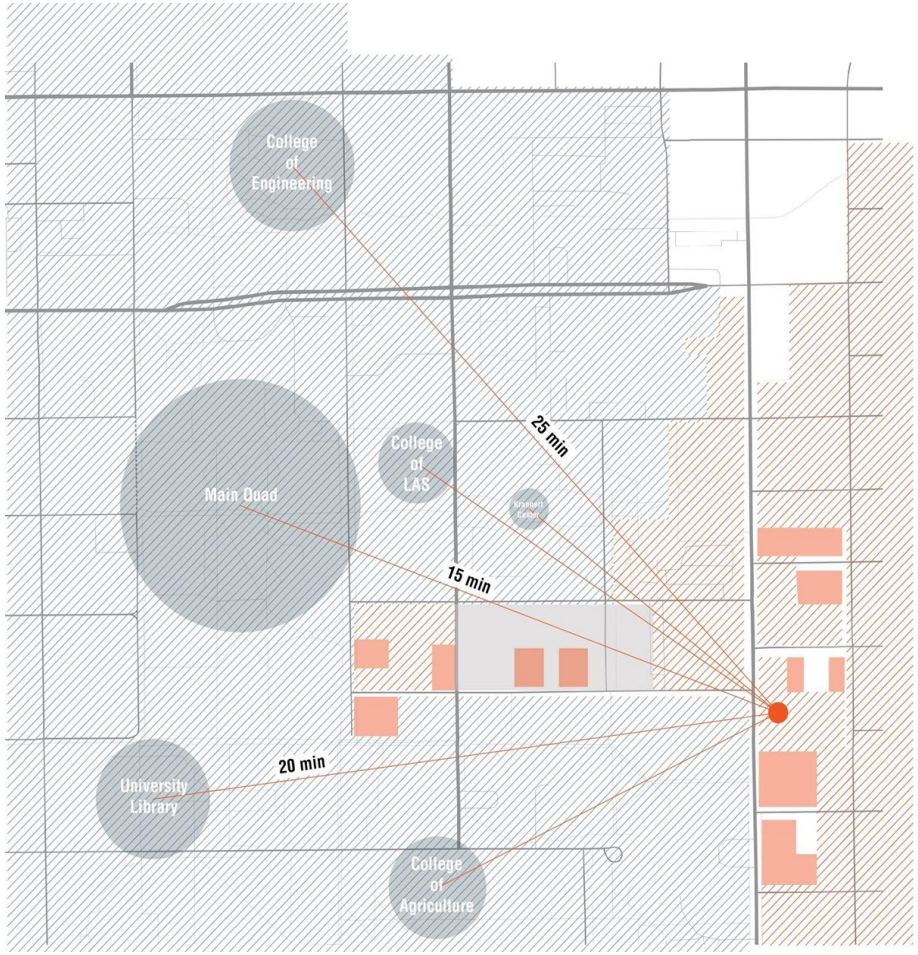


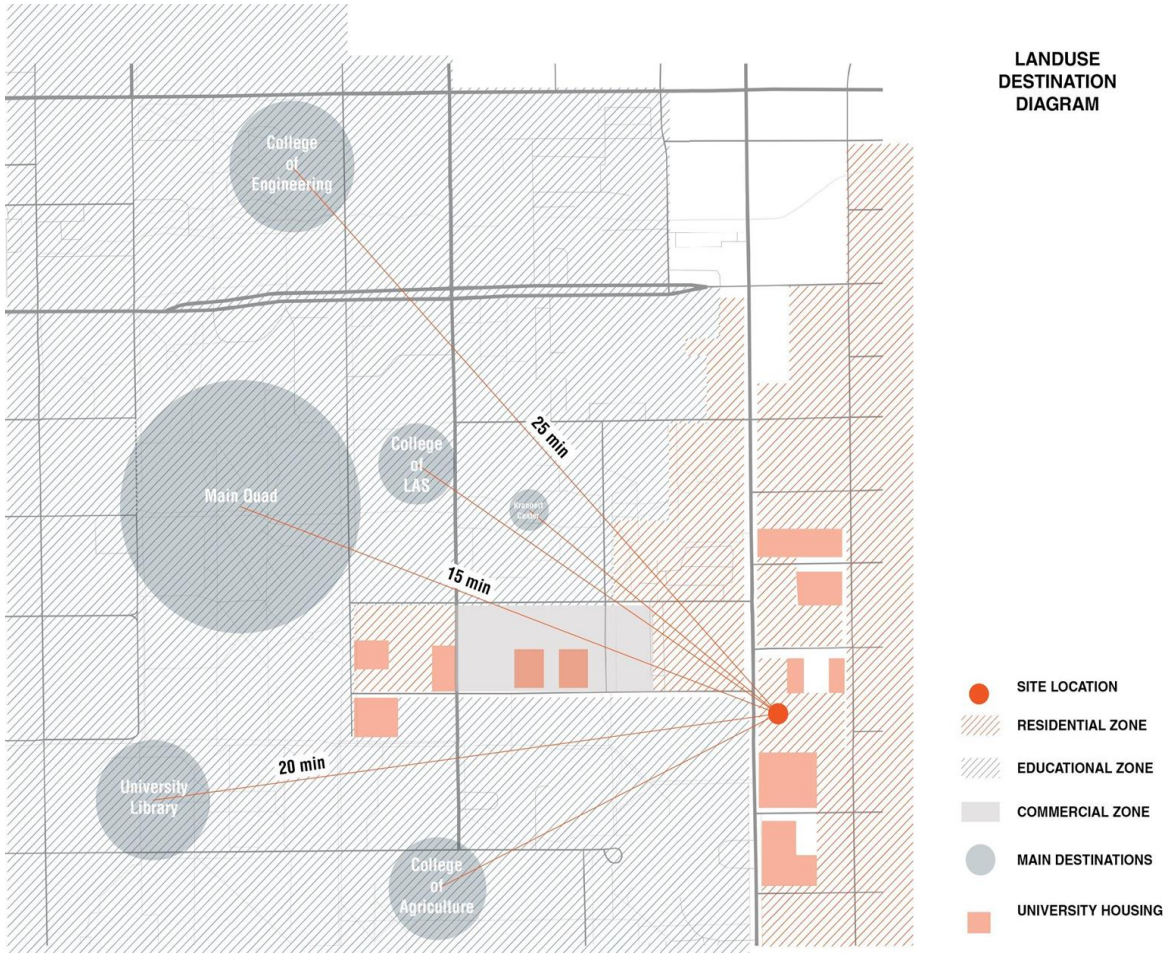
LAND USE DESTINATION



LANDUSE DESTINATION DIAGRAM

- SITE LOCATION
- RESIDENTIAL ZONE
- EDUCATIONAL ZONE
- COMMERCIAL ZONE
- MAIN DESTINATIONS
- UNIVERSITY HOUSING

LAND USE DESTINATION



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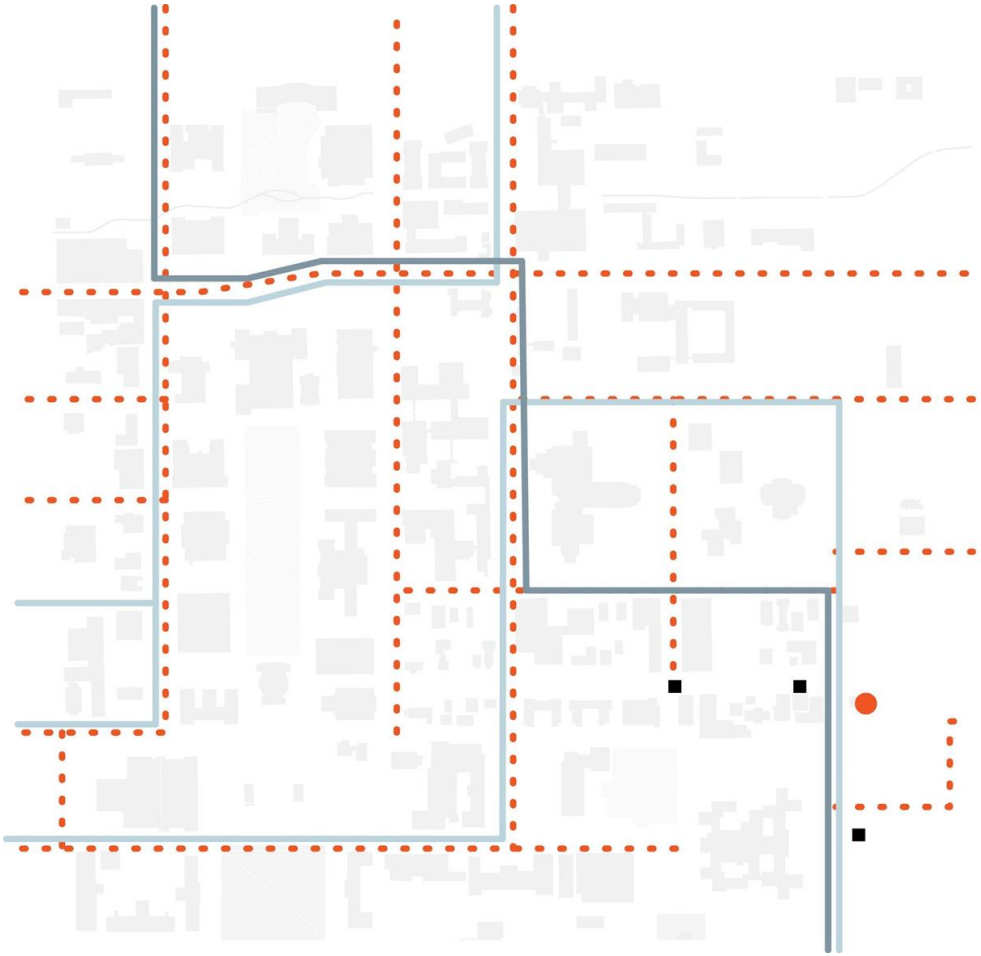
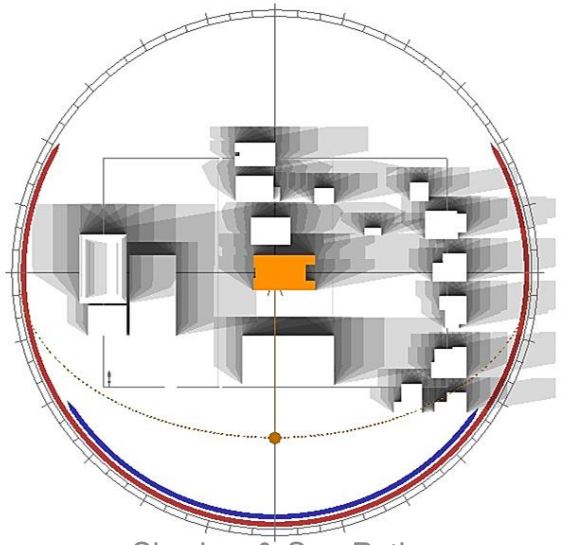
PUBLIC ACCESSIBILITY MAP



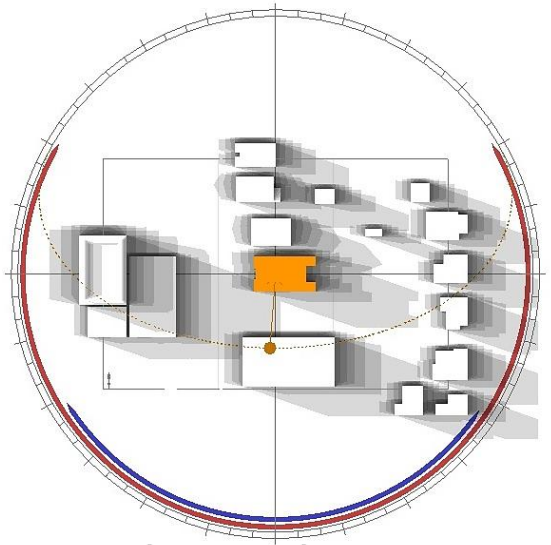
PUBLIC ACCESSIBILITY MAP

- SITE LOCATION
- BUS STOPS
- BUS 2 ROUTE
- BUS 22 ROUTE
- BIKE PATH

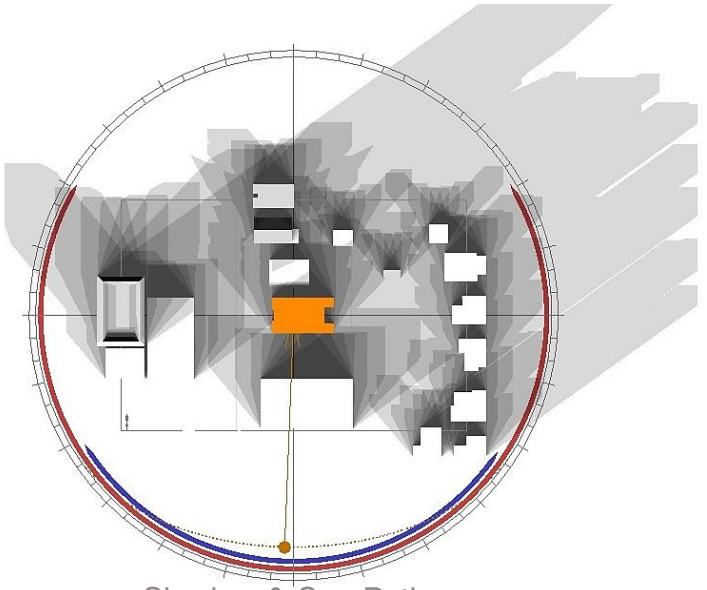
SUN AND SHADE



Shadow & Sun Path
March 22nd

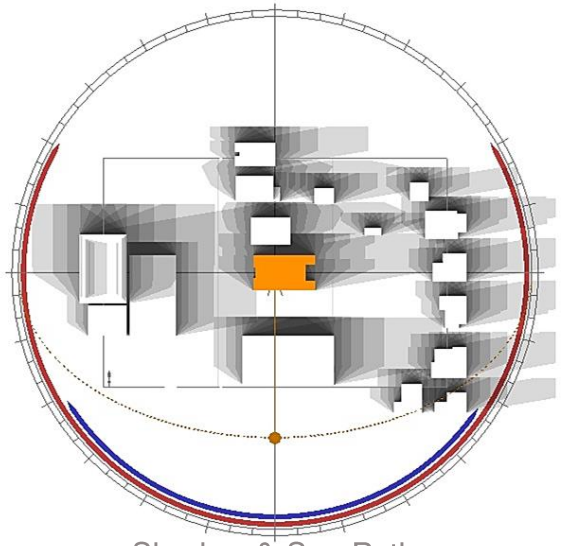


Shadow & Sun Path
June 22nd

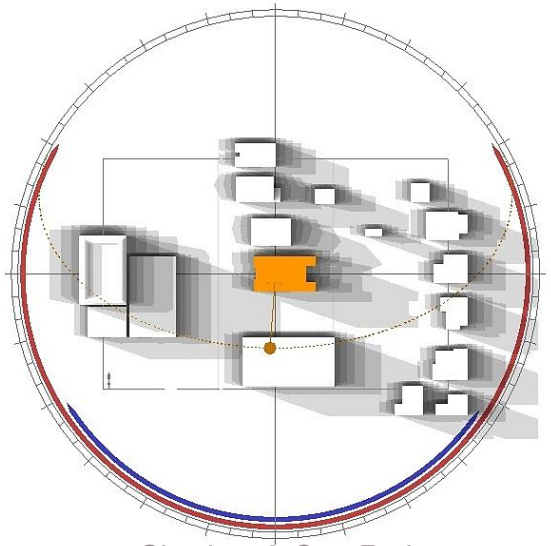


Shadow & Sun Path
December 22nd

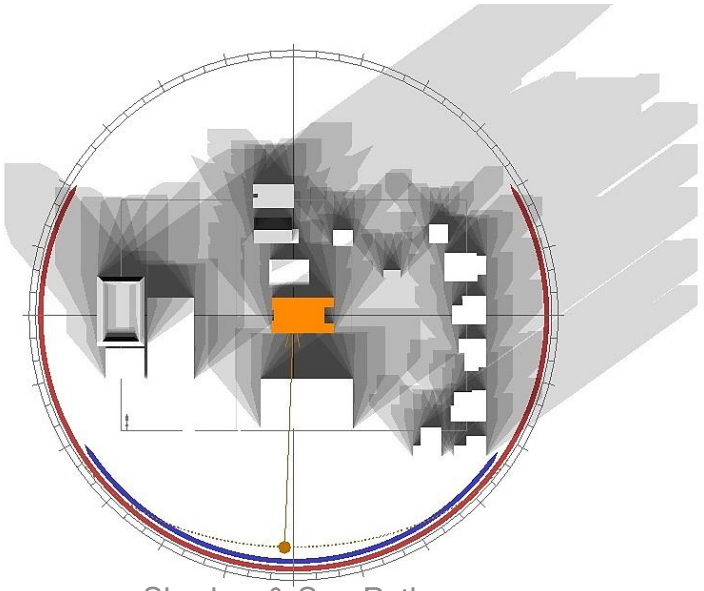
SUN AND SHADE



Shadow & Sun Path
March 22nd

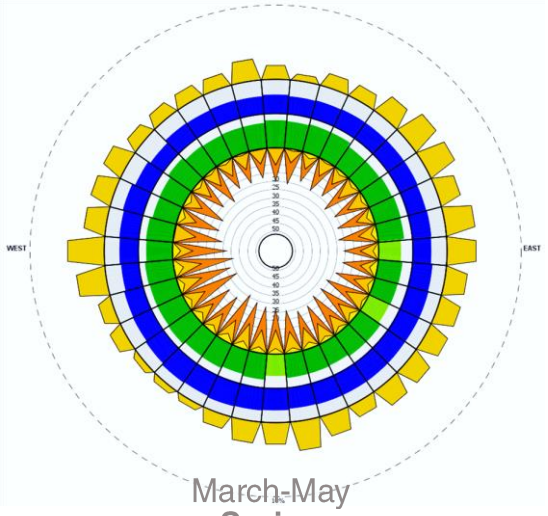


Shadow & Sun Path
June 22nd

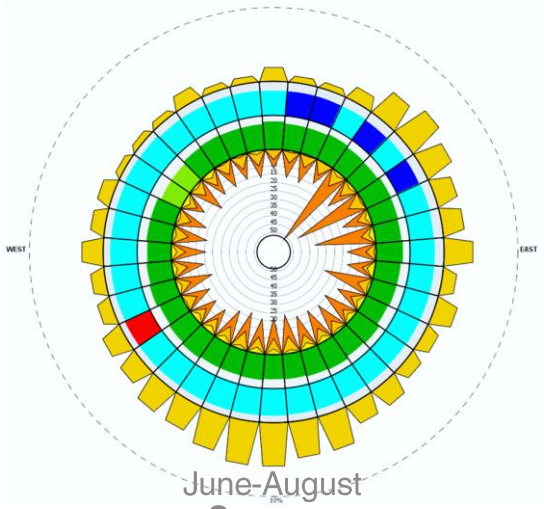


Shadow & Sun Path
December 22nd

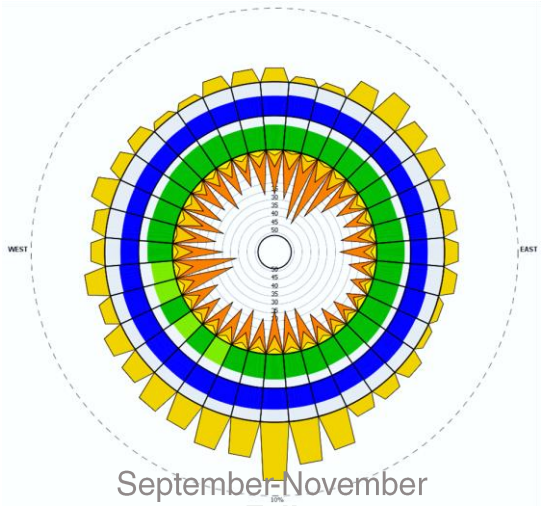
WIND



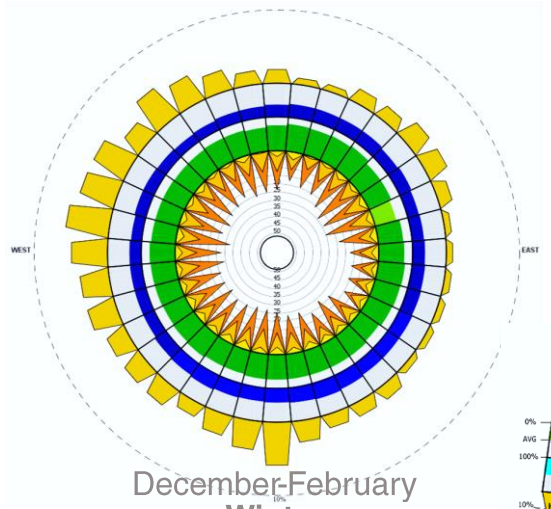
March-May
Spring



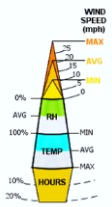
June-August
Summer



September-November
Fall

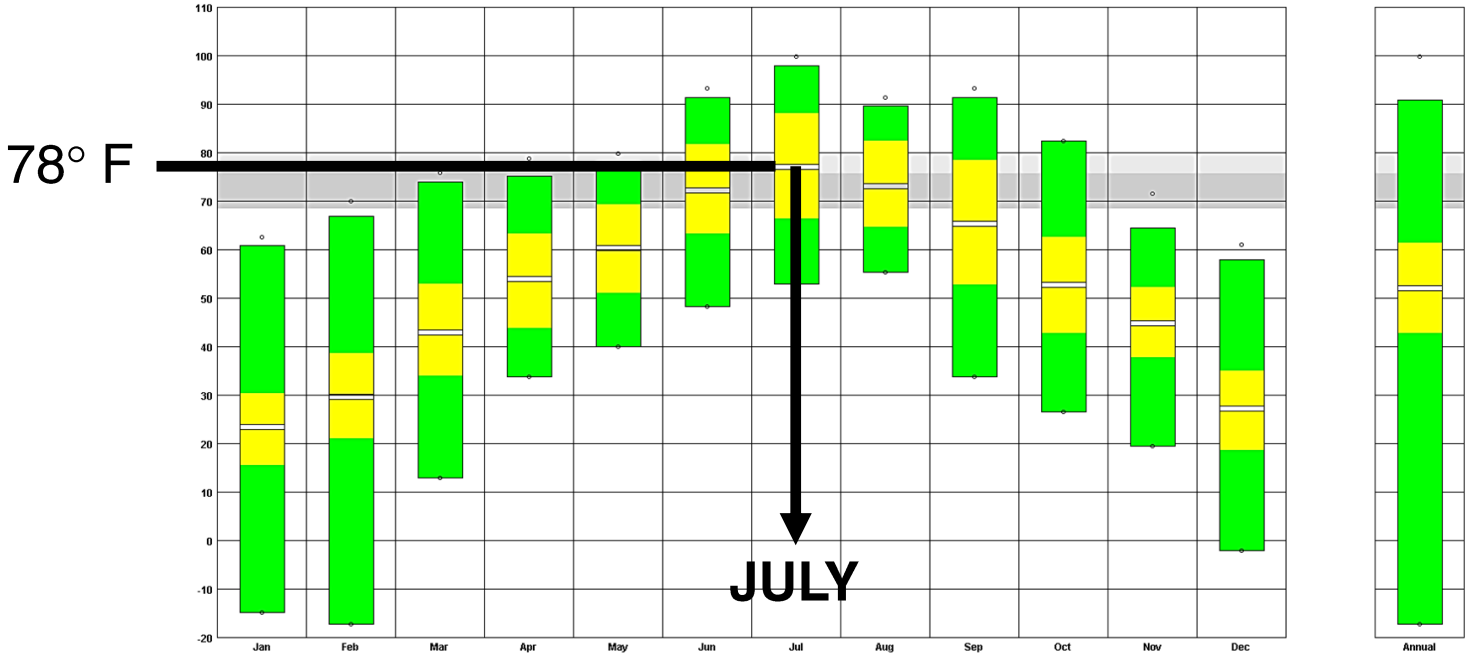


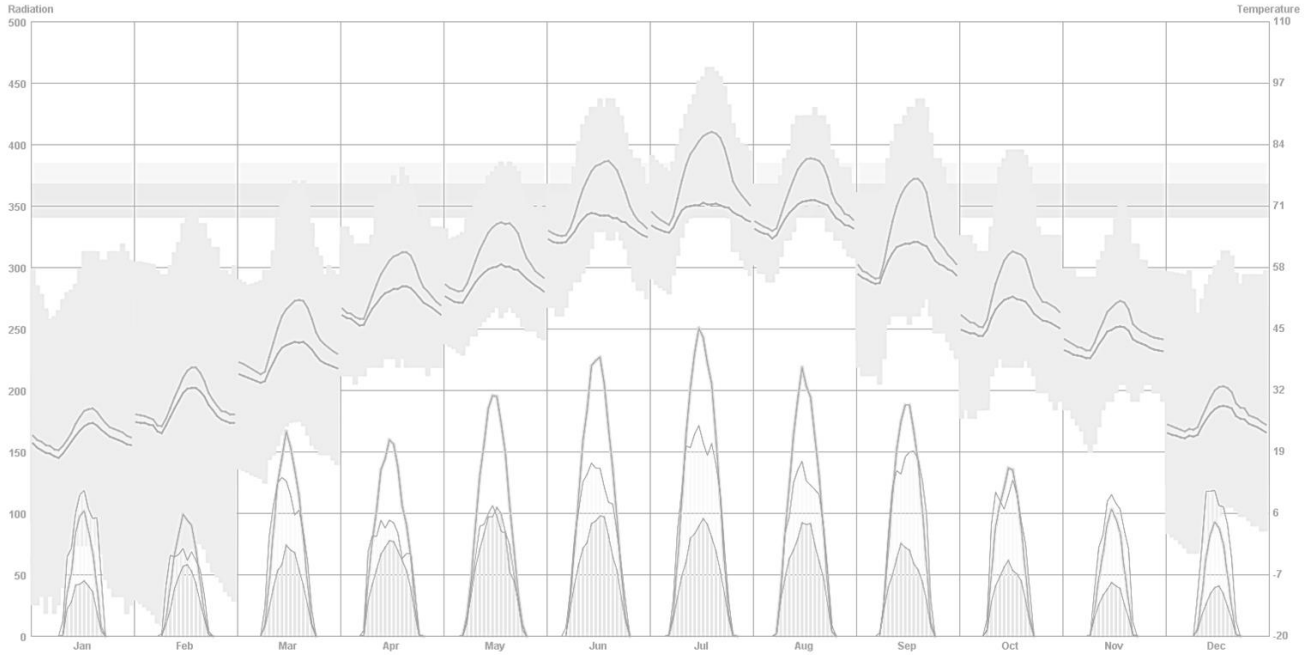
December-February
Winter



TEMPERATURE

Average Max Temp: 78° F

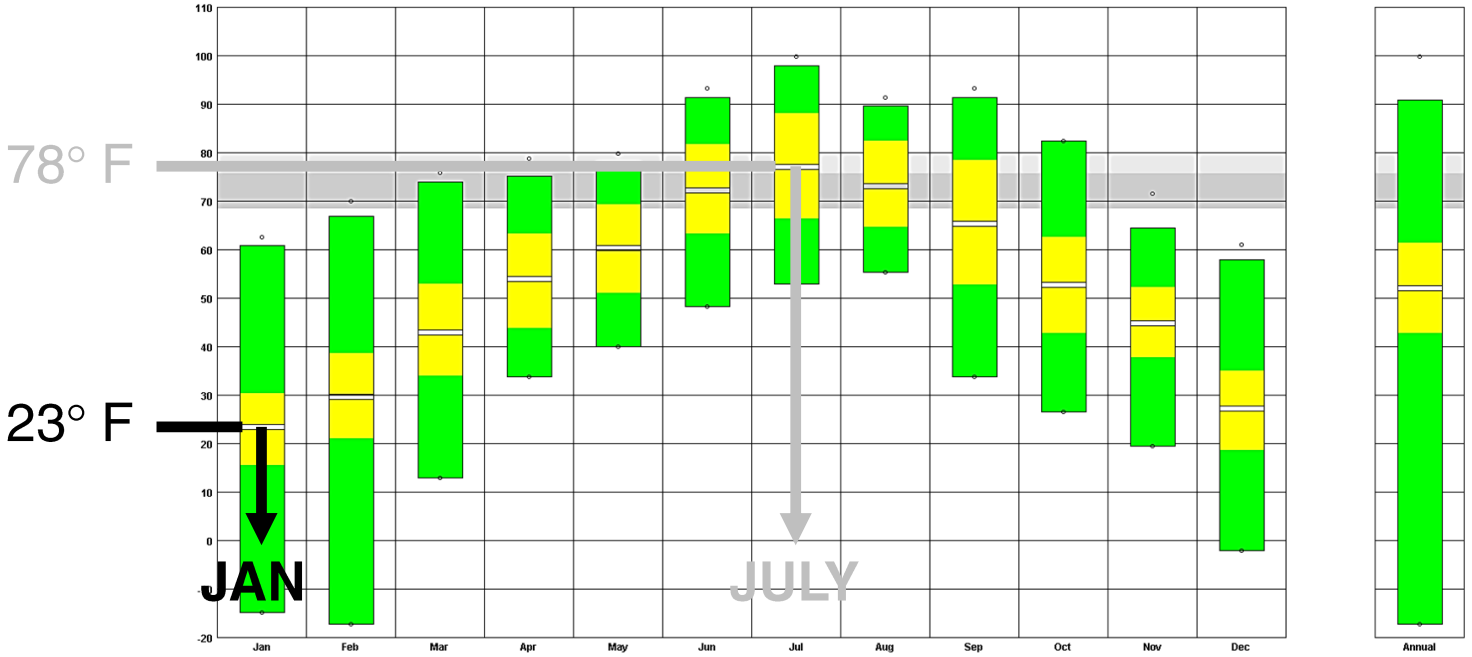


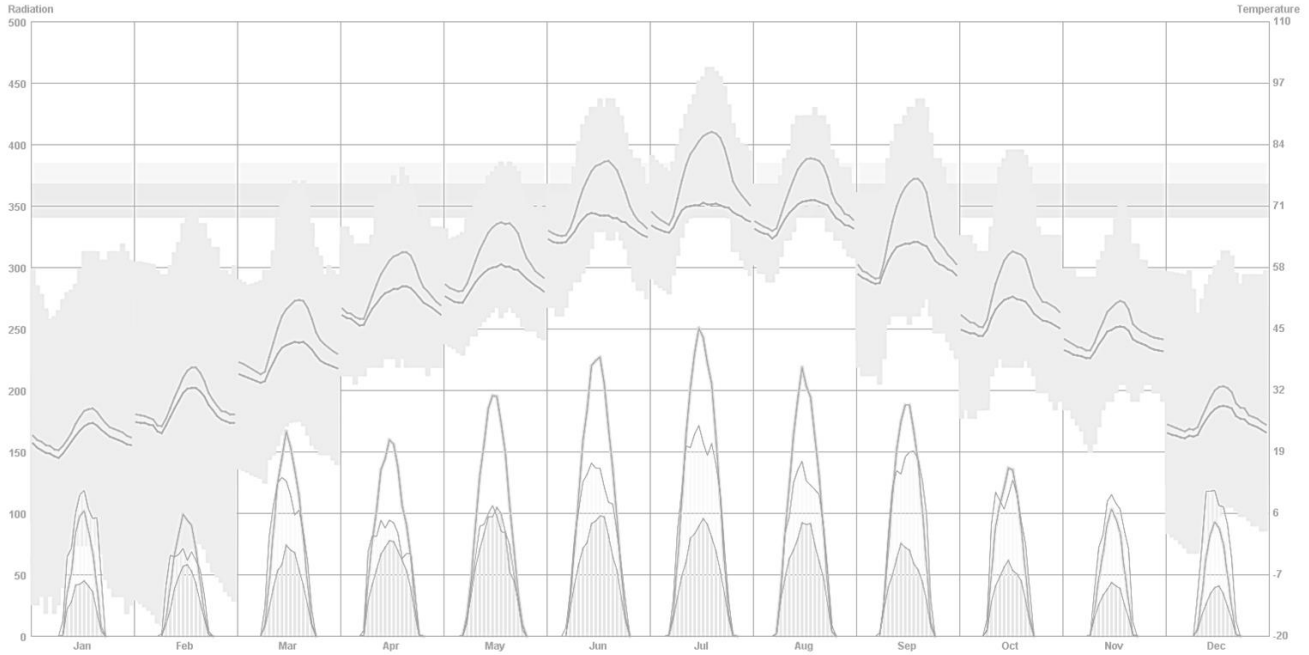


TEMPERATURE

Average Max Temp: 78° F

Average Min. Temp: 23° F



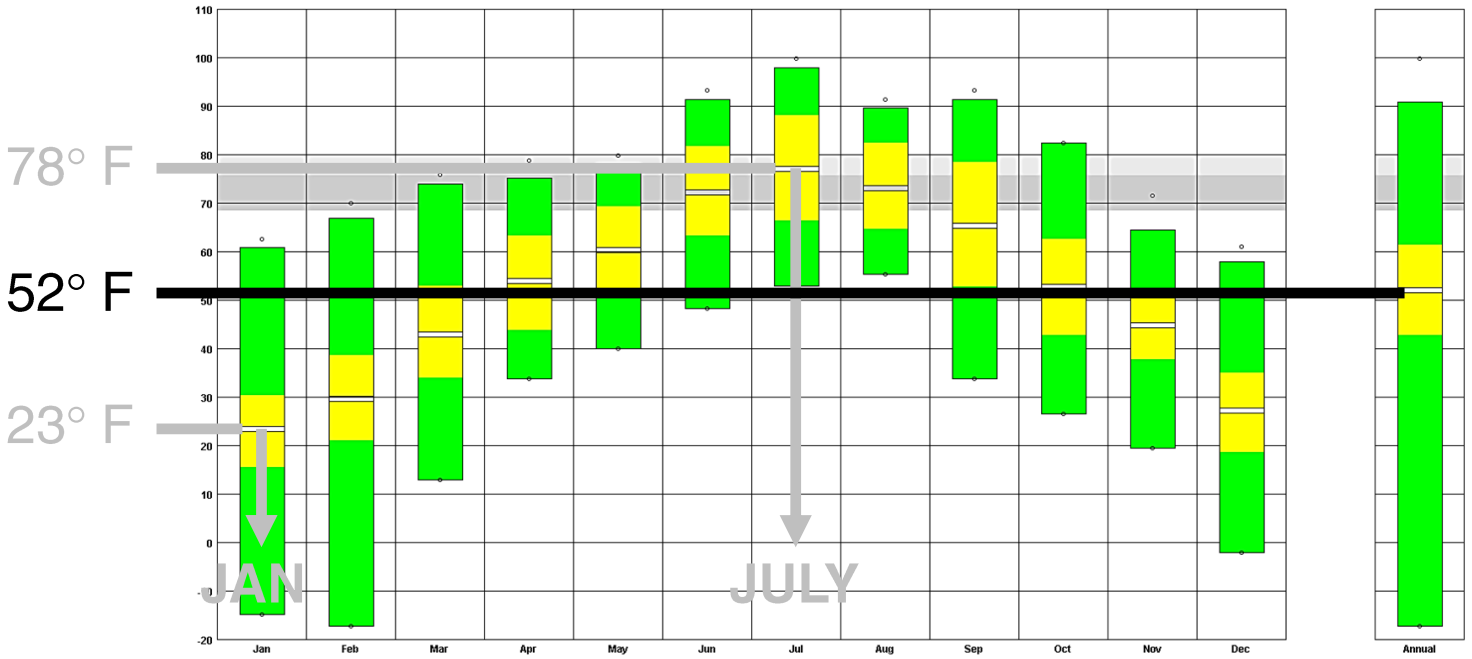


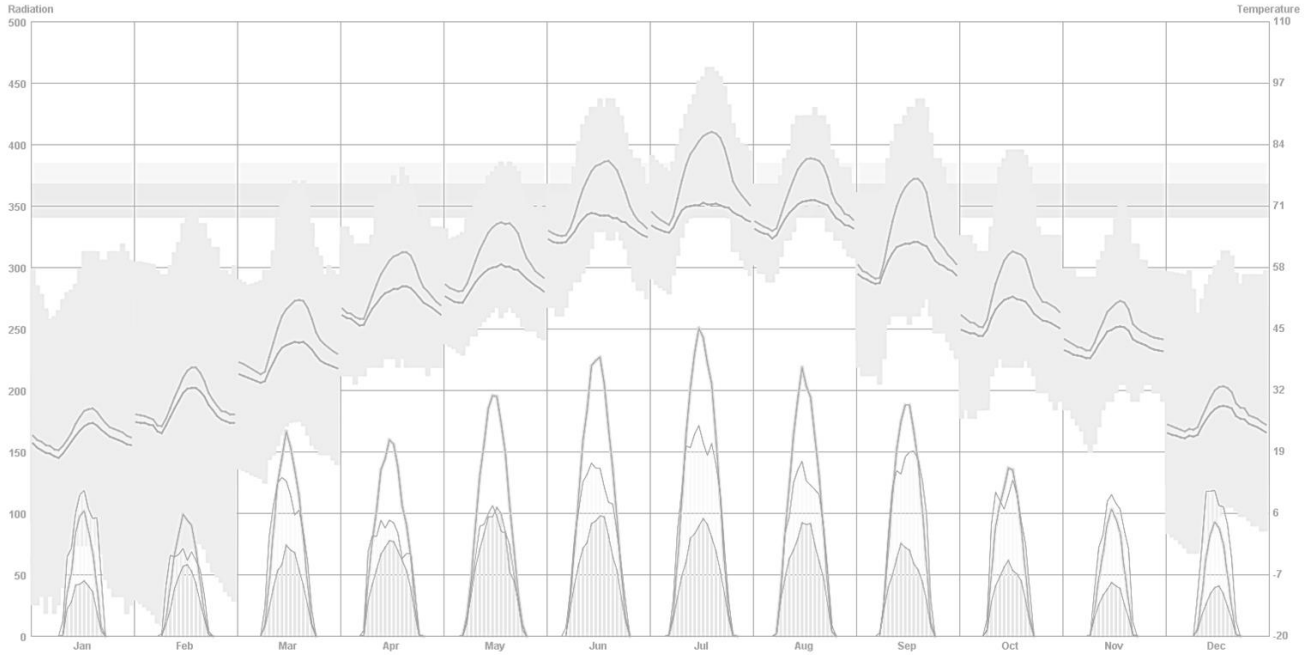
TEMPERATURE

Average Max Temp: 78° F

Average Min. Temp: 23° F

Average Annual Temp: 52° F





TEMPERATURE

Average Max Temp: 78° F
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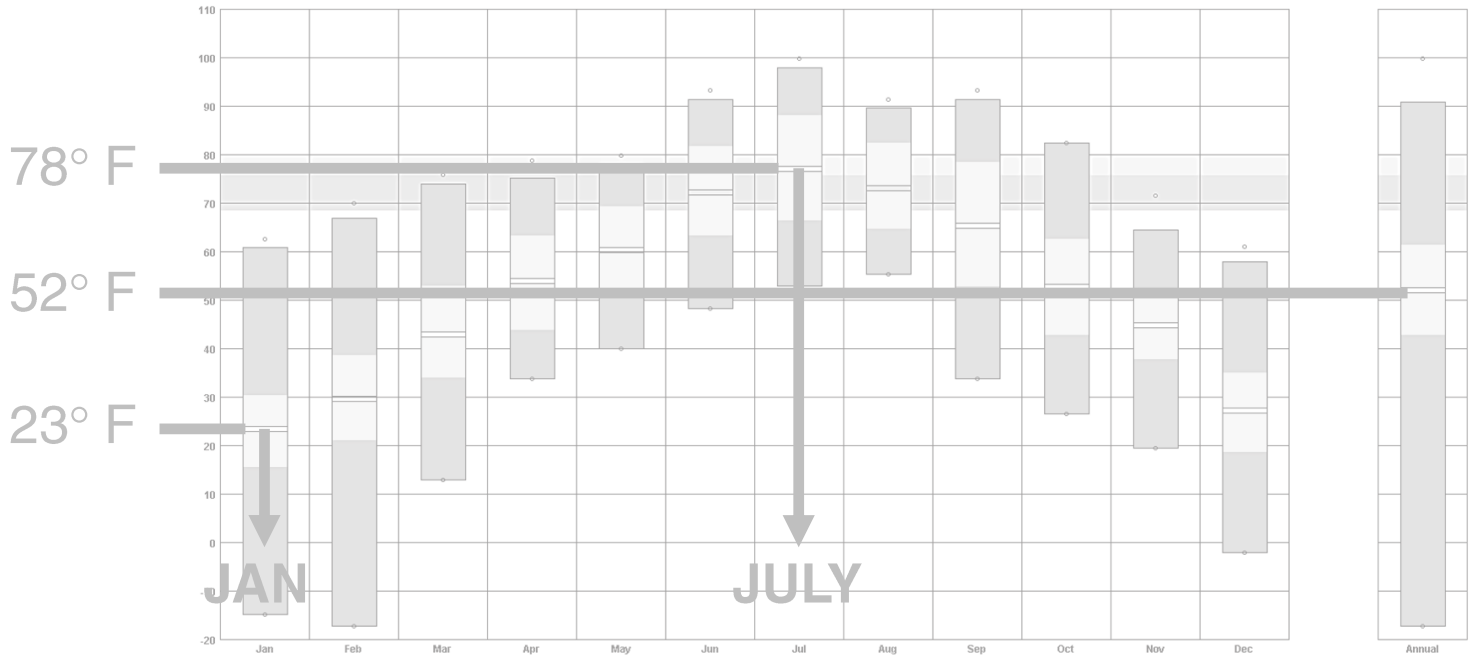
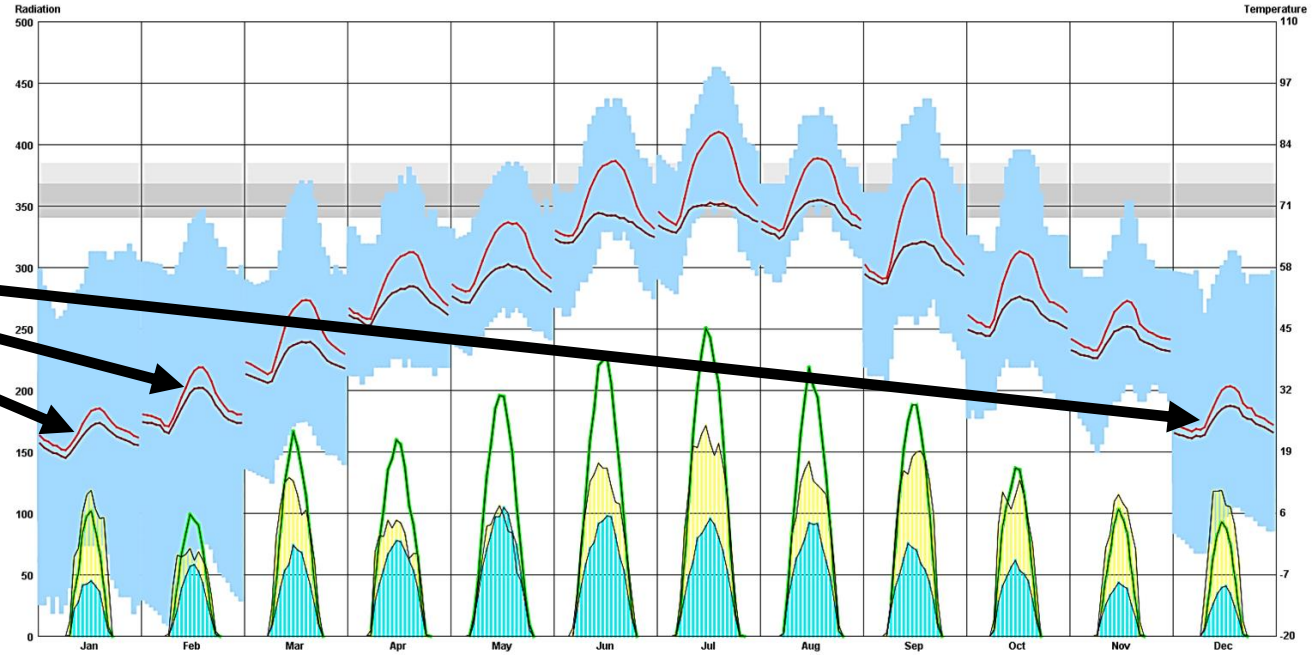


Condensation and Freeze Thaw (FT) Potential



EXISTING ARCHITECTURAL DESIGN

EVALUATE AND ADDRESS

- Lack of Green Infrastructure
- 4 units per floor
- Closed layout
- Ineffective daylighting
- Poor MEP layout
- Non ADA compliant

N

EXISTING SITE PLAN

EXISTING ARCHITECTURAL DESIGN

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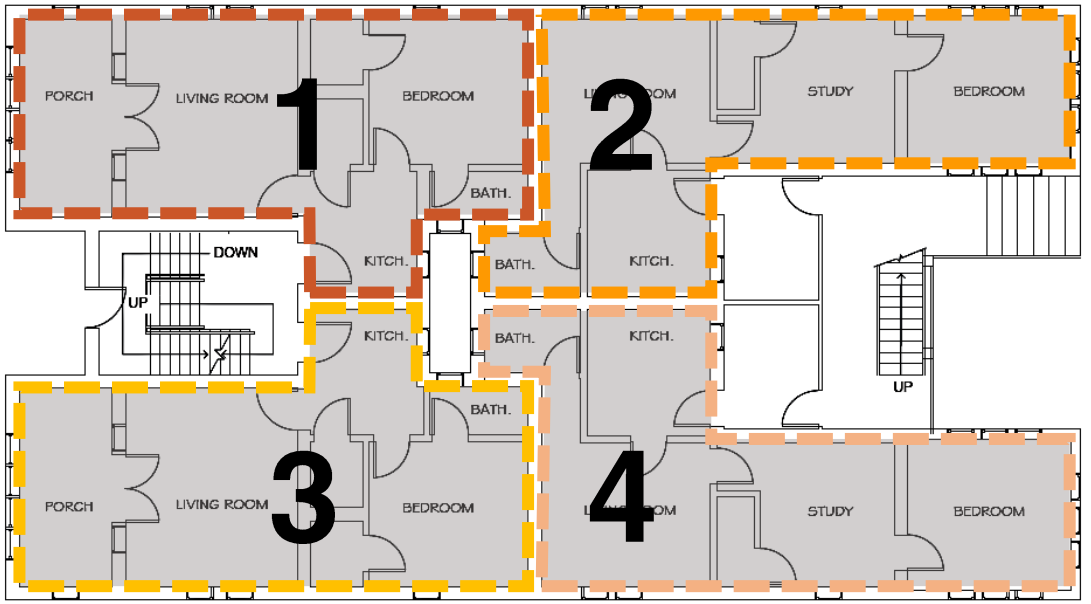
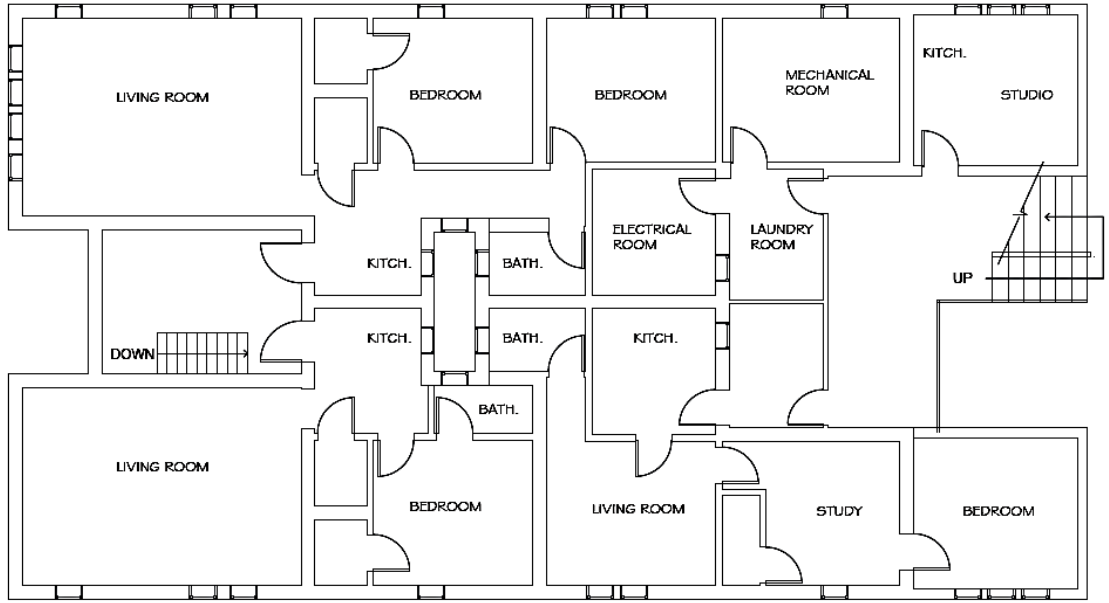


EXISTING UPPER FLOOR PLAN
3/16”=1’-00”



EXISTING BASEMENT FLOOR PLAN
3/16”=1’-00”

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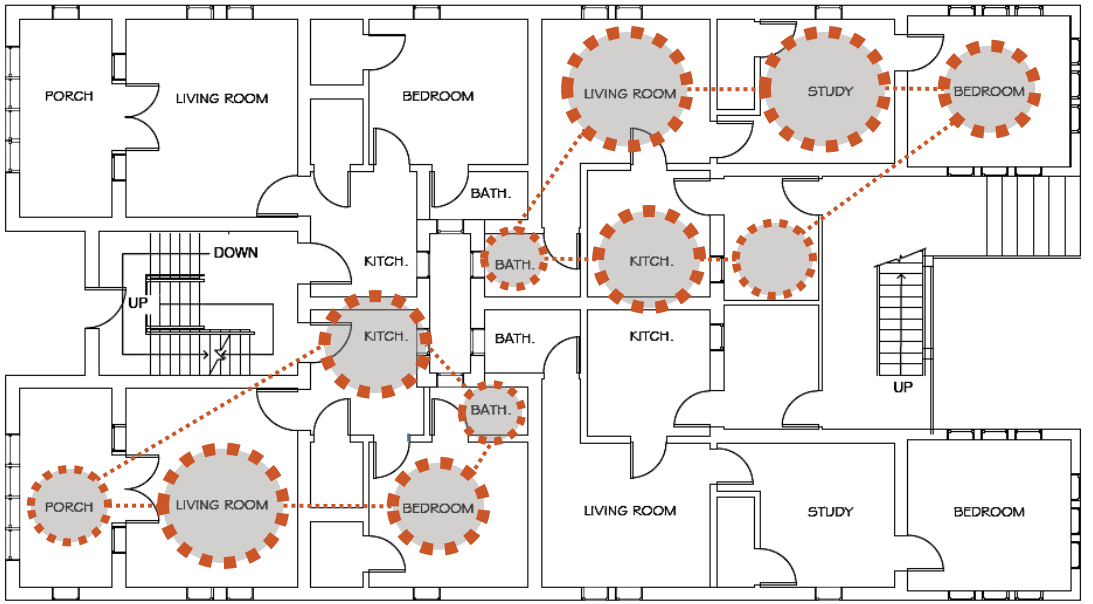

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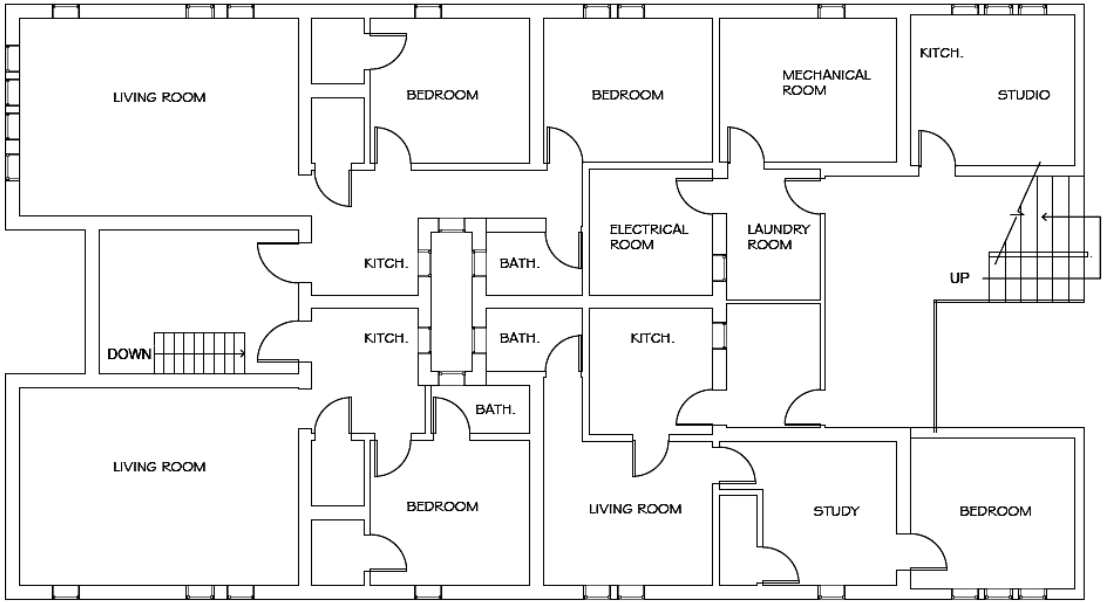

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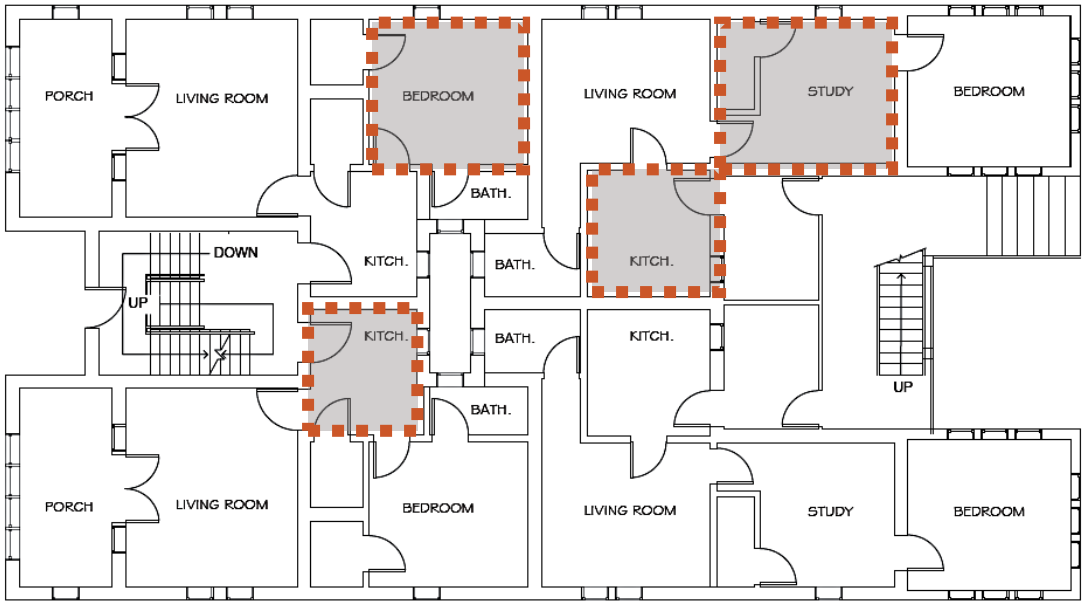

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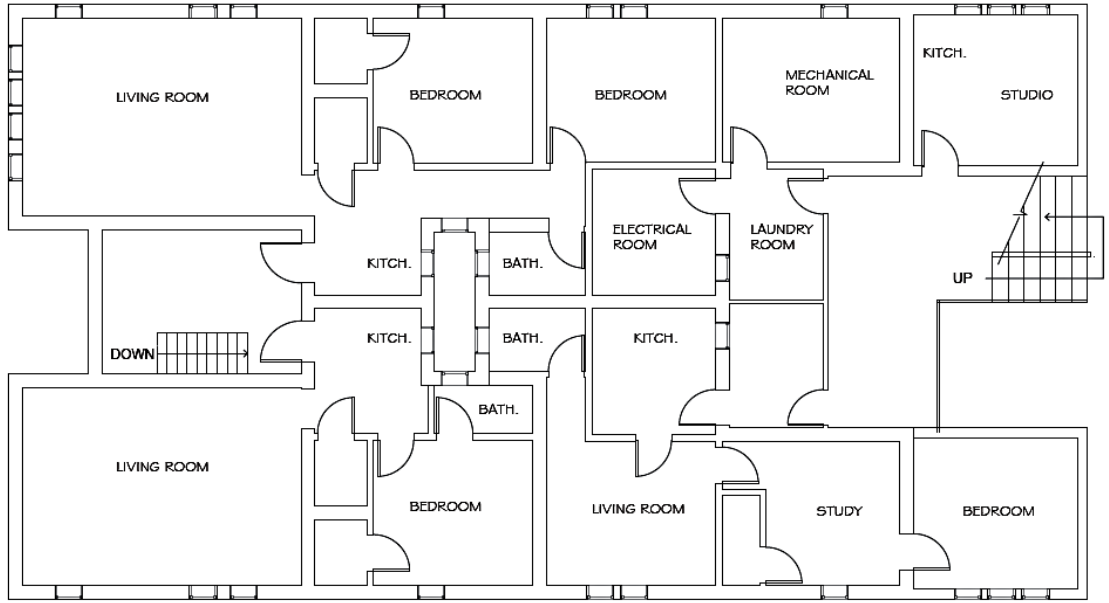

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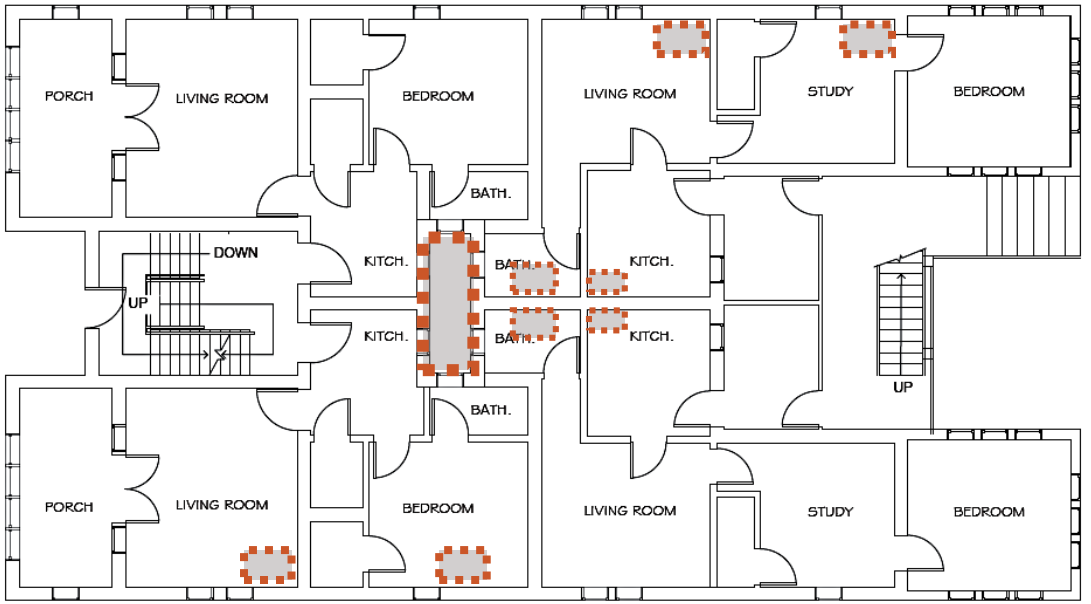
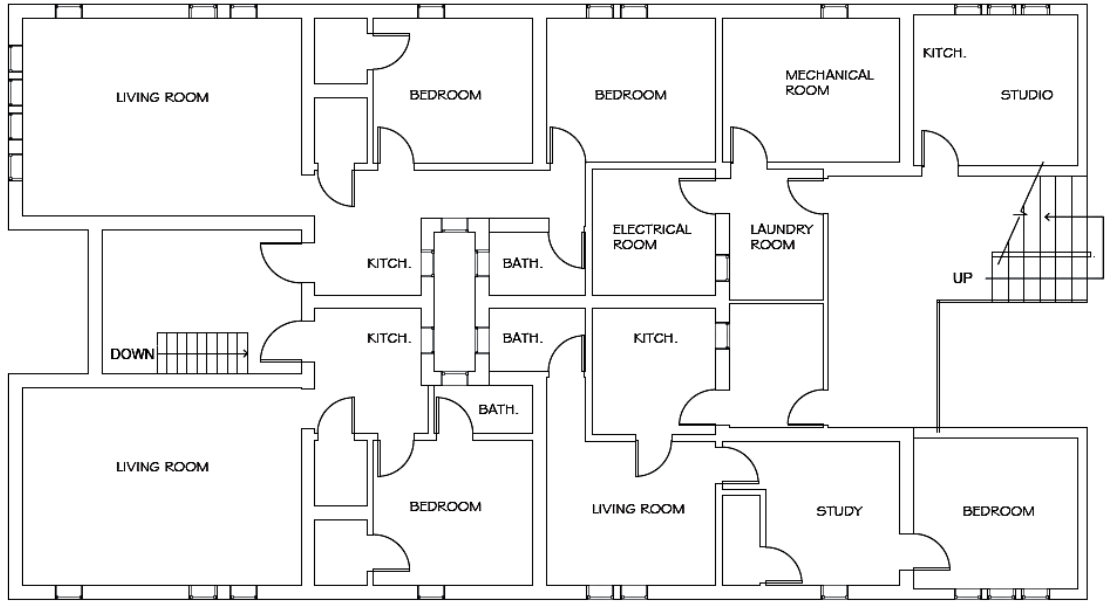


EXISTING UPPER FLOOR PLAN
3/16”=1’-00”

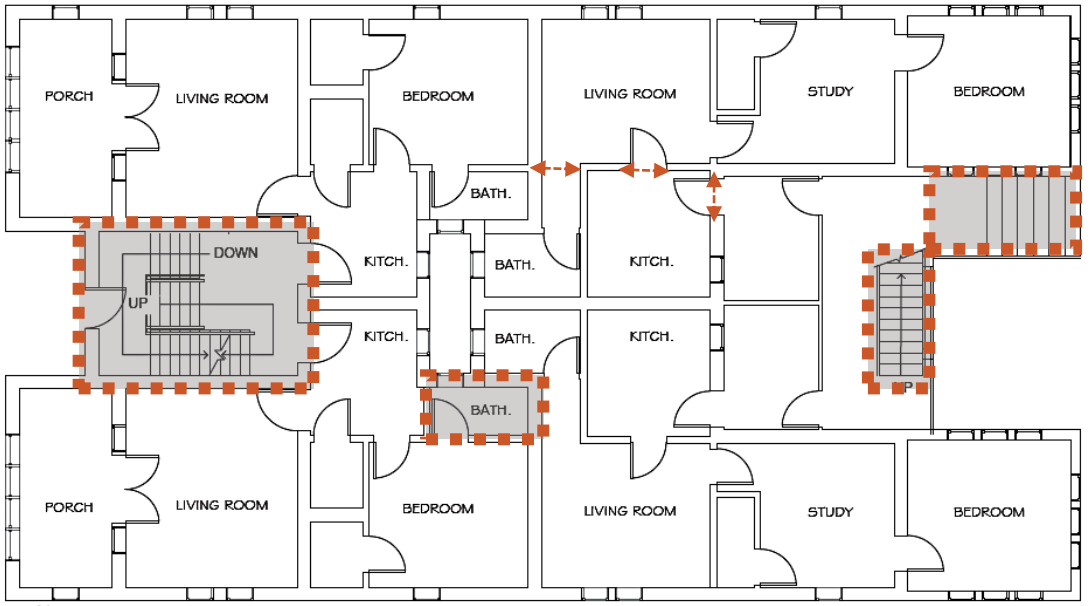


EXISTING BASEMENT FLOOR PLAN
3/16”=1’-00”

EXISTING ARCHITECTURAL DESIGN

EVALUATE AND ADDRESS

- Lack of Green Infrastructure
- 4 units per floor
- Closed layout
- Ineffective daylighting
- Poor MEP layout
- Non ADA compliant



EXISTING UPPER FLOOR PLAN
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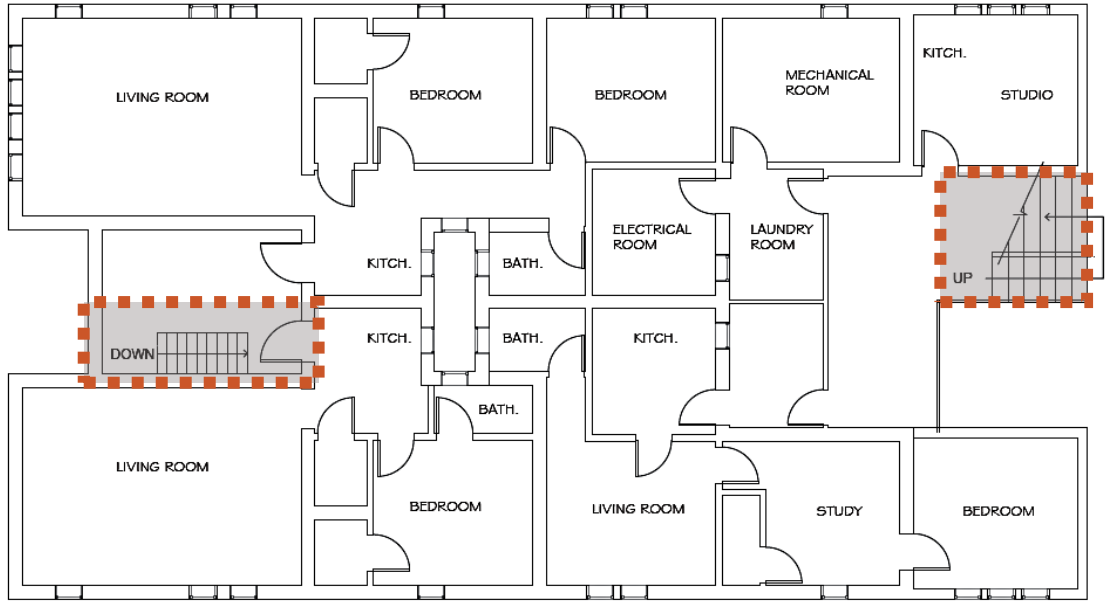


EXISTING BASEMENT FLOOR PLAN
3/16”=1’-00”

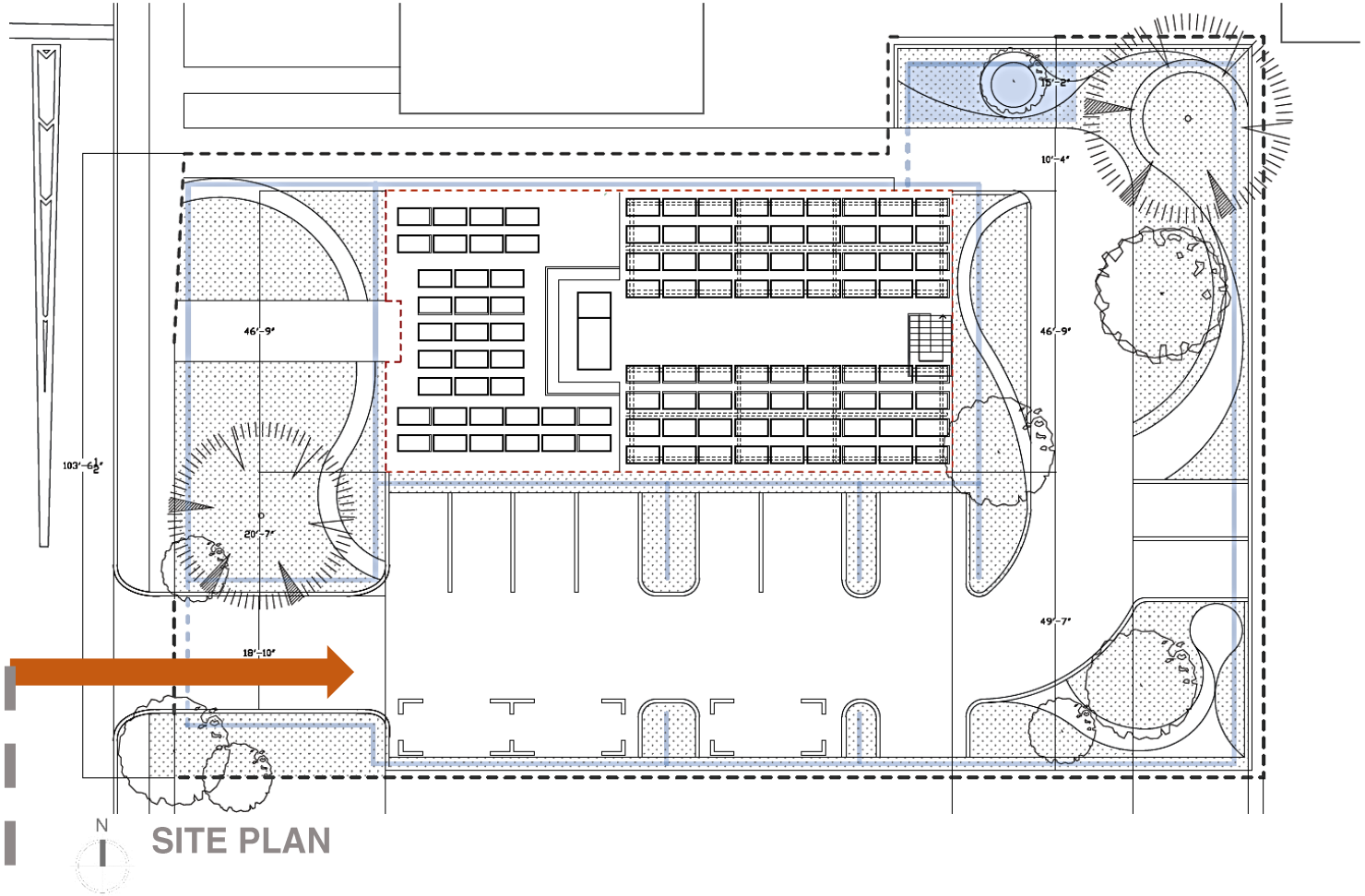
AERIAL VIEW FROM SOUTHEAST

DESIGN RENDERINGS

ARCHITECTURAL DESIGN

PROPOSE

- Green Infrastructure
- 2 units per floor
- Open layout
- Optimize daylighting
- Integrated MEP layout
- An ADA compliant Property
- A Disaster Safe Space



Convert 6,000 s.f.

of asphalt into green spaces and impermeable surfaces

ARCHITECTURAL DESIGN

PROPOSE

- Green Infrastructure
- 2 units per floor
- Open layout
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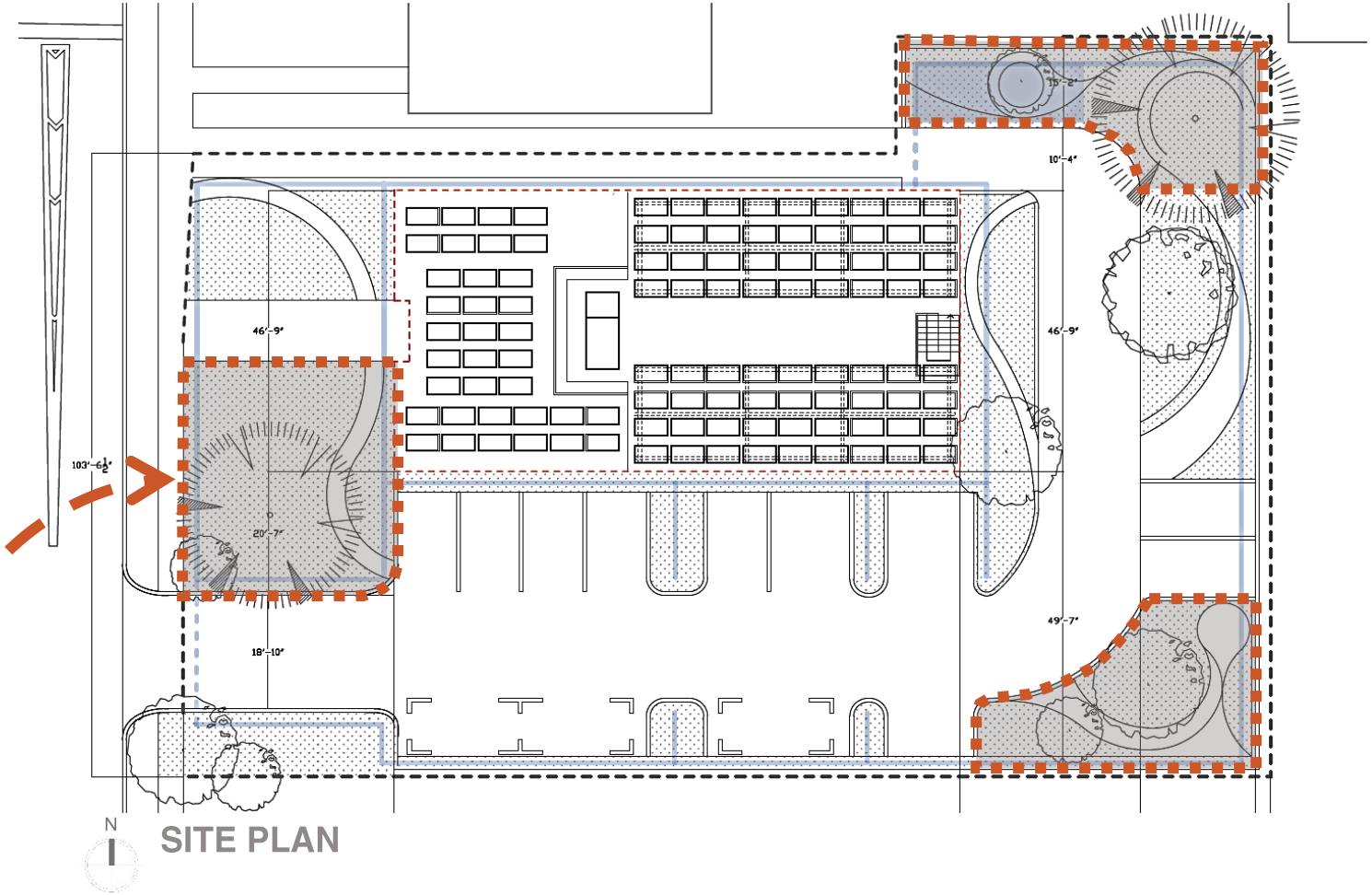

Design of 3 rain gardens

1

[1] http://icap.sustainability.illinois.edu/project/red-oak-rain-garden.

ARCHITECTURAL DESIGN

PROPOSE

- Green Infrastructure
- 2 units per floor
- Open layout
- Optimize daylighting
- Integrated MEP layout
- An ADA compliant Property
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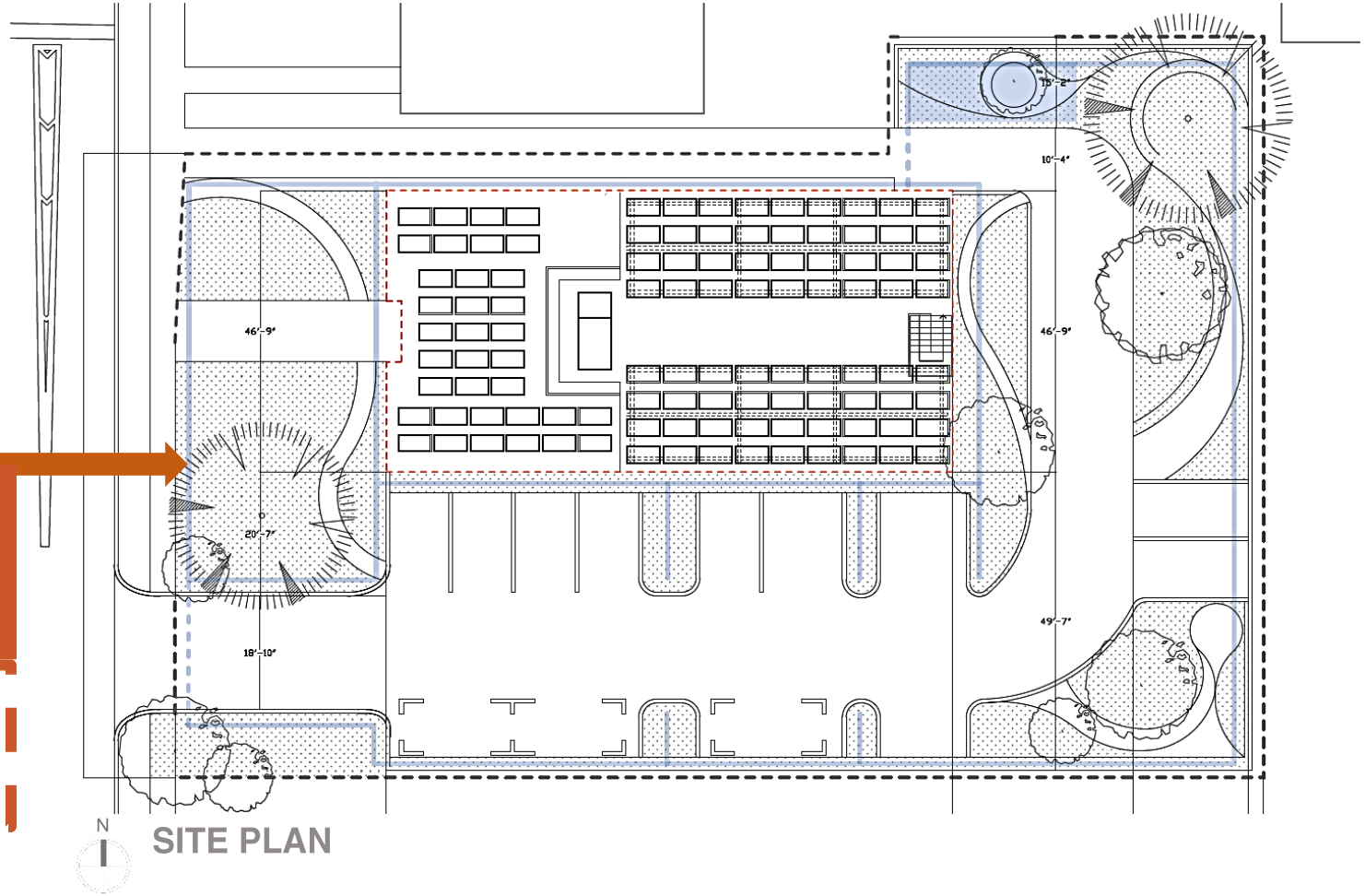
Stormwater Management System



SITE PLAN

ARCHITECTURAL DESIGN

PROPOSE

- Green Infrastructure
- 2 units per floor
- Open layout
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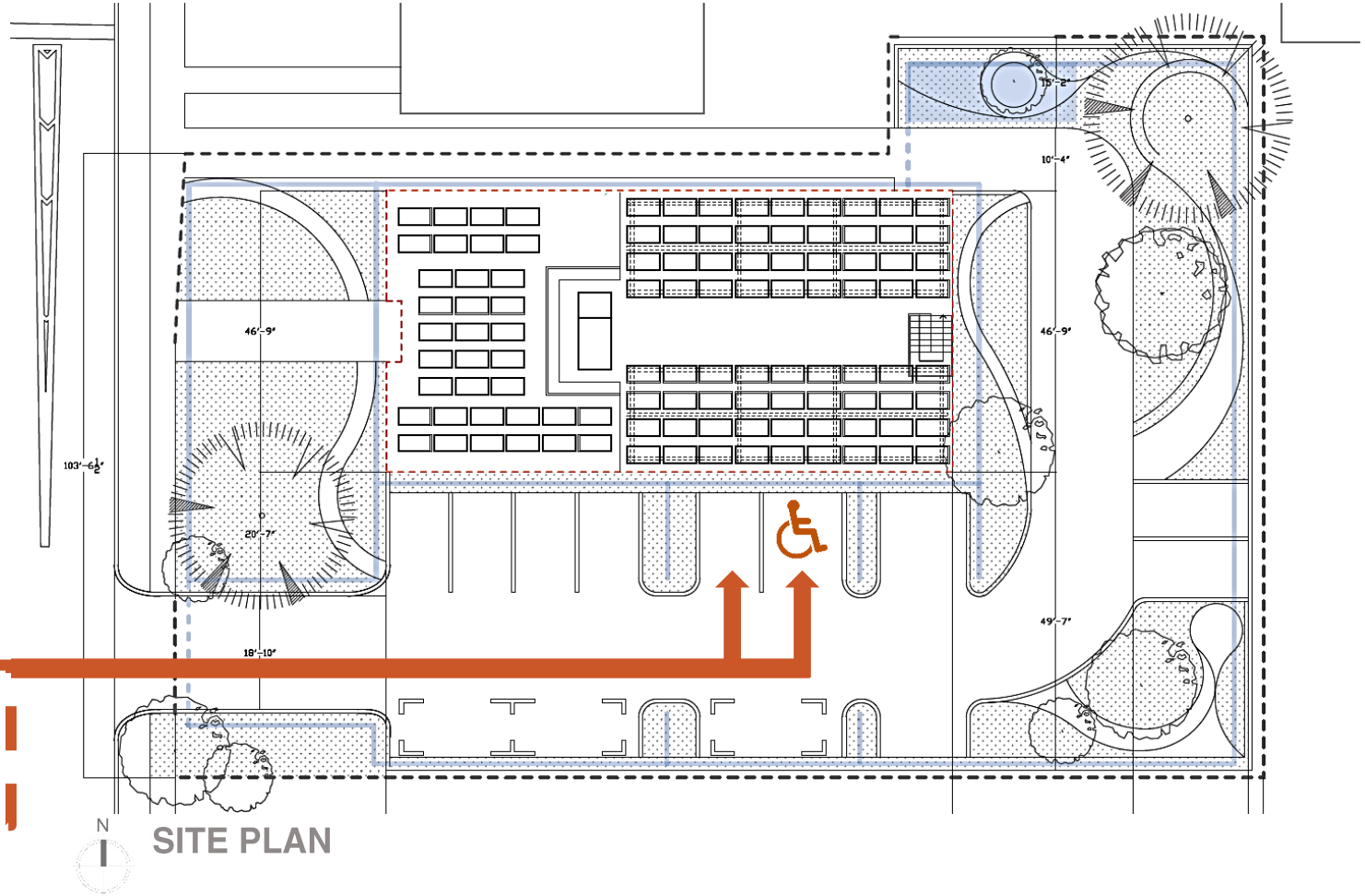

SITE PLAN

2 electrical car charging stations

ARCHITECTURAL DESIGN

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- Integrated MEP layout
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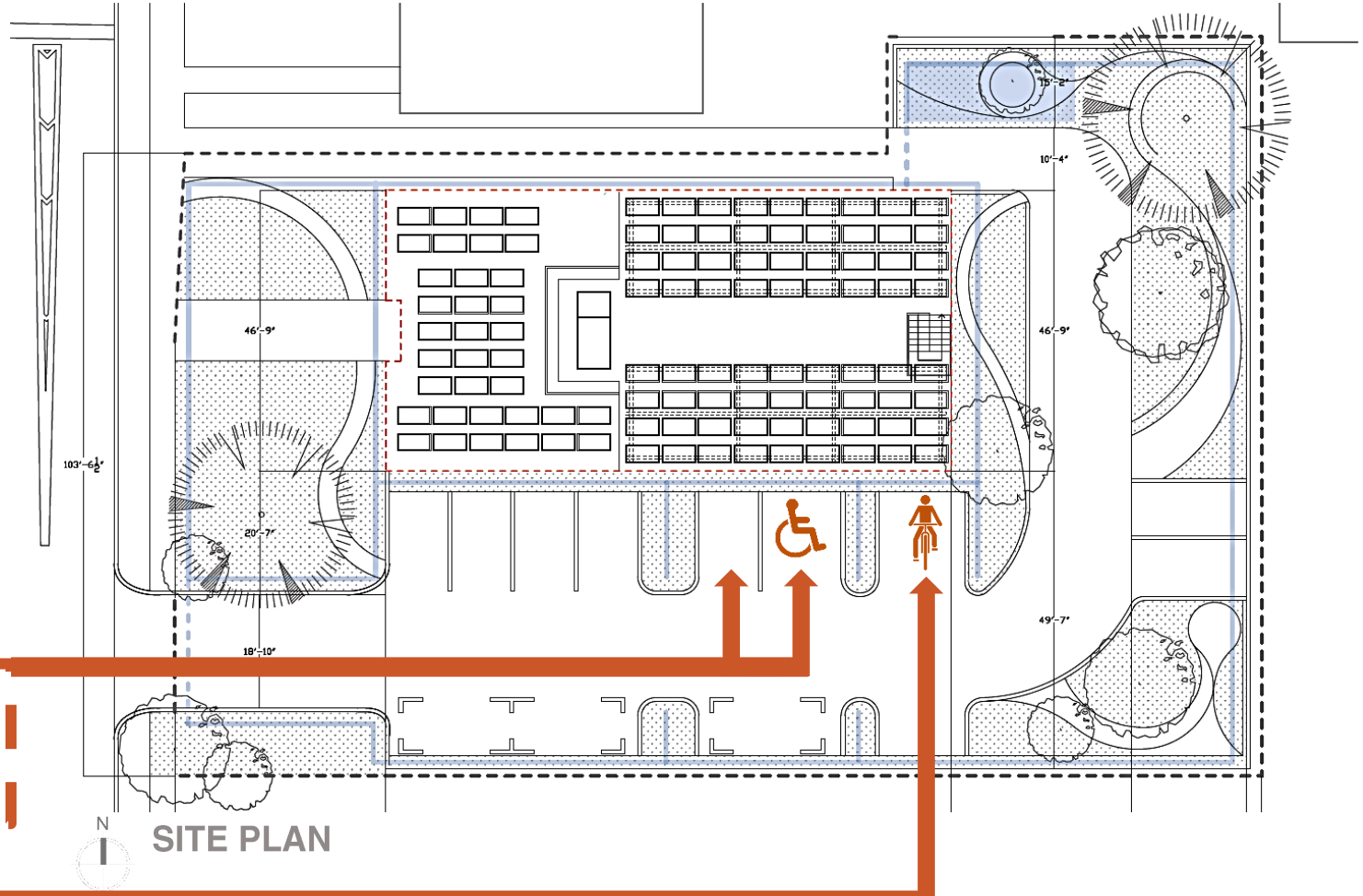
- A Disaster Safe Space



2 electrical car charging stations

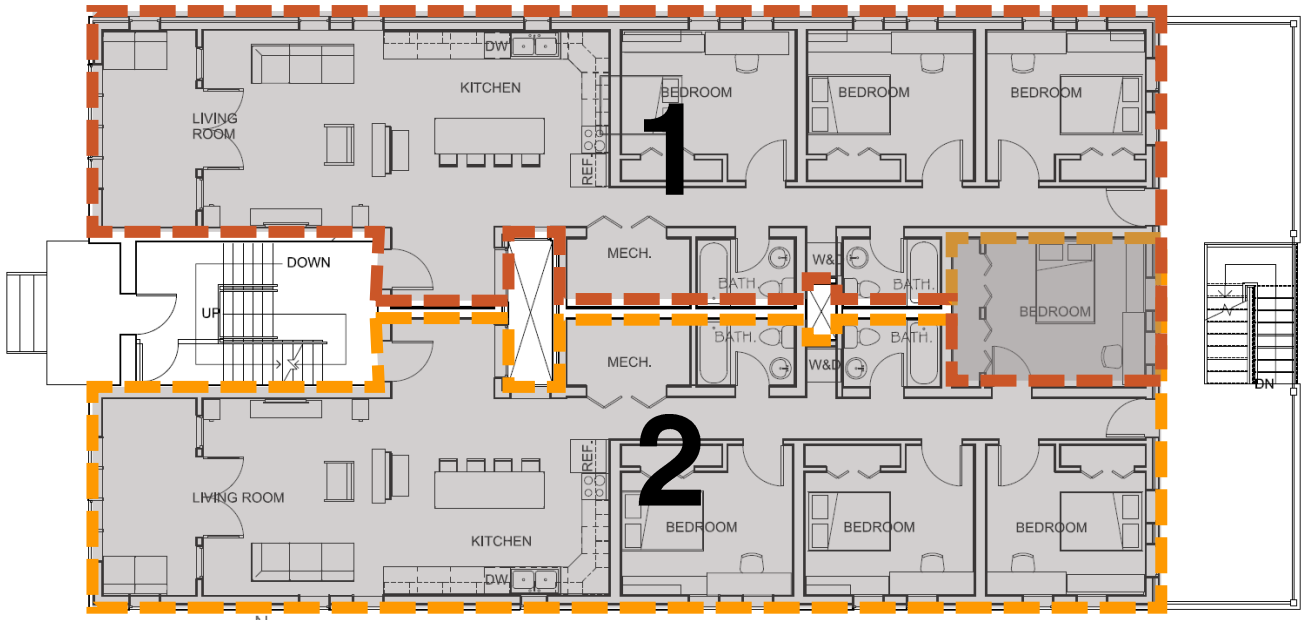
Bicycle racks

ARCHITECTURAL DESIGN

PROPOSE

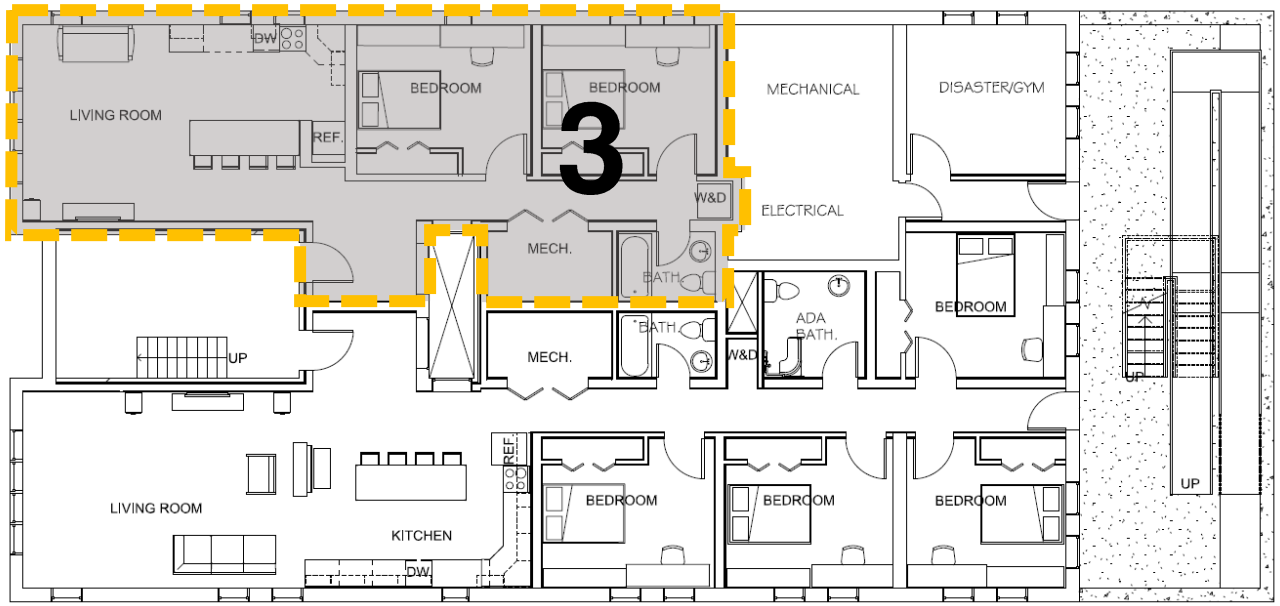
- Green Infrastructure
- 2 units per floor
- Open layout
- Optimize daylighting
- Integrated MEP layout
- An ADA compliant Unit
- A Disaster Safe Space

- 4-Bedroom:1510 s.f.
- 3-Bedroom: 1346 s.f.
- 2-Bedroom: 889 s.f.



N

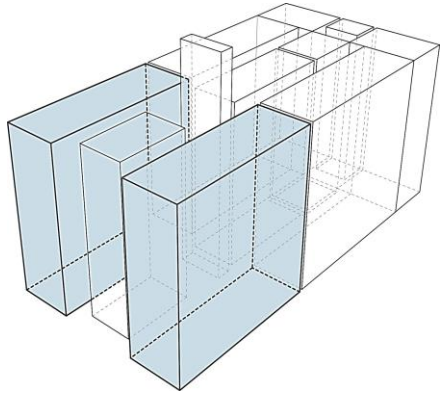
FIRST FLOOR PLAN
3/16”=1’-00”



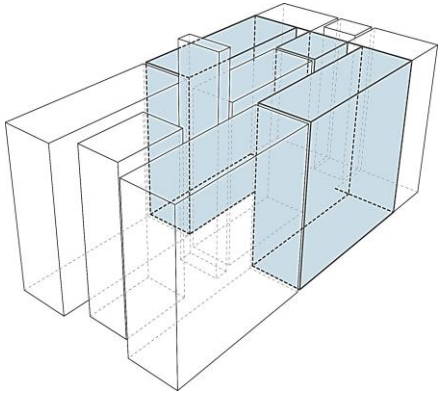
N

BASEMENT FLOOR PLAN
3/16”=1’-00”

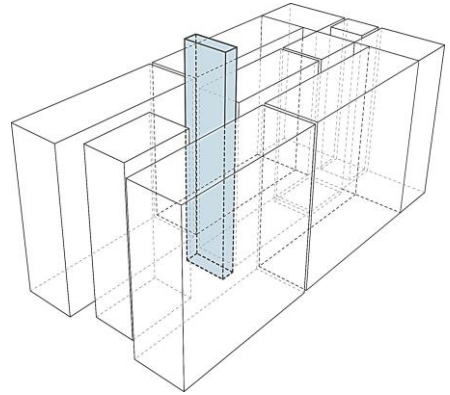
ARCHITECTURAL DESIGN



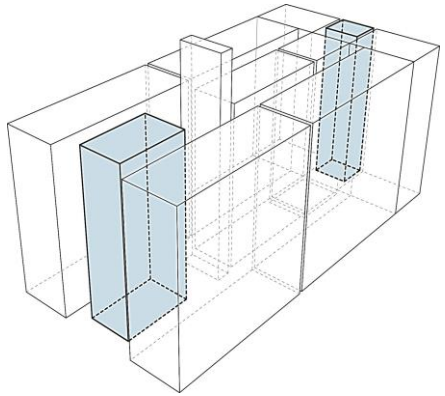
Living Room
and
Kitchen



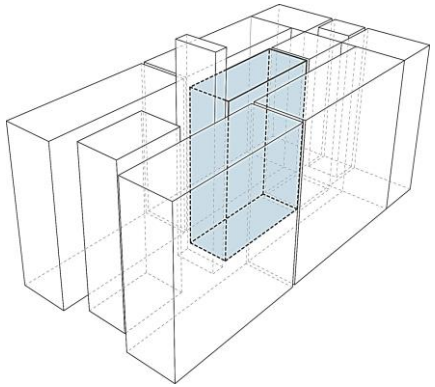
Bedroom



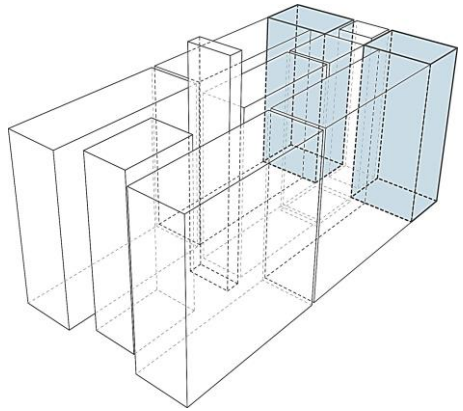
Solar Chimney



Circulation



Mechanical
and
Plumbing Core

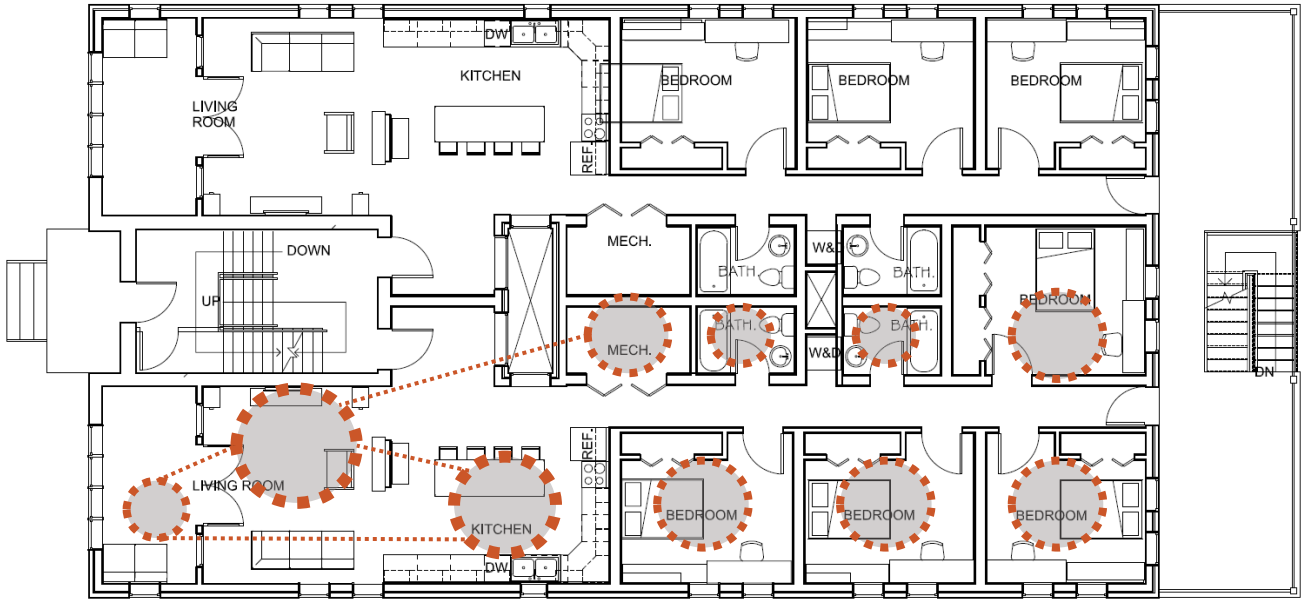


Patio

ARCHITECTURAL DESIGN

PROPOSE

- Green Infrastructure
- 2 units per floor
- Open layout
- Optimize daylighting
- Integrated MEP layout
- An ADA compliant Unit
- A Disaster Safe Space



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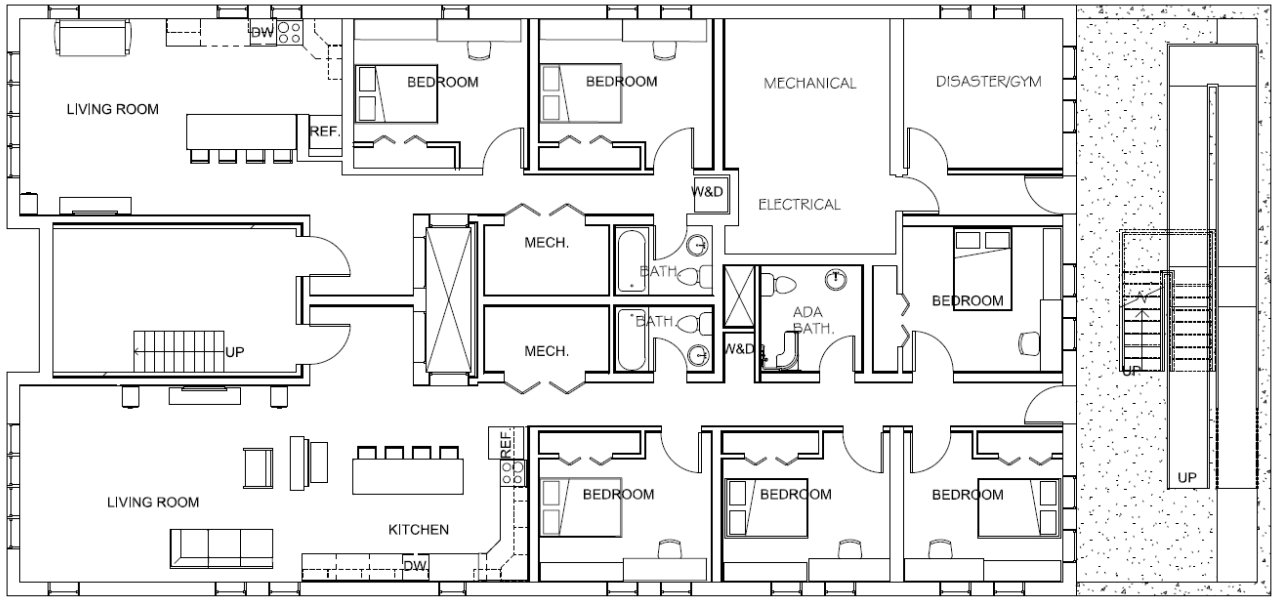
FIRST FLOOR PLAN
3/16”=1’-00”



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BASEMENT FLOOR PLAN
3/16”=1’-00”

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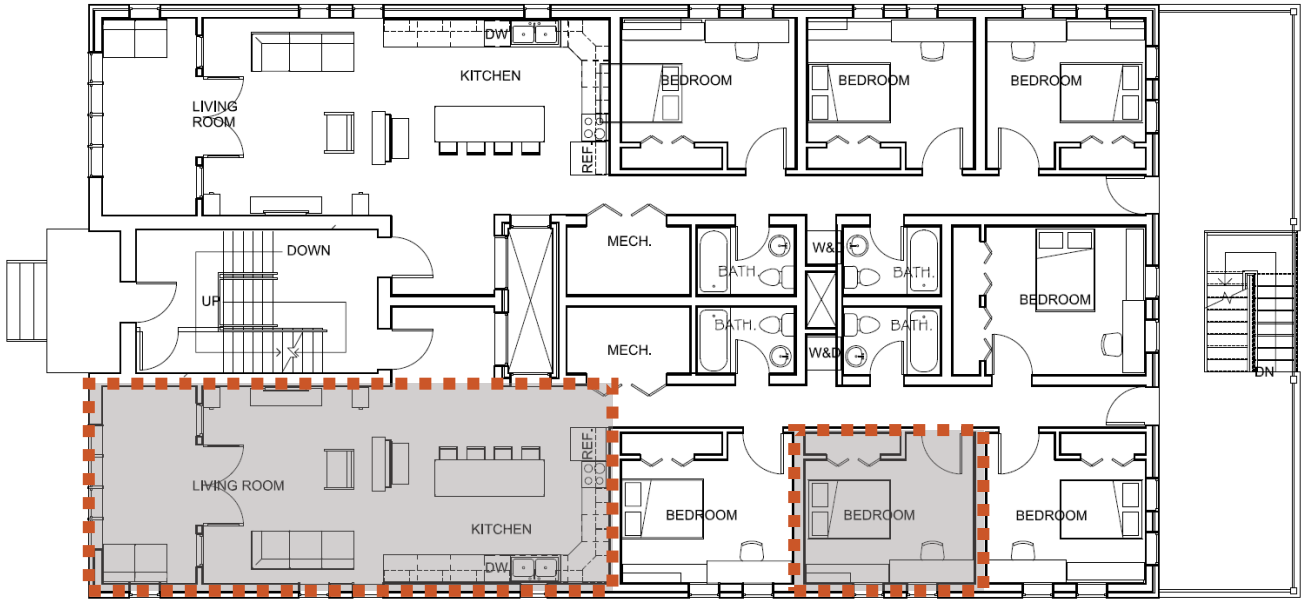

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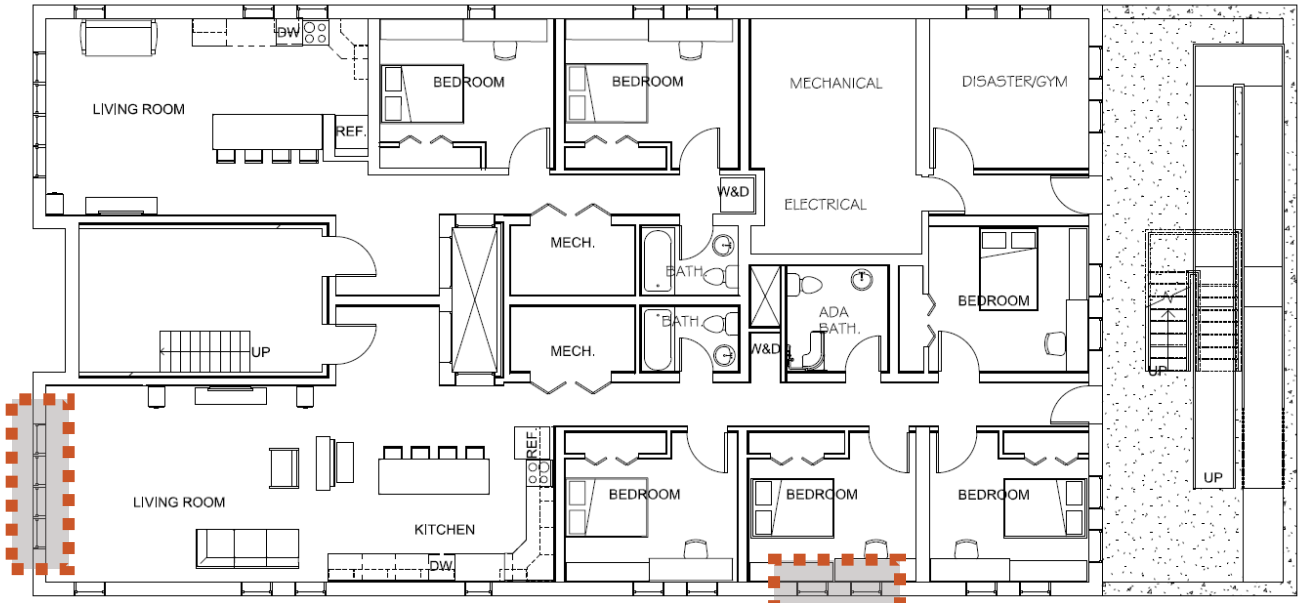

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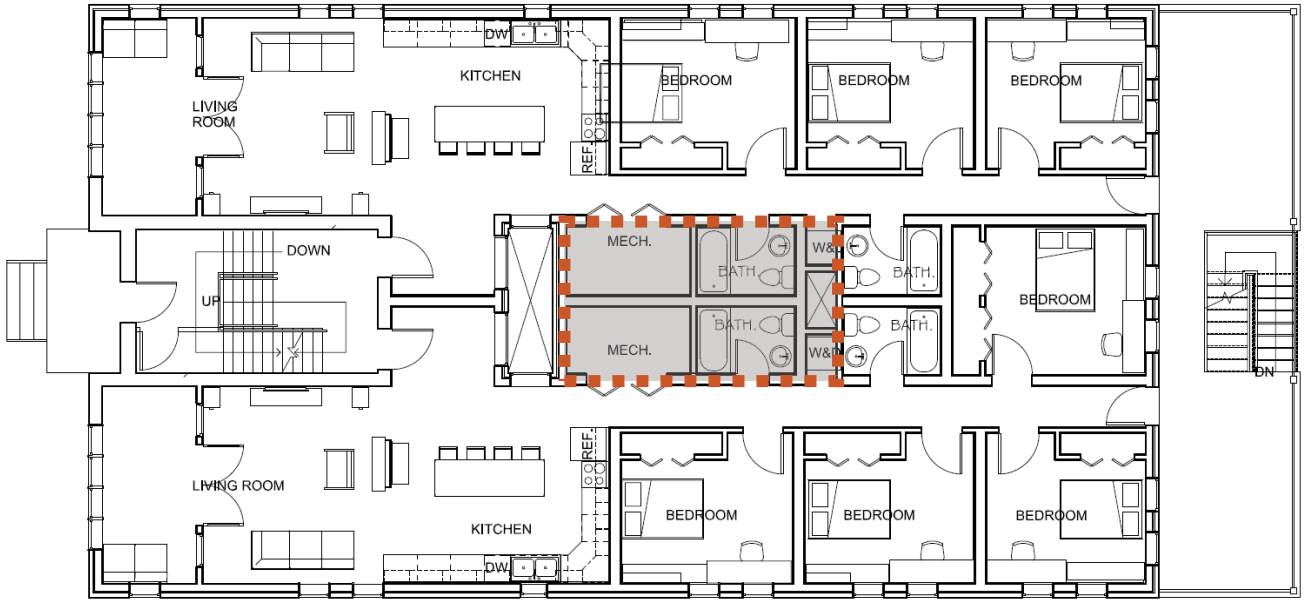

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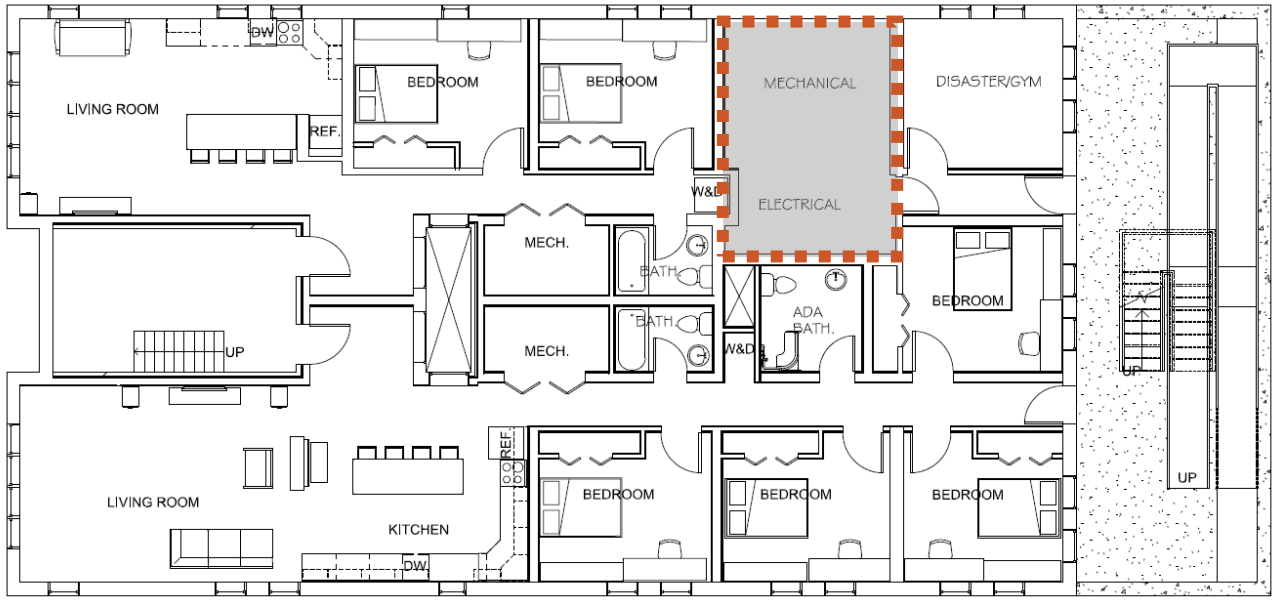

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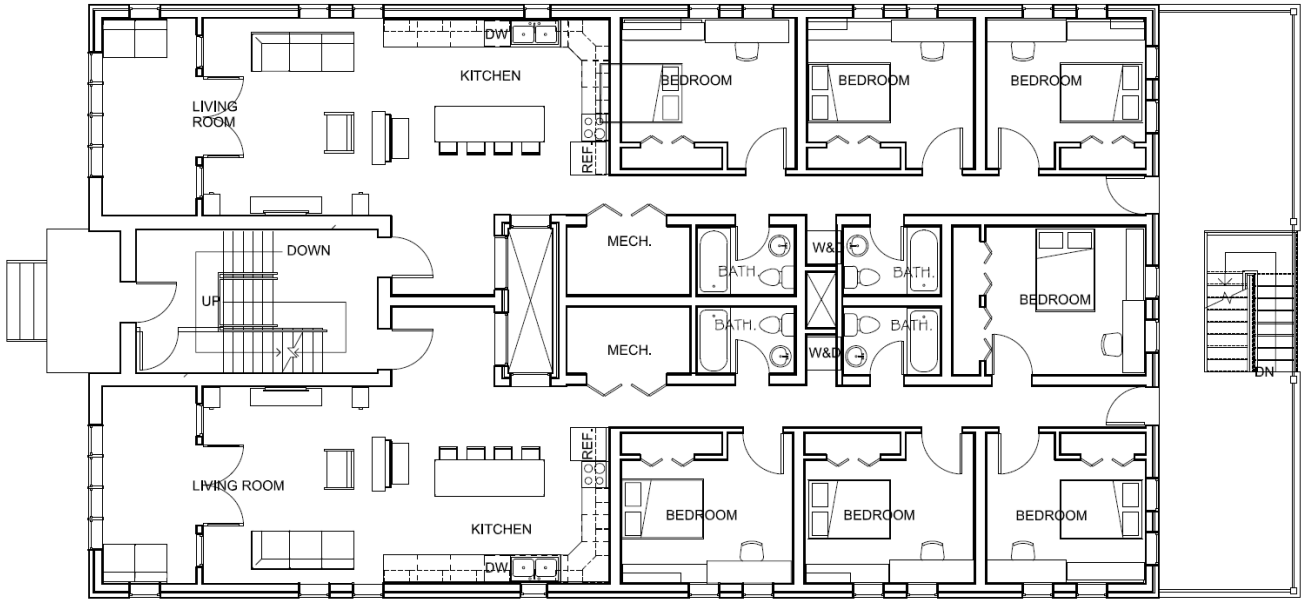

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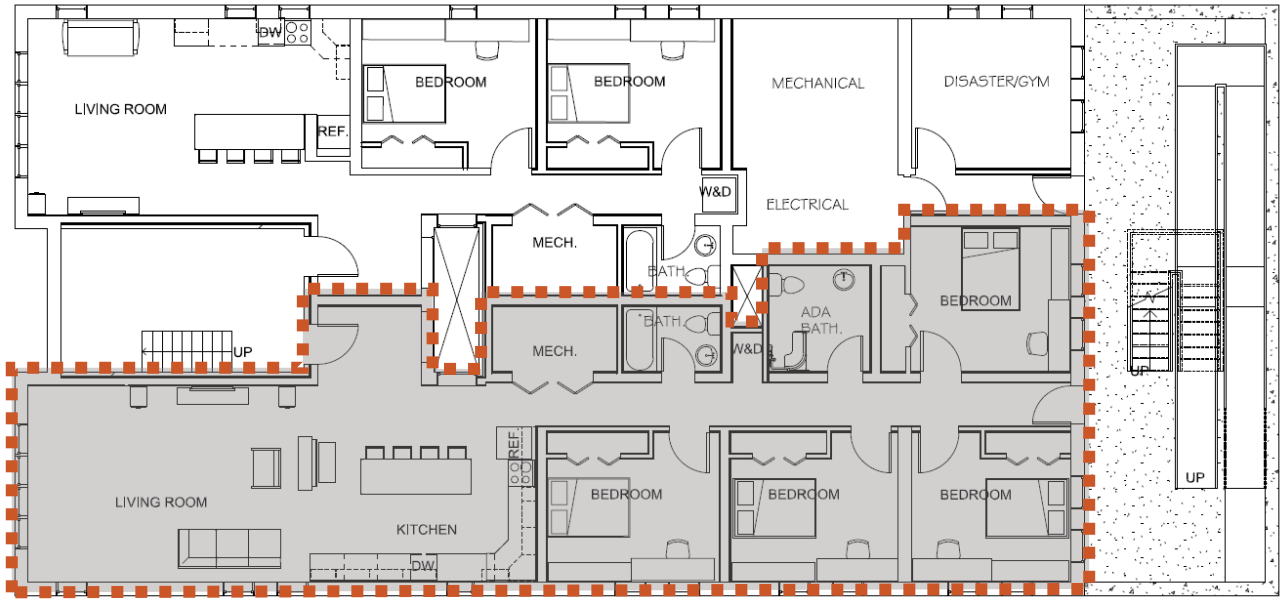

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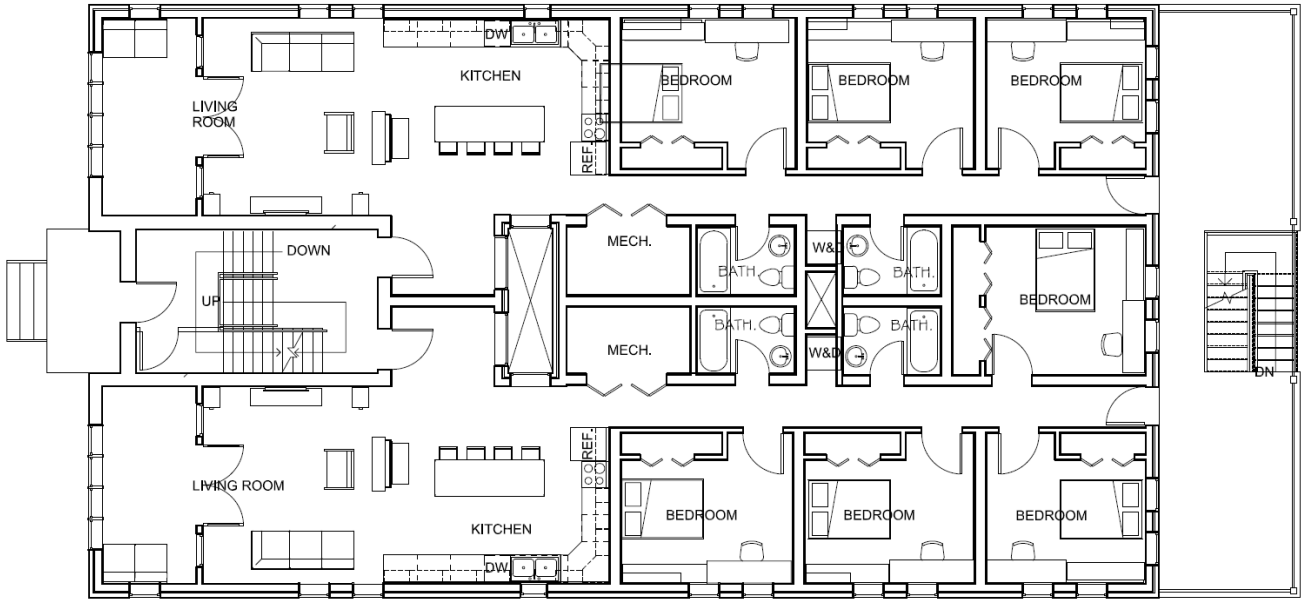
Promotes **RESILIENCY**



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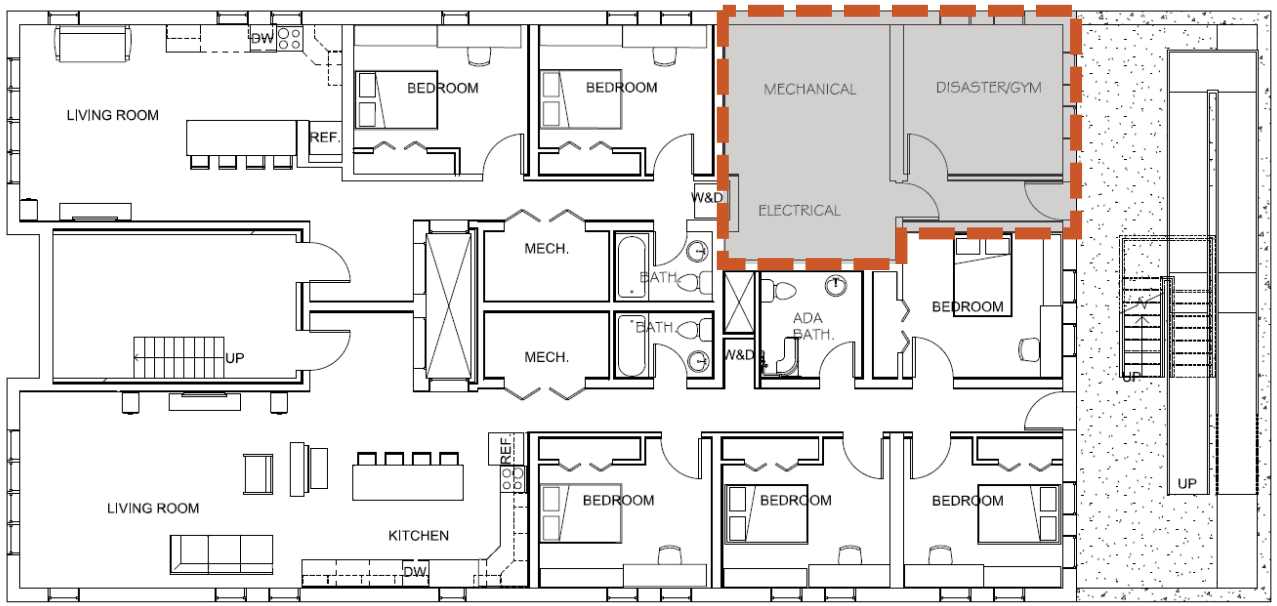

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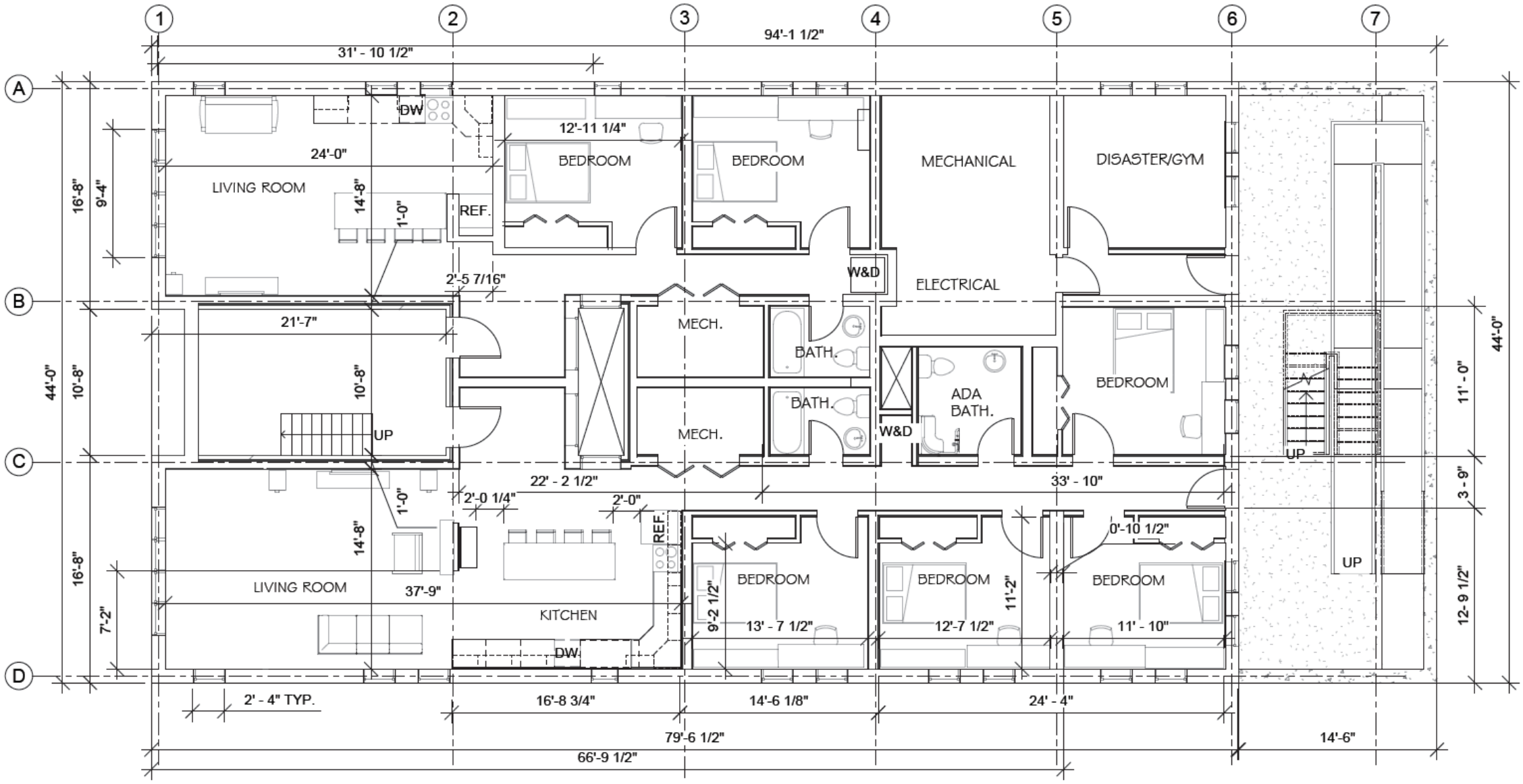

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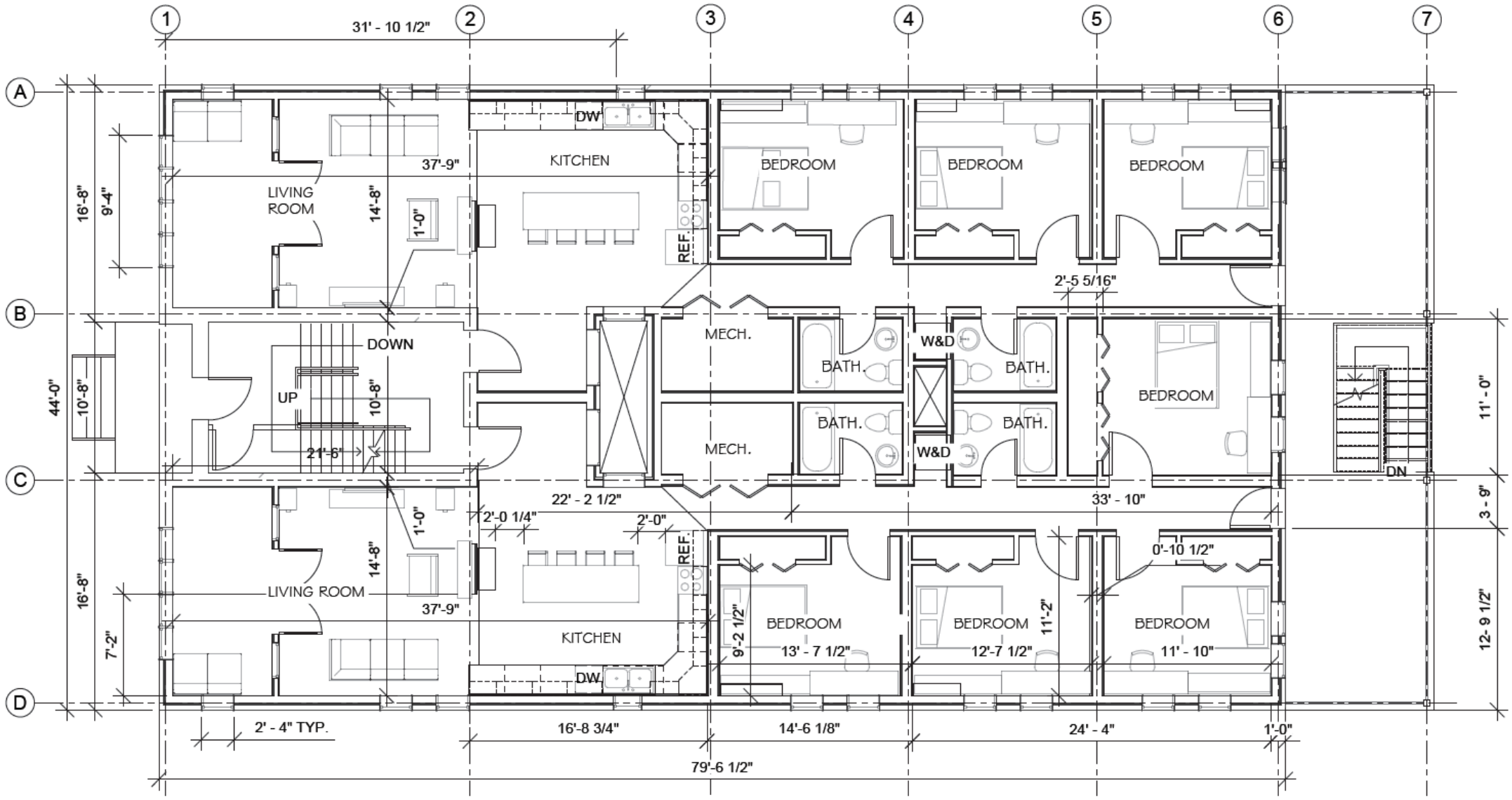
ARCHITECTURAL DESIGN



N

FIRST FLOOR PLAN

ARCHITECTURAL DESIGN

DESIGN RENDERINGS

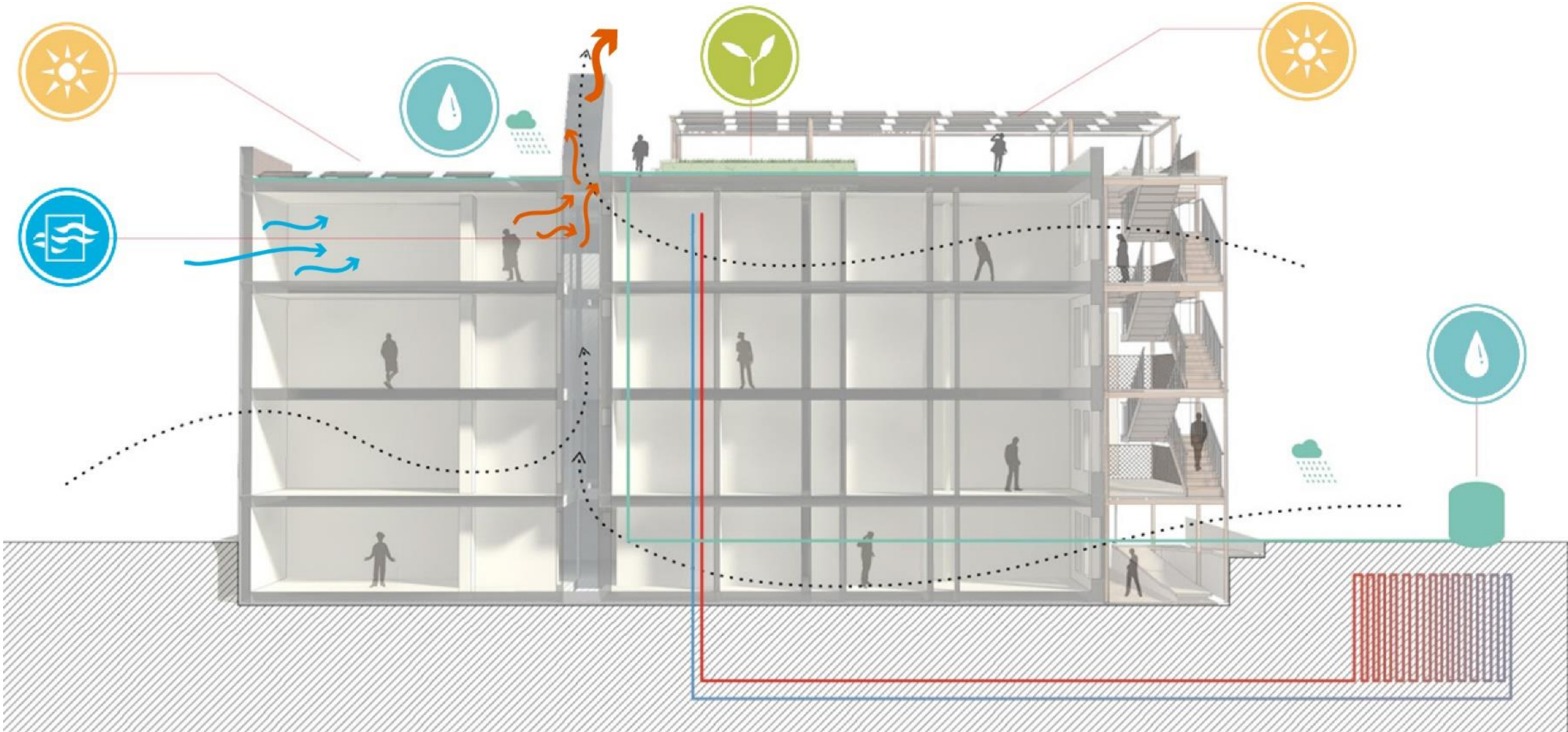
EAST ELEVATION

EAST ELEVATION

SOUTH ELEVATION

SOUTH ELEVATION

SUSTAINABILITY DIAGRAM



INTERIOR DESIGN

PROPOSE

- Flexible and fixed furniture
- Reflective paints
- Finishes and furnishing with none or limited VOCs

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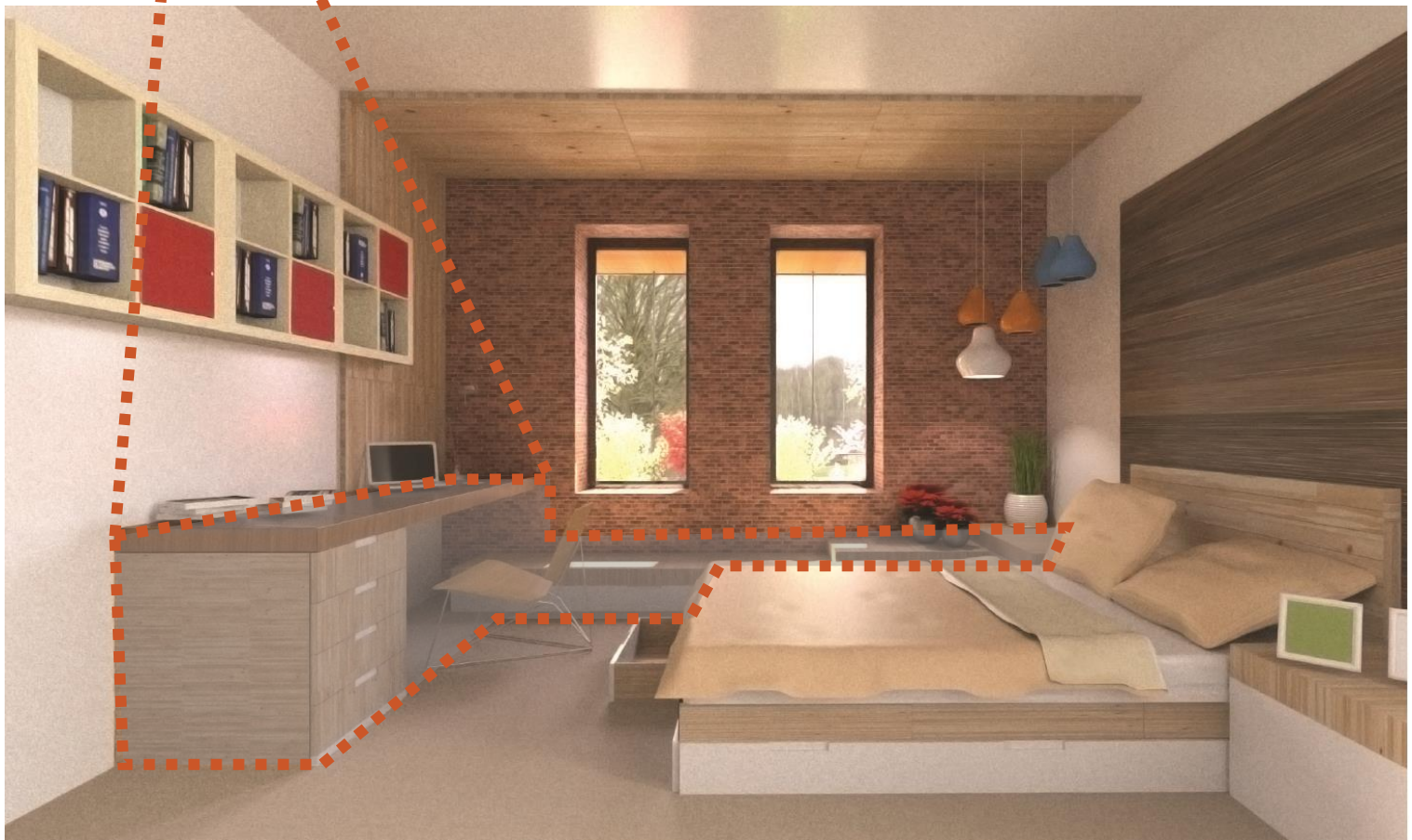

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StoDecosil K/R/MP
Not only exceptionally environmentally friendly with demonstrable mildew-inhibiting properties, but also incredibly versatile. There are no limits to the texture design options – particularly when using StoDecosil MP free style textured render.

StoSil Struktur
This physiologically harmless, filling textured paint on silicate base has mildew-inhibiting properties. It is available with fine or medium-sized grains and is ideal for matt, textured surfaces. StoSil Struktur effectively accentuates walls.

StoColor Sil In
Numerous certificates and seals of approval substantiate the unique benefits in terms of health and environmental friendliness. Thanks to its high pH-value, the matt silicate paint with good hiding power and mineral properties helps prevent mildew. Modern pastel tones bring harmony to the room.

StoLook Marmorino
Natural raw materials such as pit lime and marble powder provide a pleasant living space climate. The various application options are founded on a longstanding tradition of craftsmanship, creating individual, high-quality textures with brilliance and depth.

StoLook Fondo
The mixture of lime and coarse black and white marble sand lends elegance and naturalness to the wall. The Fondo texture can be float-finished, smoothed or individually textured. This diffusion-open product perfectly enhances a cosy interior ambience.

StoLook Effetto
The special feature of this lime product is the mineral matt texture combined with a natural mica supplement. The texture generates impressive effects, particularly when exposed to light, while the lime simultaneously creates a cosy interior ambience.

1

[1] Sto, *StoTherm In Comfort*. The Perfect Internal Insulation System, 2010.

INTERIOR DESIGN

PROPOSE

- Flexible and fixed furniture
- Reflective paints
- Finishes and furnishing with none or limited VOCs

EXISTING ENVELOPE – COPING AND PARAPET

EVALUATE AND ADDRESS

- Discontinuous and segmented cap
- Inadequate and improper drip edges
- Deterioration and degradation of cladding due to bulk water penetration

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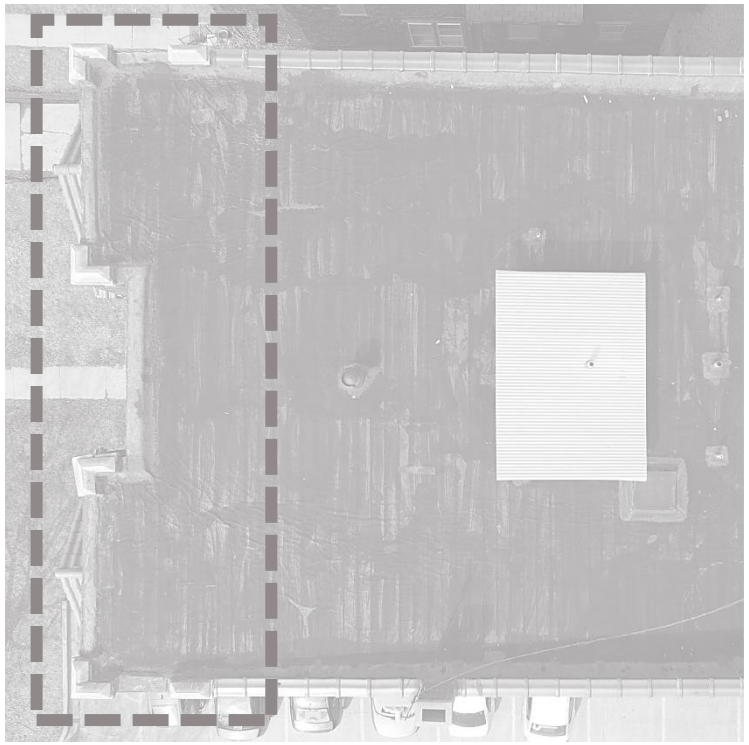
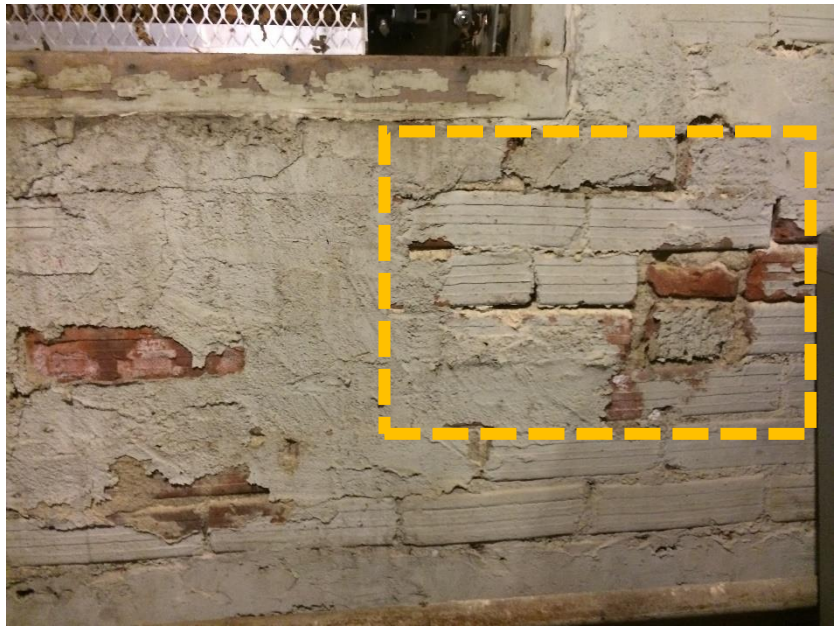


EXISTING ENVELOPE - GROUND CONTACT AND SPLASHBACK

EVALUATE AND ADDRESS

- Moisture absorption, capillary uptake, and interior spalling
- Subfluorescence damages
- Splashback of rainfall from the roof onto the wall surfaces



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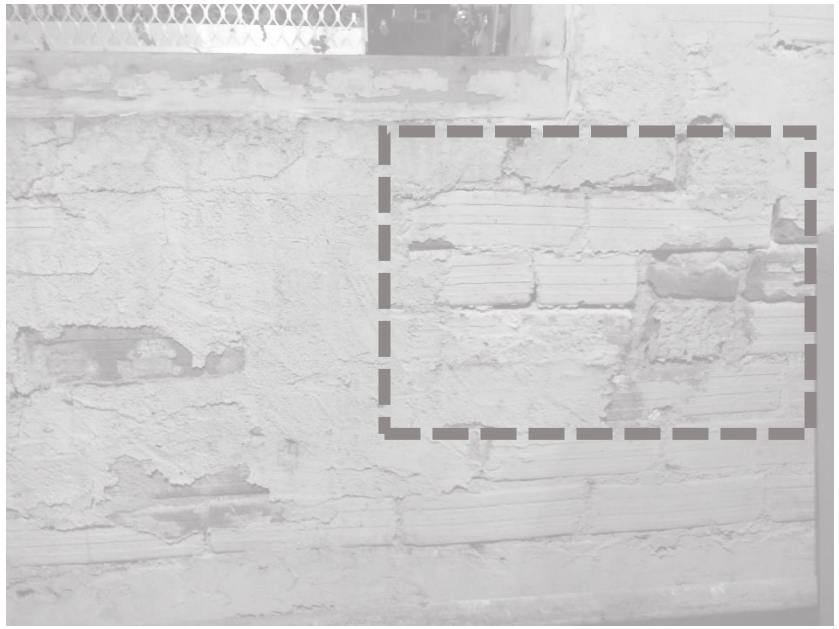
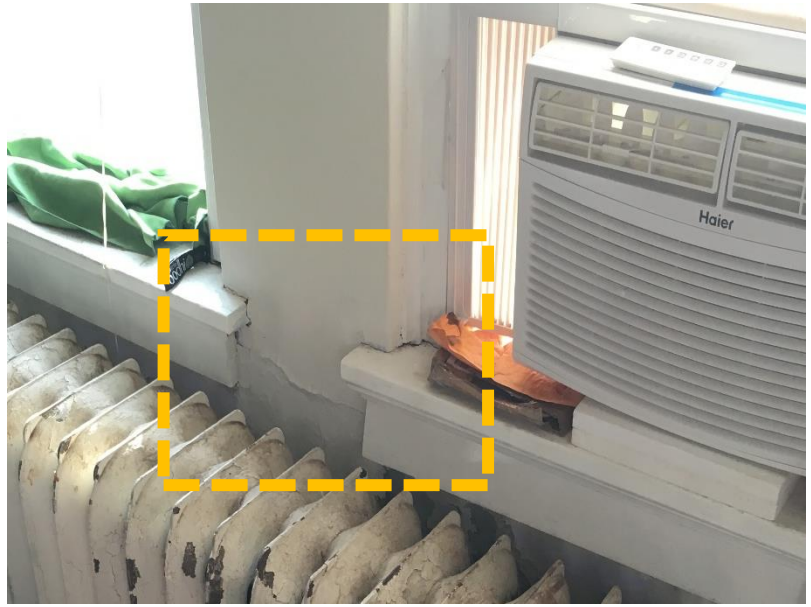


EXISTING ENVELOPE - WINDOWS

EVALUATE AND ADDRESS

- Window connection details
- Water penetration and existing water shedding strategies (rowlock window sills)
- Air infiltration and exfiltration
- High maintenance windows



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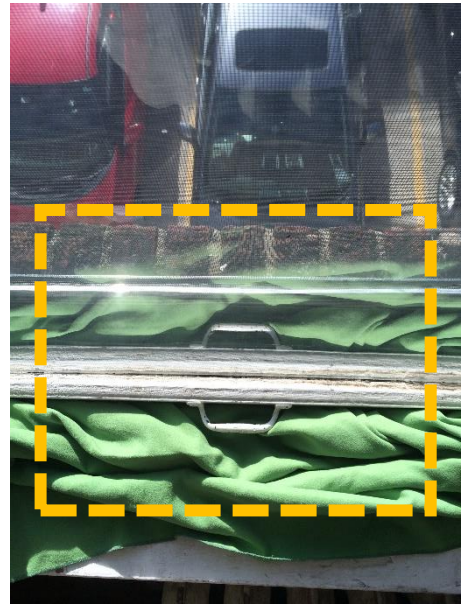

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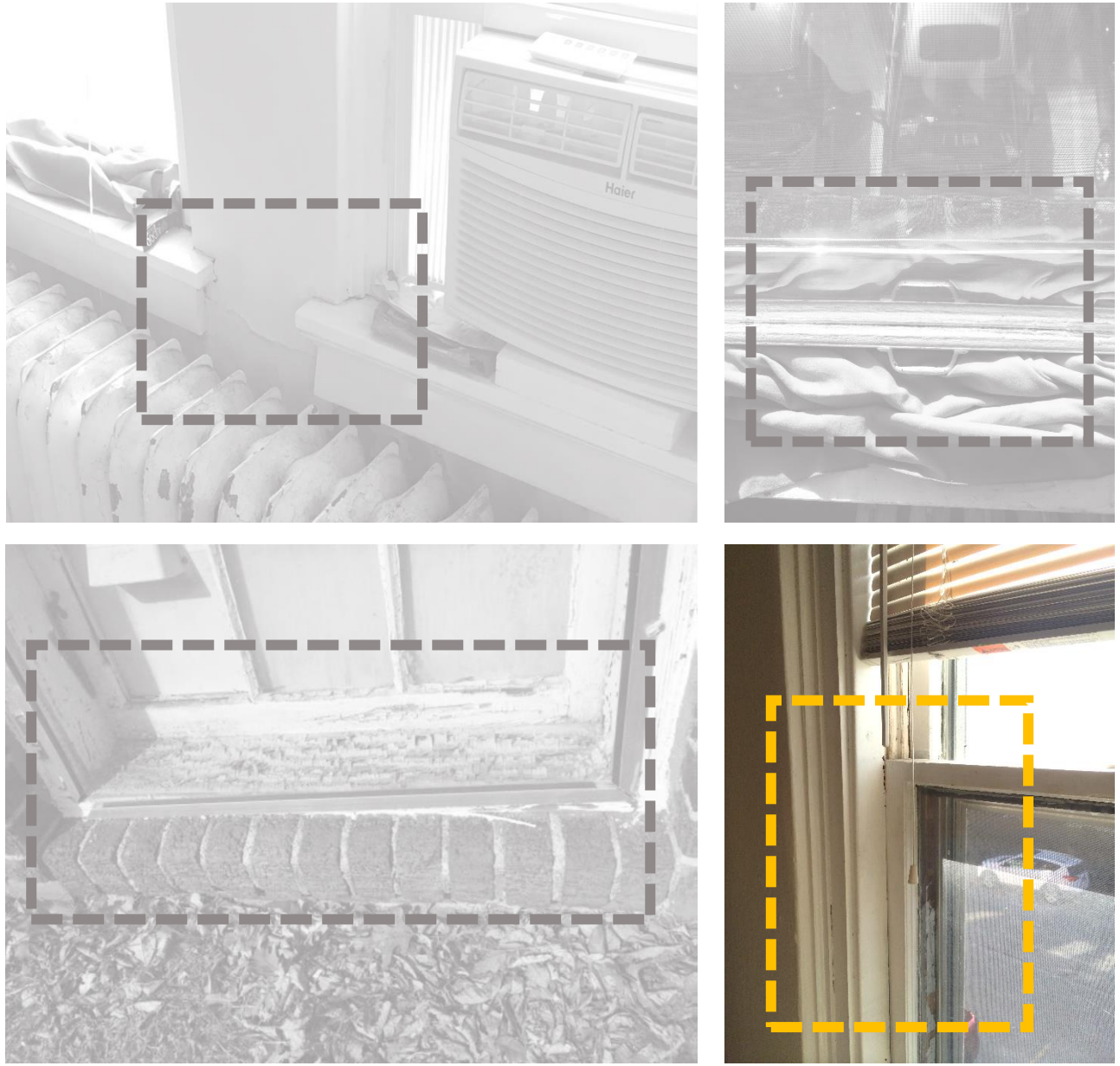

VISUAL INFRARED INSPECTION

EVALUATE AND ADDRESS

- Exterior walls insulation levels
- Water penetration, air infiltration, and thermal bridges

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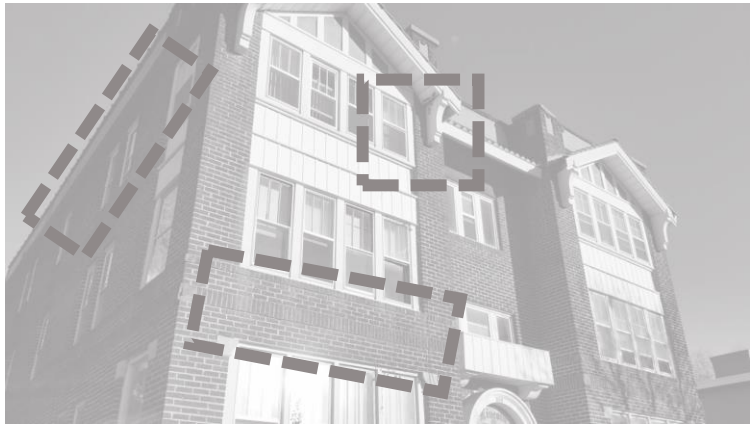
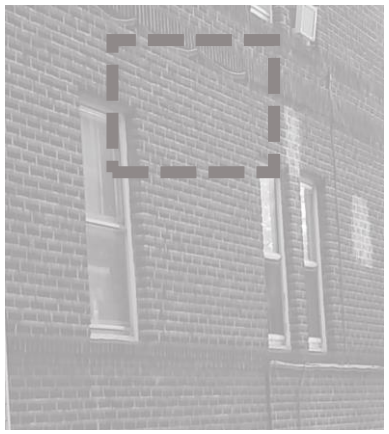
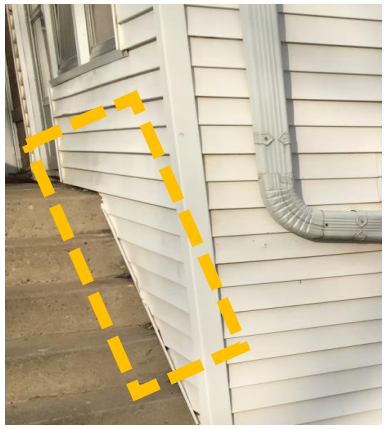
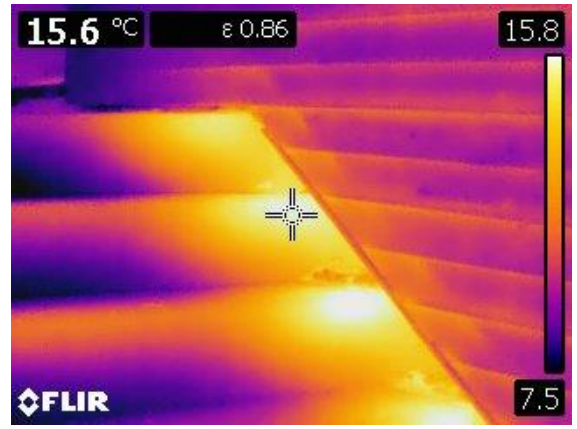




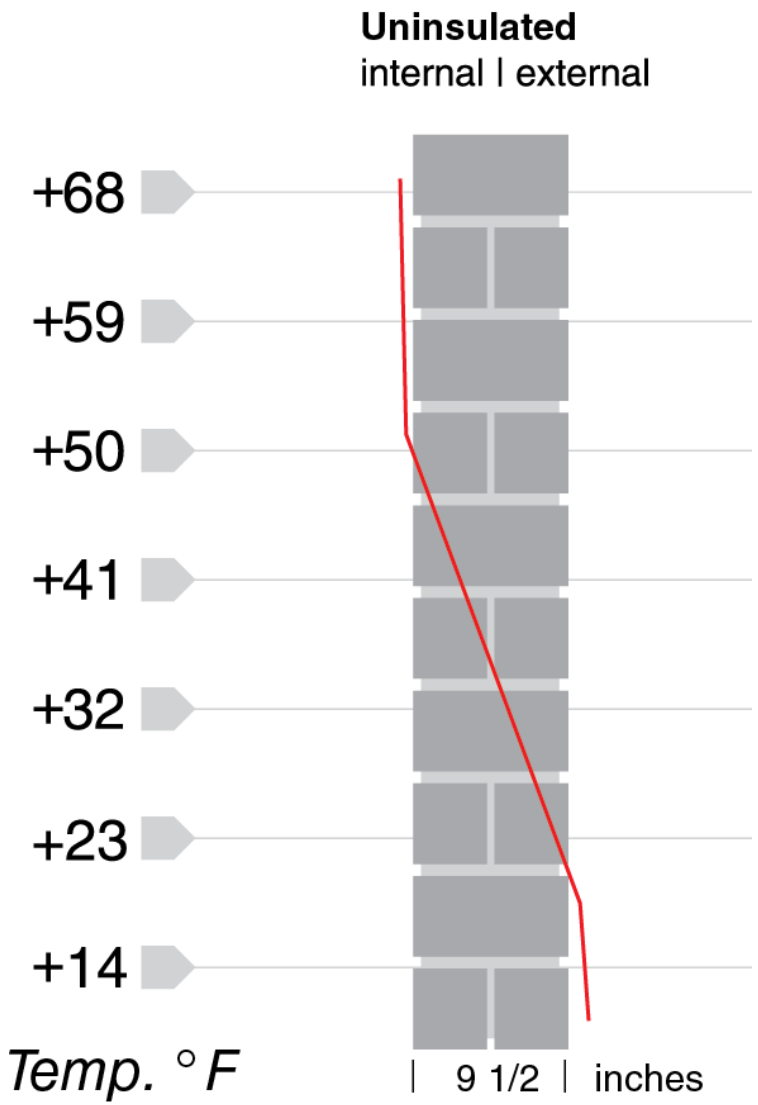




ENVELOPE DURABILITY

EVALUATE AND ADDRESS

- Interstitial condensation
- Freeze-thaw (FT) damage
- Rot and mold growth



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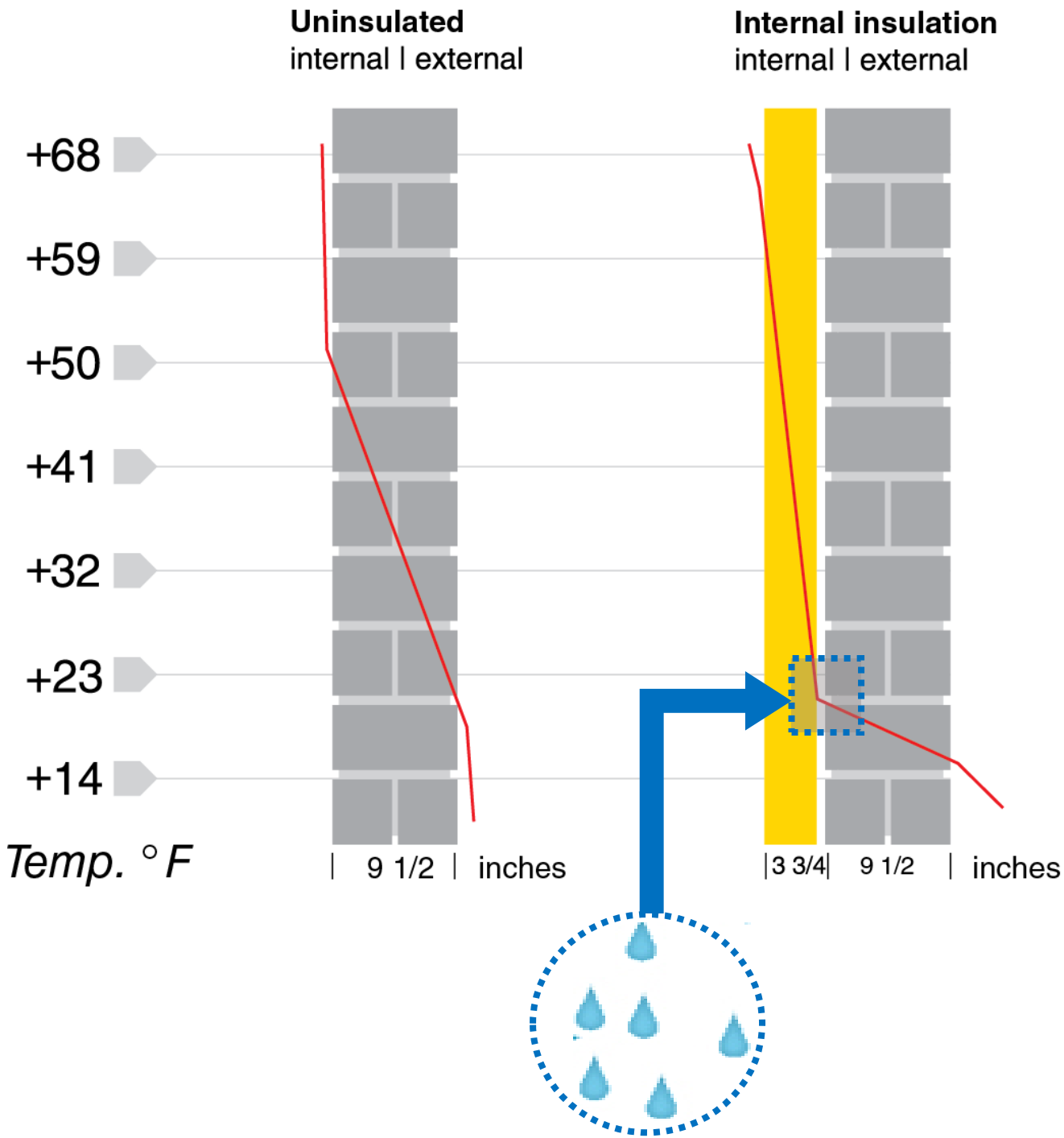

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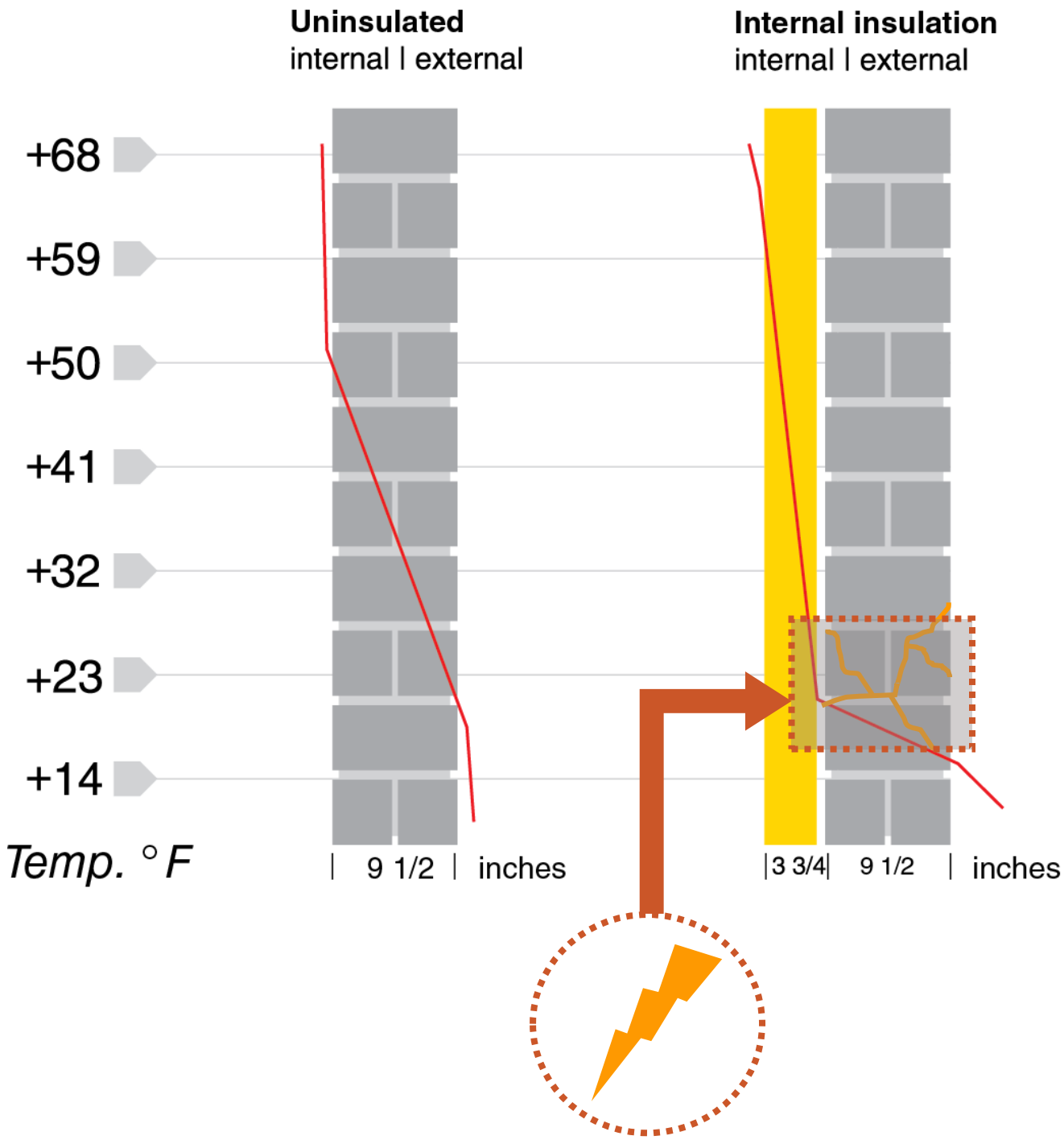
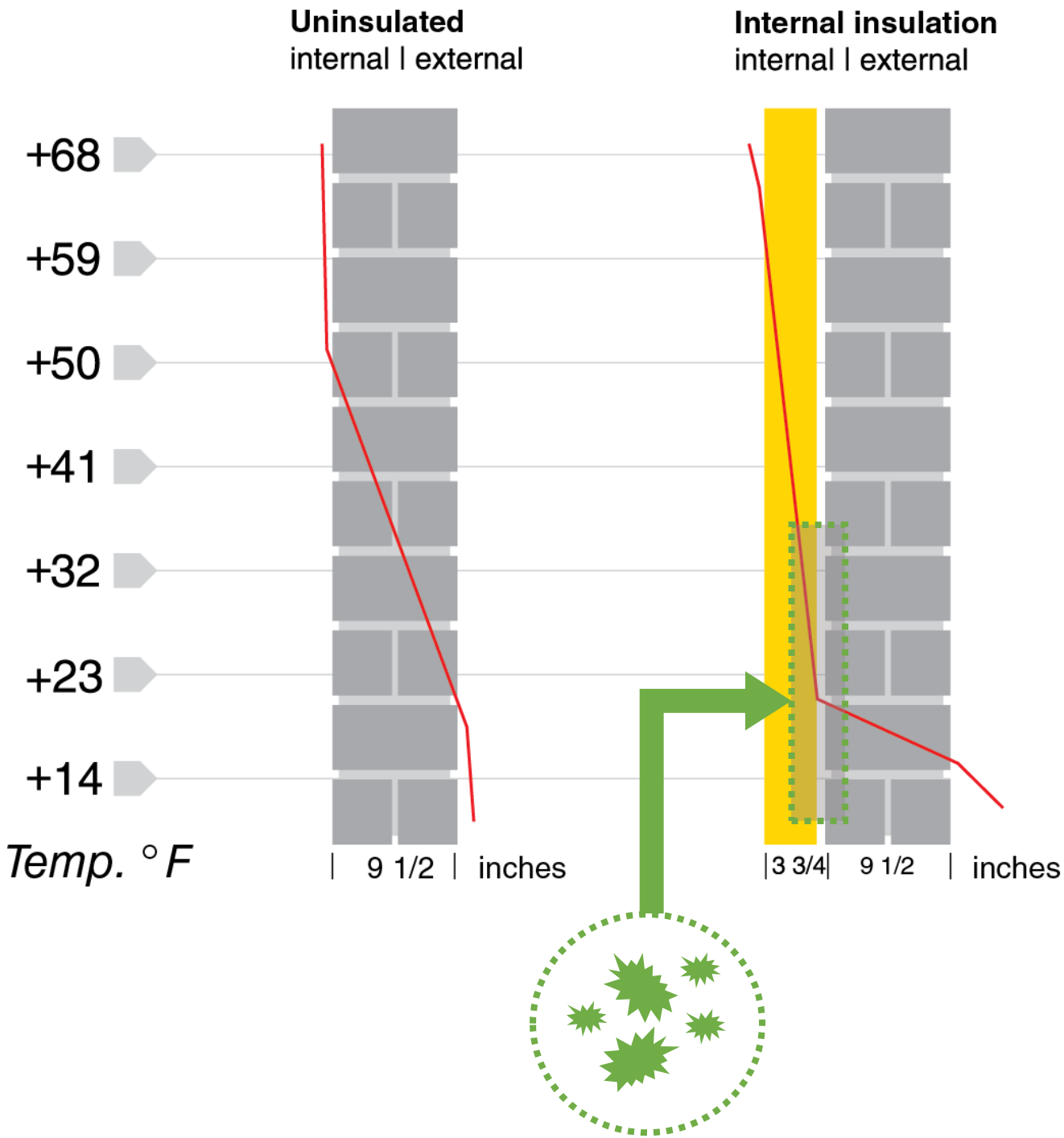
- Freeze-thaw (FT) damage
- Rot and mold growth



ENVELOPE DURABILITY

EVALUATE AND ADDRESS

- Interstitial condensation
- Freeze-thaw (FT) damage
- Rot and mold growth

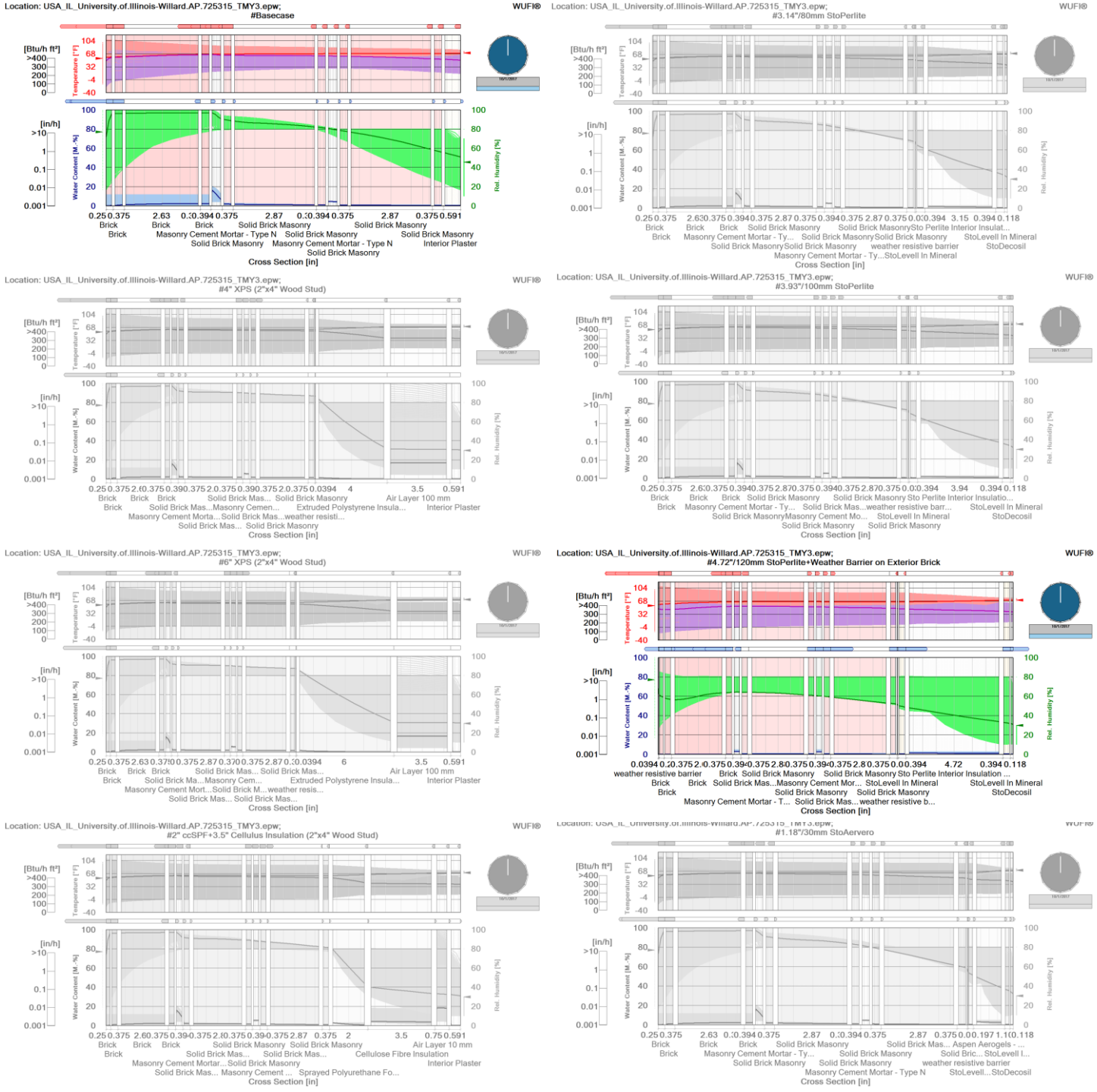


ENVELOPE DURABILITY

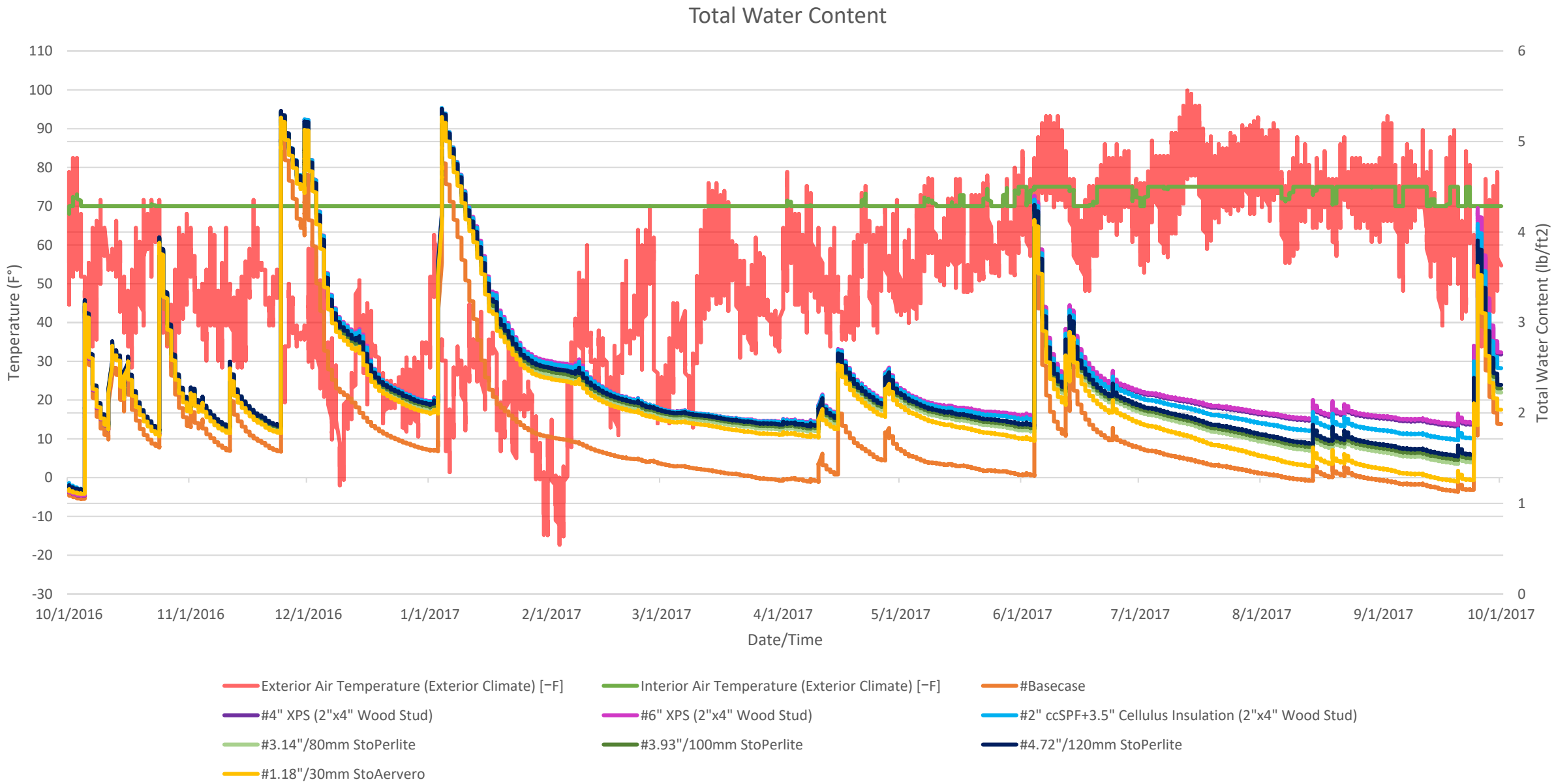
EVALUATE AND ADDRESS

- Interstitial condensation, total water content of building envelope assembly
- Overall relative humidity in building envelope components

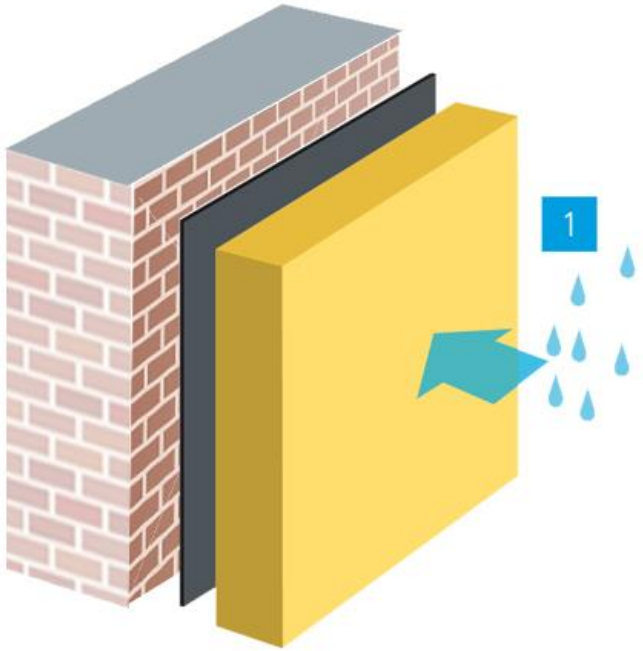
Model #	Overall Assembly Thickness (in)	Simulated Insulation Walls	Total Thermal Performance (h ft2 ˚F/Btu)	ACH@50
1	12.25	Brick	3.46	9
2	19.79	4” XPS with 2x4 Stud Walls	27.47	1.7
3	21.79	6” XPS with 2x6 Stud Walls	39.04	1.7
4	18.5	2” ccSPF with 3.5” cellulose with 2x4 Stud Wall	30.58	1.7
5	15.76	3.14” StoPerlite	13.65	1.7
6	16.54	3.94” StoPerlite	16.26	1.7
7	**17.33**	**4.72” StoPerlite**	**18.87**	**1.7**
8	13.39	1.18” Aerogel	14.6	1.7



ENVELOPE DURABILITY



ENVELOPE DURABILITY

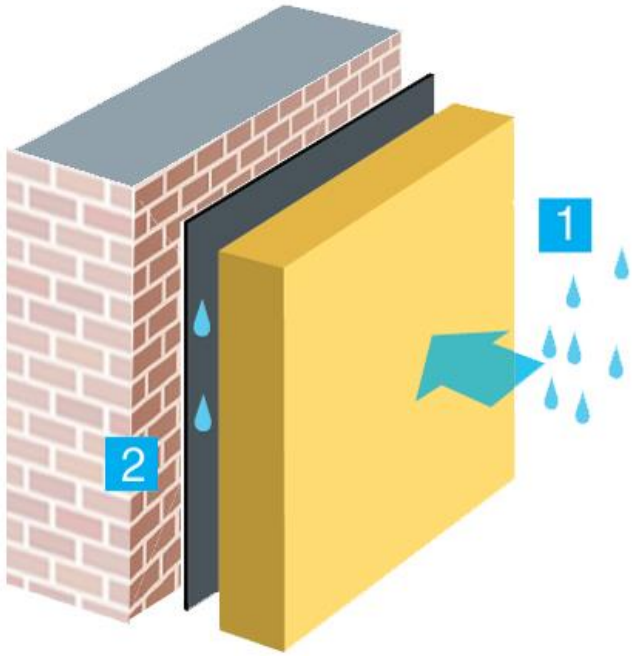


1 Moisture penetrates the diffusion-open internal insulation system[1]
2 Water can condense in the bonding layer behind the insulation board
3 The insulation board absorbs this moisture and actively distributes it within the system
4 By unburdening the system (i.e. through airing) the moisture balance is maintained within the insulated interior, thereby positively influencing drying.

Masonry
Bonding layer
Insulation board

[1] Sto, *StoTherm In Comfort*. The Perfect Internal Insulation System, 2010.

ENVELOPE DURABILITY



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Masonry
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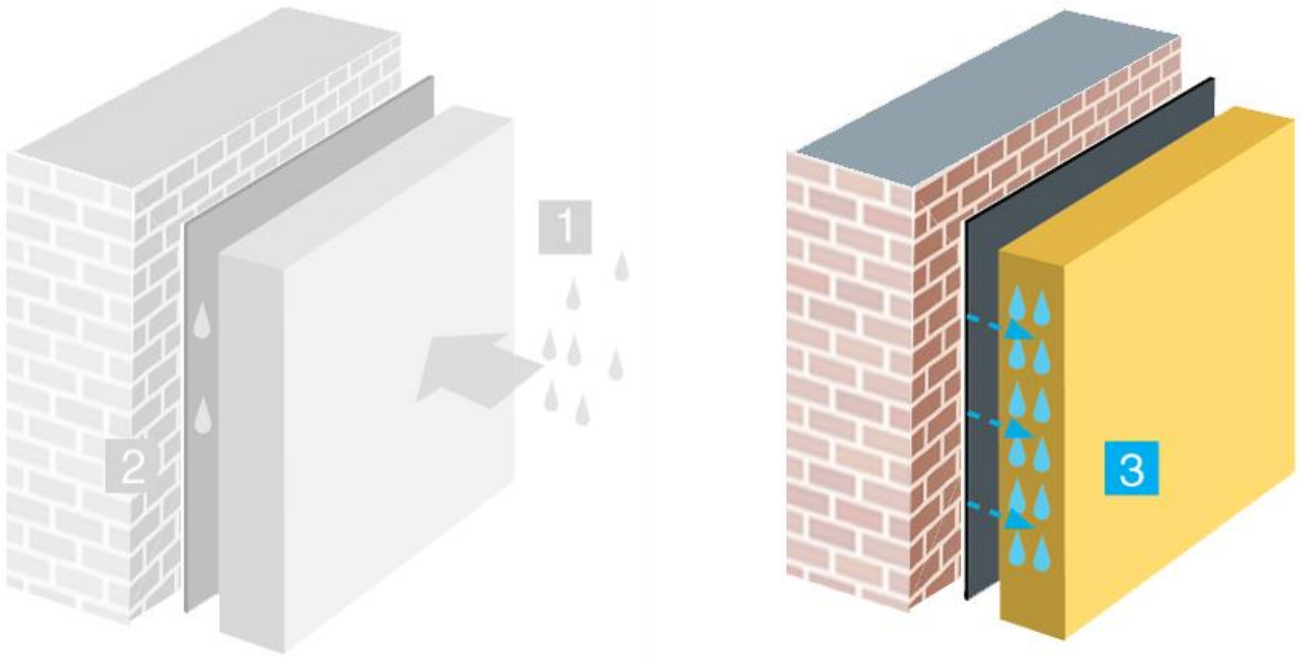
Insulation board

ENVELOPE DURABILITY



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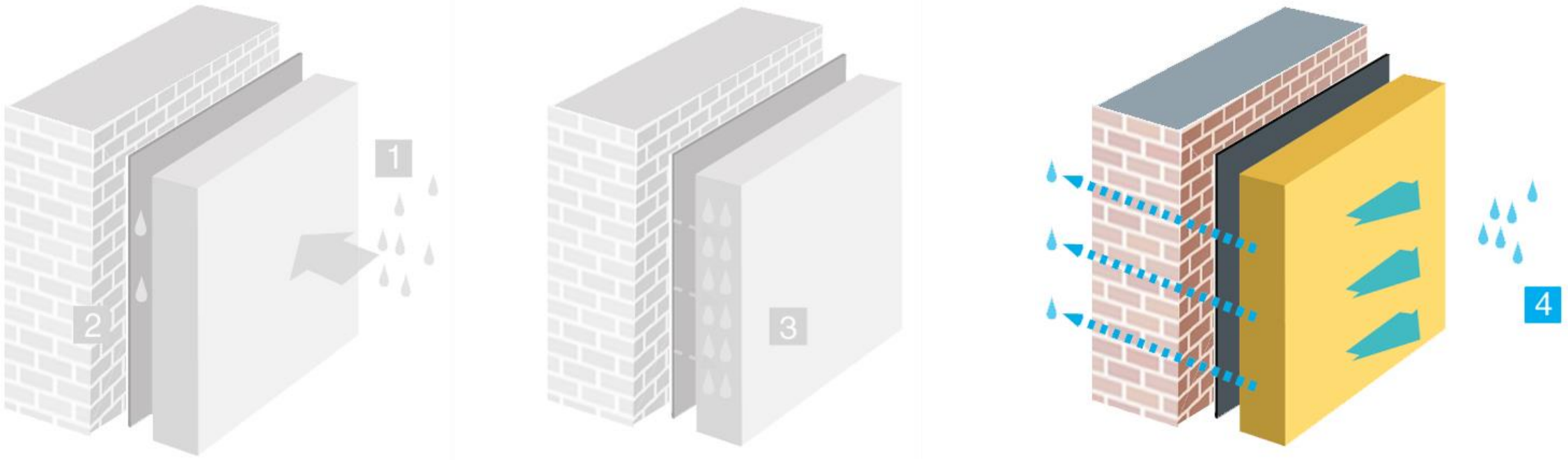
ENVELOPE DURABILITY



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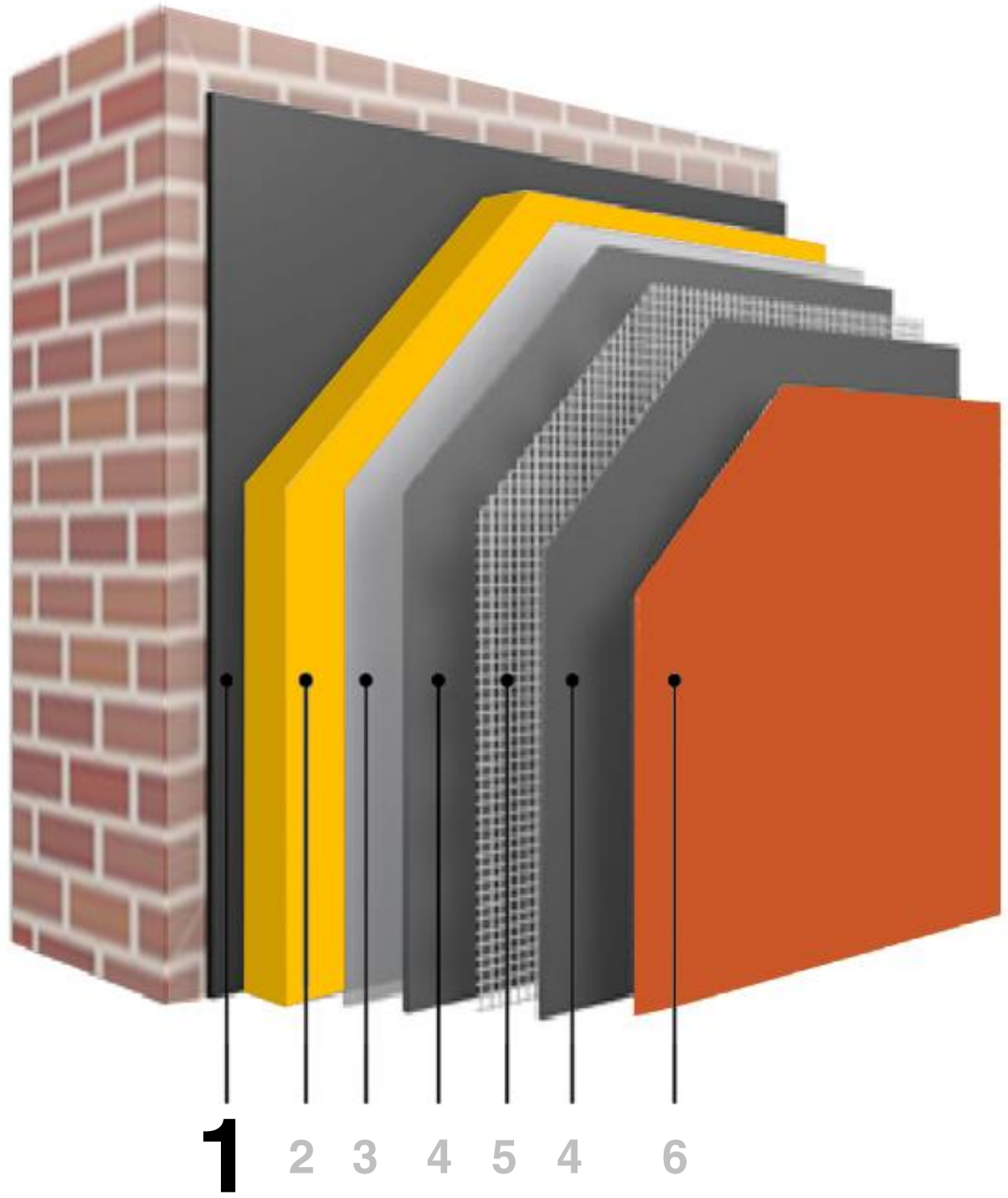
Masonry
Bonding layer
Insulation board

ENVELOPE ASSEMBLY

PROPOSE

1 **Bonding:** StoLevell In Mineral
2 **Insulation:** Sto Perlite Internal Insulation Board
3 **Primer:** StoPrim Silicate
4 **Reinforcing compound:** StoLevell In Mineral
5 **Reinforcing mesh:** Sto Glass Fibre Mesh F
6 **Top coat**

Wall: R-19



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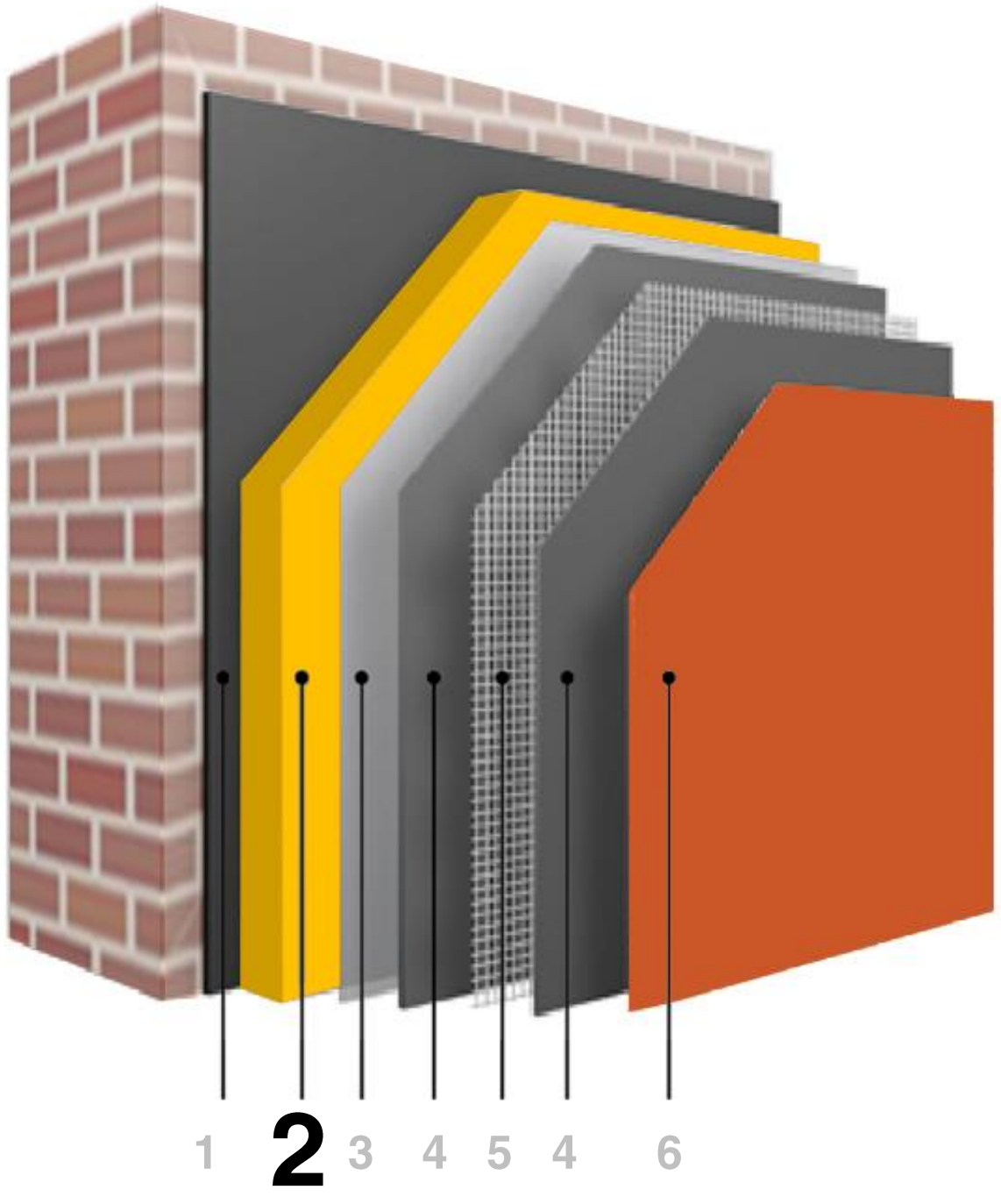

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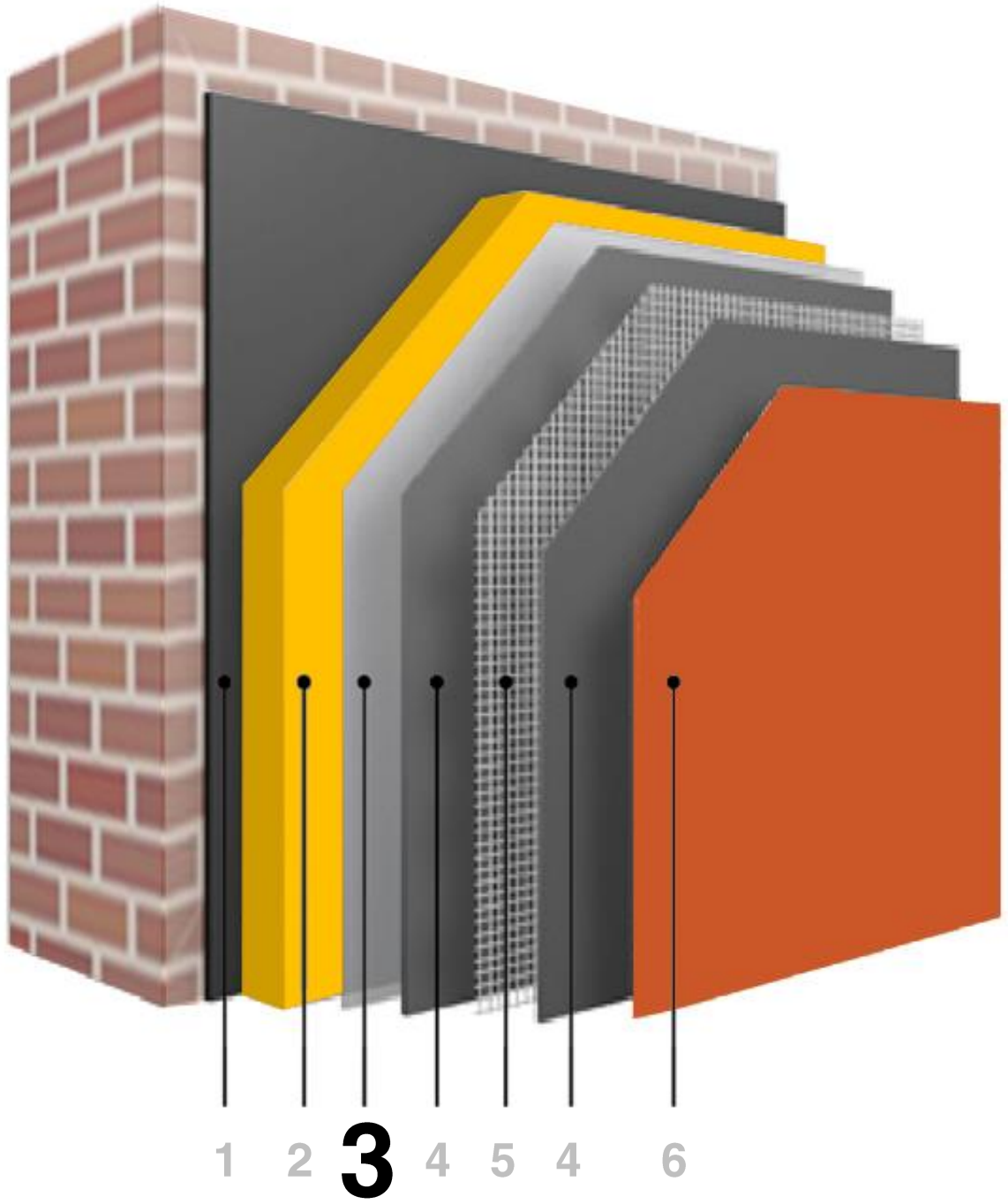

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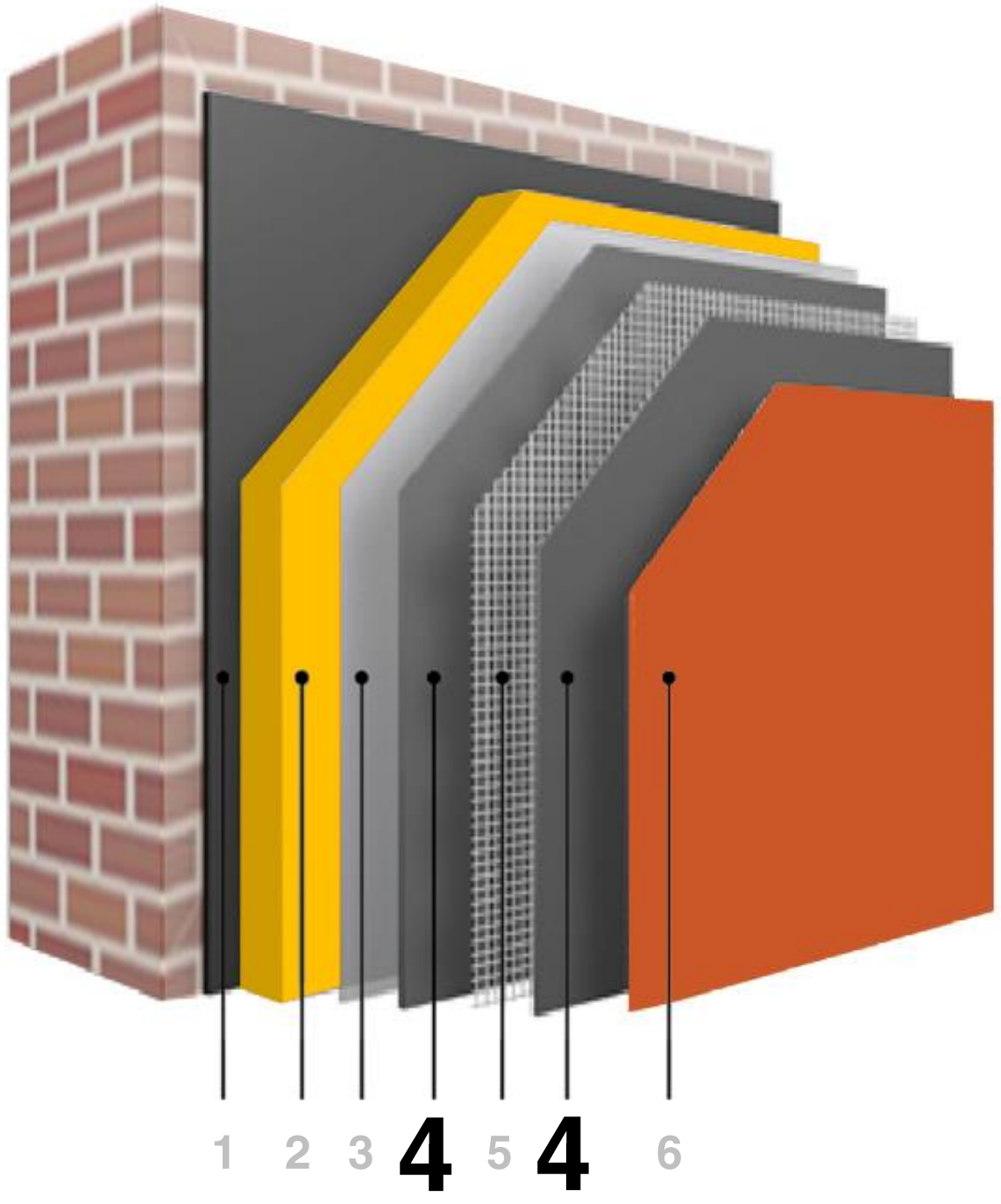

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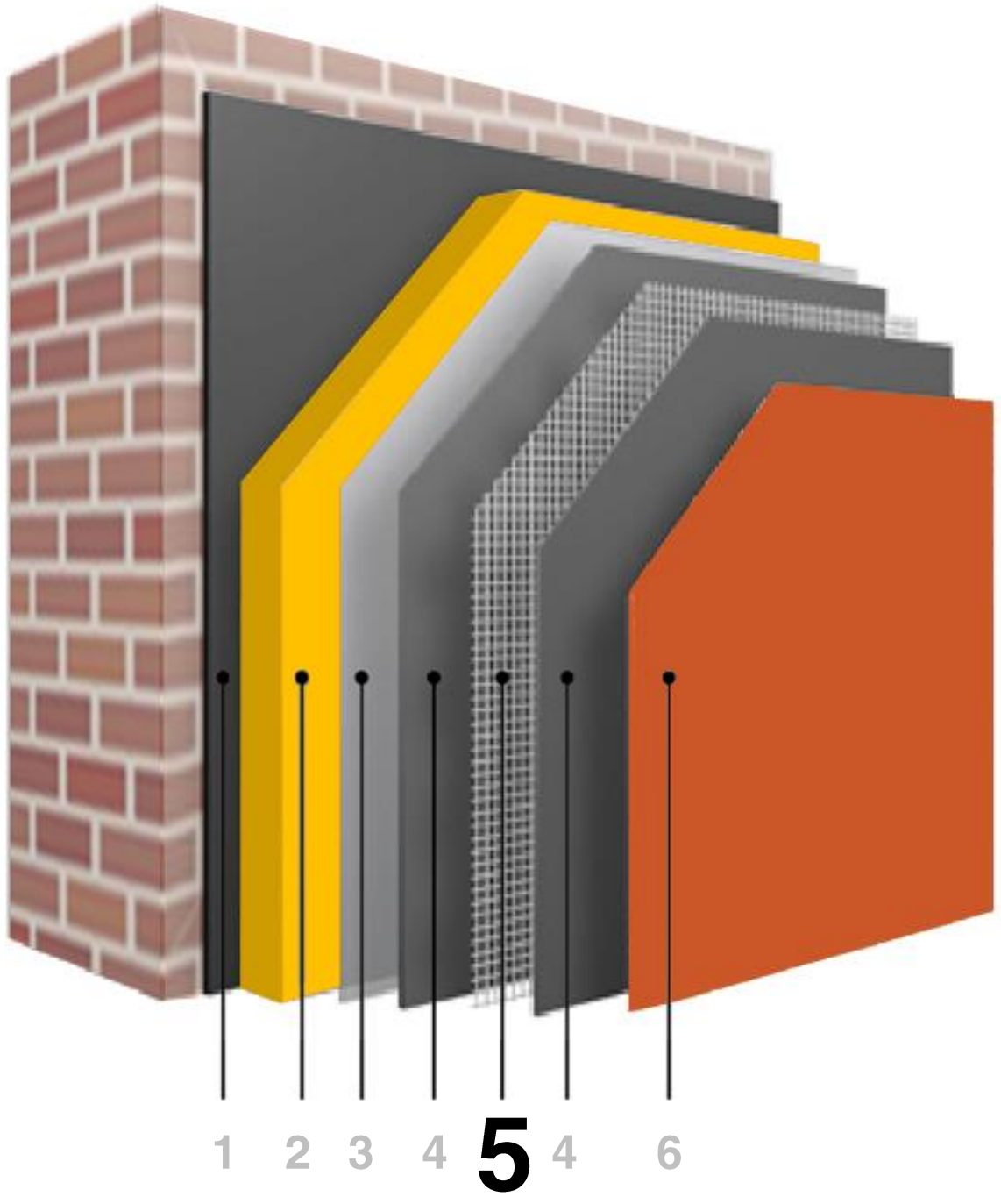

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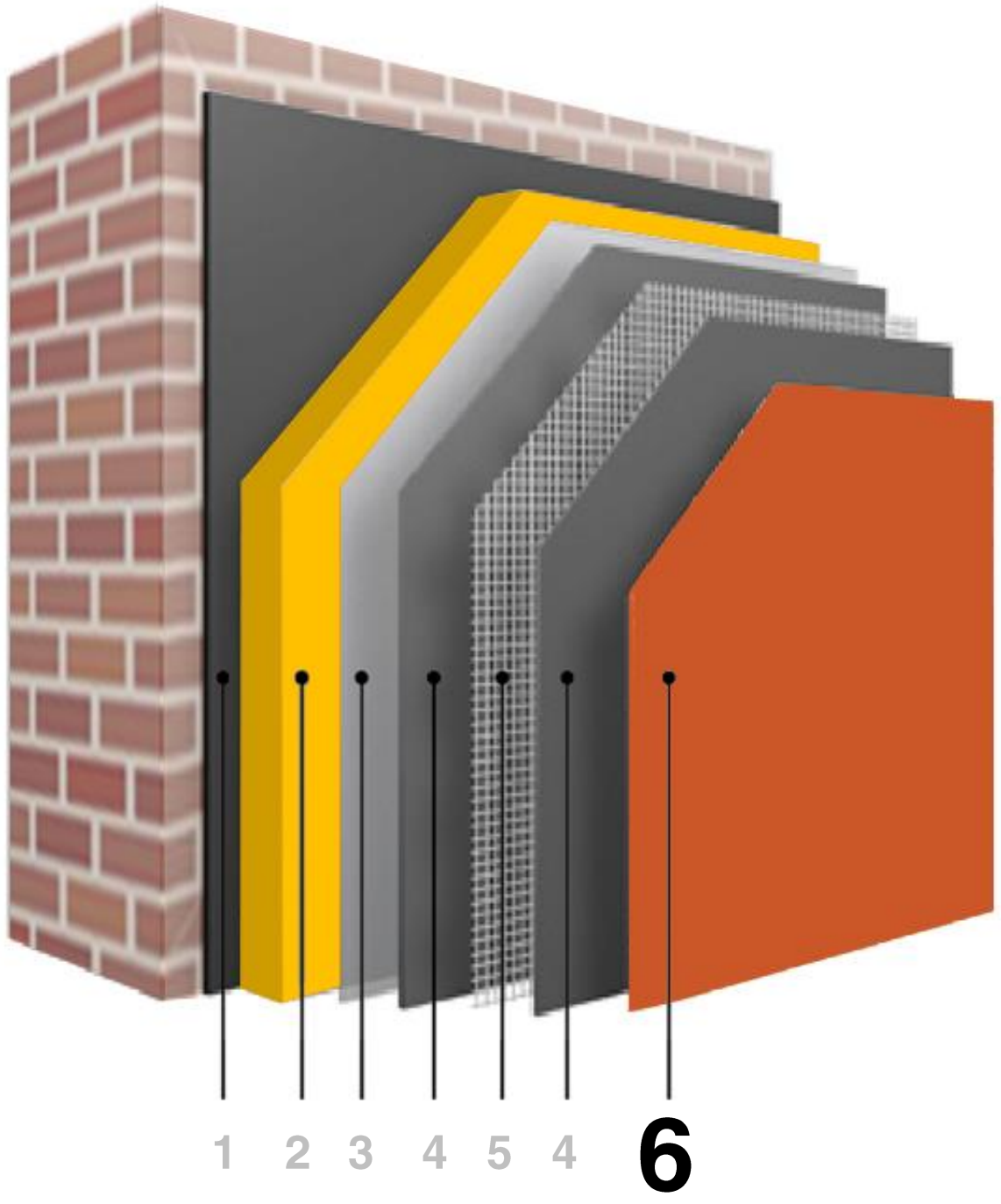
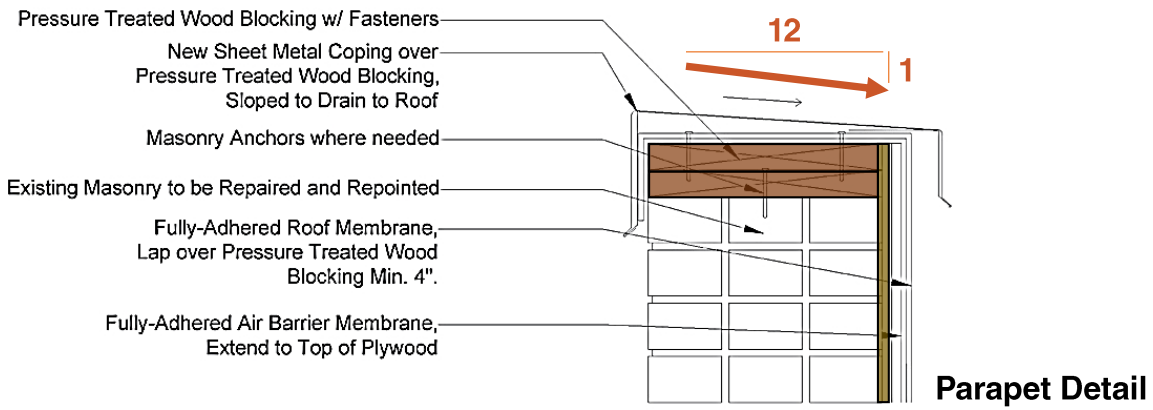


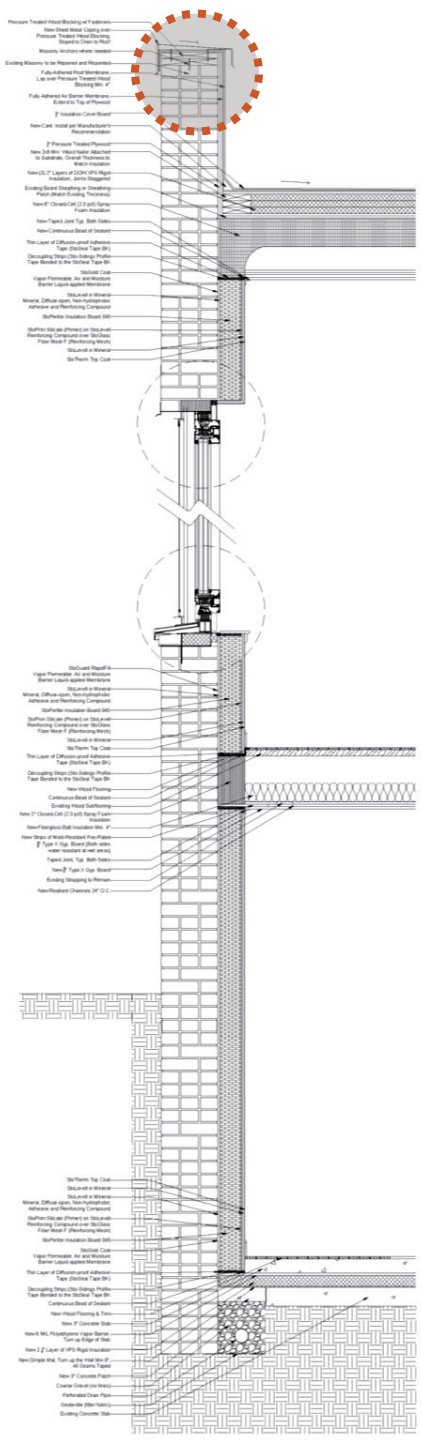
CONSTRUCTABILITY

PROPOSE

- New continuous coping that is sloped inward
- Proper drip edge and flashing cap
- New roof membrane wrap up and over the parapet



Parapet Detail



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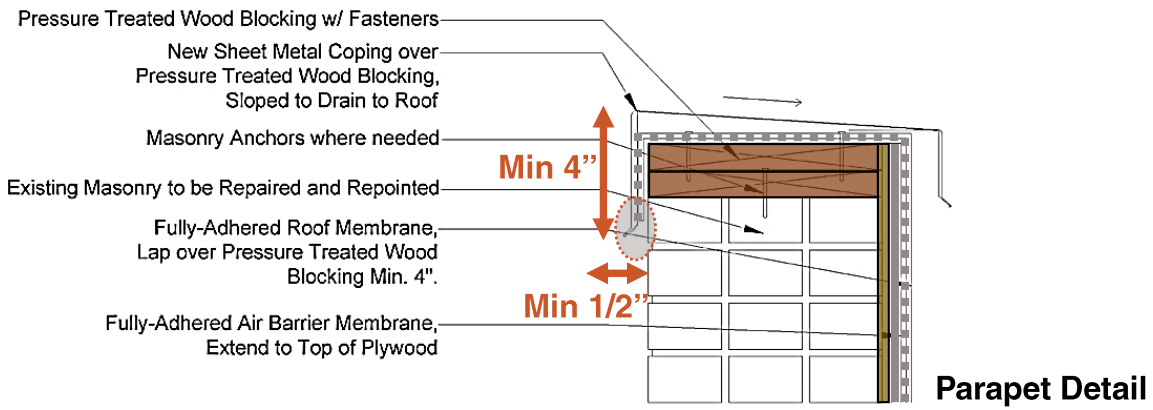
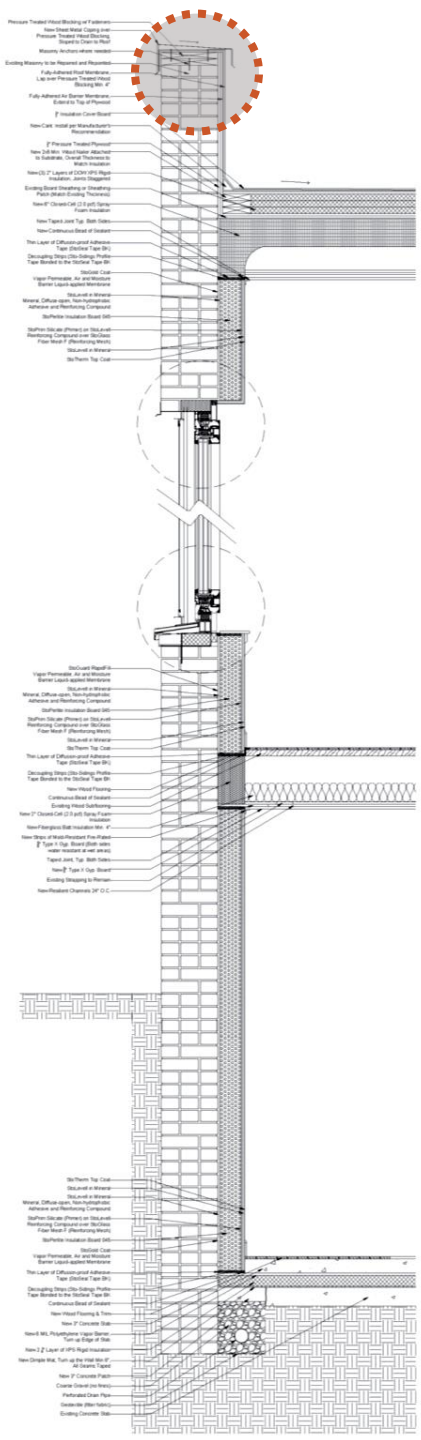


Parapet Detail



CONSTRUCTABILITY

PROPOSE

- New continuous coping that is sloped inward
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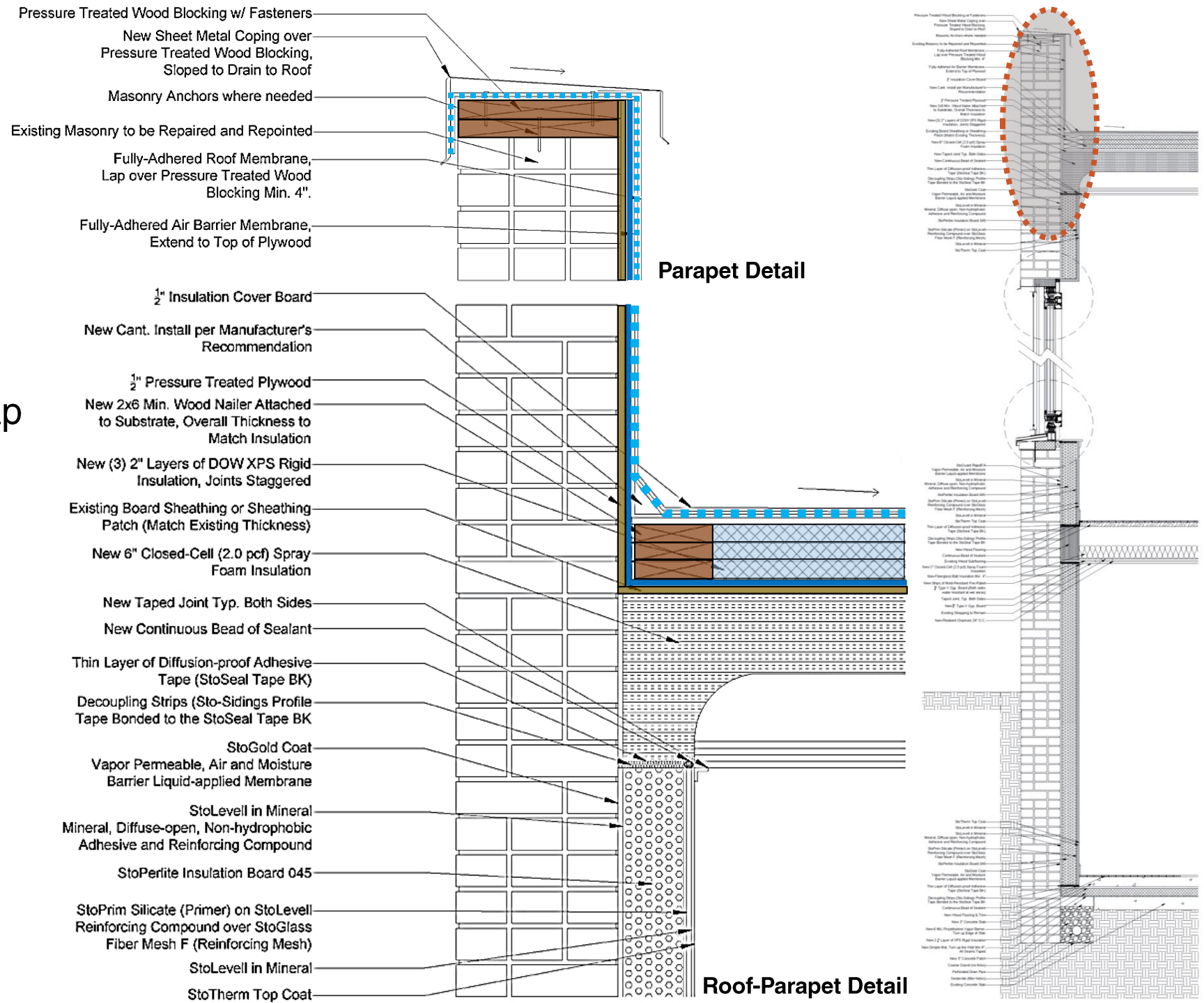
Roof: R-66

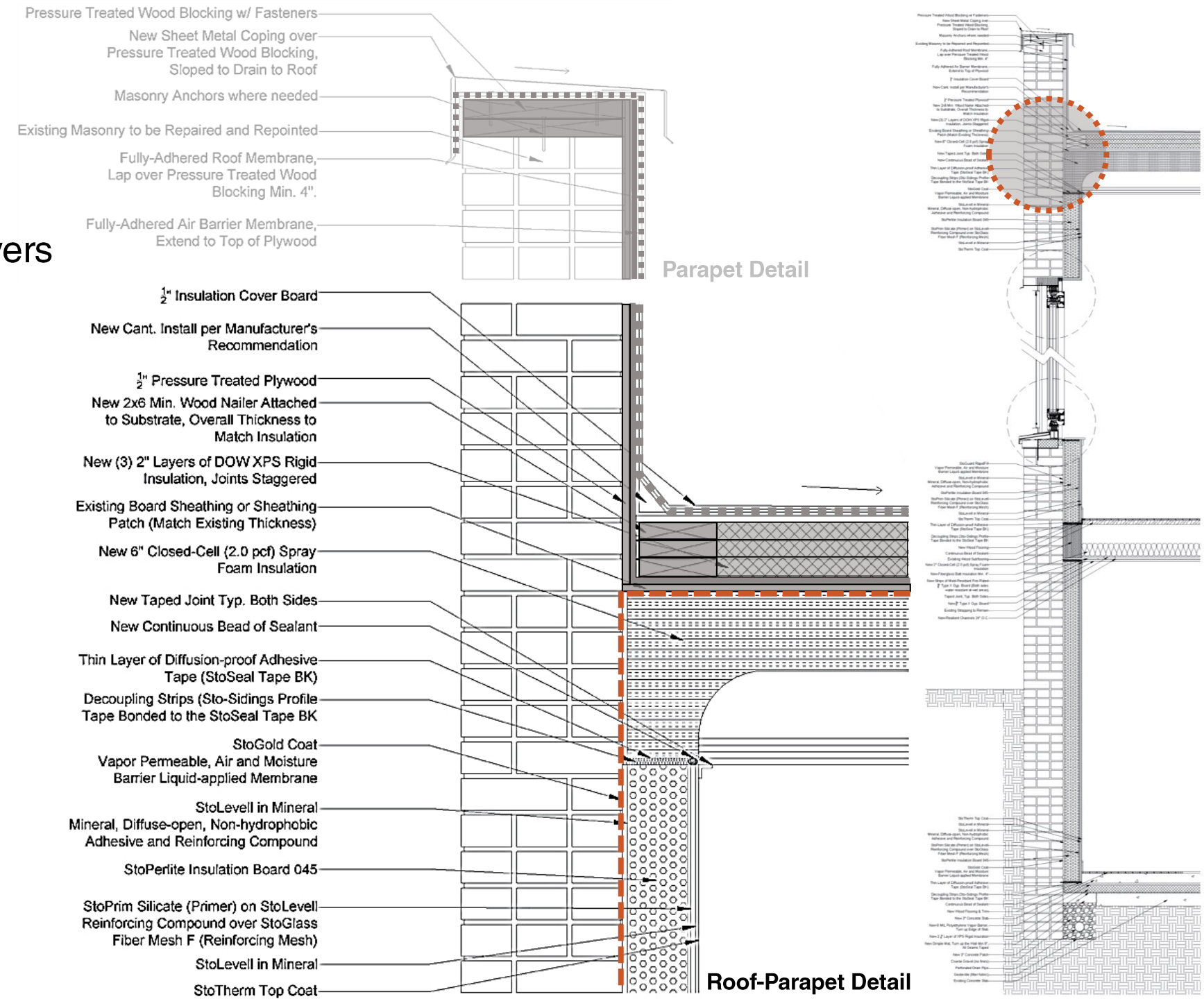


CONSTRUCTABILITY

PROPOSE

- Water and air control layers
- Vapor control layer (diffused-open)
- Thermal control layer

Roof: R-66



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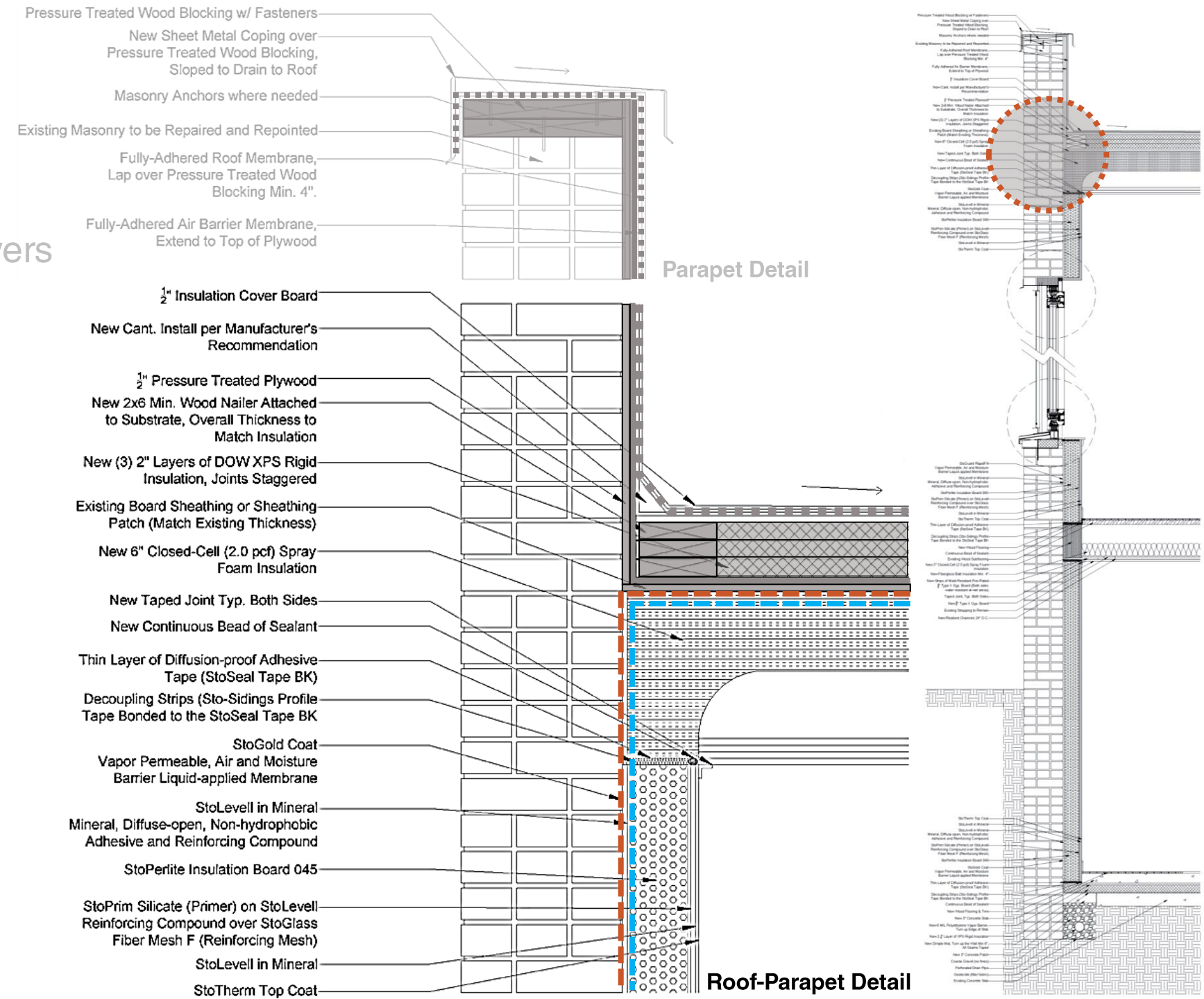

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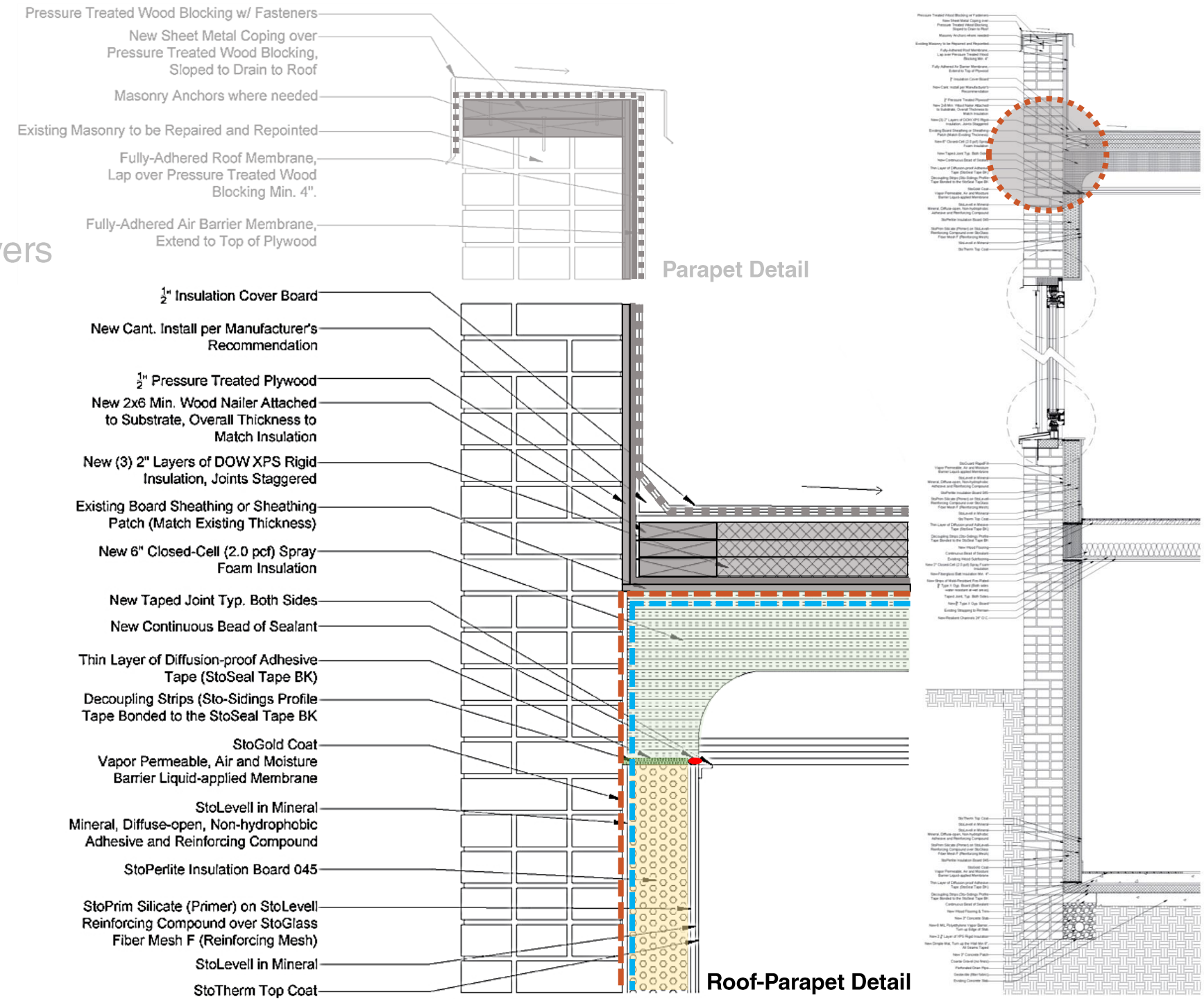

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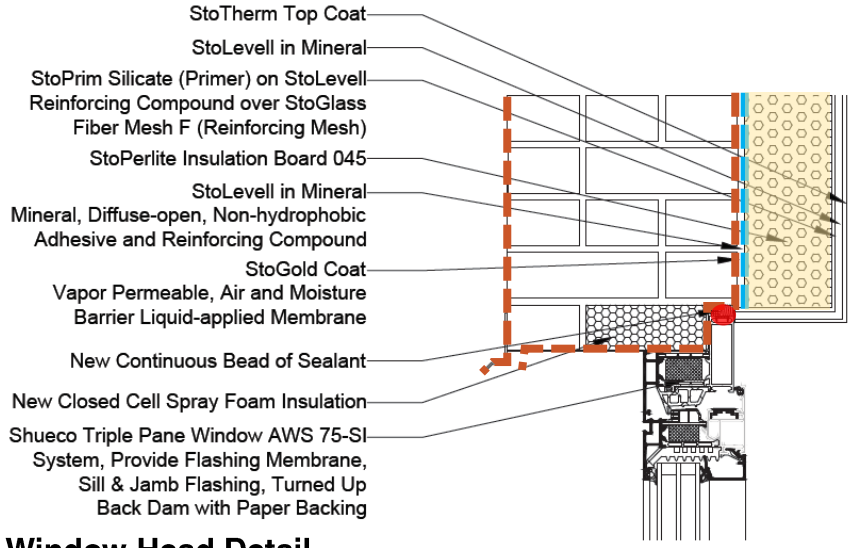


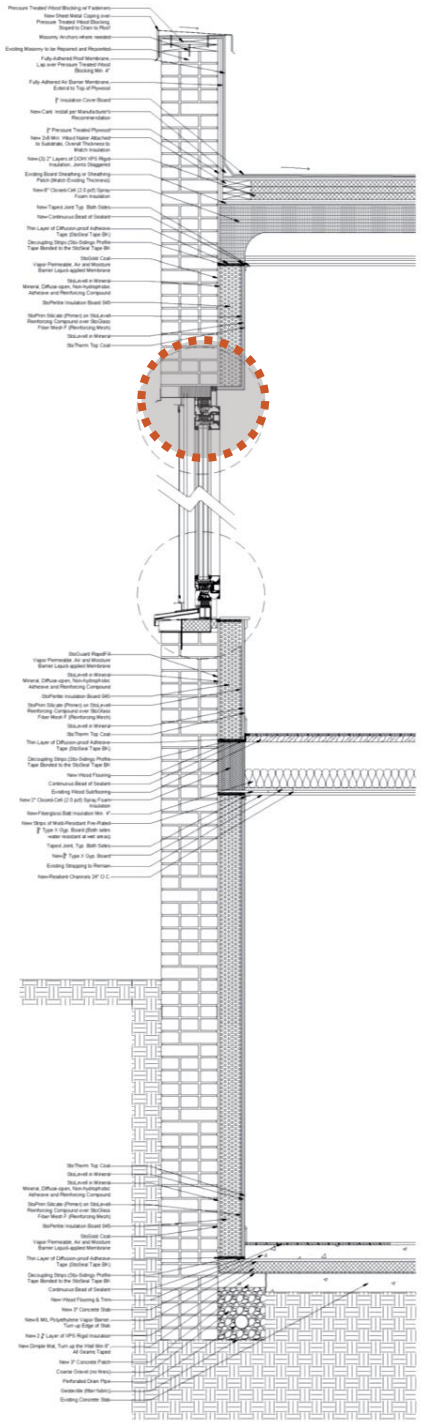
Window Head Detail

PROPOSE

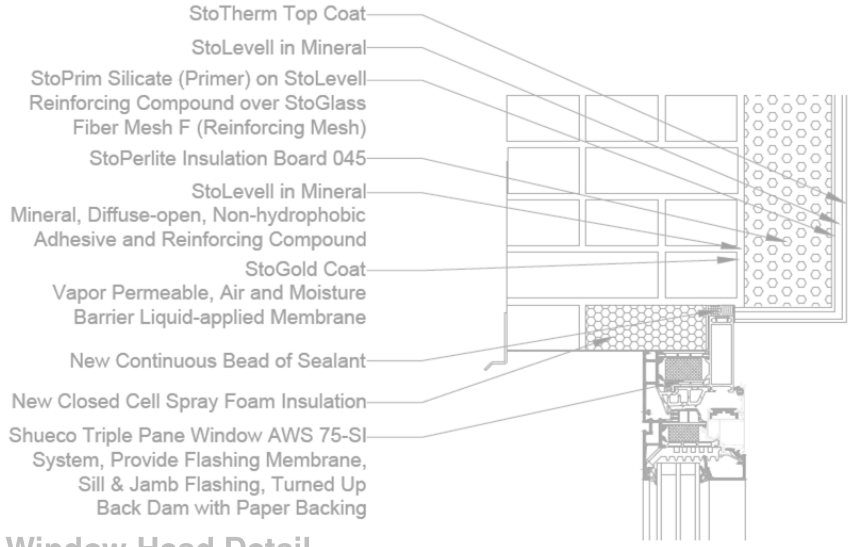
- Water and air control layers
- Vapor control layer (diffused-open)
- Thermal control layer

Windows:

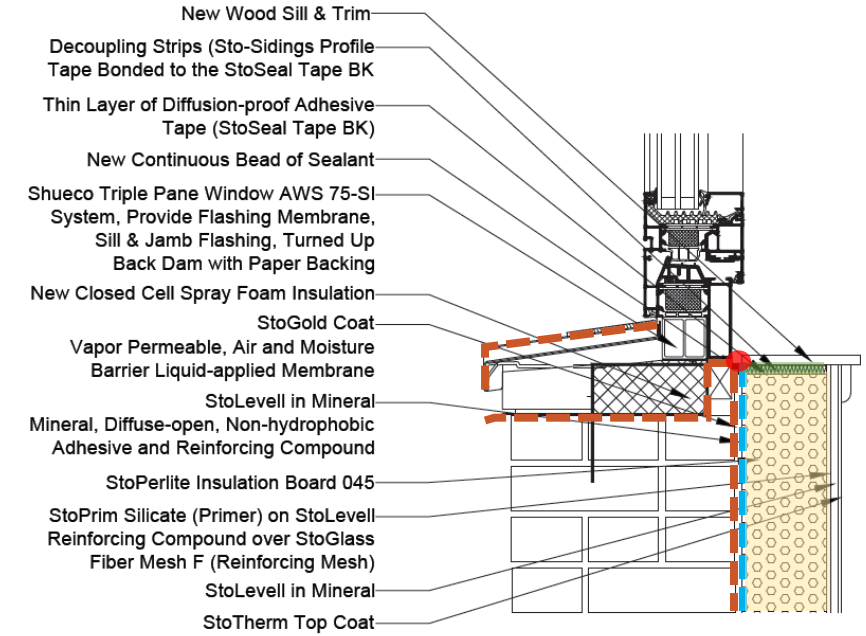
U-0.22
$SHGC_1$-0.24
$SHGC_2$-0. 40



CONSTRUCTABILITY



Window Head Detail



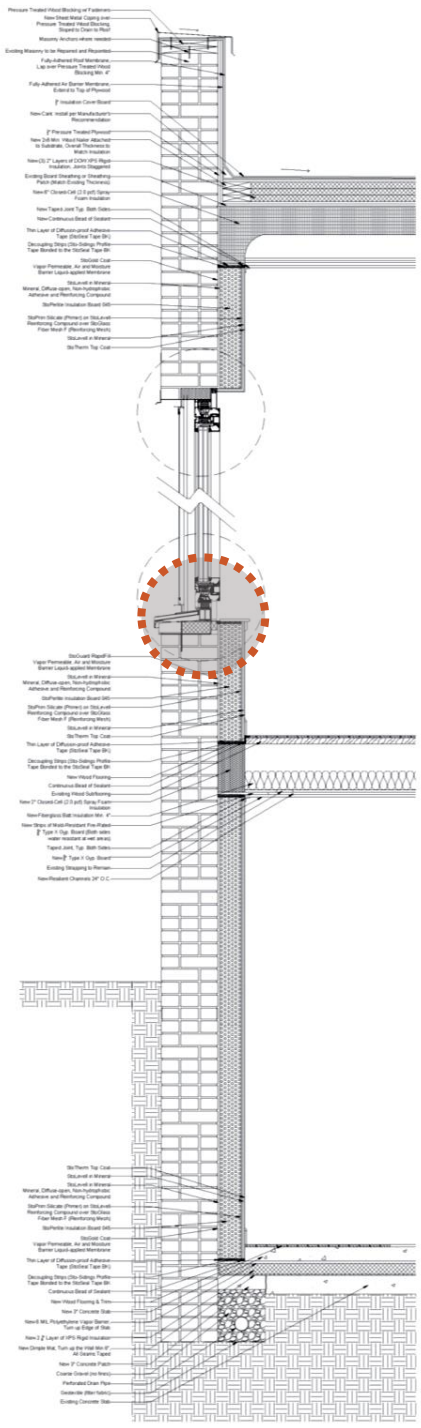
Window Sill Detail

PROPOSE

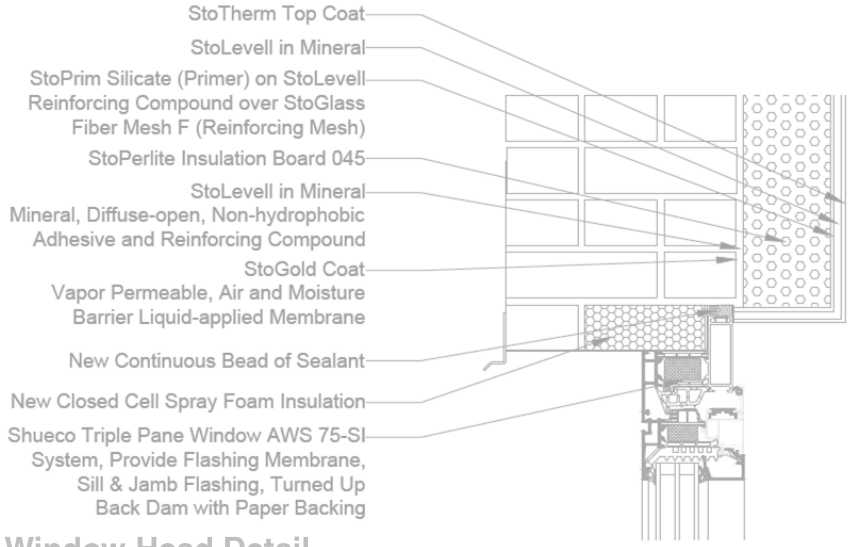
- Water and air control layers
- Vapor control layer (diffused-open)
- Thermal control layer

Windows:

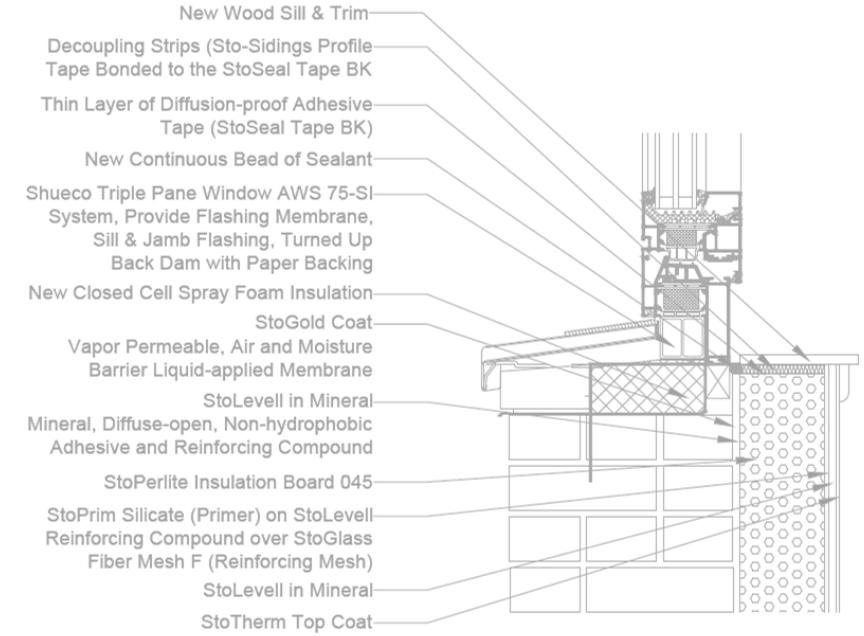
U-0.22
$SHGC_1$-0.24
$SHGC_2$-0. 40



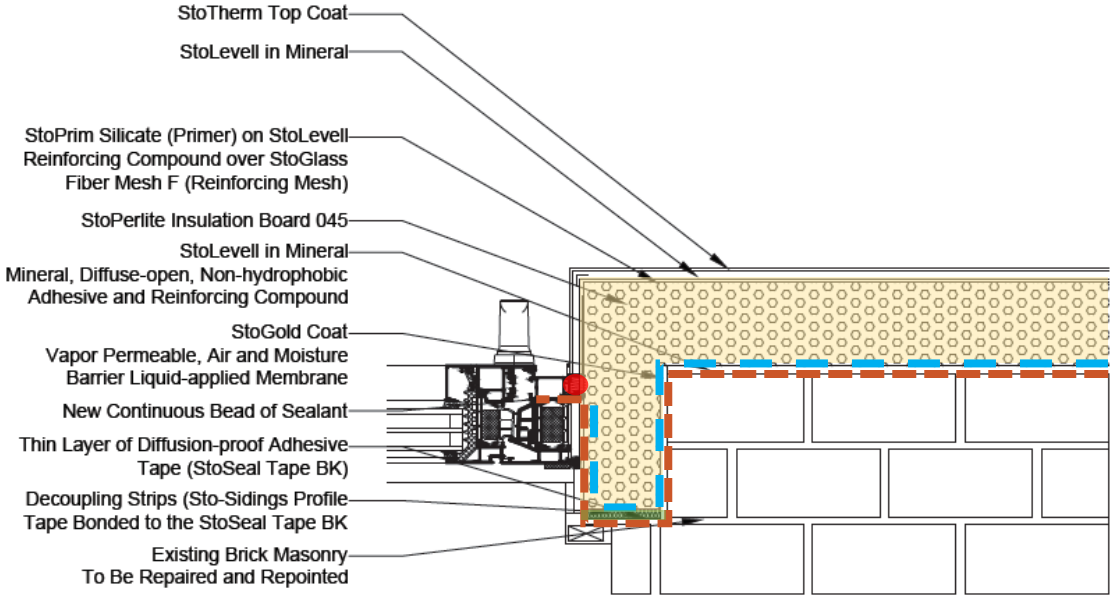
CONSTRUCTABILITY



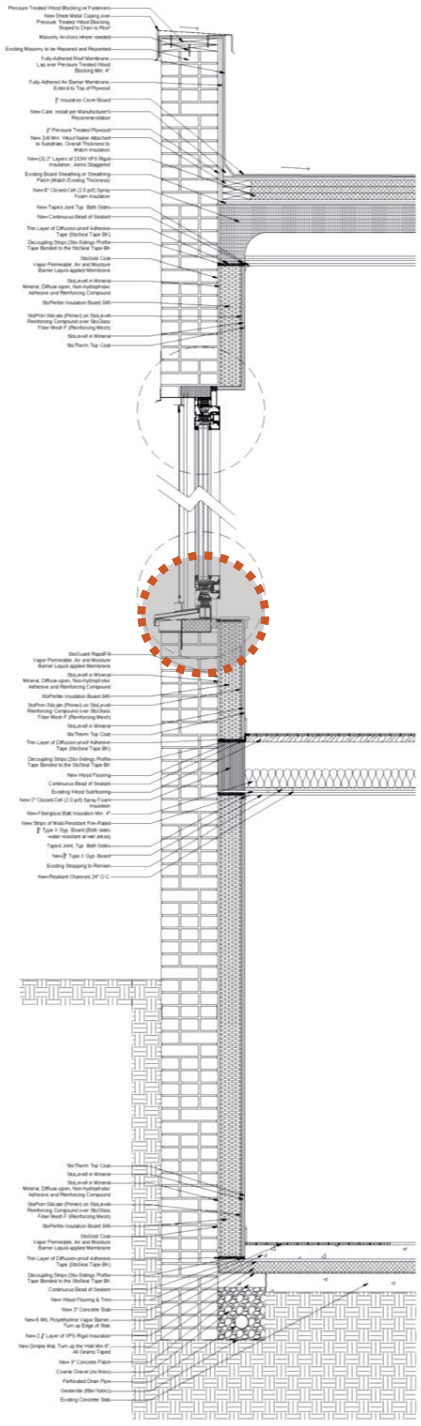
Window Head Detail



Window Sill Detail



Window Jamb Detail



PROPOSE

- Water and air control layers
- Vapor control layer (diffused-open)
- Thermal control layer

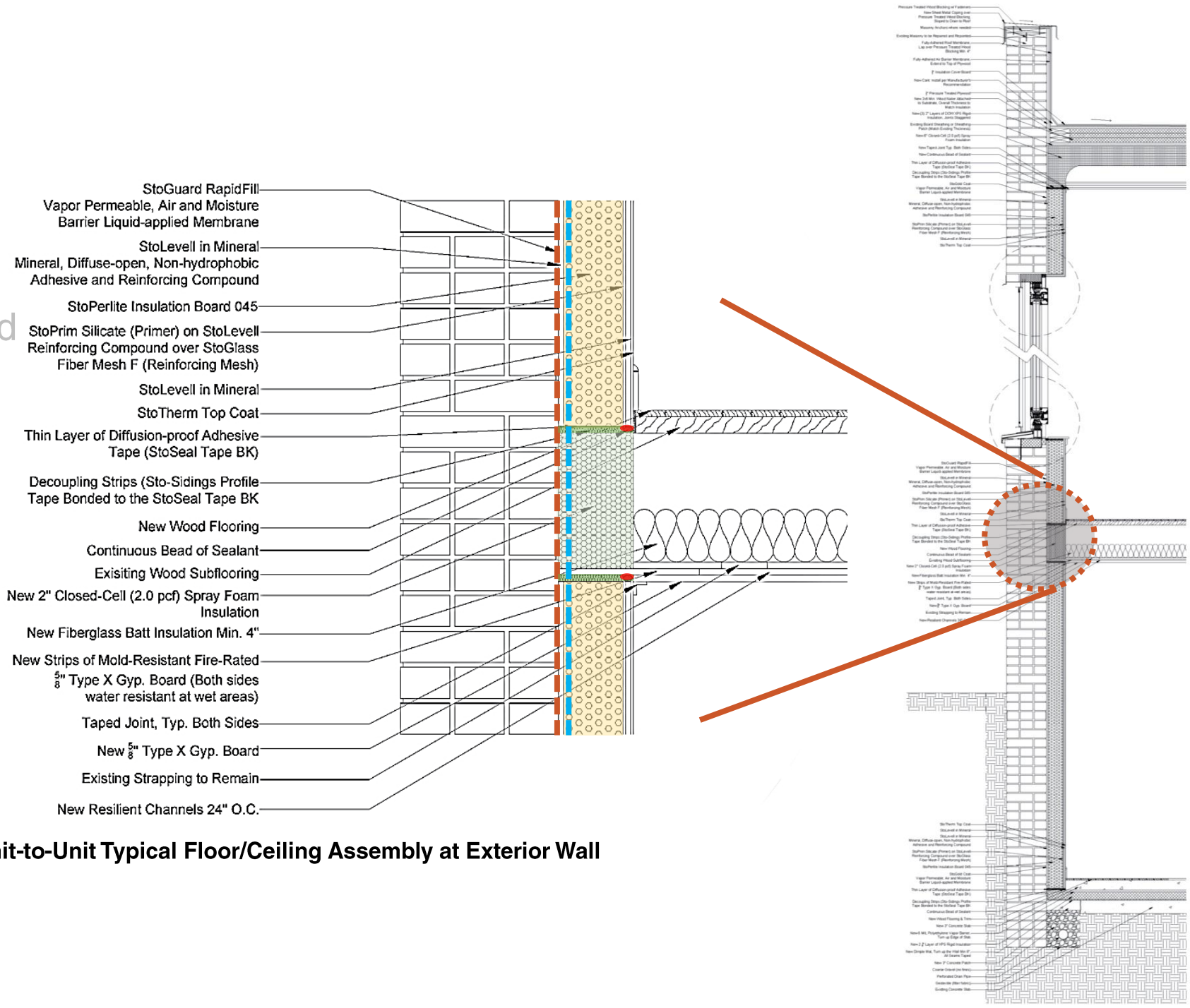
Windows:

U-0.22
$SHGC_1$-0.24
$SHGC_2$-0. 40

CONSTRUCTABILITY

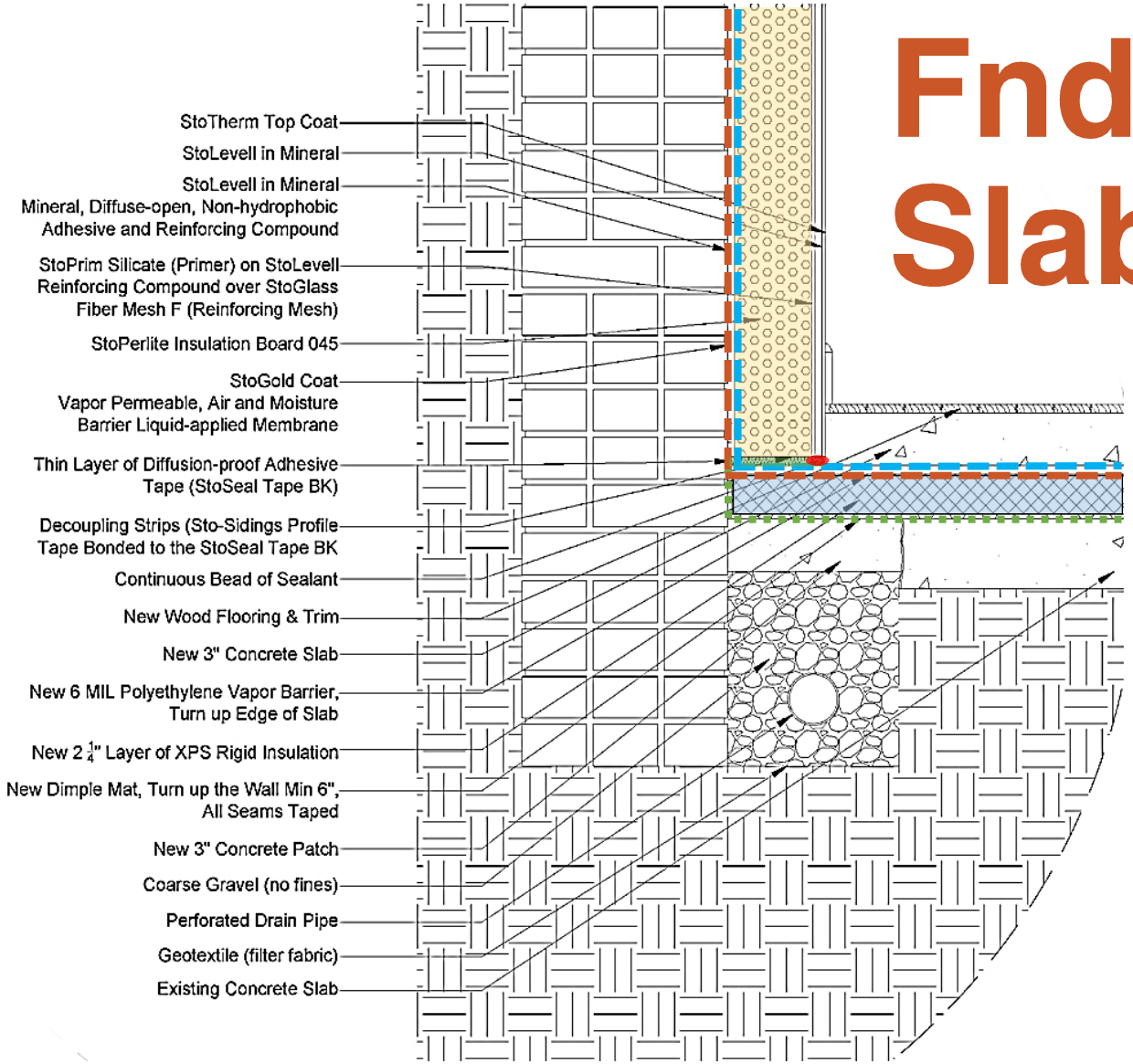
PROPOSE

- Use of maximum 1.5” to 2” ccSPF where embedded wood timber structures and rim joists are in contact with exterior wall



Unit-to-Unit Typical Floor/Ceiling Assembly at Exterior Wall

CONSTRUCTABILITY

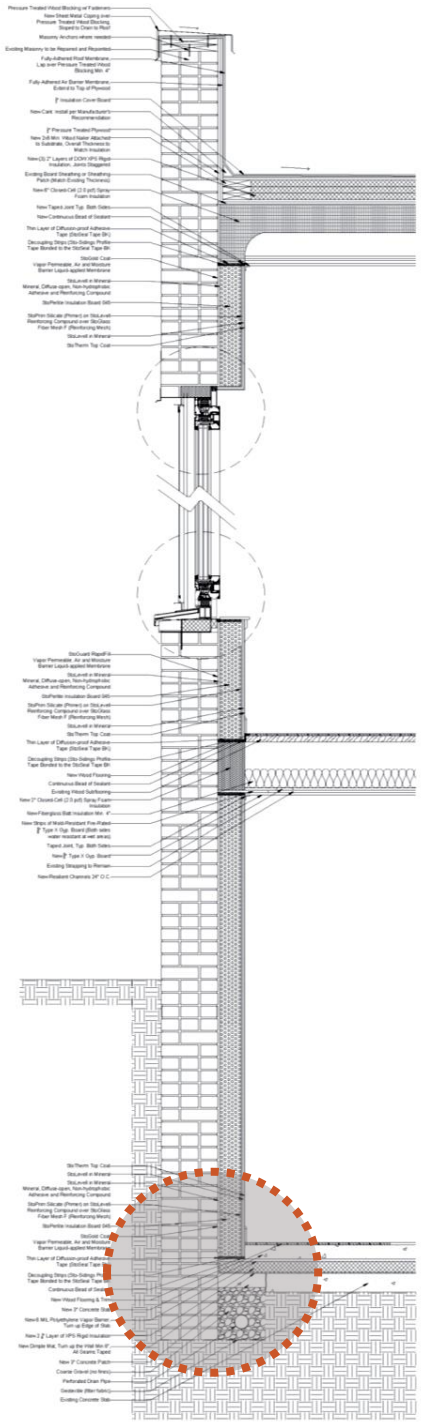


Typical Basement Slab

Fndn: R-19
Slab: R-12

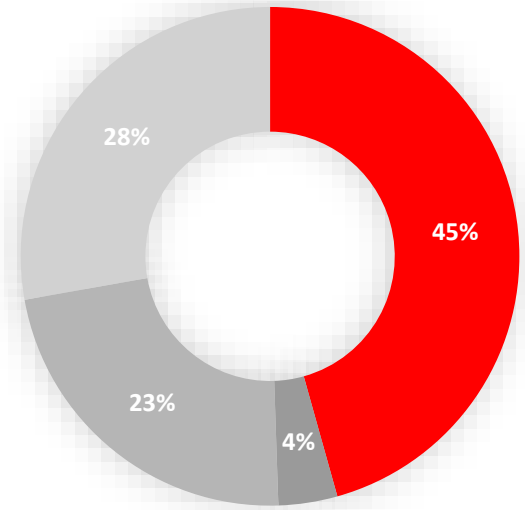
PROPOSE

- Water and air control layers
- Vapor control layer (diffused-open)
- Thermal control layer



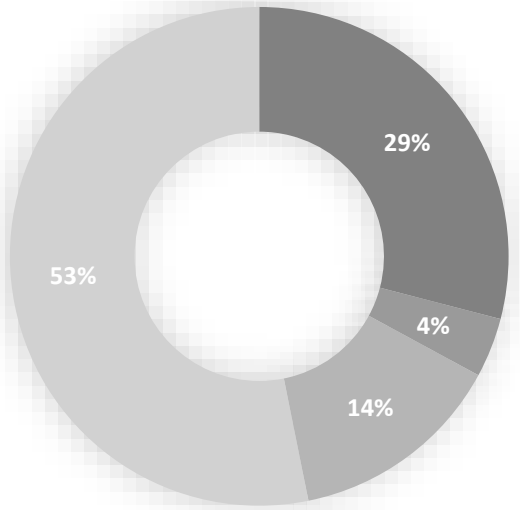
ENERGY ANALYSIS

Existing



Energy Use From Heating Dominates

Proposed



Space Heating
Cooling (Air Conditioning)
Domestic Hot Water
Appliances, Electronics, Lighting

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Cooling (Air Conditioning)
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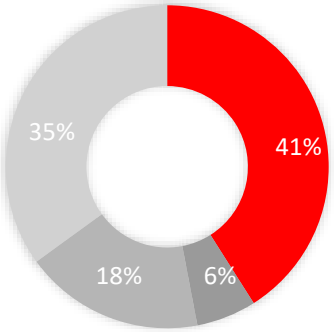
Appliances, Electronics, Lighting

U.S.



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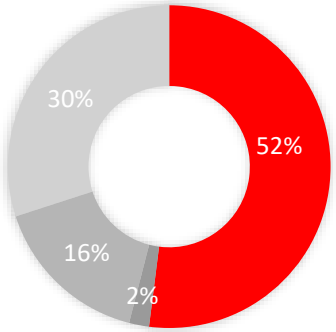

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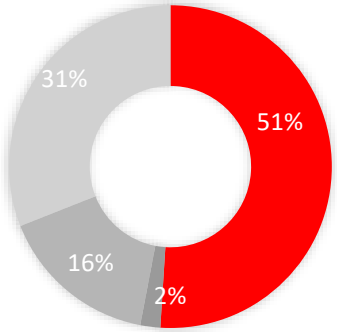
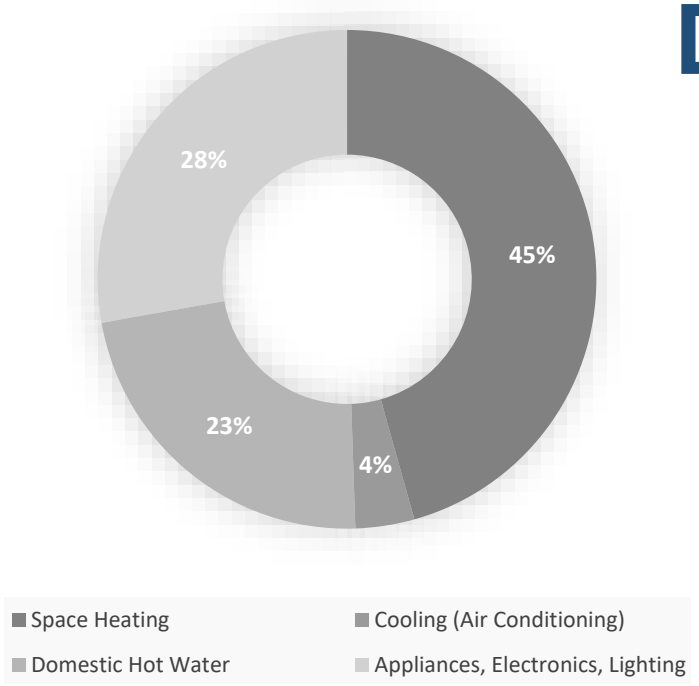


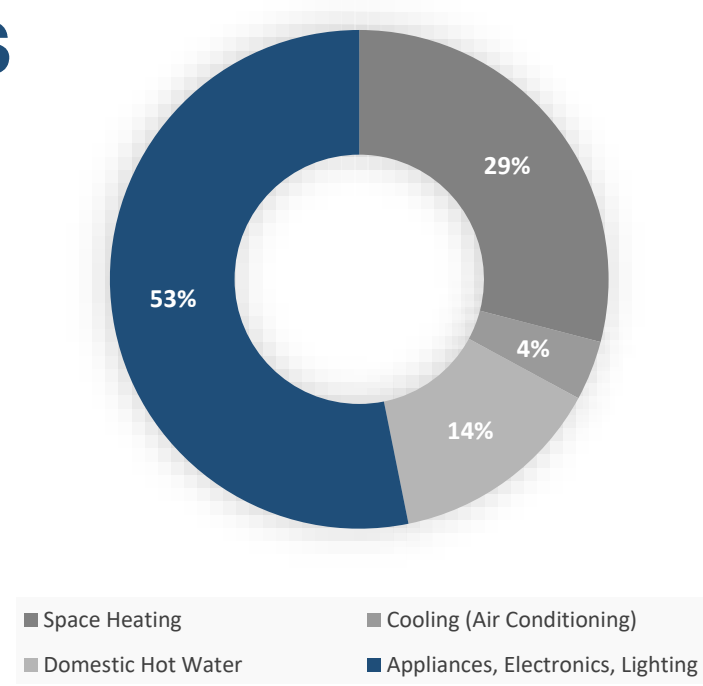
ENERGY ANALYSIS

Energy Use From Appliances Dominates

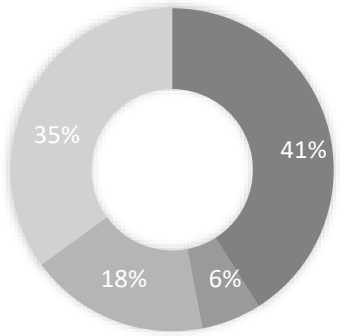
Existing



Proposed



U.S.



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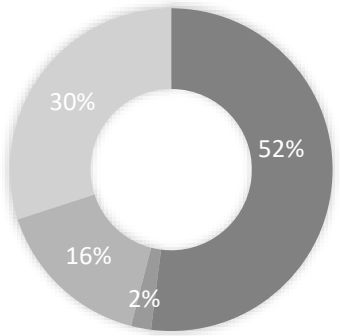

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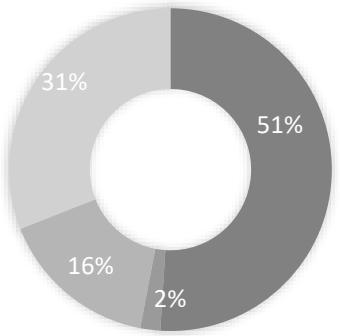
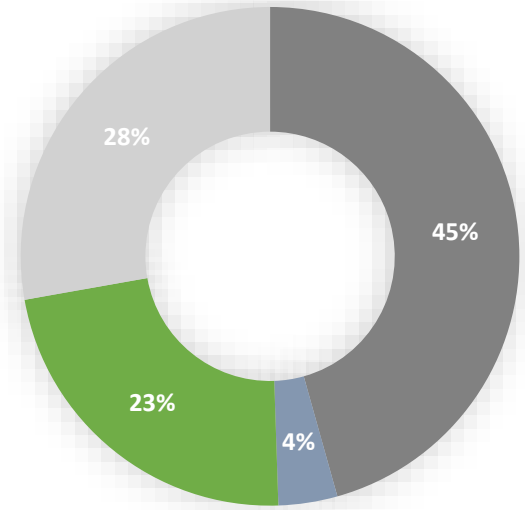


ENERGY ANALYSIS

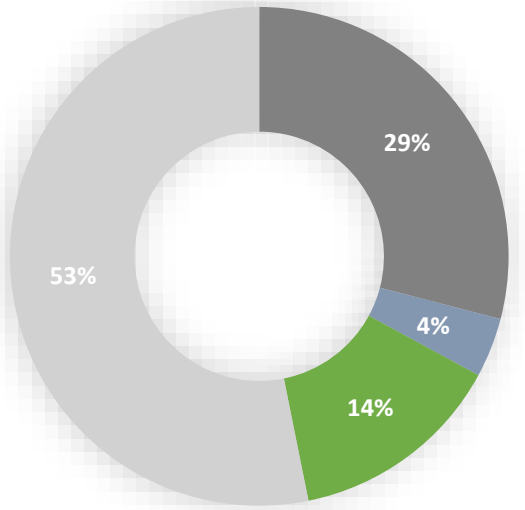
Existing



Other Energy Use is

Similar

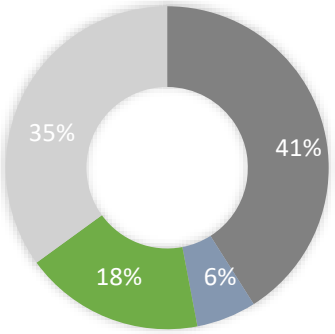
Proposed



Space Heating | Cooling (Air Conditioning) | Domestic Hot Water | Appliances, Electronics, Lighting

Space Heating | Cooling (Air Conditioning) | Domestic Hot Water | Appliances, Electronics, Lighting

U.S.



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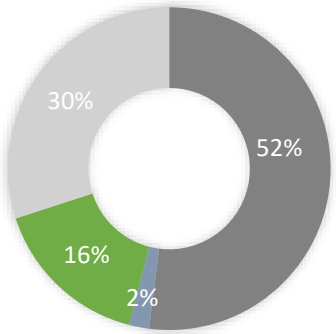

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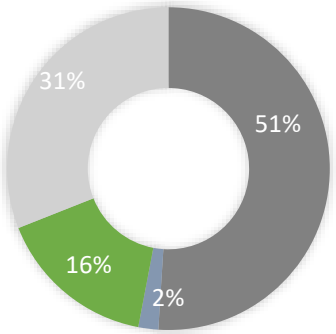
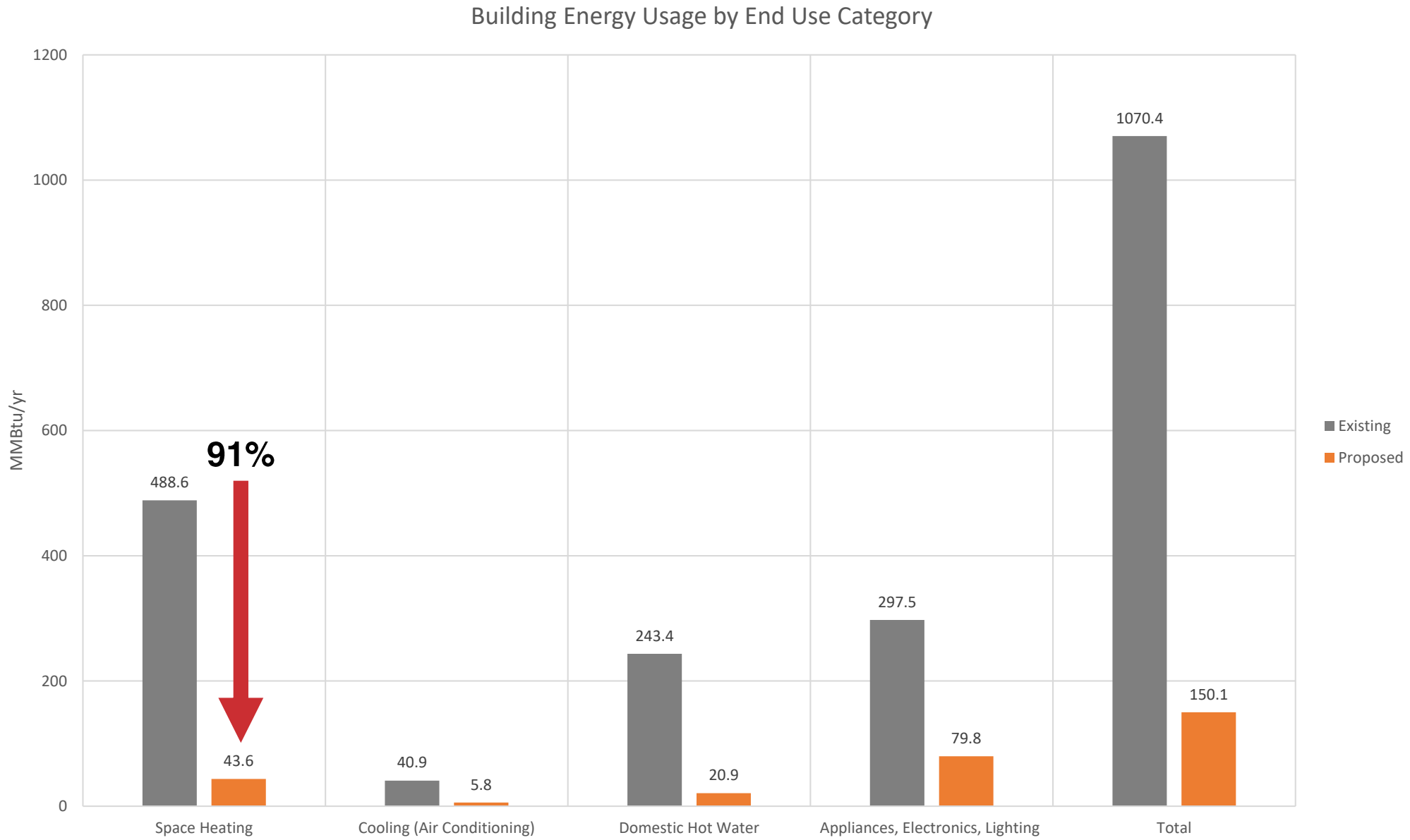
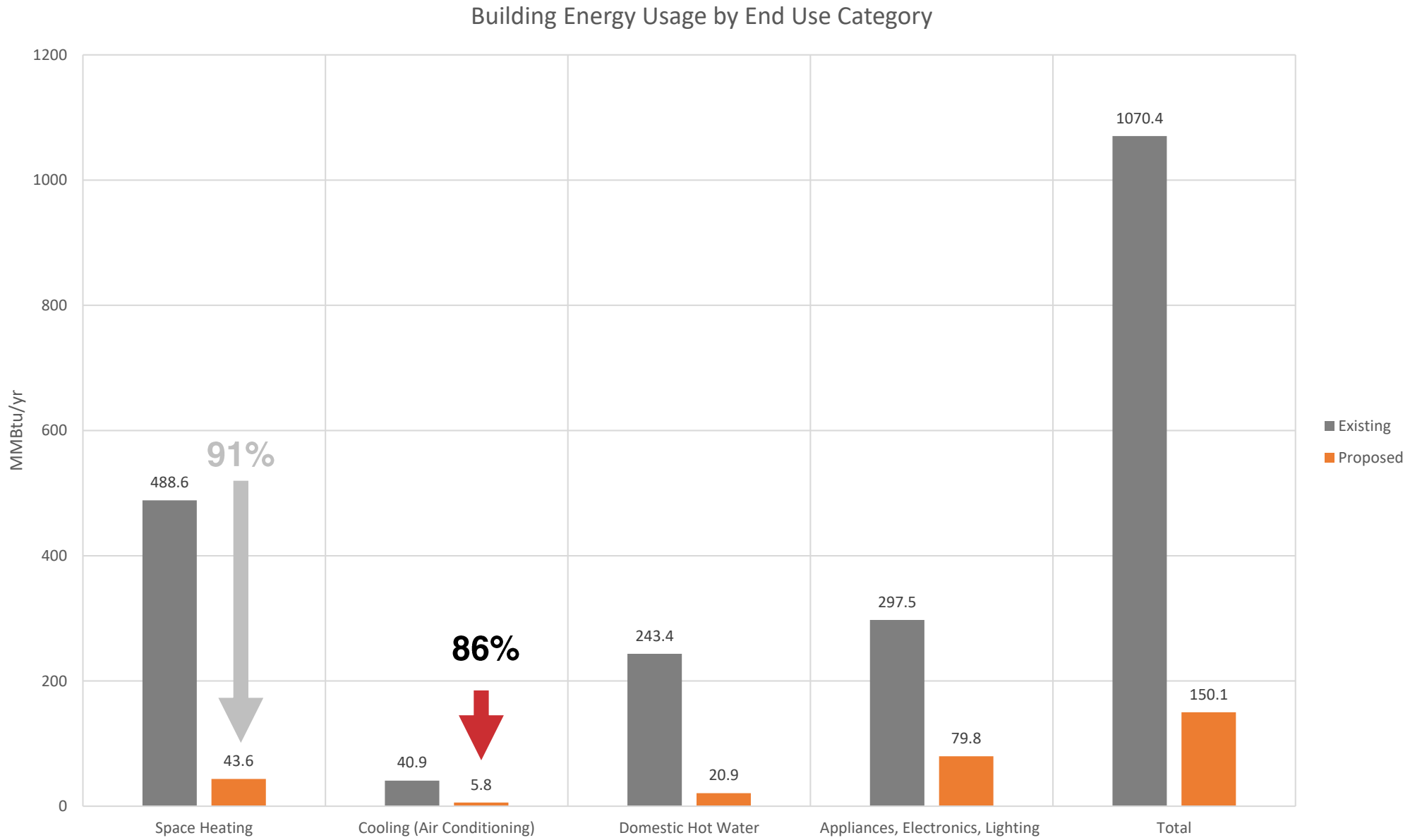


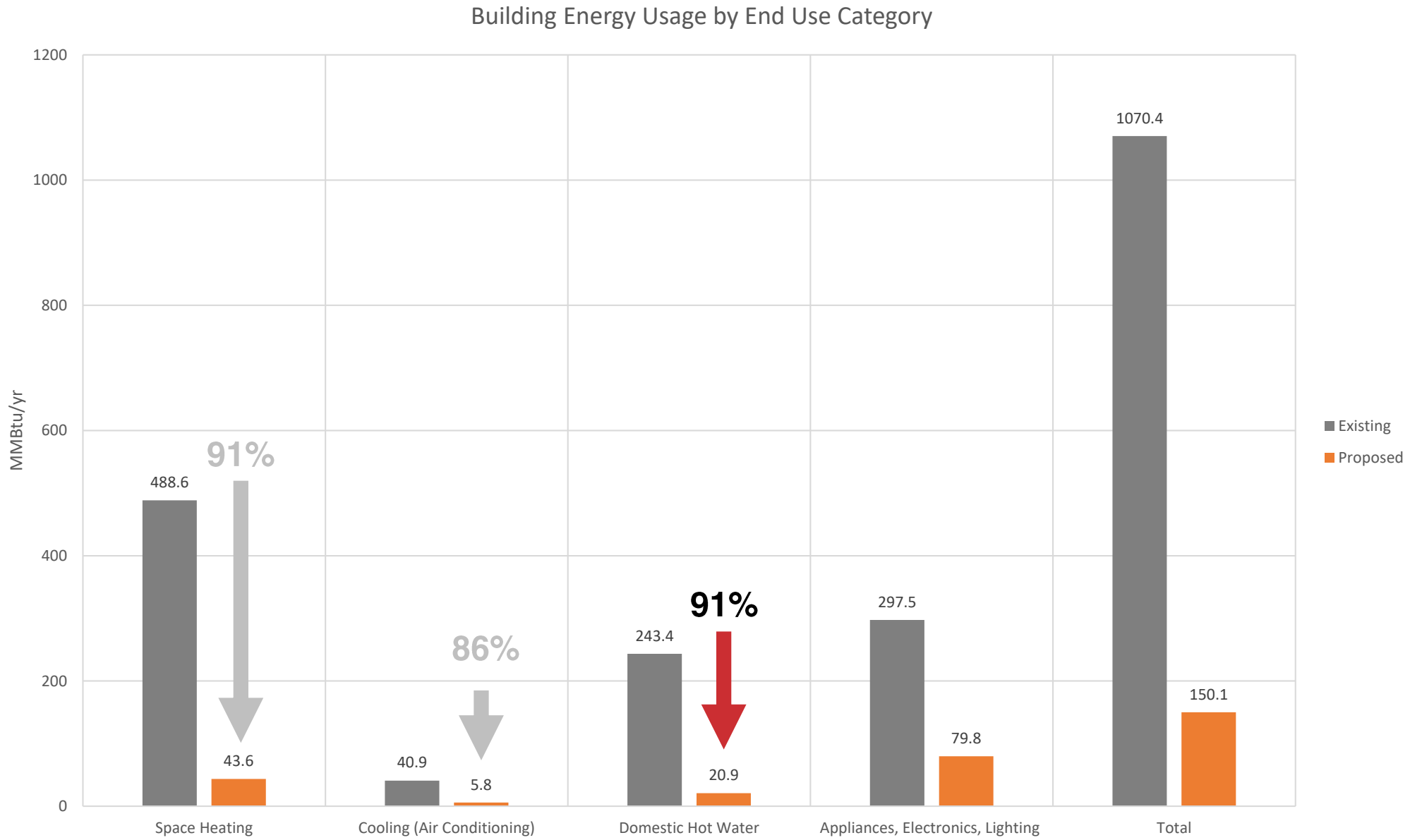
ENERGY ANALYSIS



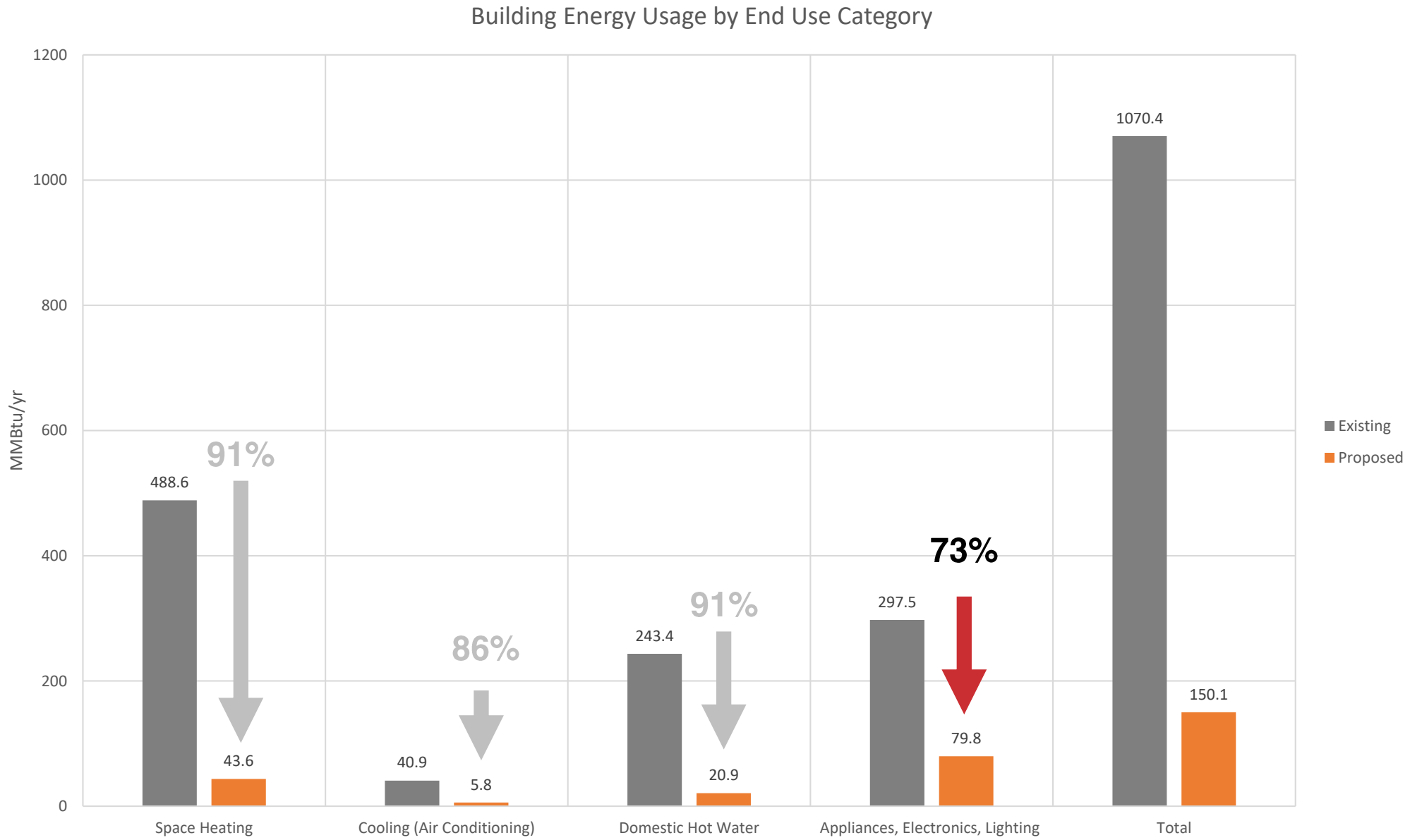
ENERGY ANALYSIS



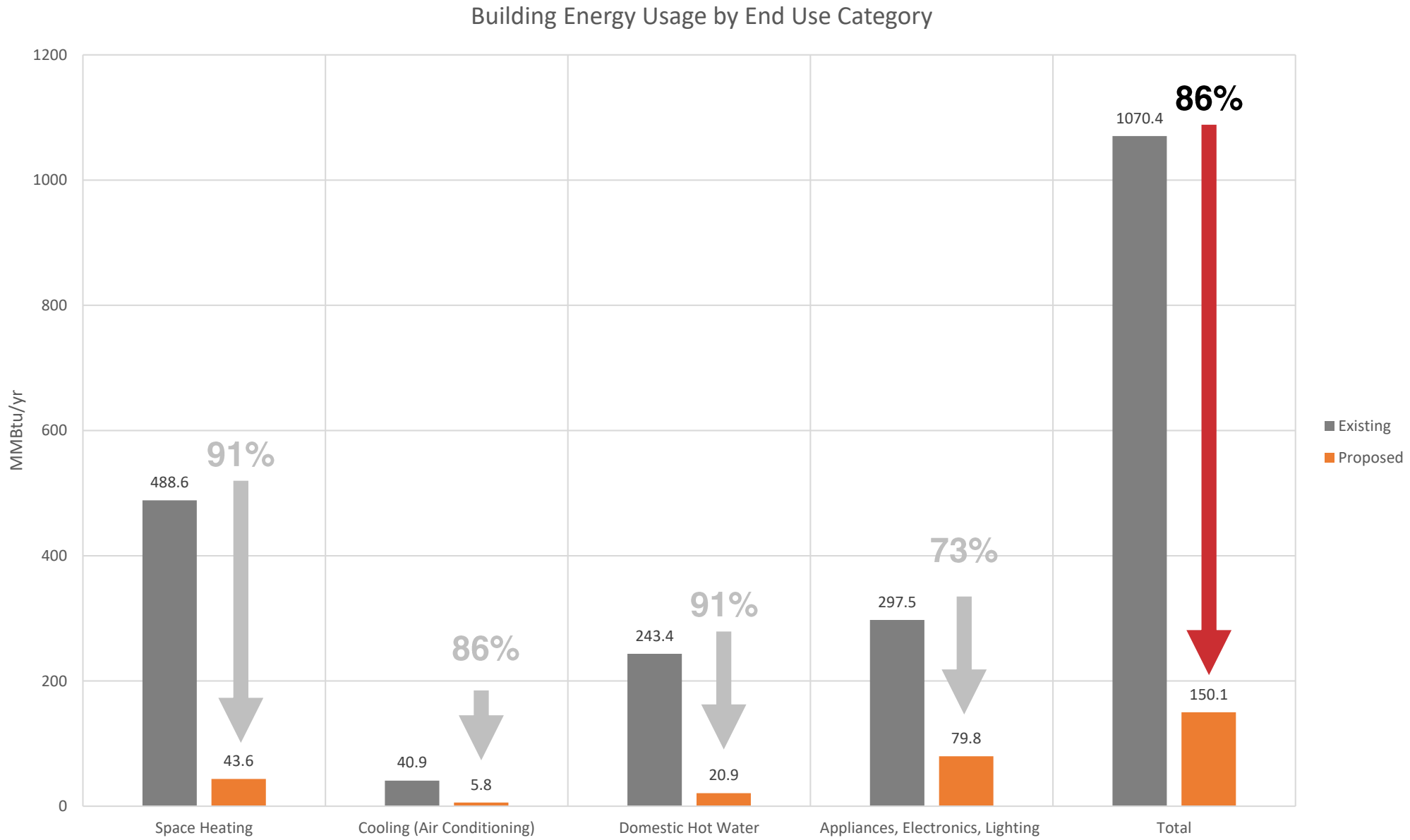
ENERGY ANALYSIS



ENERGY ANALYSIS



ENERGY ANALYSIS



EXISTING SPACE CONDITIONING

EVALUATE AND ADDRESS

- Steam Radiators
- Central Boiler
  - 78% AFUE
  - Uninsulated Piping
- Window Unit Air Conditioner
  - EER: 10.7 to 11.3
- No Ventilation Strategy

EXISTING SPACE CONDITIONING

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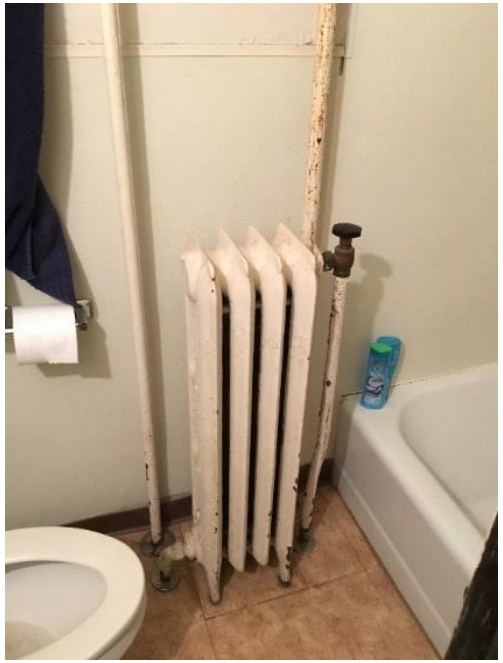

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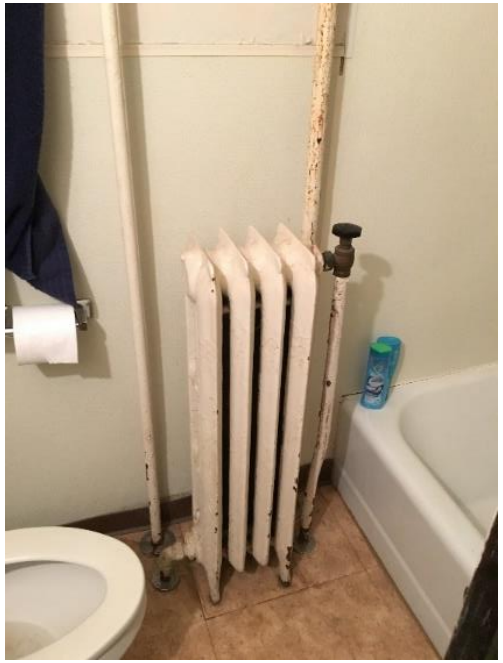

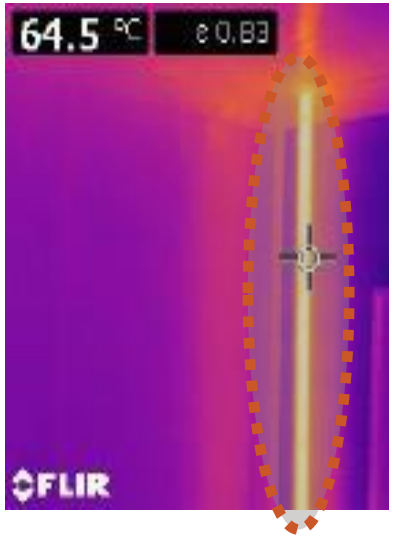

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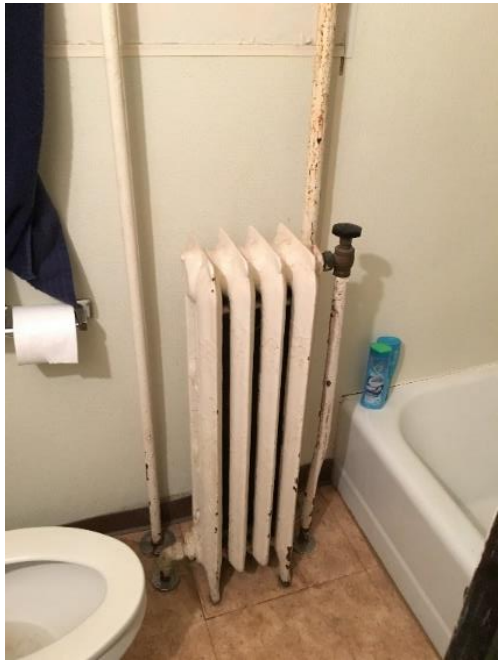

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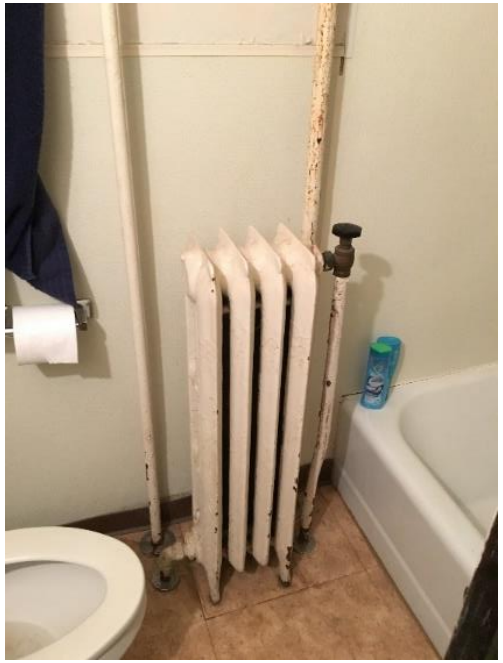
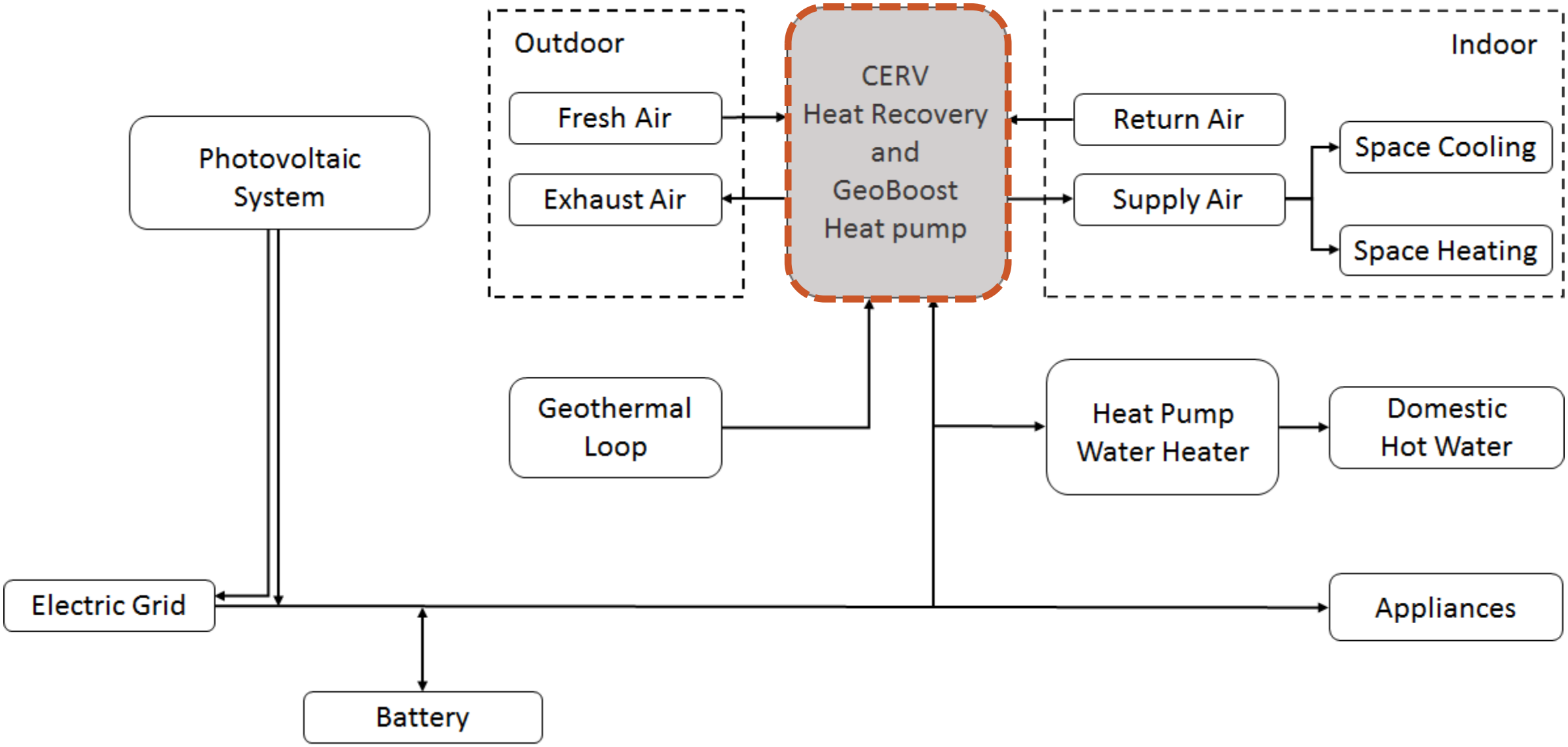


SYSTEMS OVERVIEW



PROPOSED SPACE CONDITIONING

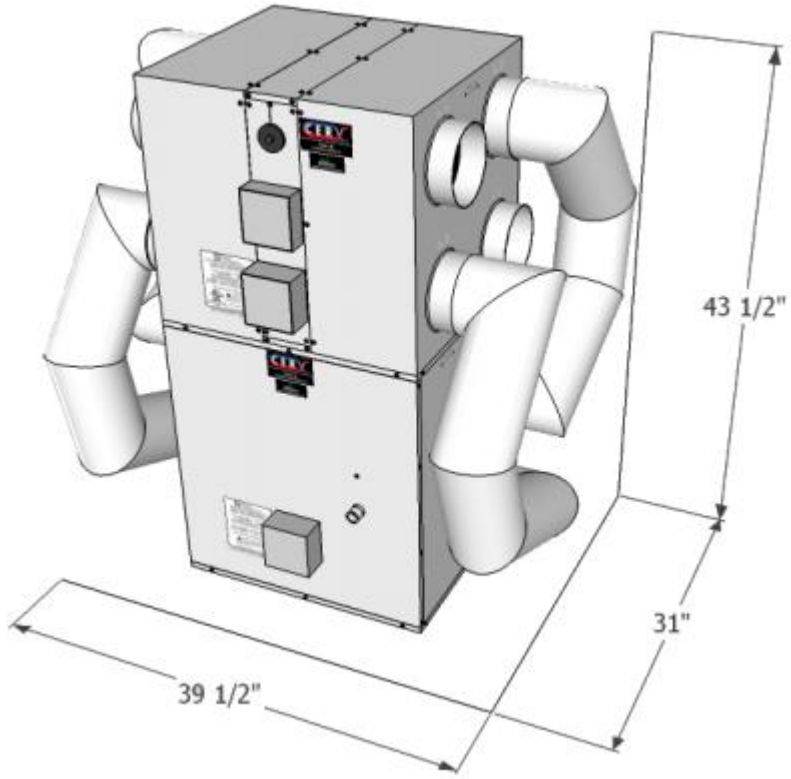
PROPOSE

- The CERV
- Inline Duct Heater
- Geothermal Heat Pump
- Natural Ventilation

8 Total CERVs

1 CERV/Unit

The CERV



Conditioning
Energy
Recovery
Ventilator

PROPOSED SPACE CONDITIONING

PROPOSE

- The CERV
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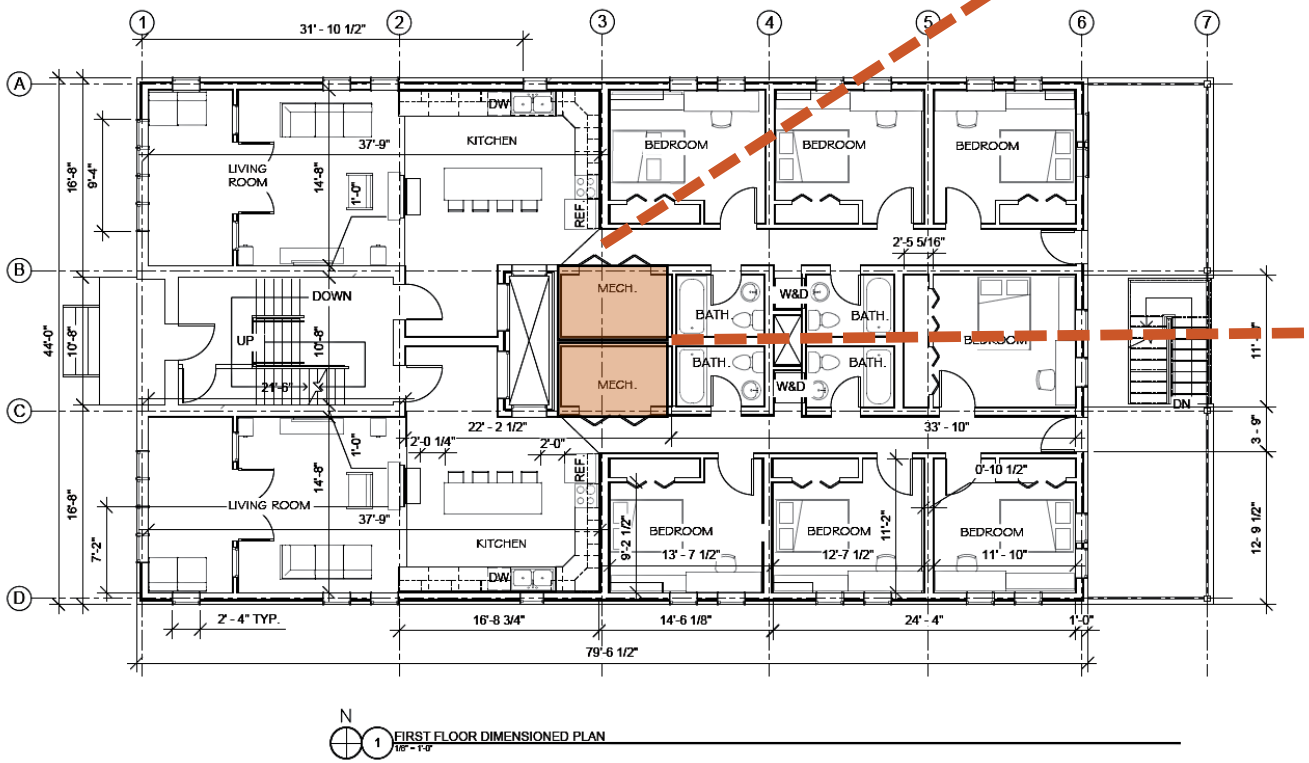
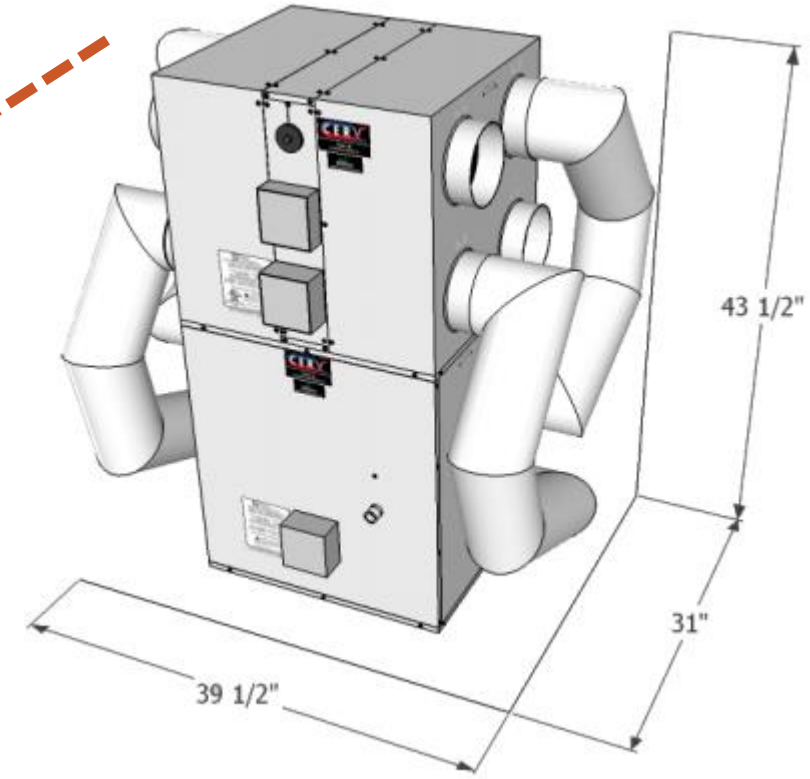


N

1 FIRST FLOOR DIMENSIONED PLAN

1/8" = 1'-0"

The CERV



Conditioning
Energy
Recovery
Ventilator

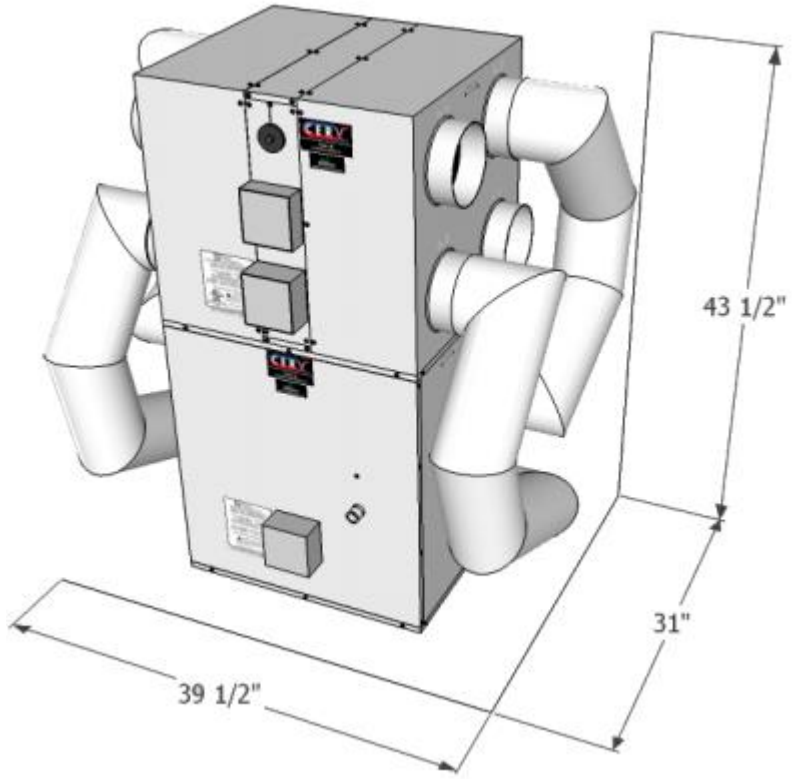
PROPOSED SPACE CONDITIONING

2 Modules

PROPOSE

- The CERV
- Inline Duct Heater
- Geothermal Heat Pump
- Natural Ventilation

The CERV



Conditioning
Energy
Recovery
Ventilator

PROPOSED SPACE CONDITIONING

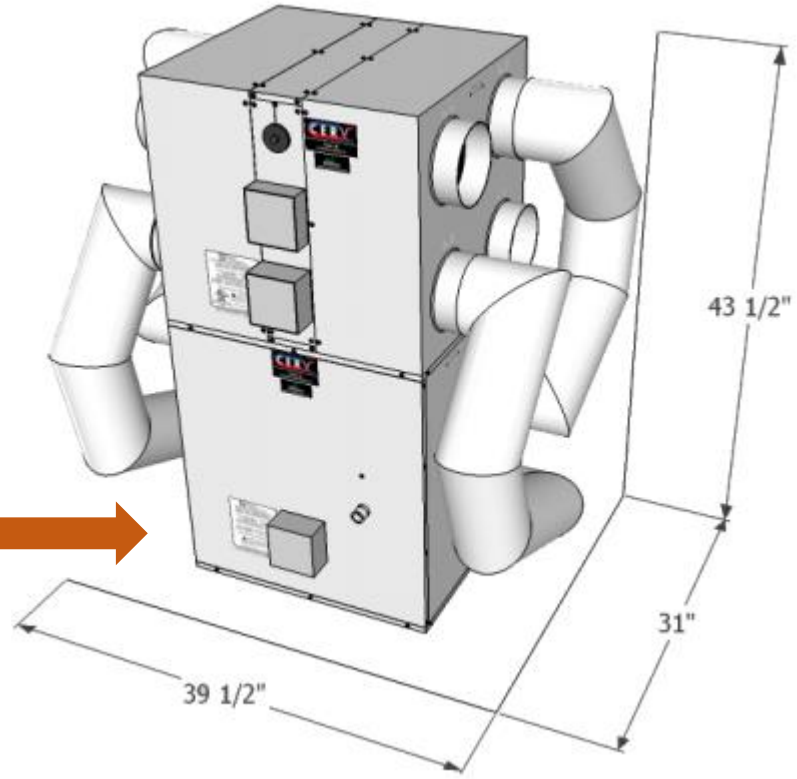
PROPOSE

- The CERV
- Inline Duct Heater
- Geothermal Heat Pump
- Natural Ventilation

2 Modules

Conditioning Module:
Built in ASHP and Temperature Sensors

The CERV



Conditioning
Energy
Recovery
Ventilator

PROPOSED SPACE CONDITIONING

PROPOSE

- The CERV
- Inline Duct Heater
- Geothermal Heat Pump
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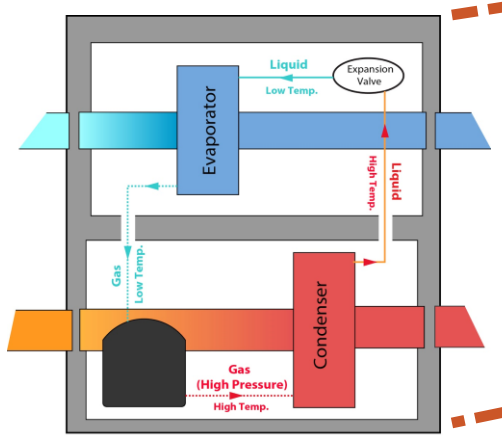

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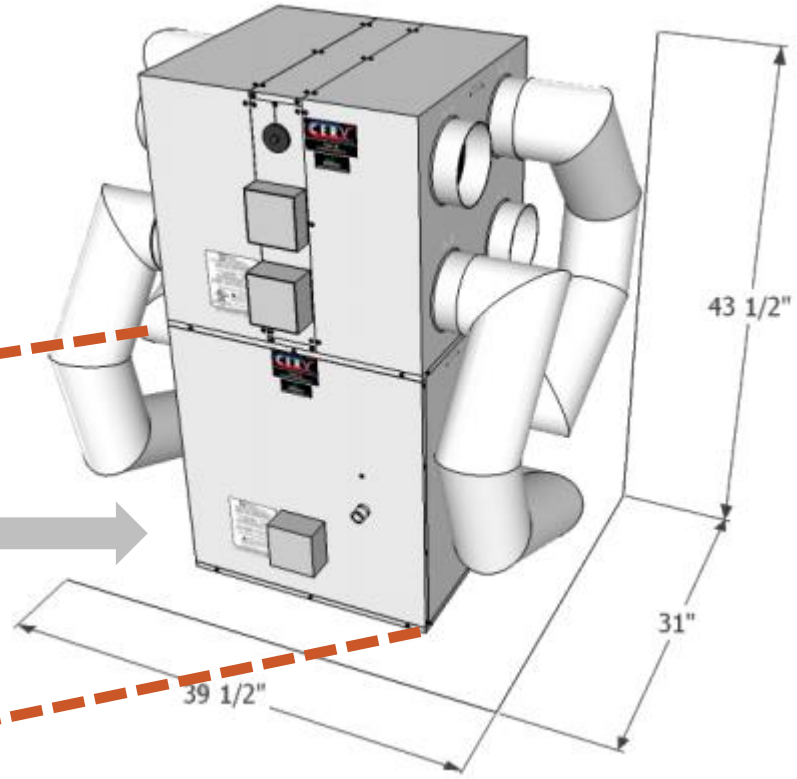


Conditioning
Energy
Recovery
Ventilator

Average Total Heating Capacity = 5.5 kBtu/hr

Average Total Cooling Capacity = 3.8 kBtu/hr

Latent Capacity = .42 - .73 kBtu/hr

PROPOSED SPACE CONDITIONING

PROPOSE

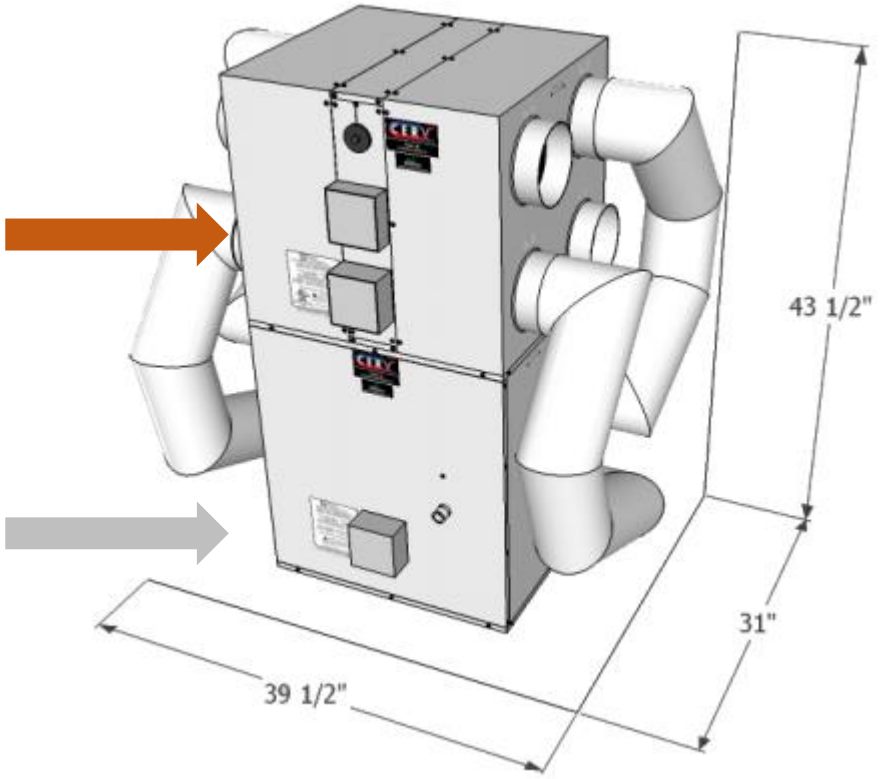
- The CERV
- Inline Duct Heater
- Geothermal Heat Pump
- Natural Ventilation

2 Modules

Fresh Air Control Module:
Internal CO2 and VOC Sensors

Conditioning Module:
Built in ASHP and Temperature Sensors

The CERV



Provides Balanced, Demand Controlled

Ventilation

Operates based on **Set points:**

CO2/VOC ppm > 1000

Conditioning
Energy
Recovery
Ventilator

PROPOSED SPACE CONDITIONING

PROPOSE

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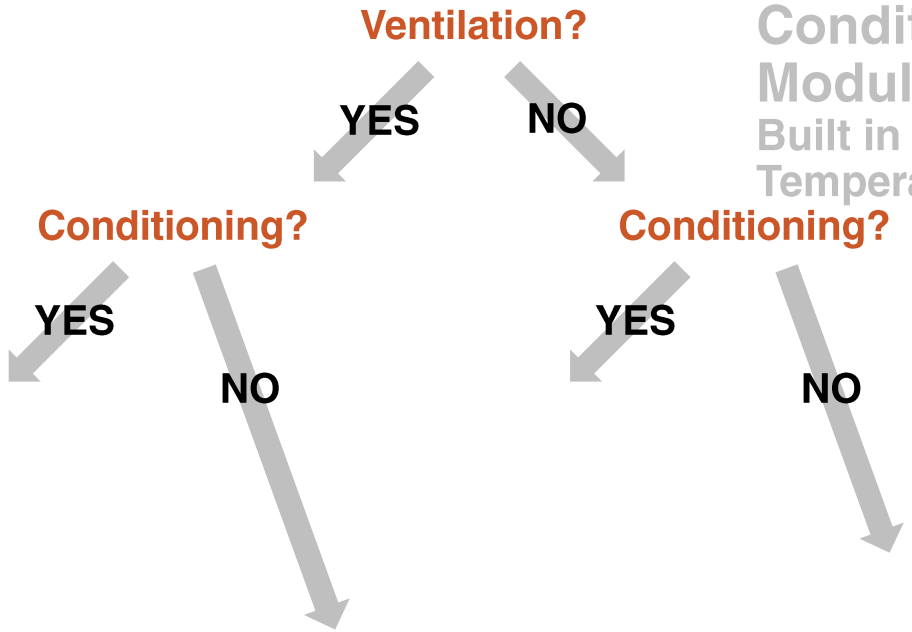
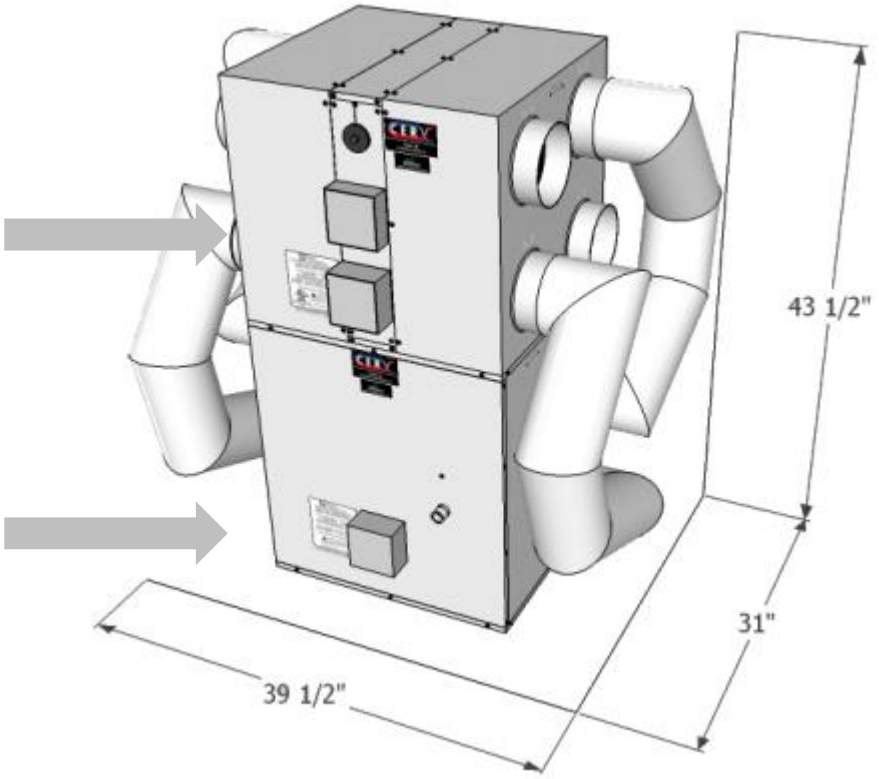


The CERV



Conditioning
Energy
Recovery
Ventilator

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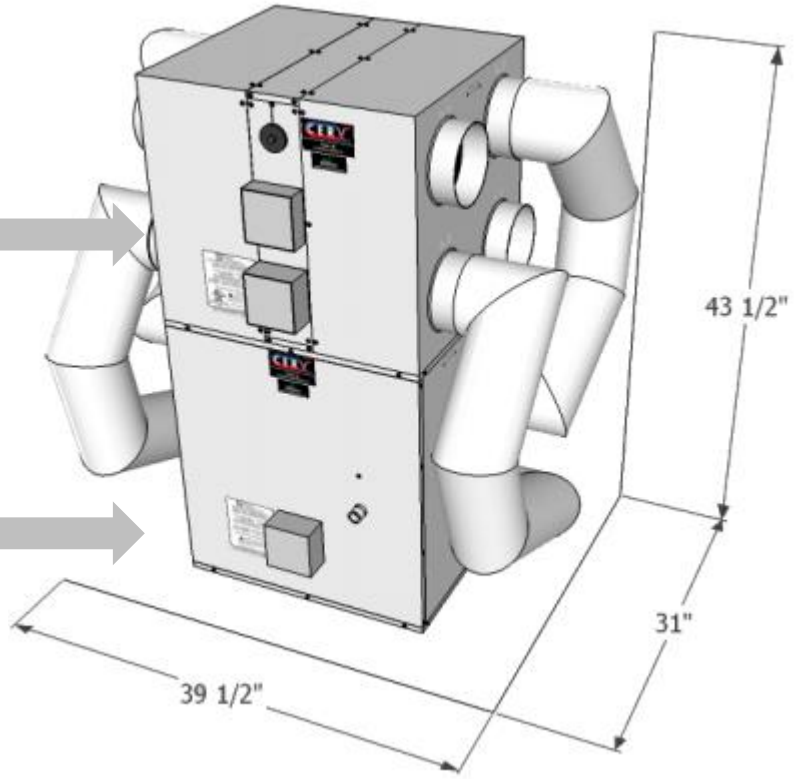
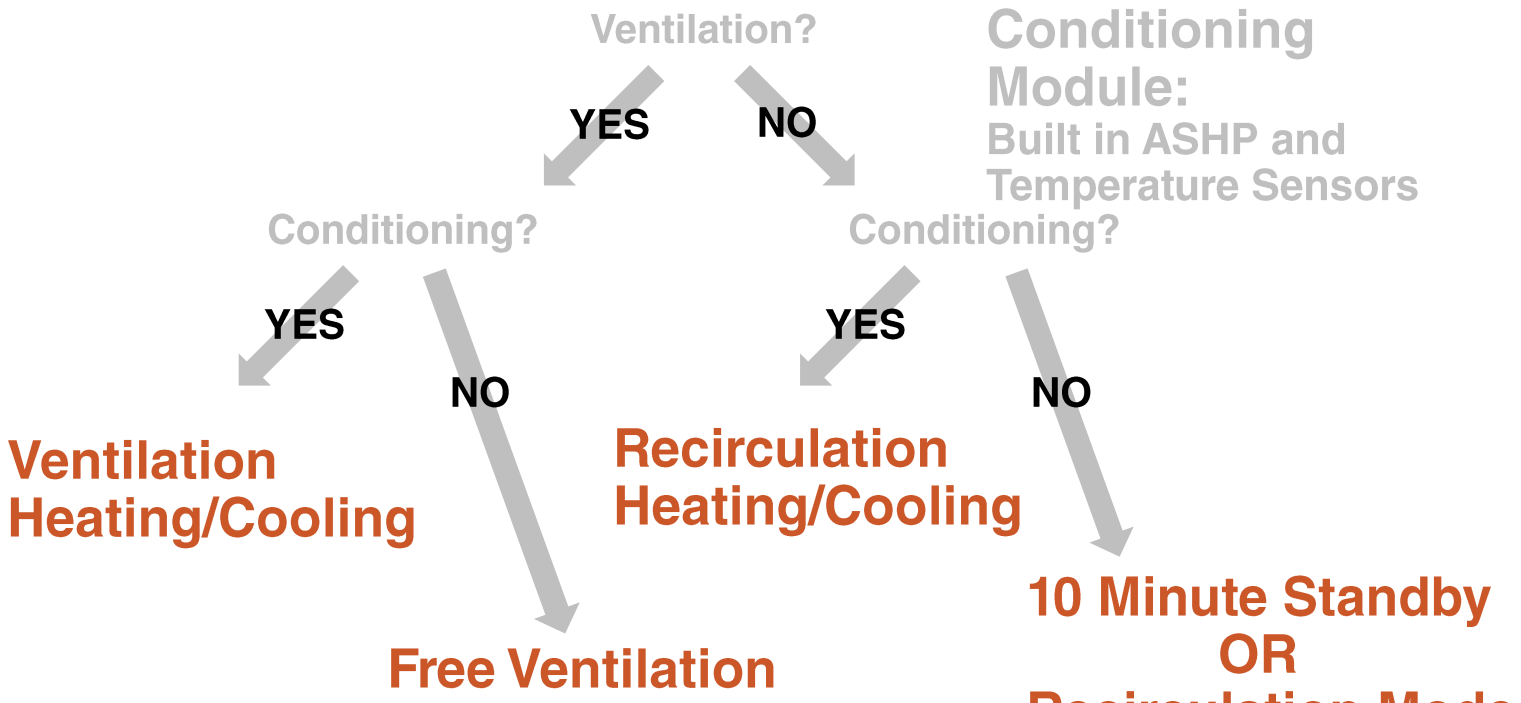




The CERV

Conditioning
Energy
Recovery
Ventilator

PROPOSED SPACE CONDITIONING

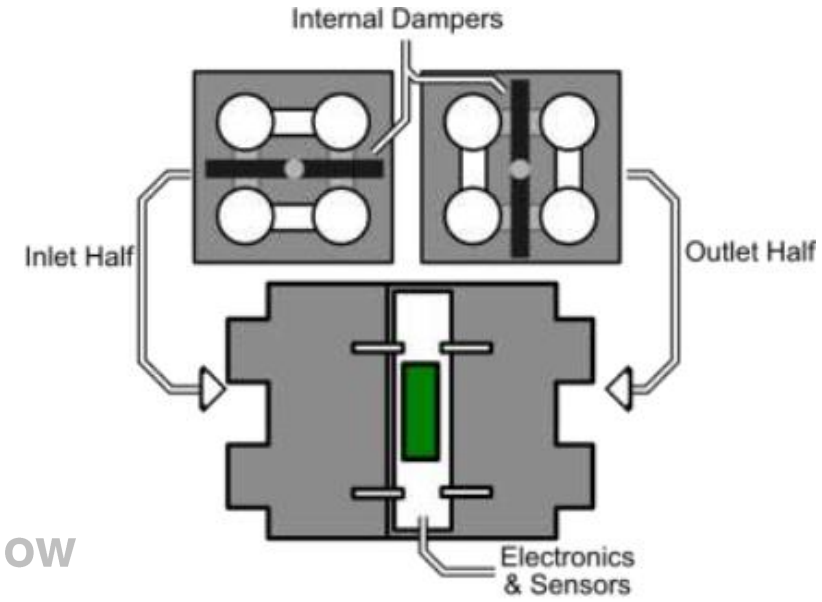
PROPOSE

- The CERV
- Inline Duct Heater
- Geothermal Heat Pump
- Natural Ventilation

Internal Dampers **Pivot**

Redirects Airflow

Fresh Air Control Module:



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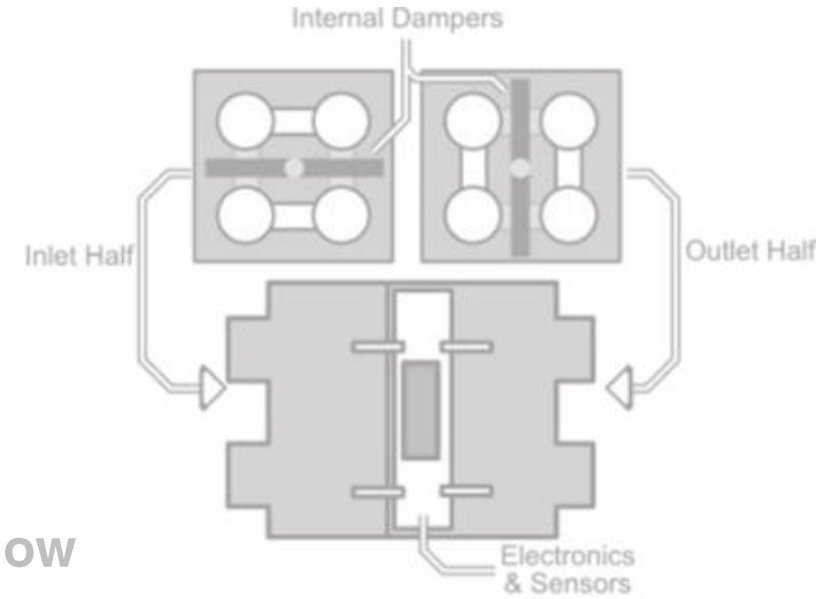
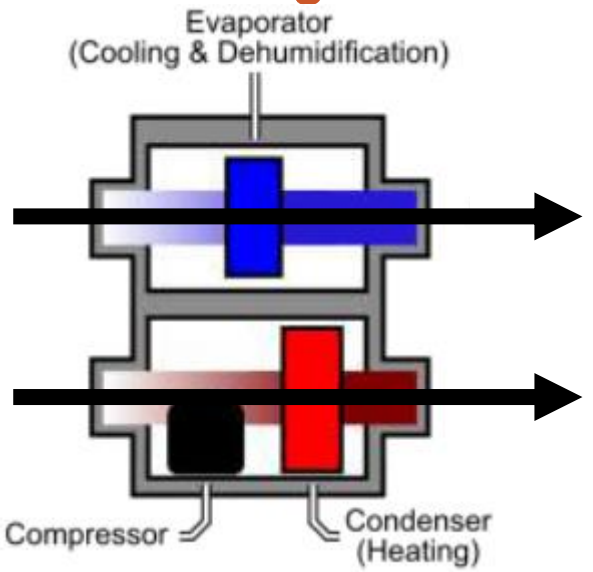


Conditioning Module:

Energy Removed

Energy Inputted

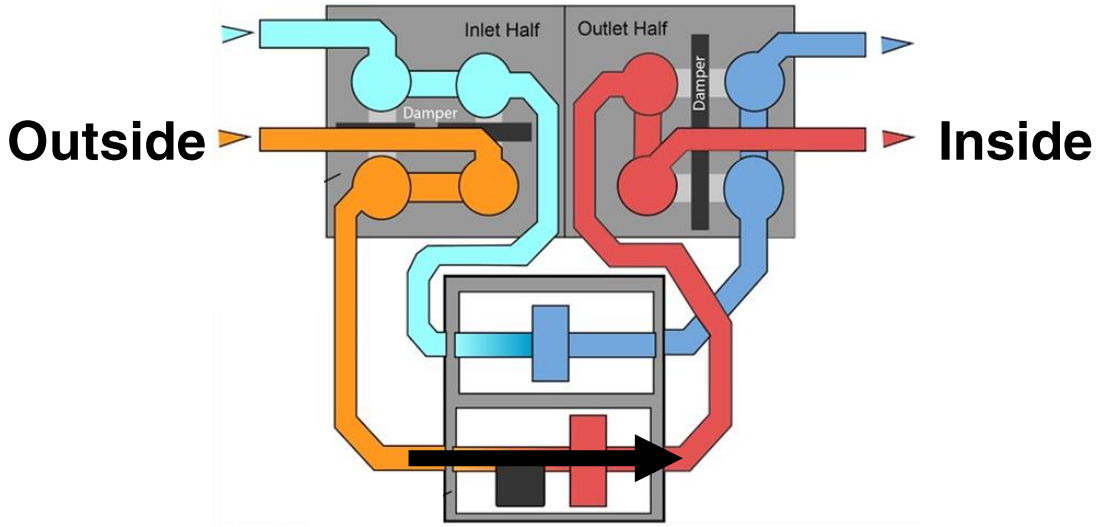


PROPOSED SPACE CONDITIONING

PROPOSE

- The CERV
- Inline Duct Heater
- Geothermal Heat Pump
- Natural Ventilation

Example: Ventilation Heating

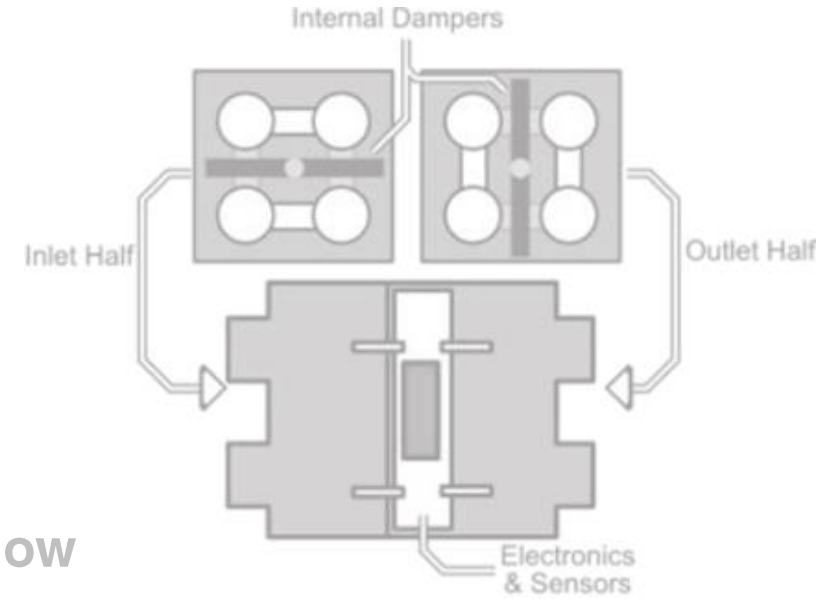


COP = 3.5 (w/out Fan)
COP = 2.7 (w/ Fan)

Internal Dampers **Pivot**

Redirects Airflow

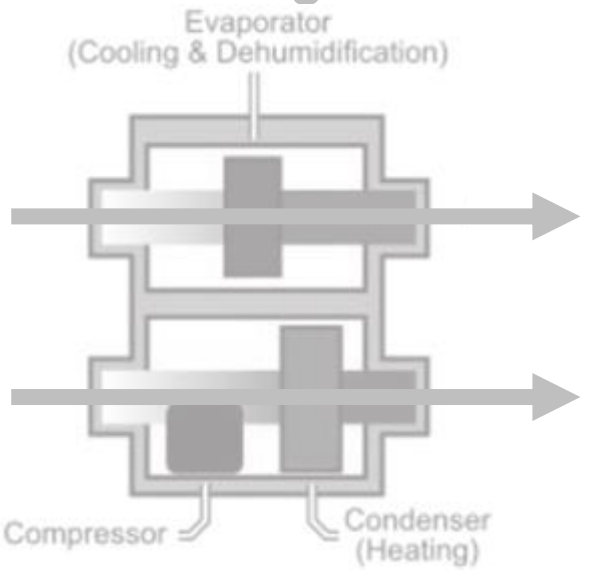
Fresh Air Control Module:



Conditioning Module:

Energy **Removed**

Energy **Inputted**

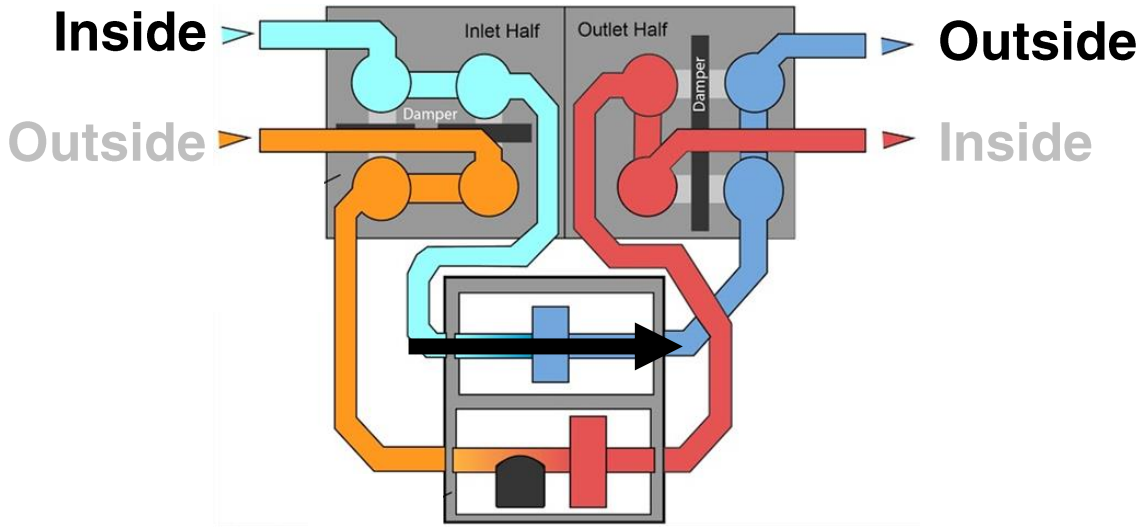


PROPOSED SPACE CONDITIONING

PROPOSE

- The CERV
- Inline Duct Heater
- Geothermal Heat Pump
- Natural Ventilation

Example: Ventilation Heating



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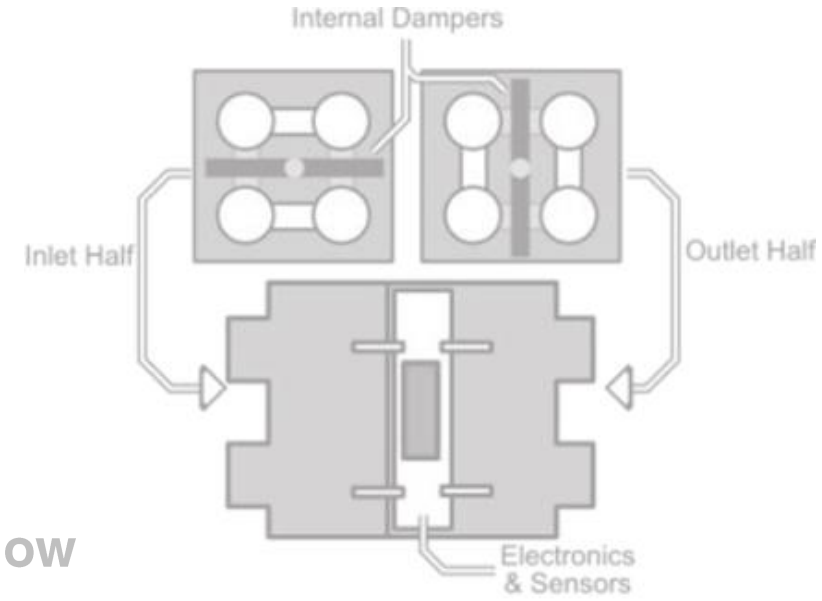
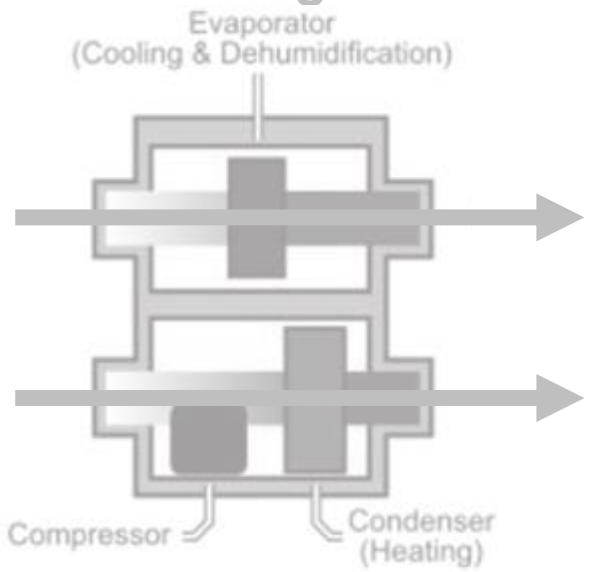


Conditioning Module:



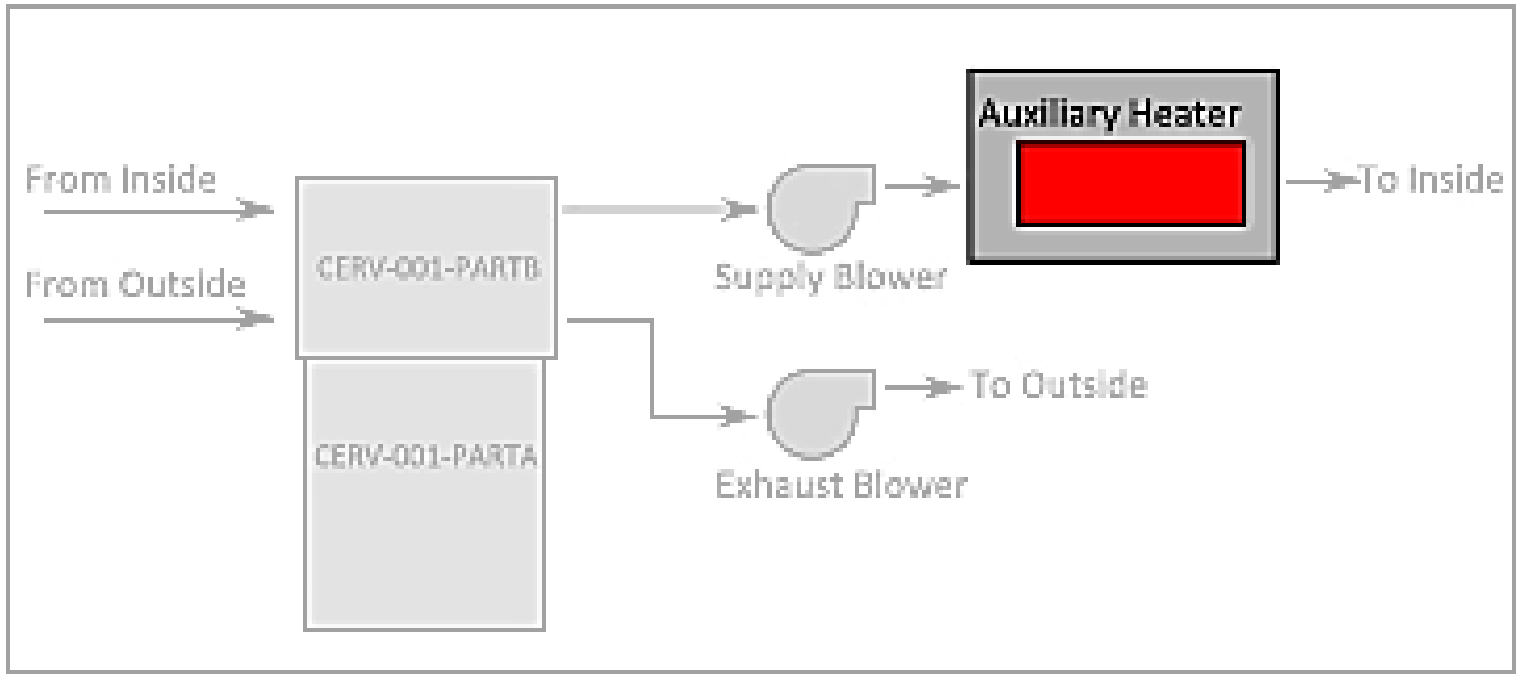
Energy **Removed**

Energy **Inputted**

PROPOSED SPACE CONDITIONING

PROPOSE

- The CERV
- Inline Duct Heater
- Geothermal Heat Pump
- Natural Ventilation



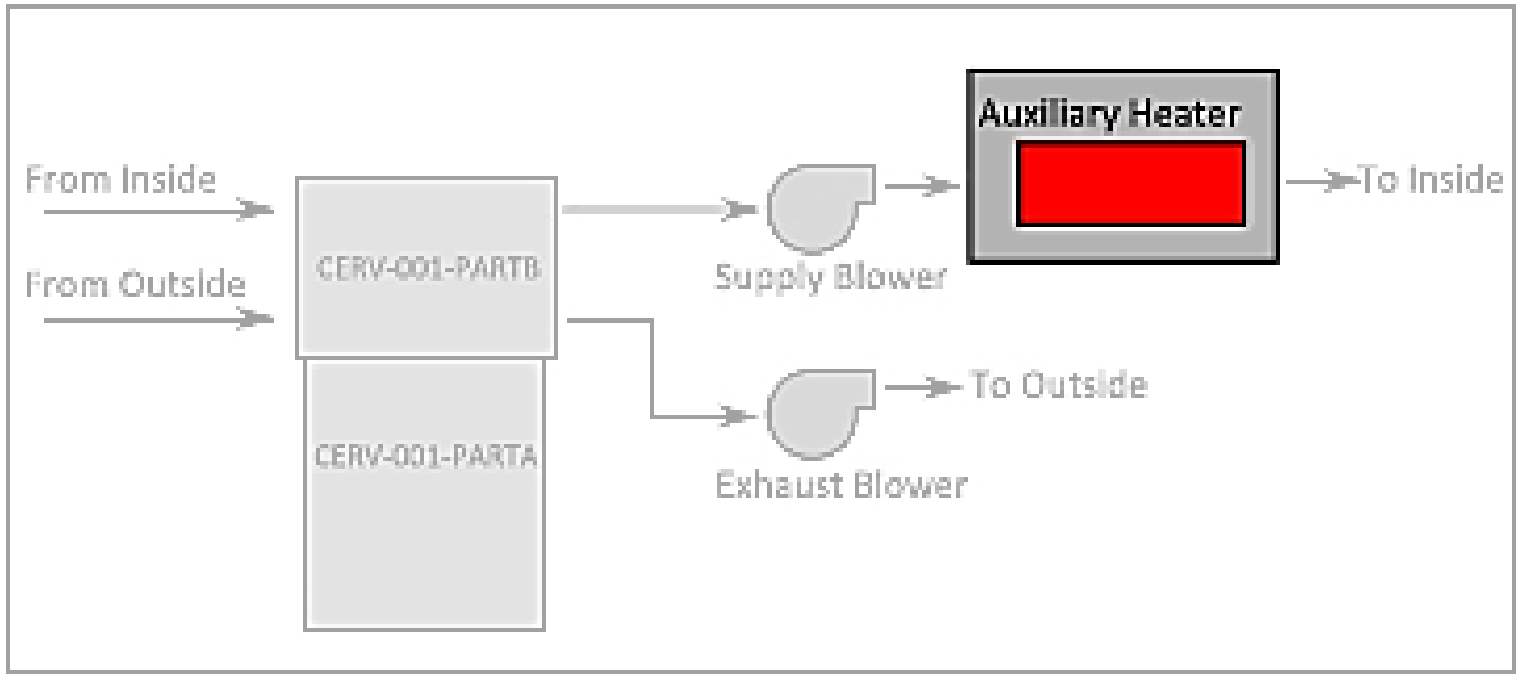
CERV Average Total Heating Capacity = 5.5 kBtu/hr

CERV w/Duct Heater Average Total Heating Capacity = 14 kBtu/hr

PROPOSED SPACE CONDITIONING

PROPOSE

- The CERV
- Inline Duct Heater
- Geothermal Heat Pump
- Natural Ventilation



CERV Average Total Heating Capacity = 5.5 kBtu/hr

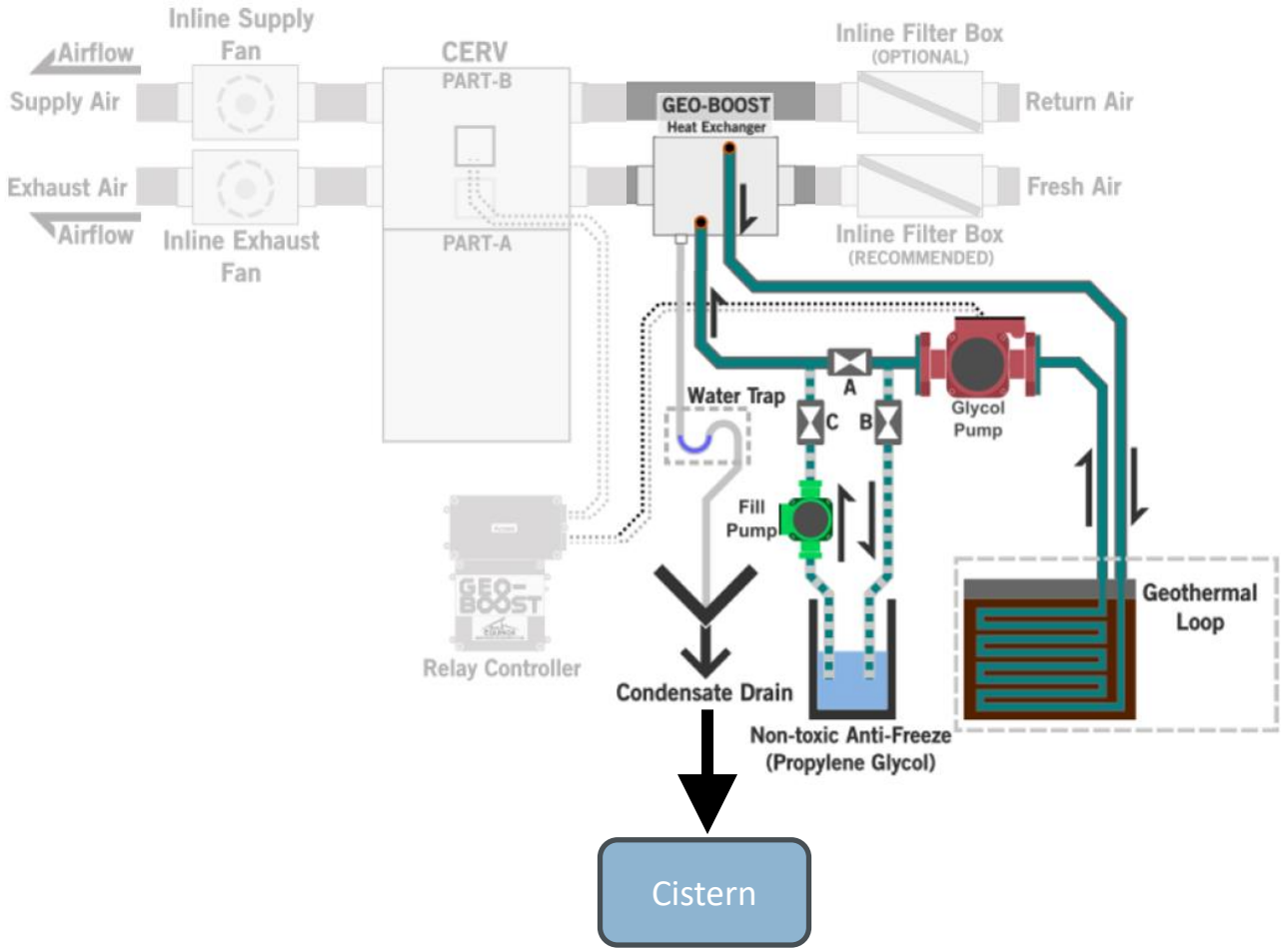
CERV w/Duct Heater Average Total Heating Capacity = 14 kBtu/hr

Design Heating Load = 8.4 kBtu/hr-unit → **Sufficient System**

PROPOSED SPACE CONDITIONING

PROPOSE

- The CERV
- Inline Duct Heater
- Geothermal Heat Pump
- Natural Ventilation



PROPOSED SPACE CONDITIONING

PROPOSE

- The CERV
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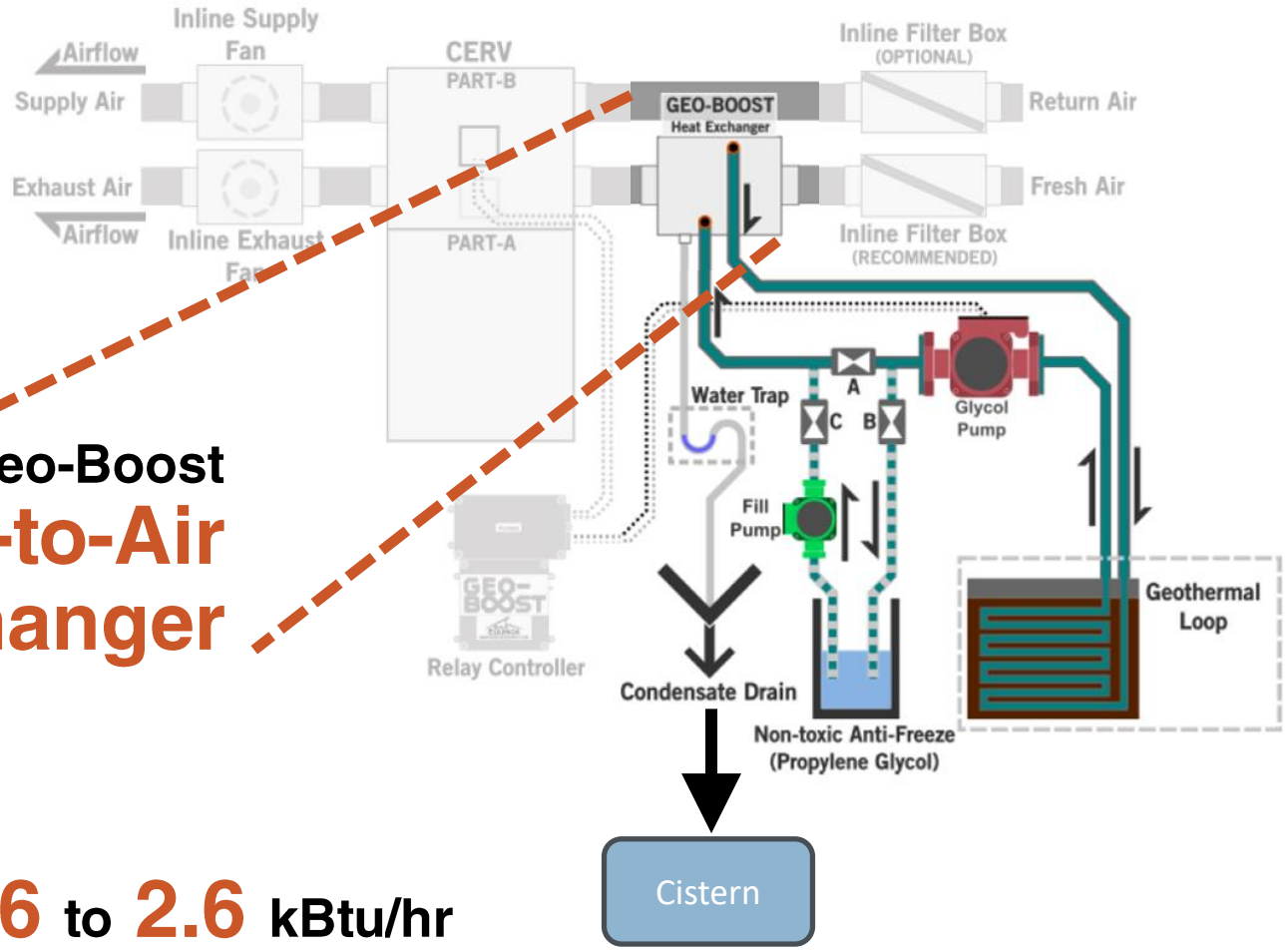
- Geothermal Heat Pump
- Natural Ventilation

Geo-Boost

Liquid-to-Air Heat Exchanger



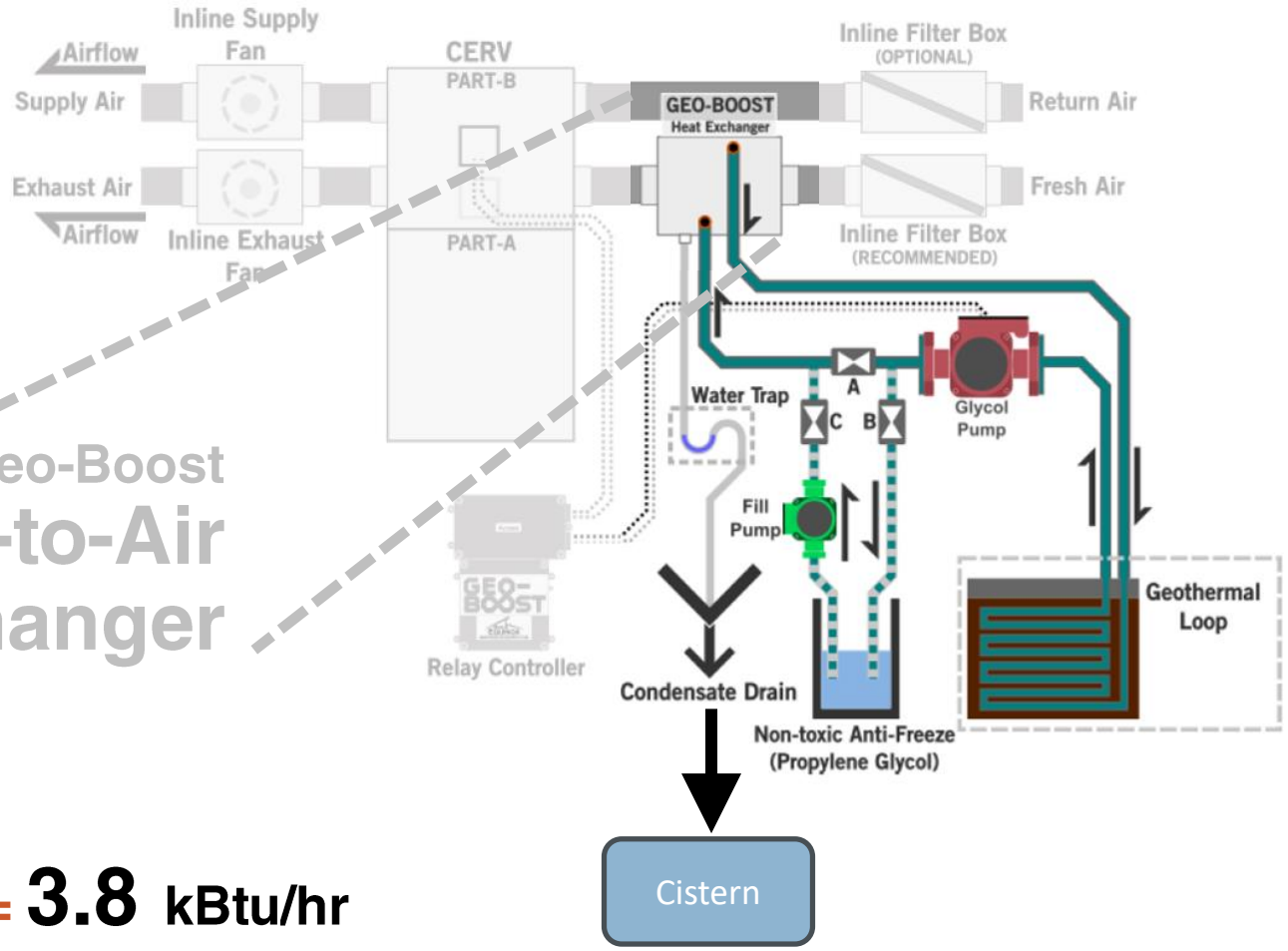
Capacity to ADD or REMOVE 1.6 to 2.6 kBtu/hr depending on ground conditions

PROPOSED SPACE CONDITIONING

PROPOSE

- The CERV
- Inline Duct Heater
- Geothermal Heat Pump
- Natural Ventilation

Geo-Boost
Liquid-to-Air
Heat Exchanger



CERV Average Total Cooling Capacity = 3.8 kBtu/hr

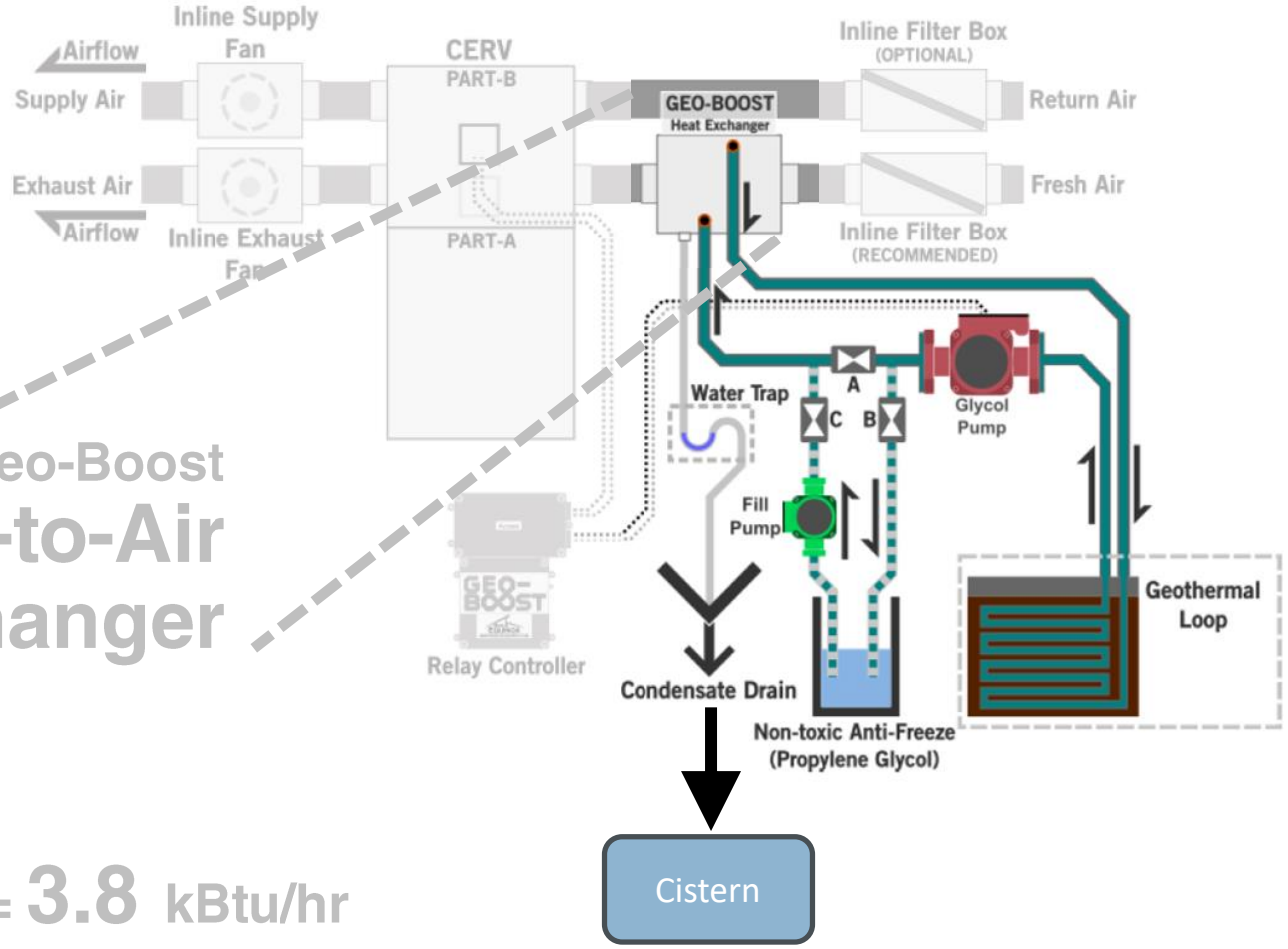
CERV w/Geo-Boost Total Cooling Capacity = 5.4 to 6.2 kBtu/hr

PROPOSED SPACE CONDITIONING

PROPOSE

- The CERV
- Inline Duct Heater
- Geothermal Heat Pump
- Natural Ventilation

Geo-Boost
Liquid-to-Air
Heat Exchanger



CERV Average Total Cooling Capacity = 3.8 kBtu/hr

CERV w/Geo-Boost Total Cooling Capacity = 5.4 to 6.2 kBtu/hr

Design Cooling Load = 6.2 kBtu/hr-unit → **Sufficient System**

PROPOSED SPACE CONDITIONING

PROPOSE

- The CERV
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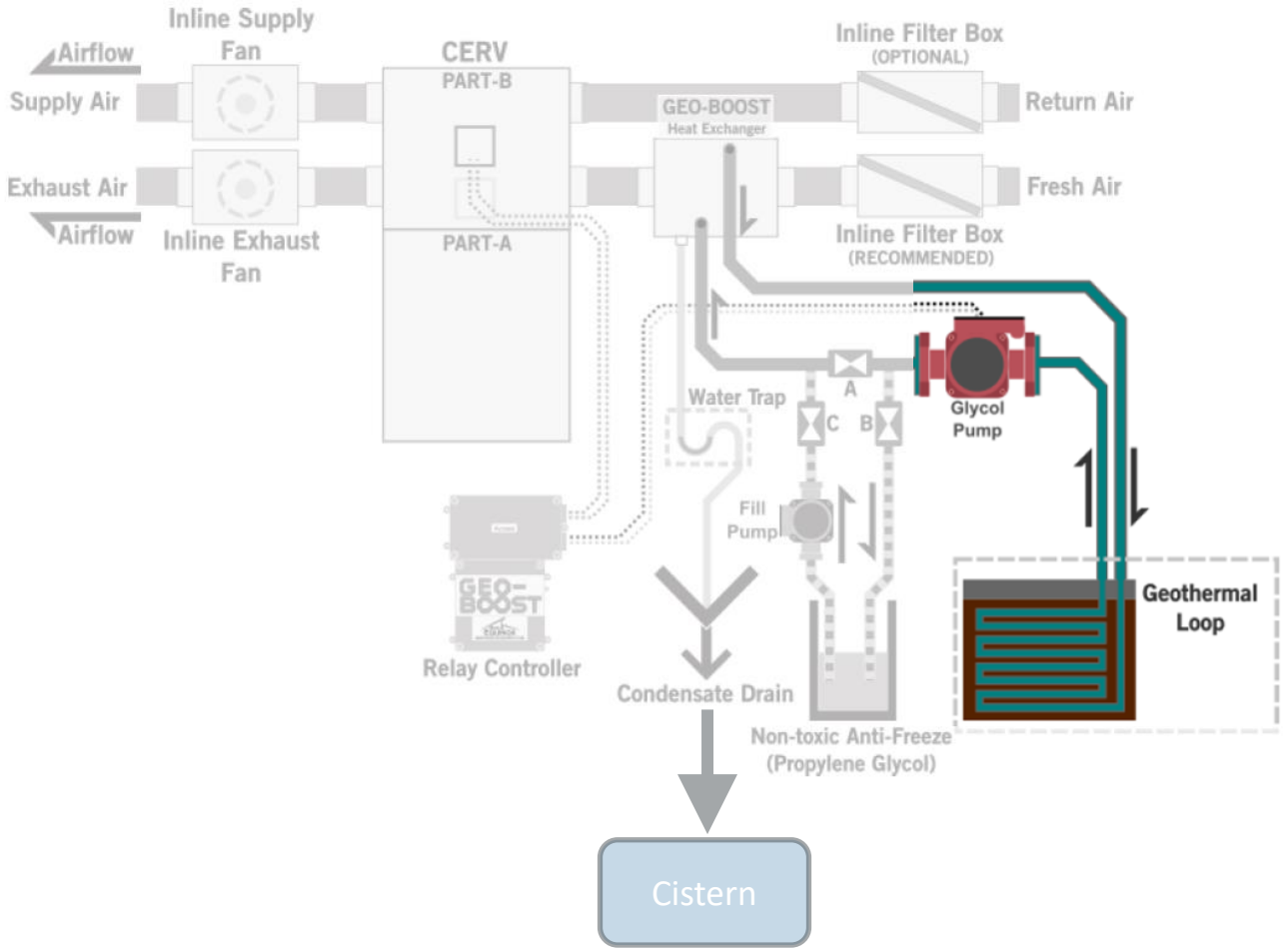


Vertical wells: Closed-geothermal loops

300’ of ½” PEX per main loop = 2400’ PEX
1:1 mix of propylene glycol and water

PROPOSED SPACE CONDITIONING

PROPOSE

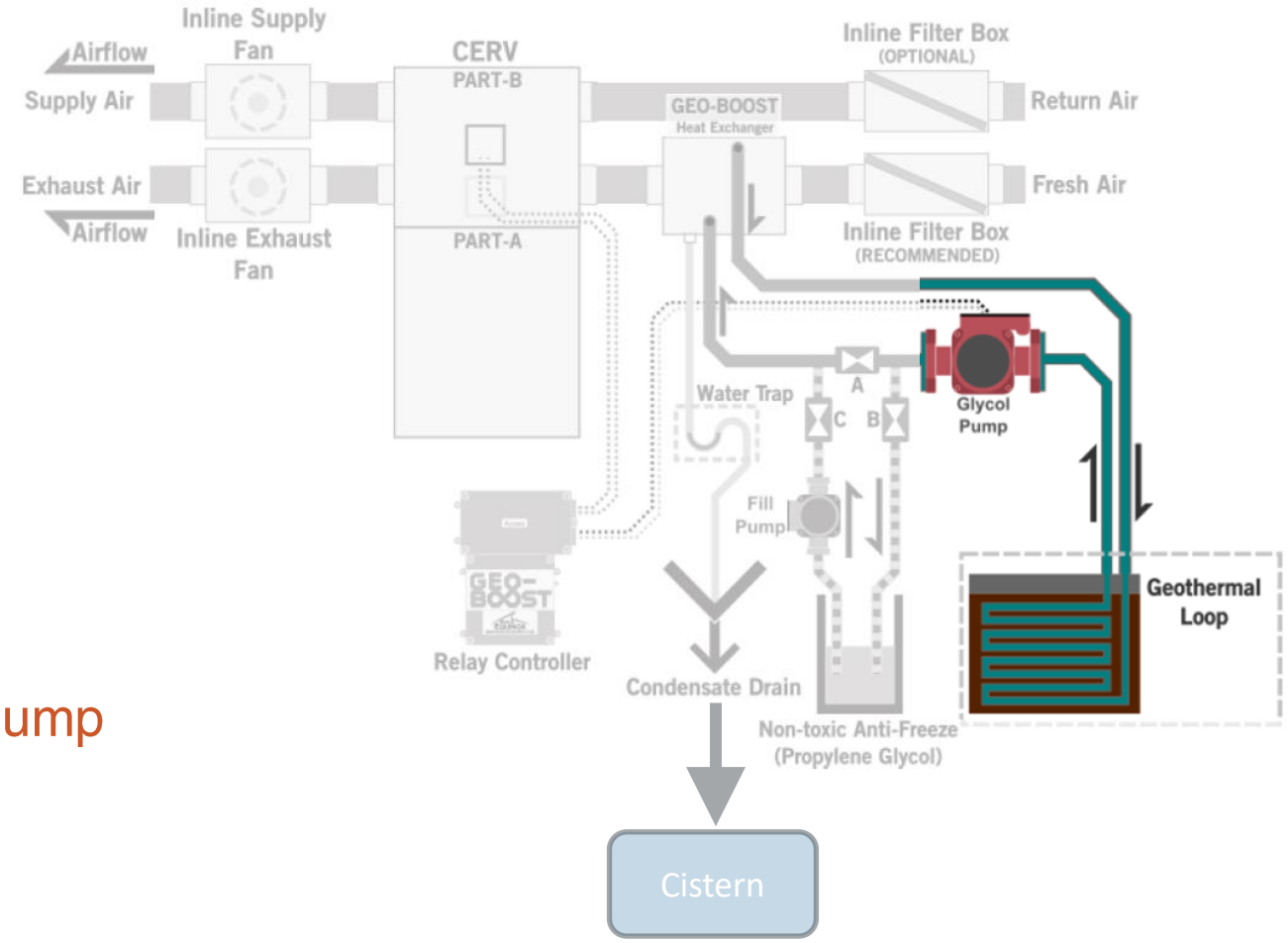
- The CERV
- Inline Duct Heater
- Geothermal Heat Pump
- Natural Ventilation

Vertical wells: Closed-geothermal loops

300’ of ½” PEX per main loop = 2400’ PEX
1:1 mix of propylene glycol and water

Stiebel Eltron CP3S15-62FC circulation pump

340 Btu/hr Pump
1 – 2 gpm flowrate



PROPOSED SPACE CONDITIONING

PROPOSE

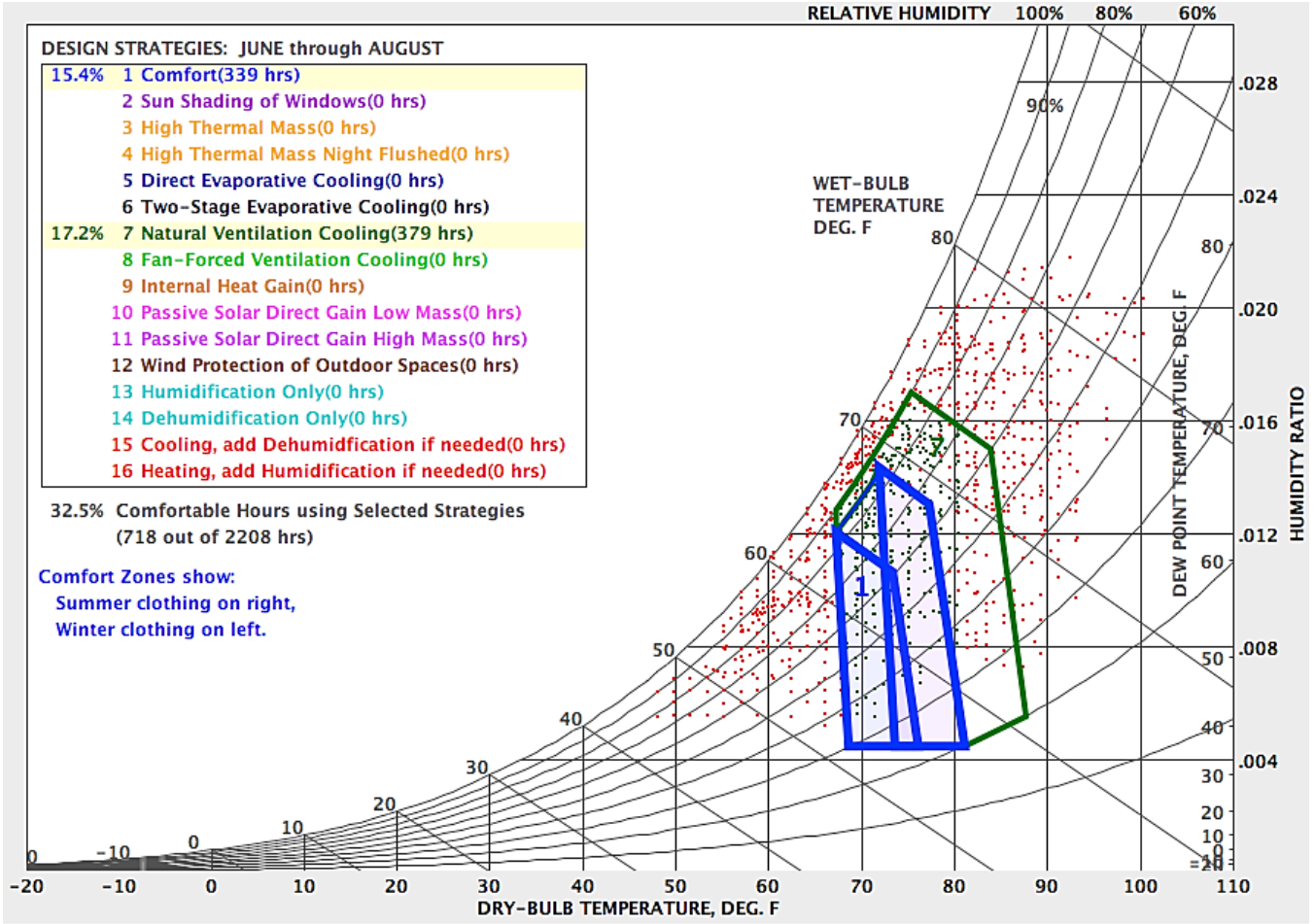
- The CERV
- Inline Duct Heater
- Geothermal Heat Pump
- Natural Ventilation

June to August:

Occupant Comfort

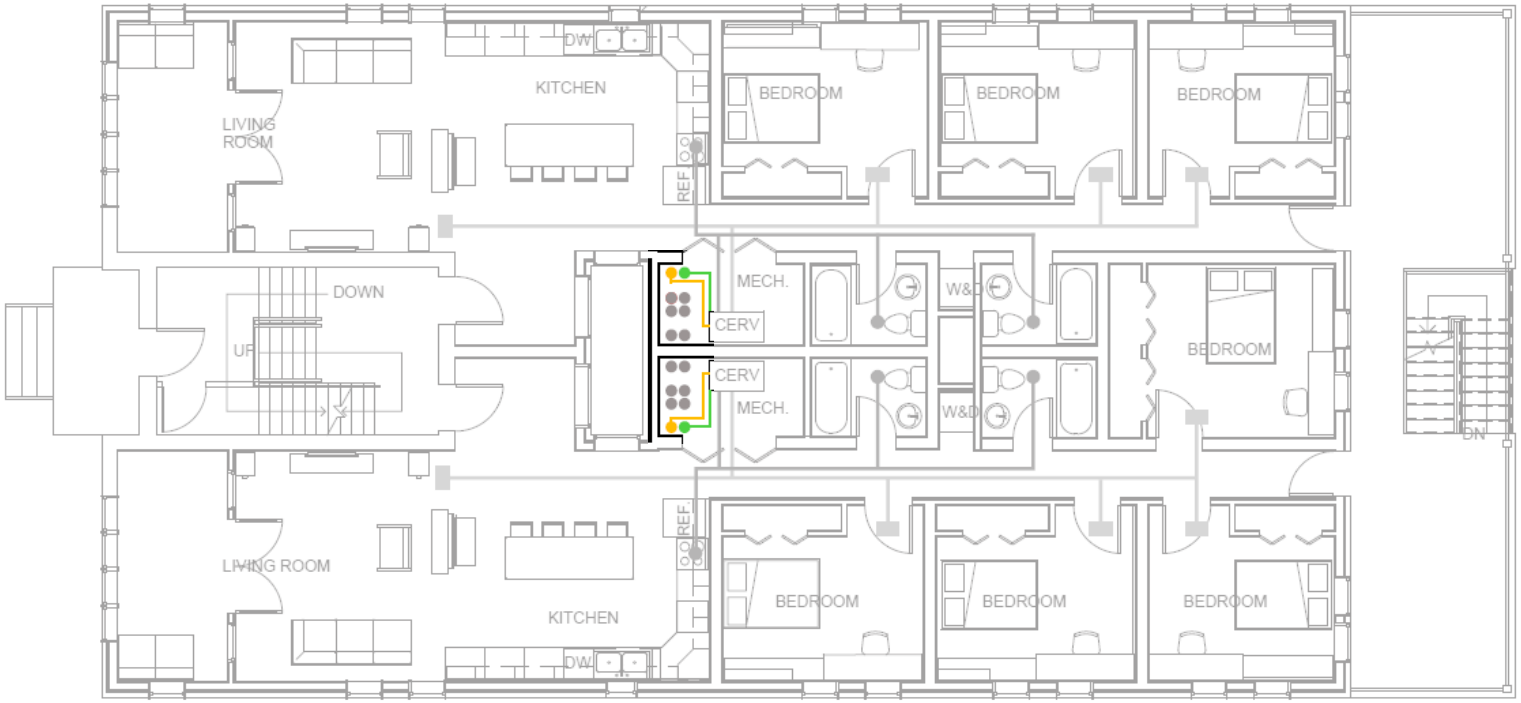
Achieved **17.2%**

with Natural Ventilation Alone



Climate Consultant 5.5 Output for Champaign-Willard Airport

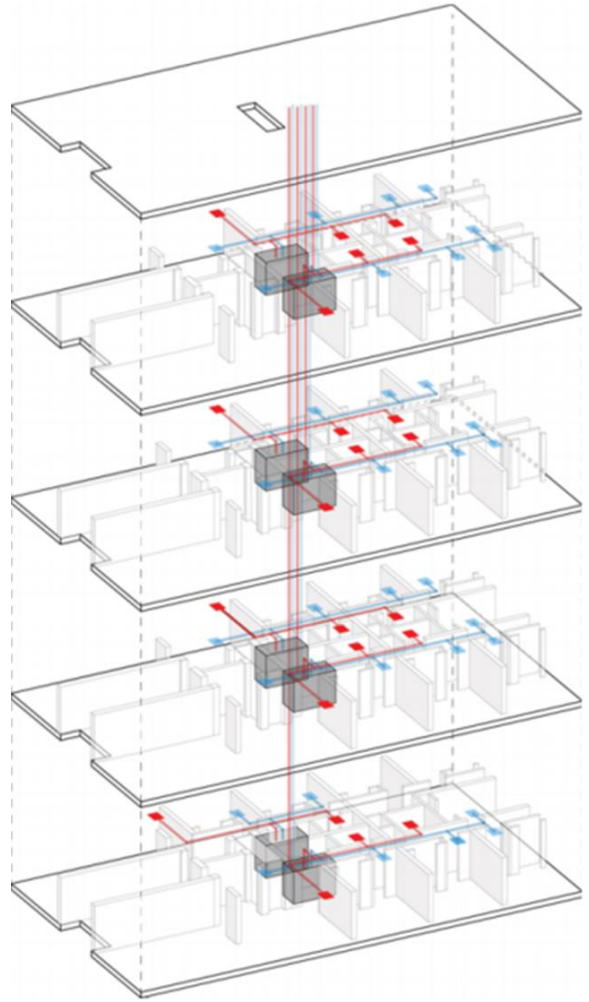
HVAC SYSTEMS LAYOUT



LEGEND

- Exhaust Air
- Fresh Air
- Supply Air
- Return Air

Typical Upper Floor Plan



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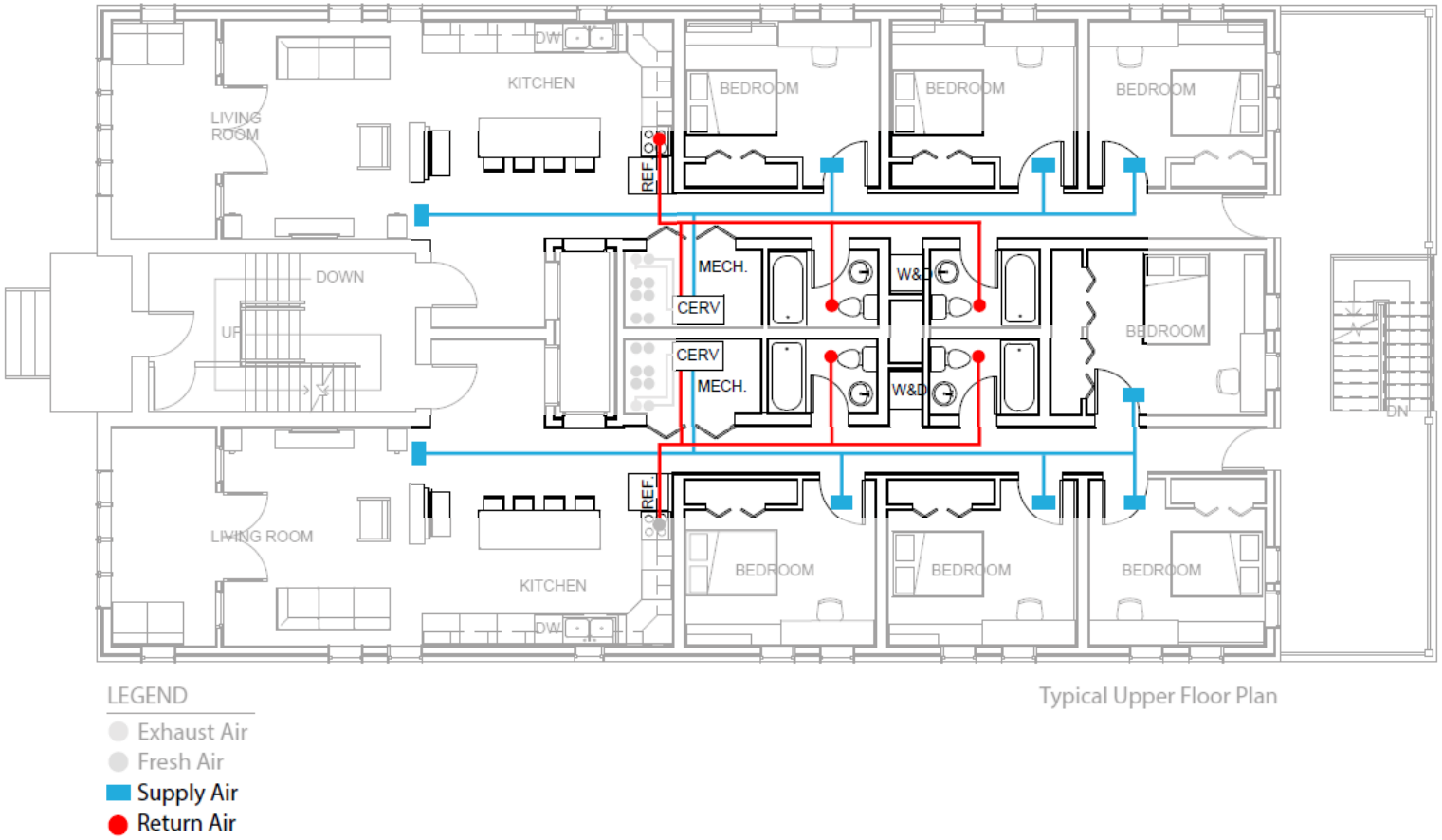
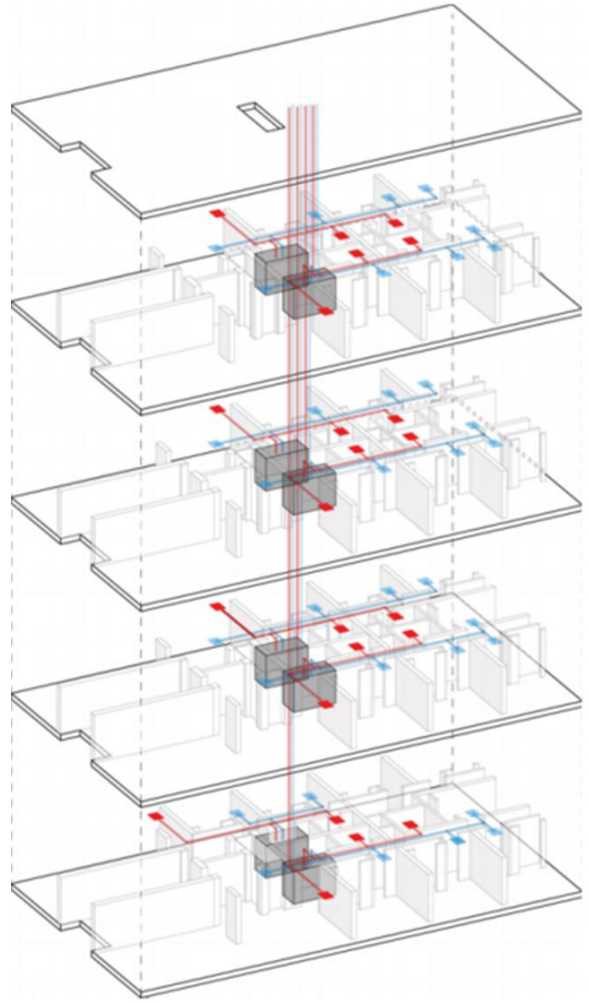


Typical Upper Floor Plan



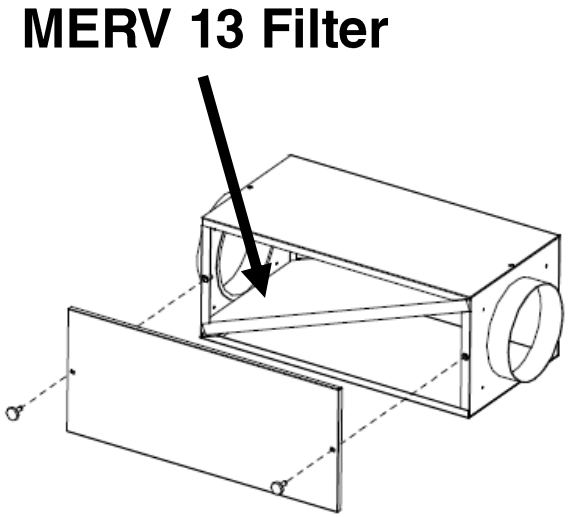
PROPOSED VENTILATION

ASHRAE 62.2 - 2013

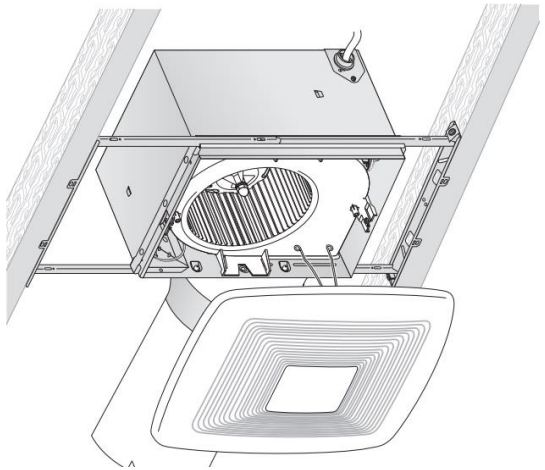
Ventilation Requirements

2 Bed	3 Bed	4 Bed
50 cfm	68 cfm	81 cfm

EPA Indoor airPLUS QUALIFIED HOMES



Inline Filter Box



Broan XB110 Vent Fan

PROPOSED VENTILATION

ASHRAE 62.2 - 2013

Ventilation Requirements

2 Bed	3 Bed	4 Bed
50 cfm	68 cfm	81 cfm

Proposed Ventilation

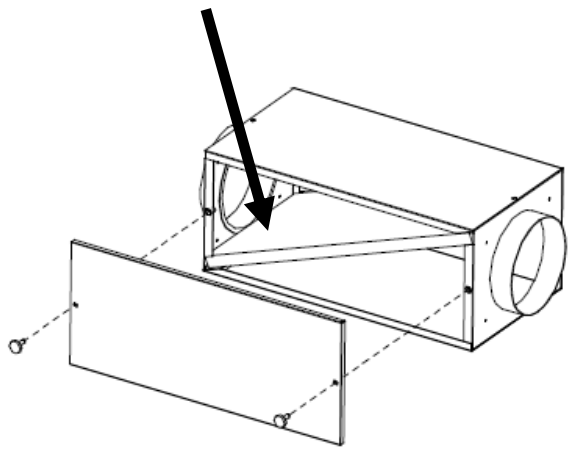
2 Bed	3 Bed	4 Bed
110 cfm	140 cfm	170 cfm

Supply

Bedroom: **30 cfm**
Living Area: **50 cfm**

Exhaust

Kitchen: **100 cfm**
Mech. Room: **10 cfm**
Laundry Room: **10 cfm**
Bathroom: **25 cfm**



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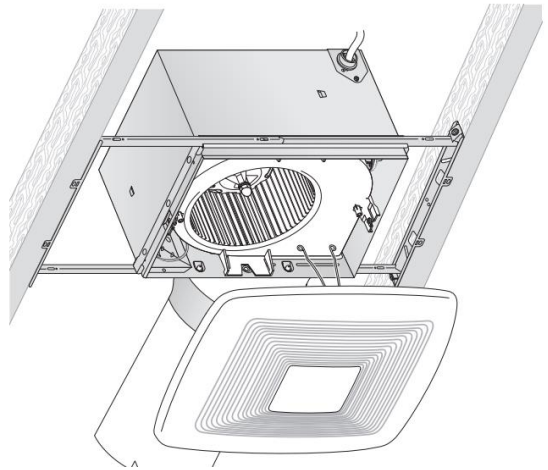


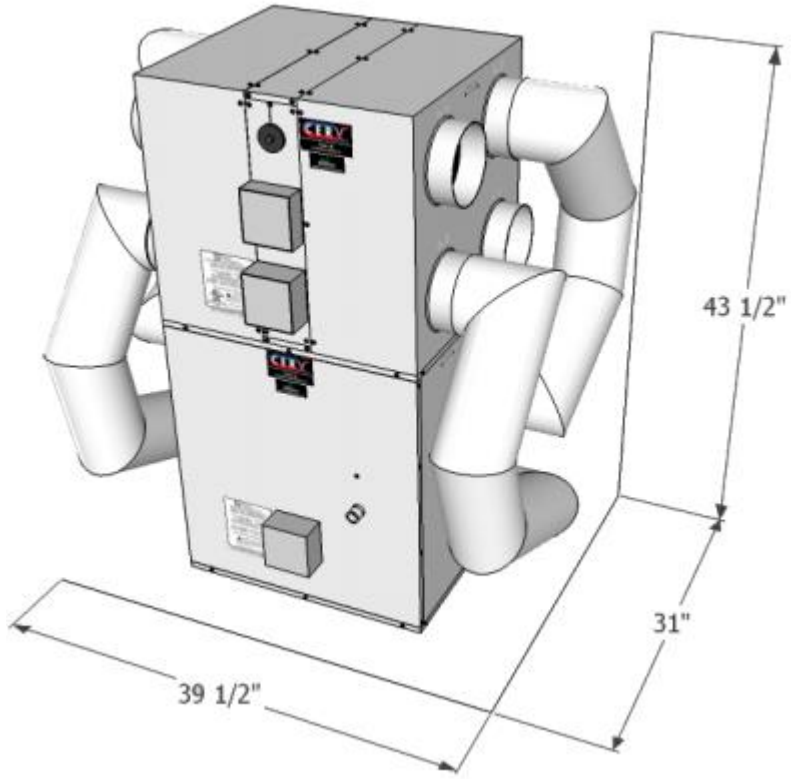
Broan XB110 Vent Fan

PROPOSED SPACE CONDITIONING

CONCLUSION

		Installed Cost
The CERV	CERV (w/FV20)	$4,500
	Geo-Boost	$750
	Insulated Filter Box	$190
	Duct Heater	$570
	Stiebel Eltron Pump	$245
	Total	$6,255
Mini-Split w/HRV	Typical Mini-Split	$3,000 - $5,000[4]
	Typical HRV	$4,000 - $5,000[5]
	Total	$7,000 - $10,000
Radiant System w/HRV	4 Bedroom (1510 sf)	$13,060 - $14,060
	3 Bedroom (1346 sf)	$12,076 – $13,076
	2 Bedroom (889 sf)	$9,334 - $10,334

The CERV



Conditioning
Energy
Recovery
Ventilator

LIGHTING AND APPLIANCES

EVALUATE AND ADDRESS

- Non Energy Star appliances
- Natural gas stoves
- Shared washer/dryer
- Mainly incandescent lighting
- No motion detectors for lights
- Lighting levels don't comply with IECC 2012 and IECC 2015

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LIGHTING AND APPLIANCES

PROPOSE

- Energy Star appliances
- Energy efficiency and performance
- Enhanced Safety

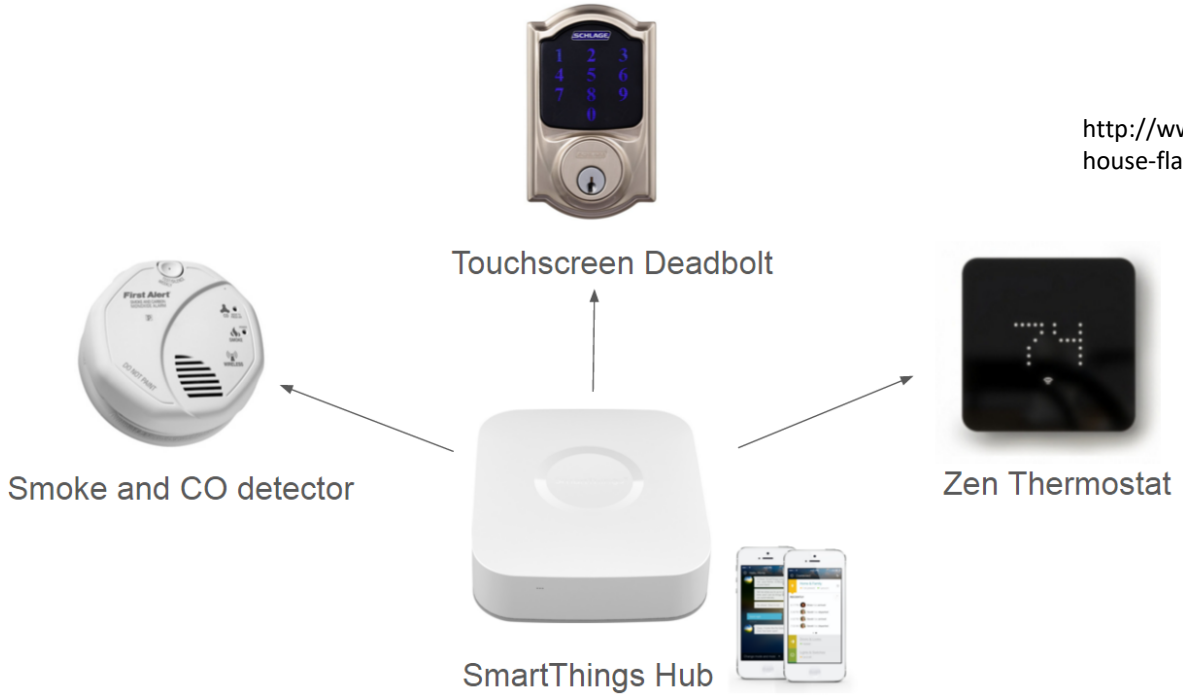
ENERGY STAR HOMES

HOME AUTOMATION

PROPOSE

- LINKoln App
- Sensor, light, and lock control
- Automate lighting
- Simple Set-up
- Smartphone app with SmartThings

http://www.dreamstime.com/stock-photography-smart-house-flat-illustration-concept-image38055952



EXISTING WATER EQUIPMENT

EVALUATE AND ADDRESS

- 65 and 75 Gallon Natural Gas Water Heaters
- Hot water supplied at 100 – 120 °F
- Piping which is not insulated
- Residual heat loss in pipes
- Non WaterSense fixtures
- Resident Dissatisfaction

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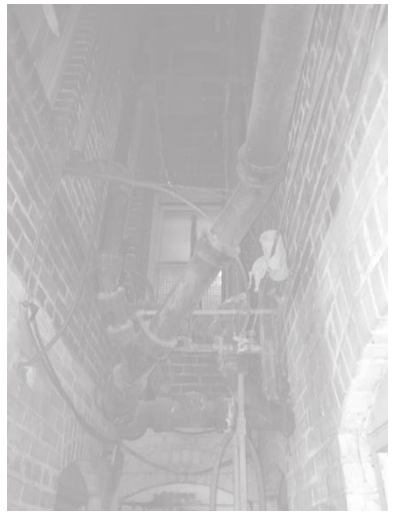

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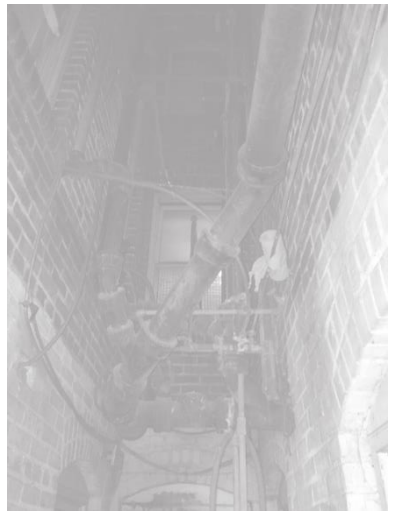
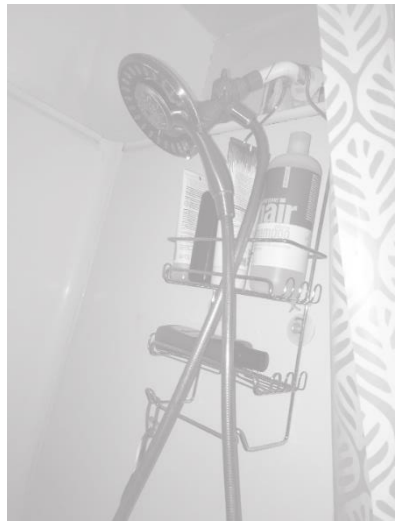





DOMESTIC HOT WATER

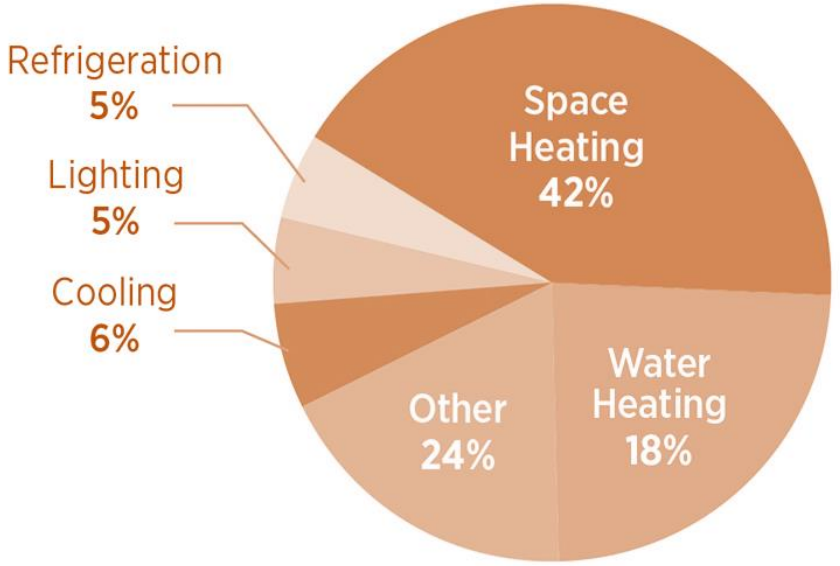
Demand-Initiated Recirculation System

Save Energy

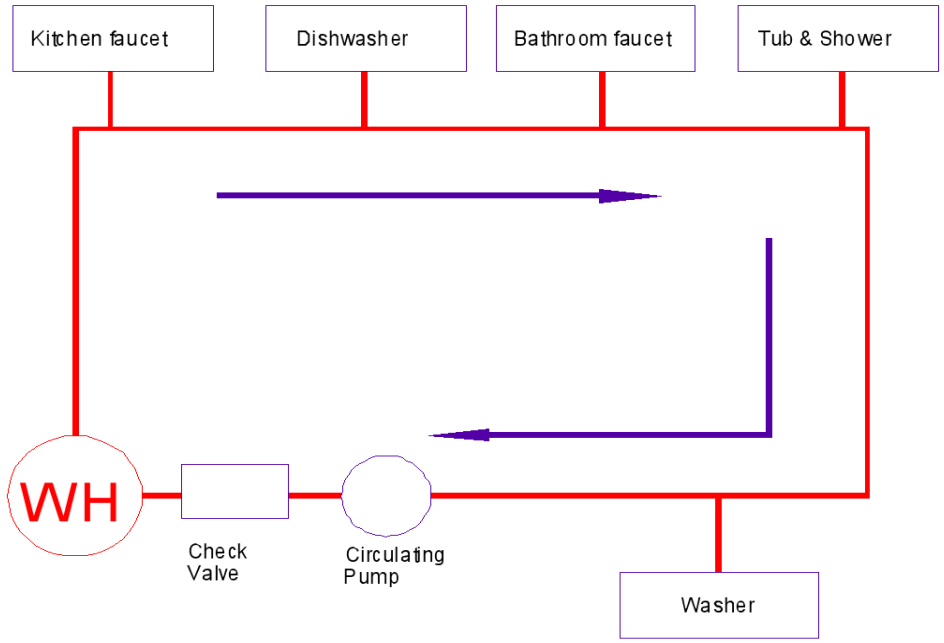
- Minimal required reheating energy
  - Return warmer water to the water heater
- High distribution flow rate
  - Reduce heat loss during distribution
  - Require less hot water for recirculation

Save Water

- Fast hot water delivery to fixtures
  - Reduce hot water wait time
- Less ambient-temperature water waste



http://energy.gov/energysaver/tips-your-homes-energy-use



DOMESTIC HOT WATER

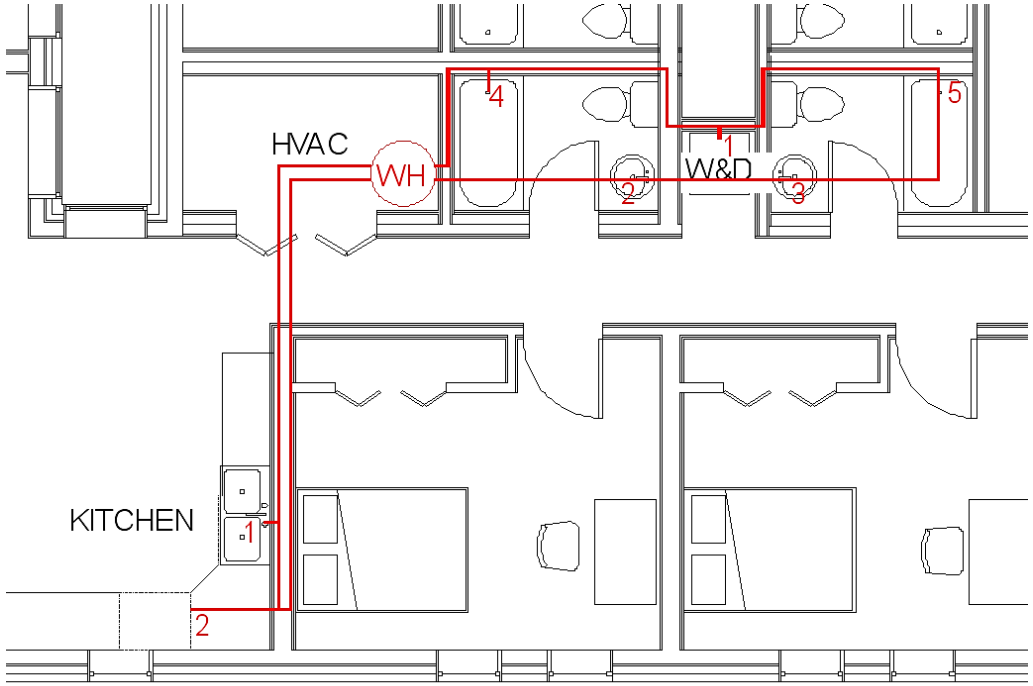
GeoSpring™ Hybrid Electric Water Heater

- Capacity: 50-gallon
- Energy Factor: 3.25>2.0
- Annual Saving: $370-$490
- Four operating modes
  - Heat Pump
  - Electric
  - Hybrid
  - High Demand

Tank Capacity	Tank Diameter	Tank Height	Energy Factor	Fuel Type	First Hour Delivery
50 gal.	21.75 in.	59.5 in.	3.25	Electric	67 gal.

http://www.geappliances.com/ge/heat-pump-hot-water-heater.htm

DOMESTIC HOT WATER



Hot Water Delivery System Layout

- Pipe storage limit : 0.5 gallons
- ASPE performance: 10s hot water waiting time

Fixtures	Pipe Segment	Pipe Diameter (in)	Water Capacity (oz/ft)	Pipe Length (ft)	Water Volume (gal)
Washer	Drop from Loop	1/2	1.89	10	0.15
	1	1/2	1.89	1	0.01
				Total Water Volume (gal)	0.16
				Hot Water Wait Time (sec)	4.42
Bath 1 Sink	Drop from Loop	1/2	1.89	10	0.15
	2	1/2	1.89	1	0.01
				Total Water Volume (gal)	0.16
				Hot Water Wait Time (sec)	6.49
Bath 2 Sink	Drop from Loop	1/2	1.89	10	0.15
	3	1/2	1.89	1	0.01
				Total Water Volume (gal)	0.16
				Hot Water Wait Time (sec)	6.49
Bath 1 Tub	Drop from Loop	1/2	1.89	10	0.15
	4	1/2	1.89	1	0.01
				Total Water Volume (gal)	0.16
				Hot Water Wait Time (sec)	6.49
Bath 2 Tub	Drop from Loop	1/2	1.89	10	0.15
	5	1/2	1.89	1	0.01
				Total Water Volume (gal)	0.16
				Hot Water Wait Time (sec)	6.49

RAINWATER COLLECTION

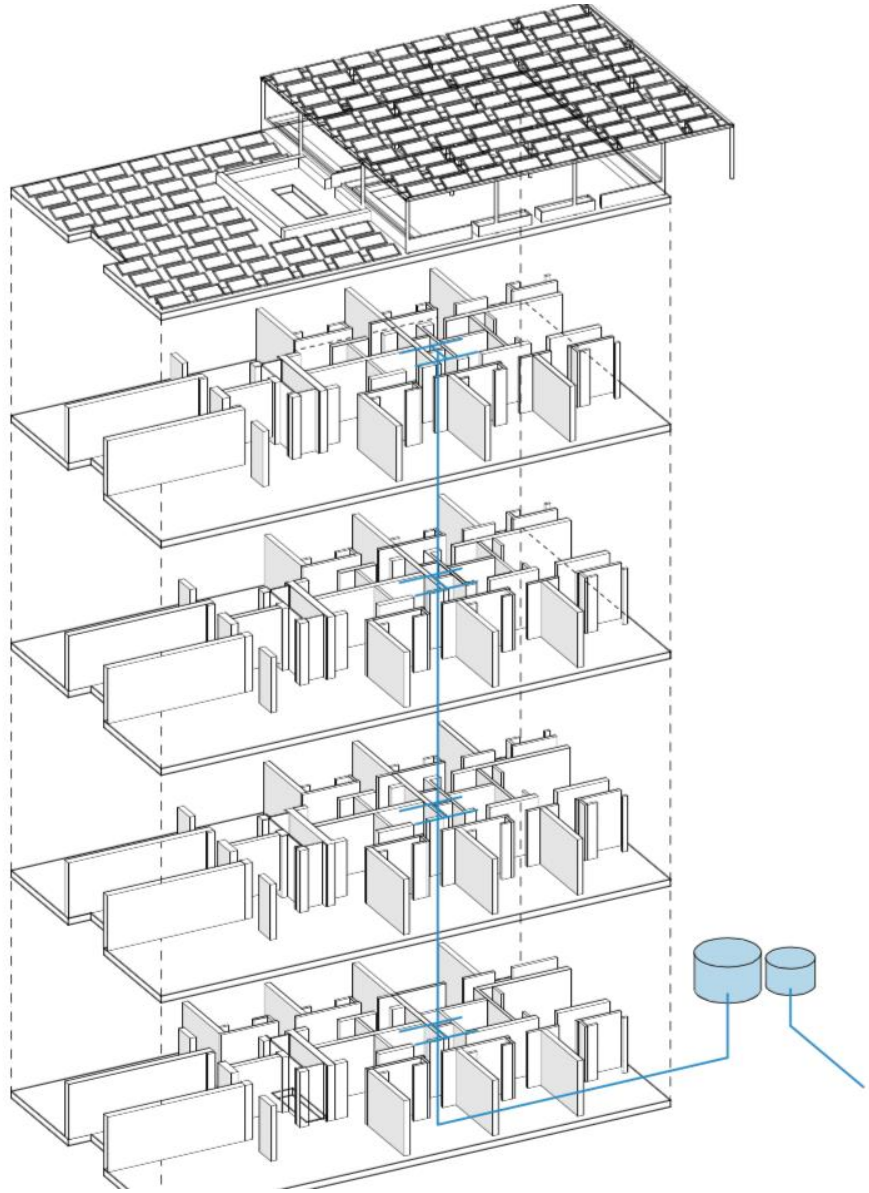
Monthly Average Precipitation
- around 3.43”

Estimated Water Usage
- Toilet: 4872 gal/month
- Irrigation: 969 gal/month

Rainwater Collection: Roof & Ground
- Used for flushing (Roof 3500 ft2)
- Used for irrigation (Ground 13298 ft2)

3 Cisterns are located outside

Rainwater collection	Highest gal/month		Lowest gal/month		Average gal/month	
	Roof	Parking	Roof	Parking	Roof	Parking
	10647.3	40453.6	4472.7	16993.8	7483.6	28433.5
Reuse	Flushing gal/month		Irrigation gal/month			
	4972		969			

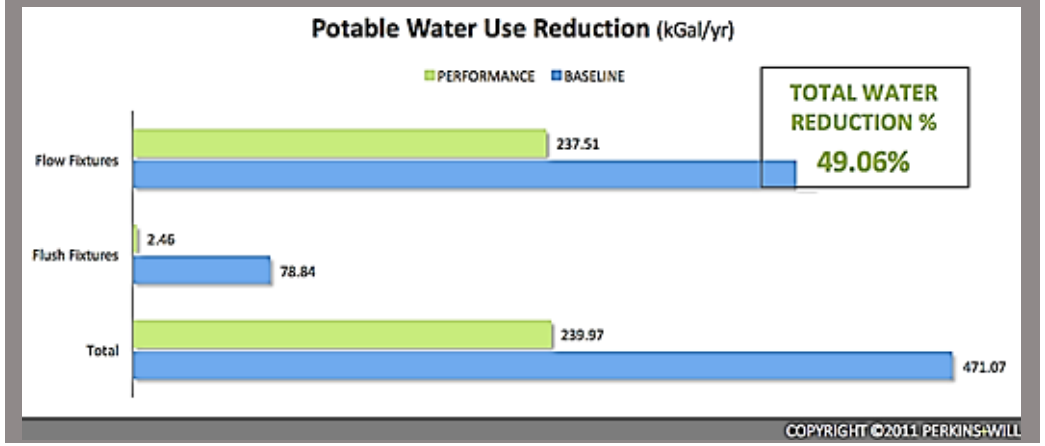


WATER SAVING

Fixtures	Manufacturer	Model#	Price	Other Information
Kitchen Faucet	Delta	B2310	$85.35	1.80 gpm @ 60 psi
Bath Faucet	Delta	21C154	$102.80	0.50 gpm
Tub & Shower	Delta	T13420-SO S-H2OT	$126.80	1.50 gpm @ 80 psi
Toilet	Nepon	Foam-Flush Toilet		3-ounce

- Energy Star Product
- Reasonable Price

Compared with fixtures of IPC/UPC (CODE), our building can save **49%** potable water usage.



PHOTOVOLTAIC SYSTEM

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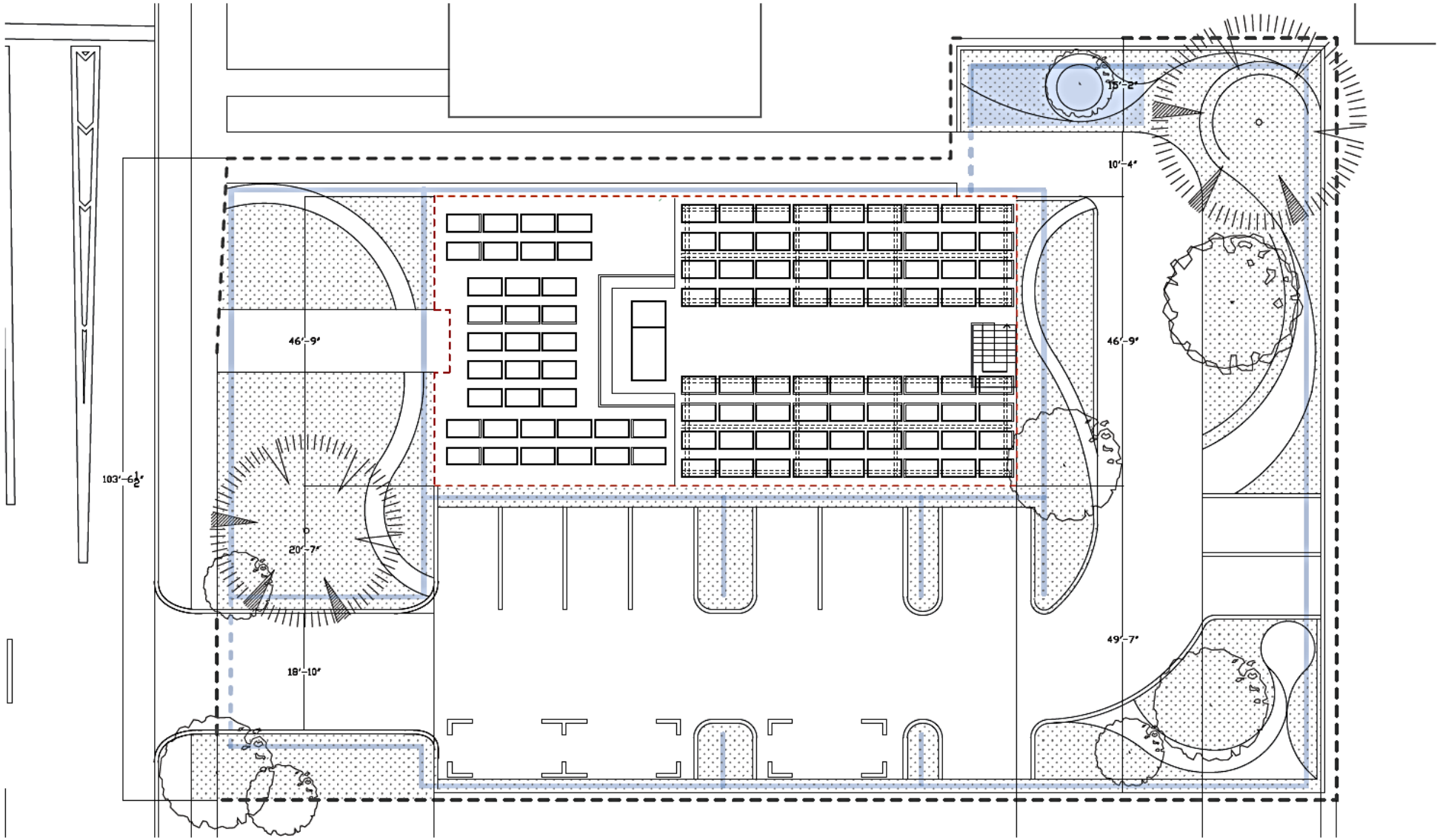
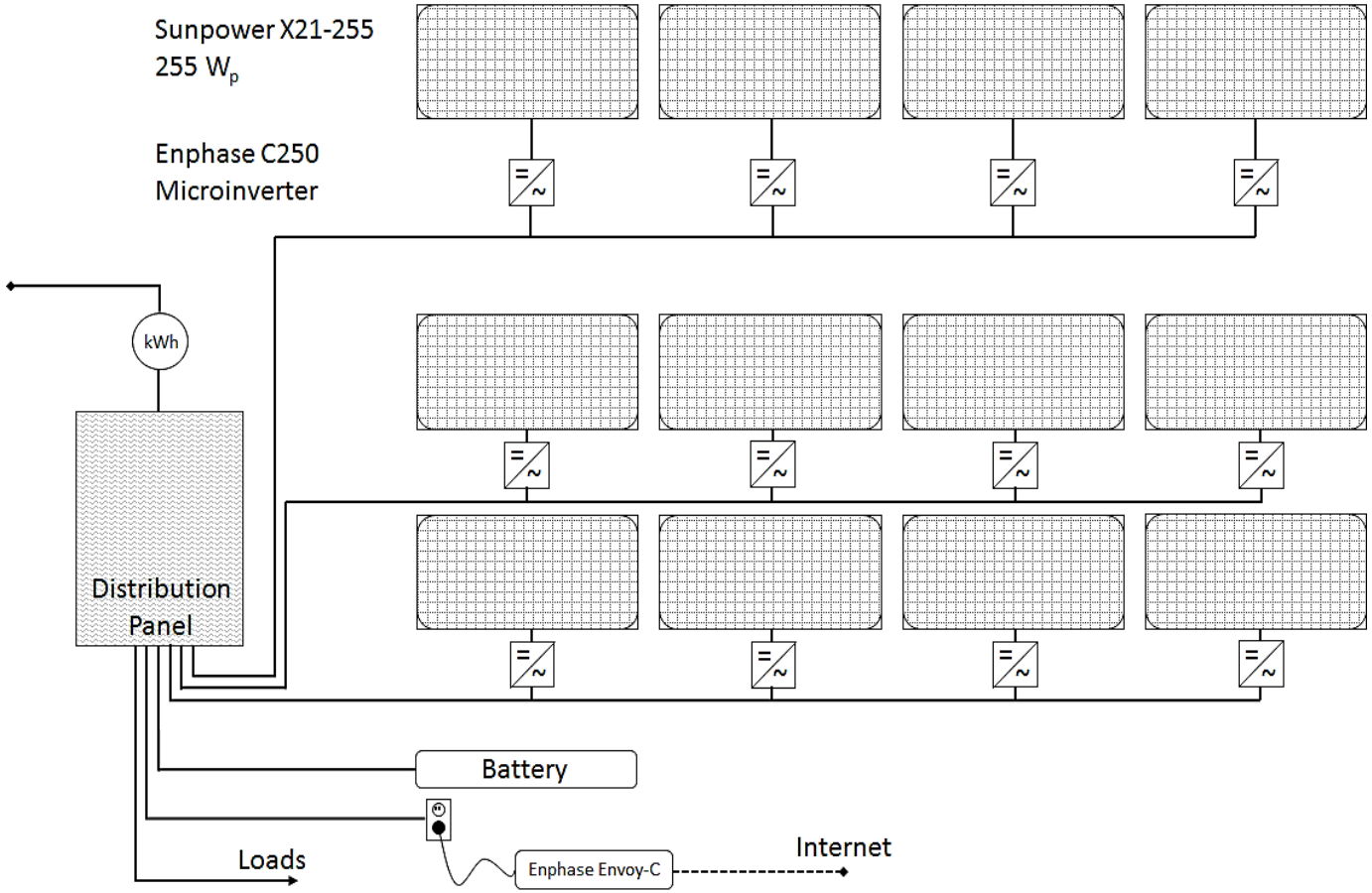


PV SYSTEM DESIGN

107 Panels (27 kW)

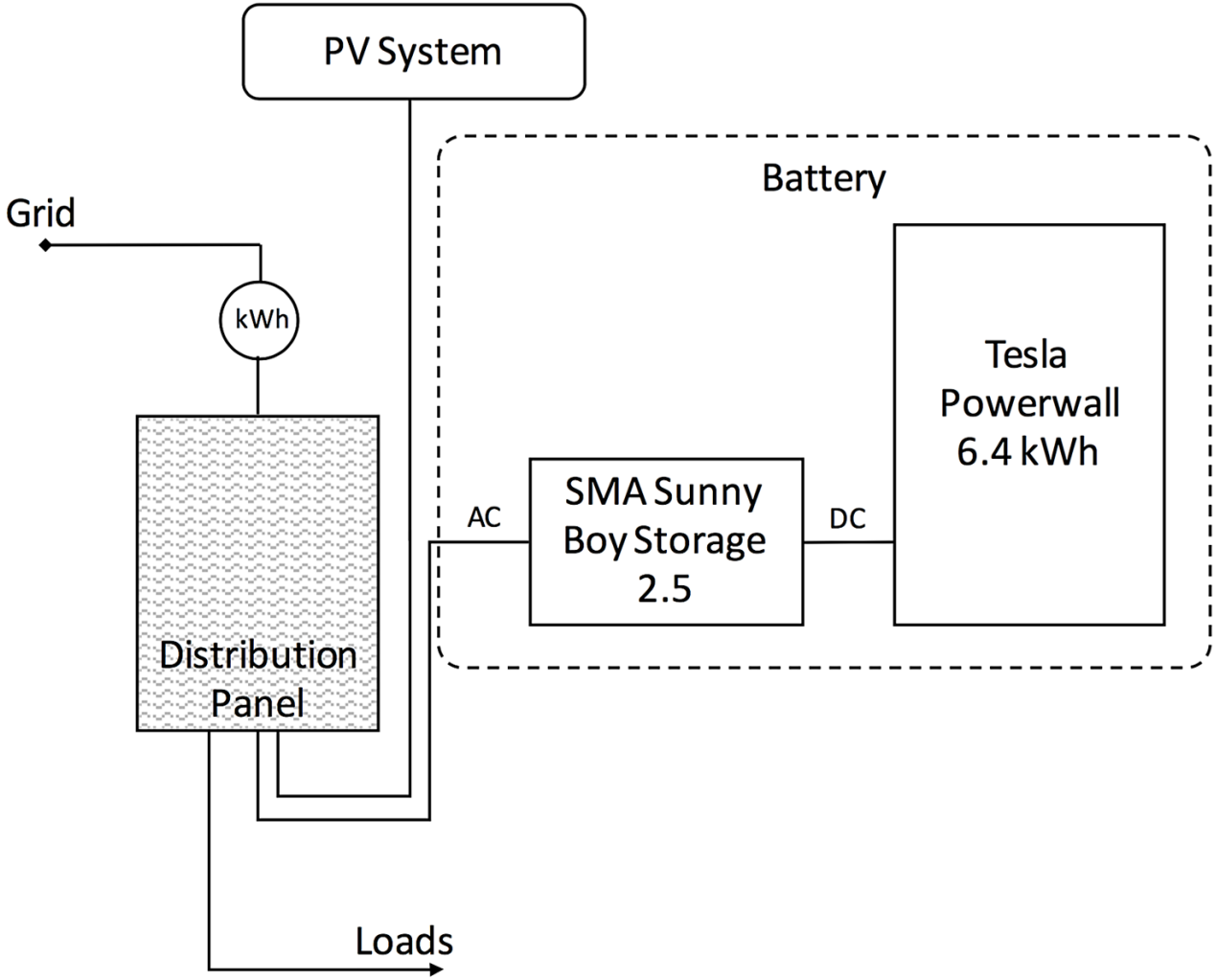
- Sunpower 21.5%
- Enphase micro-inverter
- Tilt: 180° South at 29° Tilt
- Annual Production: 37,700 kWh
- Offsets 92% of total consumption



LED LIGHTING BACKUP POWER

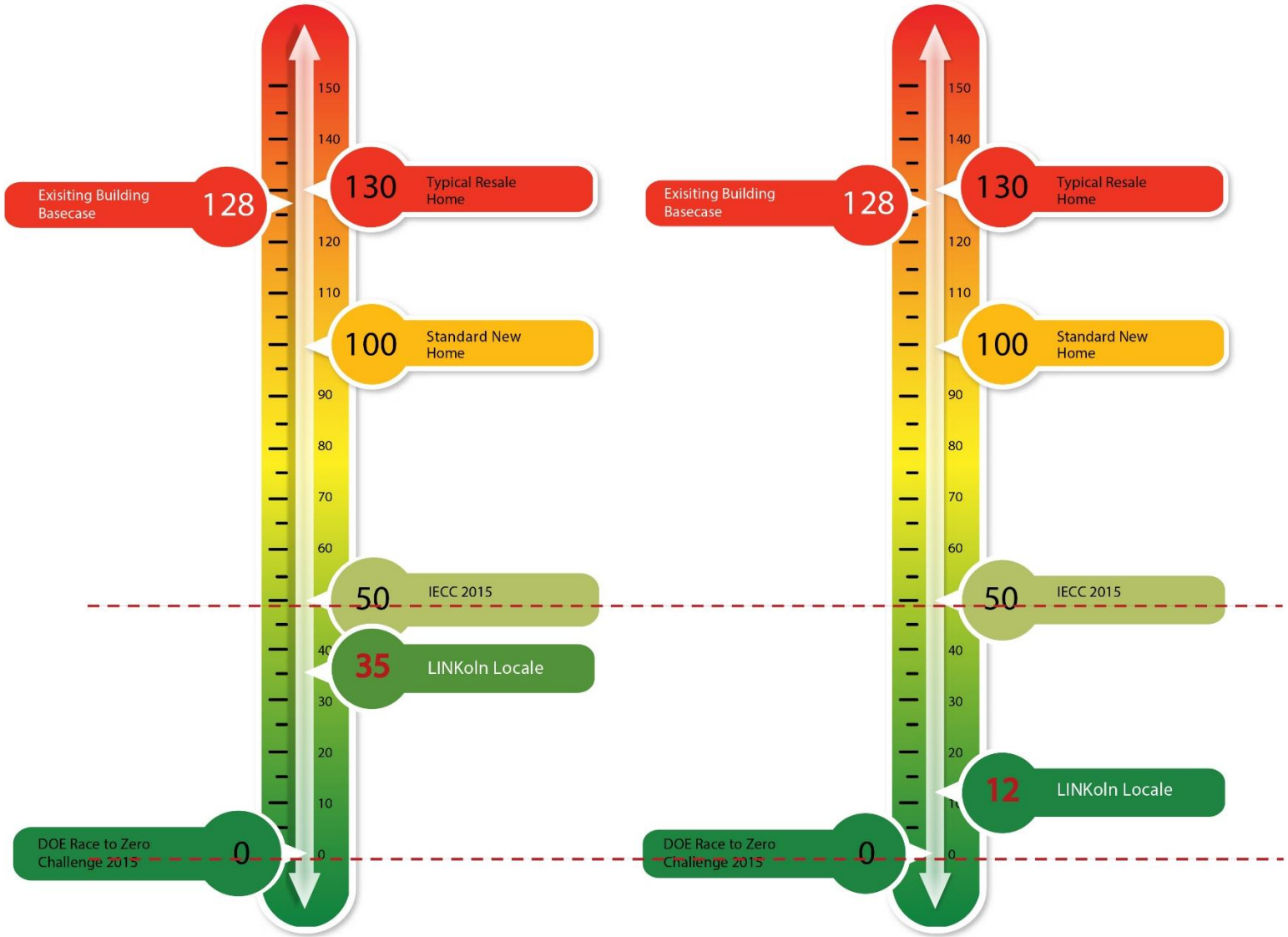
- Grid compatible
- Off-grid operations
- 6.4 kwh capacity

Available as of March 2016.



http://www.energymatters.com.au/wp-content/uploads/2015/12/Datasheet-Daily-Powerwall.pdf
http://www.sma.de/fileadmin/user_upload/SBS25-DEN1604-V10web.pdf

ENERGY ANALYSIS



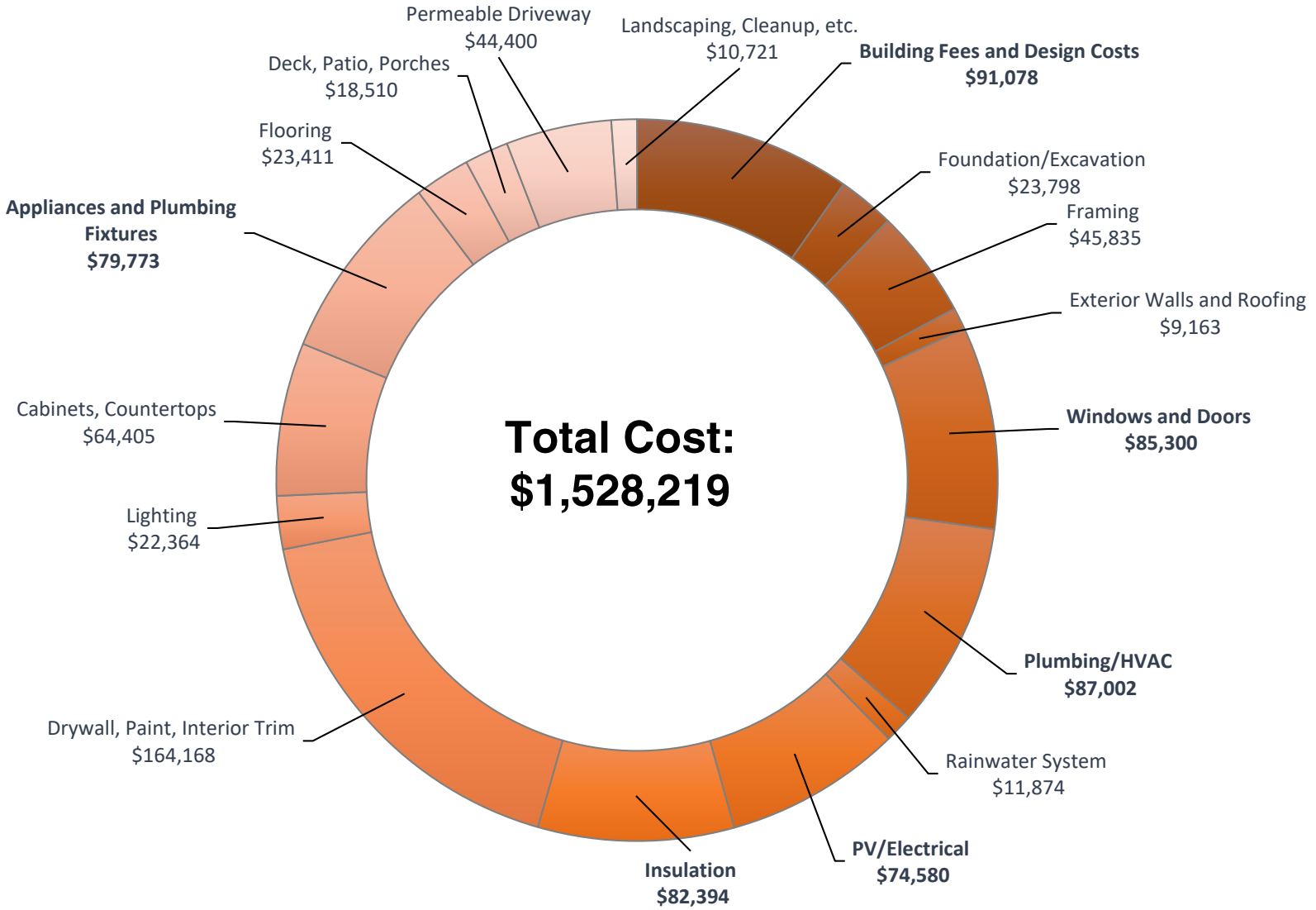
LINKoln Locale - w/o Photovoltaic Panels

LINKoln Locale - w/ Photovoltaic Panels

FINANCIAL ANALYSIS

Key Items Cost Breakdown:

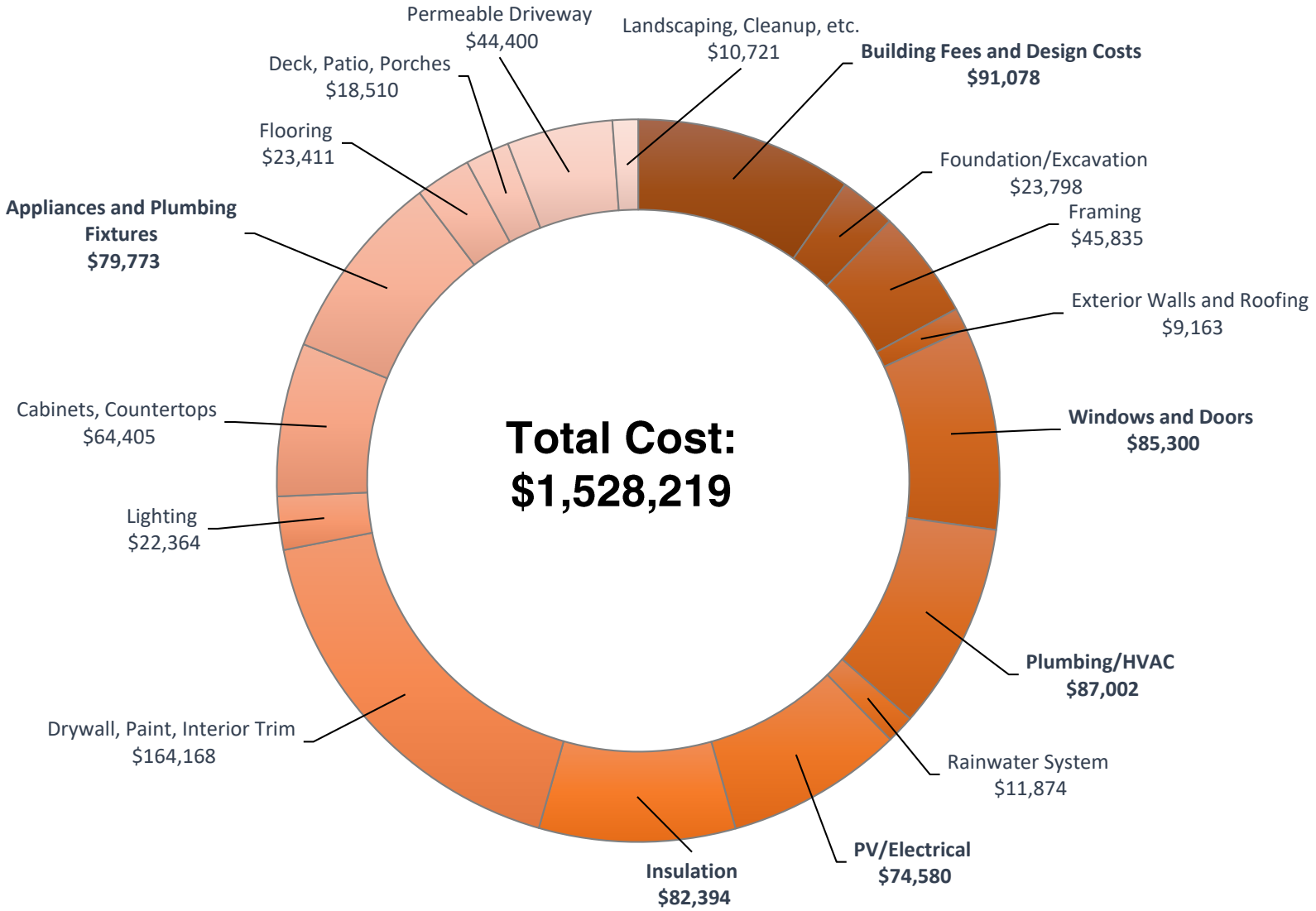
Building Fees and Design Costs	$ 91,078



FINANCIAL ANALYSIS

Key Items Cost Breakdown:

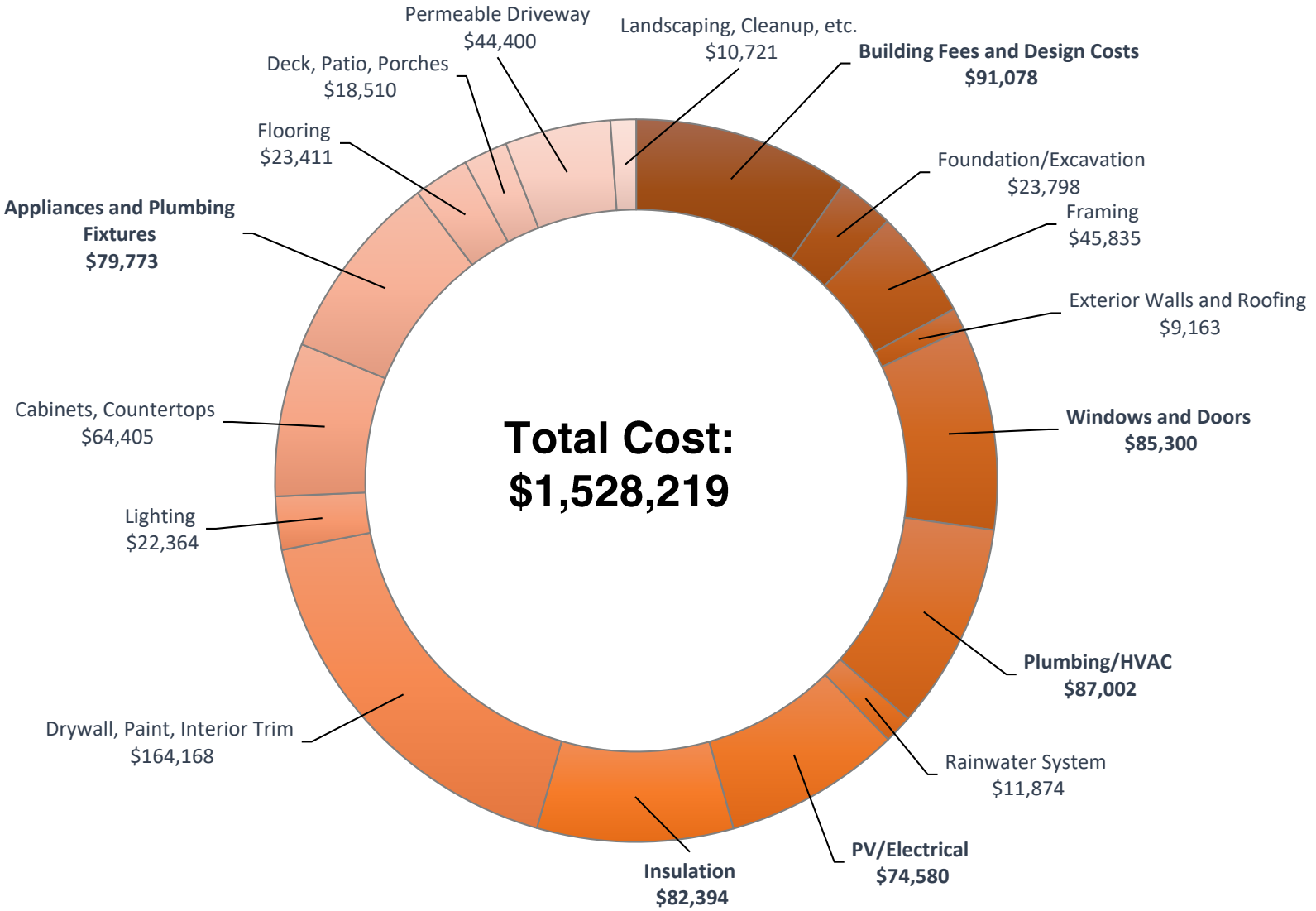
Building Fees and Design Costs	$ 91,078
Plumbing/HVAC	$ 87,002



FINANCIAL ANALYSIS

Key Items Cost Breakdown:

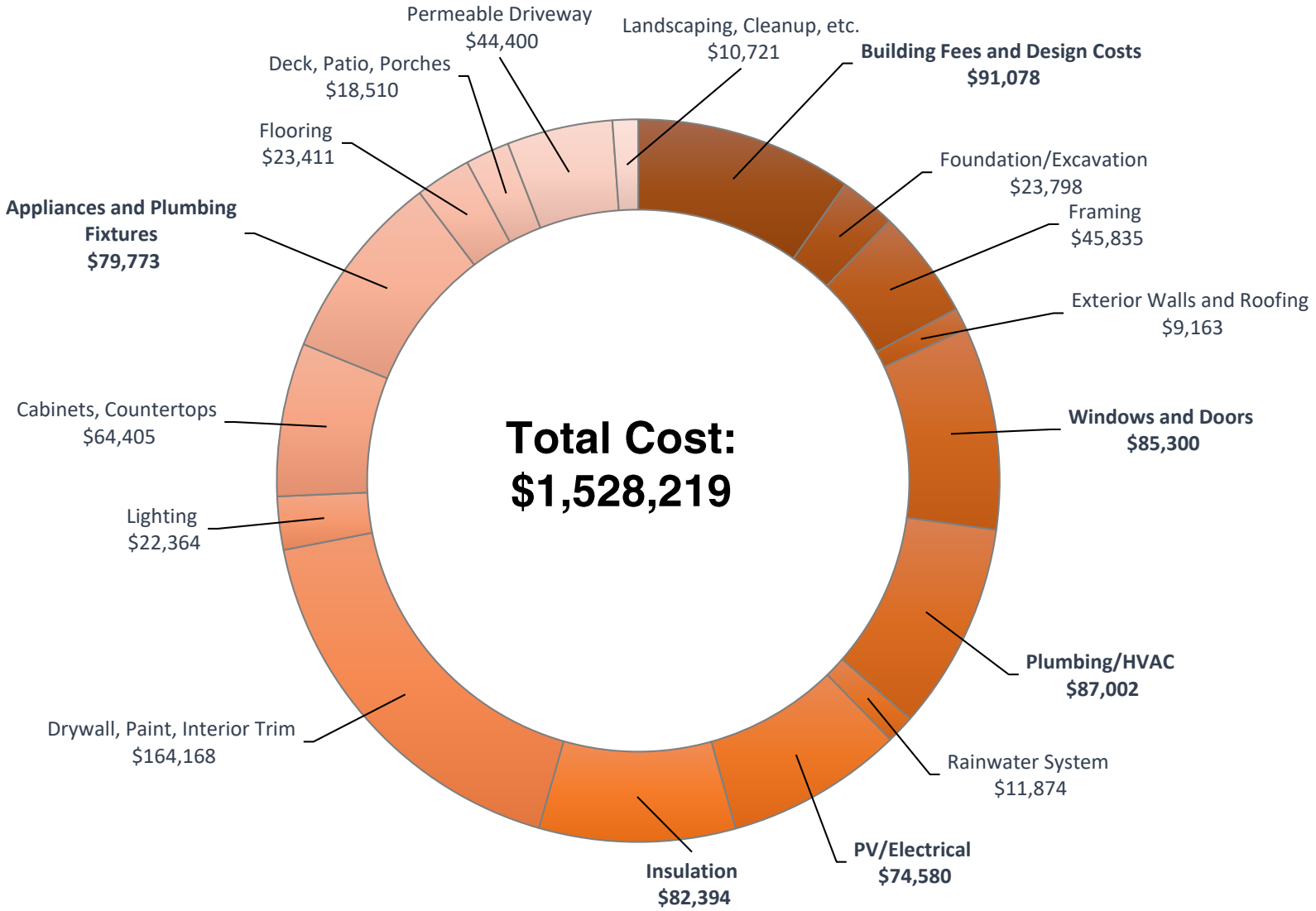
Building Fees and Design Costs	$ 91,078
Plumbing/HVAC	$ 87,002
Windows and Doors	$ 85,300



FINANCIAL ANALYSIS

Key Items Cost Breakdown:

Building Fees and Design Costs	$ 91,078
Plumbing/HVAC	$ 87,002
Windows and Doors	$ 85,300
Insulation	$ 82,394



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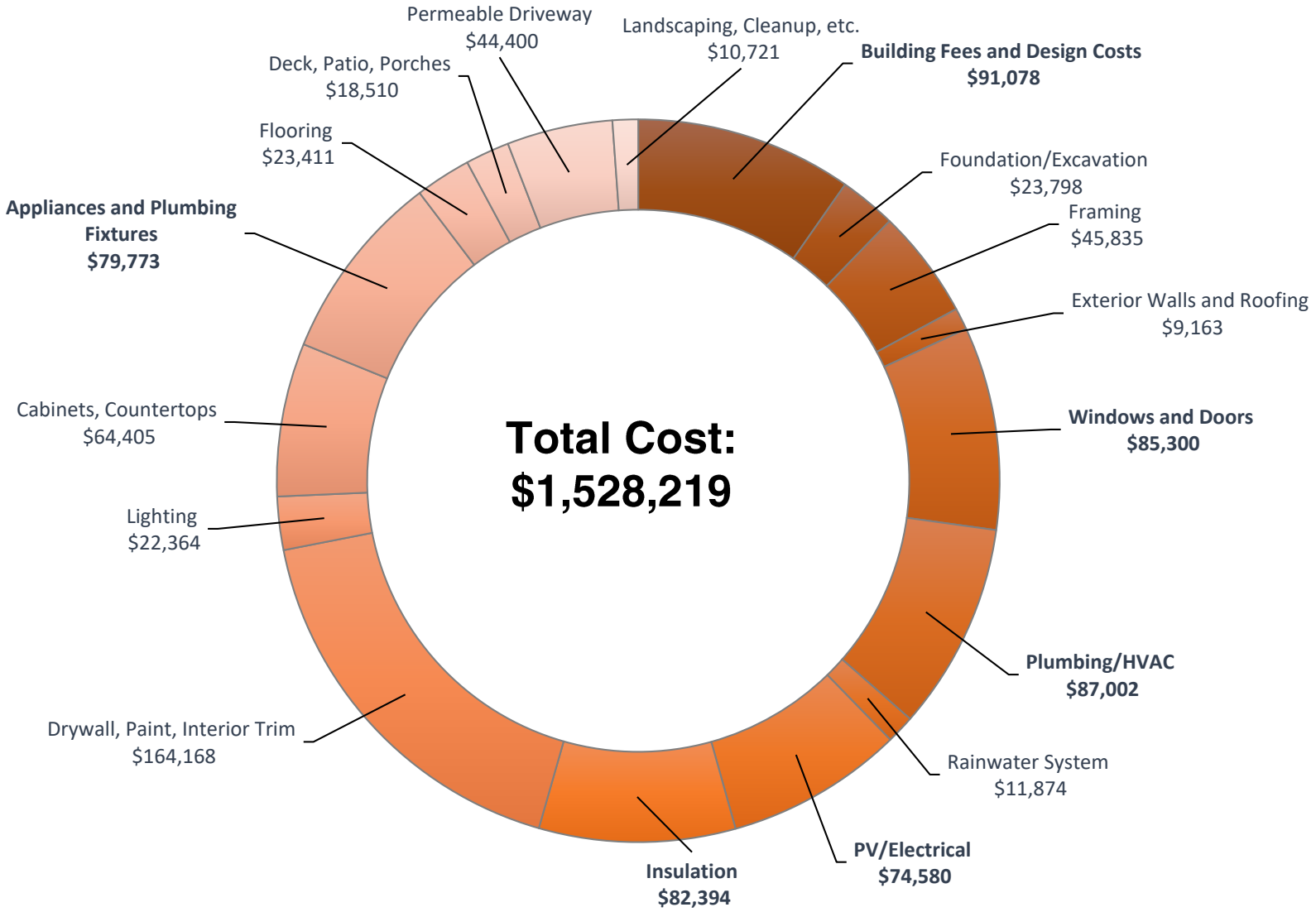
Windows and Doors	$ 85,300
Insulation	$ 82,394
Appliances and Plumbing Fixtures	$ 79,773



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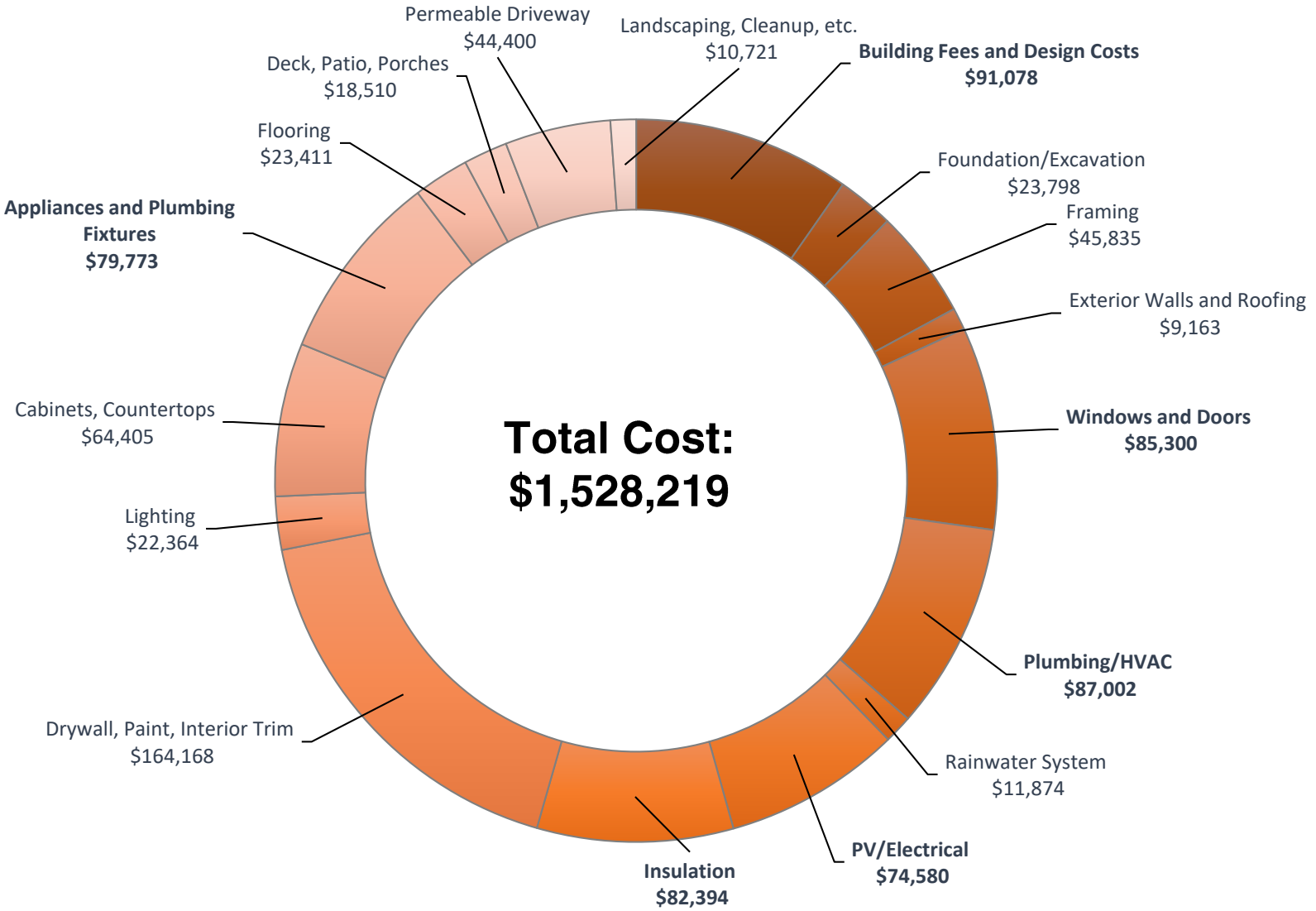
Windows and Doors	$ 85,300
Insulation	$ 82,394
Appliances and Plumbing Fixtures	$ 79,773
PV/Electrical	$ 74,580



FINANCIAL ANALYSIS

National Average for new Standard Construction:

$125-$150/s.f.[1,2]

[1] http://www.homeadvisor.com/cost/architects-and-engineers/build-a-house/

[2] http://www.fixr.com/costs/build-apartment

[3] http://www.deptofnumbers.com/rent/illinois/champaign/

FINANCIAL ANALYSIS

National Average for new Standard Construction:	$125-$150/s.f.[1,2]
LINKoln Locale Total Cost:	$1,528,219

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Debt to Income Ratio Calculation	
Annual Median Family Income (MFI)	$ 54,916
Monthly Household Debt (0.5% MFI)	$ 34
Operations and Maintenance Costs	$ 24
Monthly Utility Costs	$ 10
Property Tax	$ 369
Insurance	$ 10
Mortgage Payment	$ 718
Home Ownership Affordability Target	**38%**

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Home Ownership Affordability Target	**38%**
Calculated Debt to Income Ratio	**25%**

Pass

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Pass

Financing Breakdown	
Annual Interest Rate	3.9%
Years	30 years
Payments per Year	12
Number of Payments	360
Down payment	$ 305,644
Principle Amount	$1,222,575
Monthly Payment	**$ 5,746**
Property Tax Rate	2.32%
Annual Property Tax	$ 35,455
Monthly Payment w/Distributed Property Tax	**$ 8,701**

[1] http://www.homeadvisor.com/cost/architects-and-engineers/build-a-house/

[2] http://www.fixr.com/costs/build-apartment

[3] http://www.deptofnumbers.com/rent/illinois/champaign/

FINANCIAL ANALYSIS

National Average for new Standard Construction: $125-$150/s.f.[1,2]

LINKoln Locale Total Cost: $1,528,219

LINKoln Locale Normalized Cost: $110/s.f.

Financing Breakdown	
Annual Interest Rate	3.9%
Years	30 years
Payments per Year	12
Number of Payments	360
Down payment	$ 305,644
Principle Amount	$1,222,575
Monthly Payment	$ 5,746
Property Tax Rate	2.32%
Annual Property Tax	$ 35,455
Monthly Payment w/Distributed Property Tax	$ 8,701

Debt to Income Ratio Calculation	
Annual Median Family Income (MFI)	$ 54,916
Monthly Household Debt (0.5% MFI)	$ 34
Operations and Maintenance Costs	$ 24
Monthly Utility Costs	$ 10
Property Tax	$ 369
Insurance	$ 10
Mortgage Payment	$ 718
Home Ownership Affordability Target	38%
Calculated Debt to Income Ratio	25%

Champaign-Urbana Average Rent: $784/bed[3]

Pass

[1] http://www.homeadvisor.com/cost/architects-and-engineers/build-a-house/

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Champaign-Urbana Average Rent: $784/bed[3]

The University Group Proposed Rent: $850/bed

[1] http://www.homeadvisor.com/cost/architects-and-engineers/build-a-house/

[2] http://www.fixr.com/costs/build-apartment

[3] http://www.deptofnumbers.com/rent/illinois/champaign/

SUMMARY

Environmental Impacts of LINKoln Locale vs. New Construction

Climate Change

SUMMARY

Environmental Impacts of LINKoln Locale vs. New Construction

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Human Health

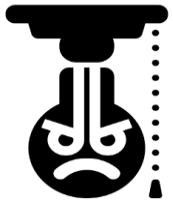
SUMMARY

Environmental Impacts of LINKoln Locale vs. New Construction

Climate Change

Human Health

Resource Depletion



SUMMARY

Environmental Impacts of LINKoln Locale vs. New Construction

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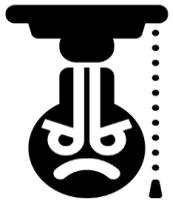
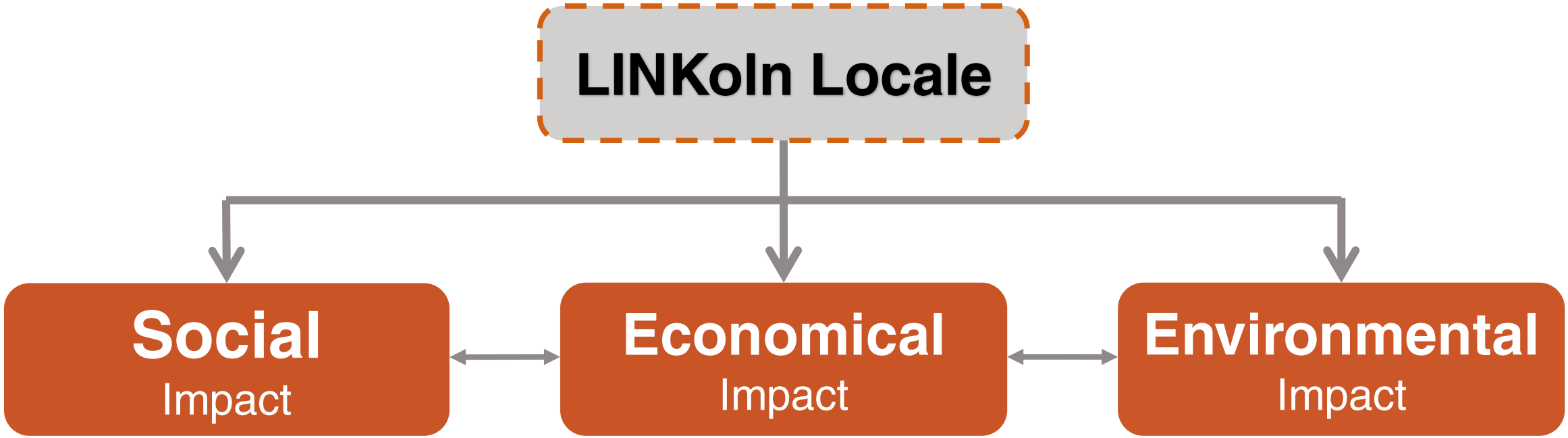
Resource Depletion

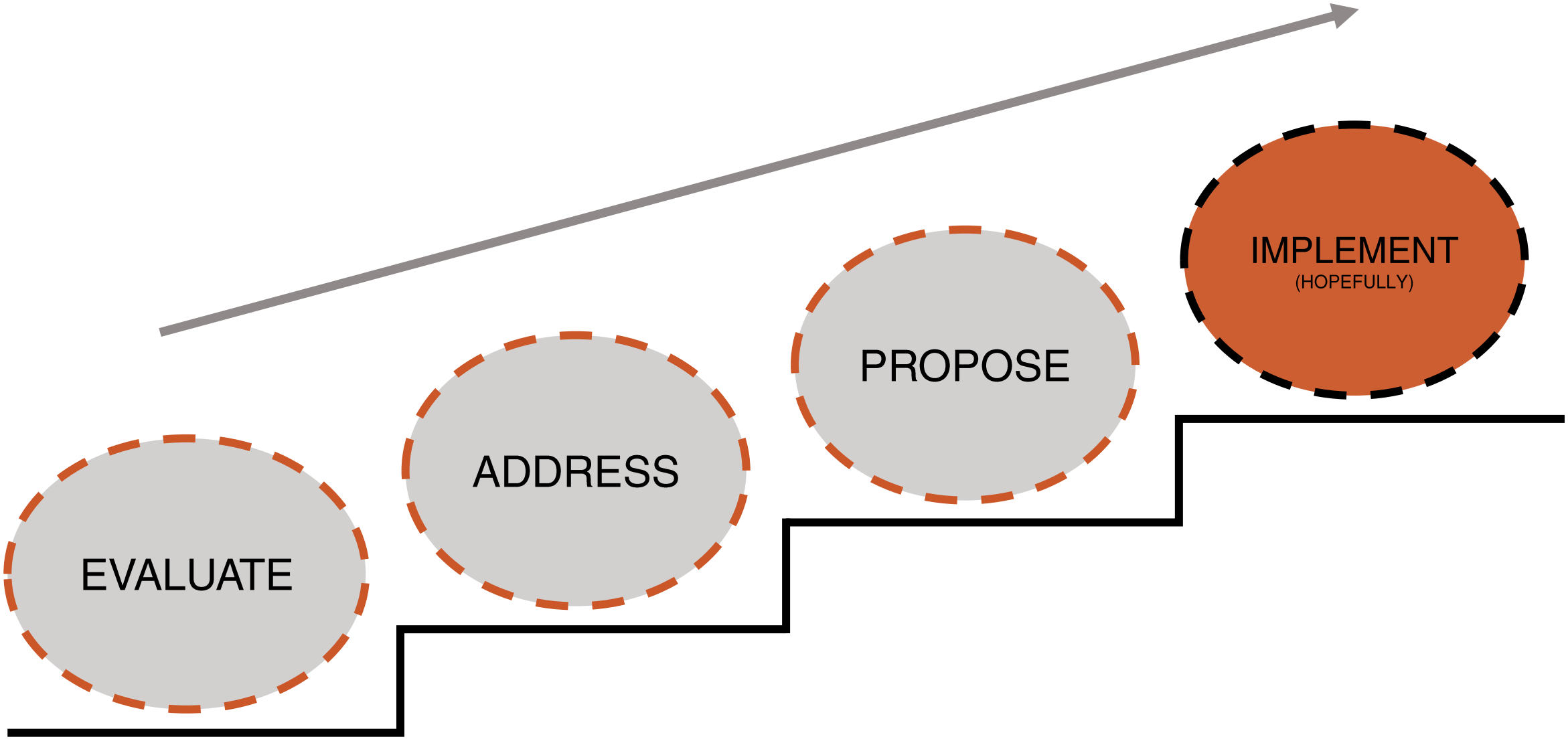


Ecosystem Quality

SUMMARY


LINKoln Locale
Social
Impact
Economical
Impact
Environmental
Impact

SUMMARY



INDUSTRY PARTNERS AND INSTITUTIONAL SUPPORT

PERKINS + WILL

SCHÜCO

NEWELL INSTRUMENTS

KENNEDY HUTSON ASSOCIATES

sto

DOW CORNING

The University Group

SEDAC
Smart Energy Design Assistance Center
Providing Effective Energy Strategies for Public and Private Buildings in Illinois

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

ILLINOIS SOLAR DECATHLON

BEST 5 CONFERENCE
Building Enclosure Science & Technology

THANK YOU
Questions?

New Construction or Deep Retrofit?
Roadmap to Build a Case for Deep Retrofit

ZERO ENERGY READY HOME U.S. DEPARTMENT OF ENERGY
EPA WaterSense
EPA Indoor airPLUS QUALIFIED HOMES
ENERGY STAR HOMES
U.S. GREEN BUILDING COUNCIL LEED USGBC

TEAM LINKoln

U.S. DEPARTMENT OF ENERGY RACE TO ZERO STUDENT DESIGN COMPETITION