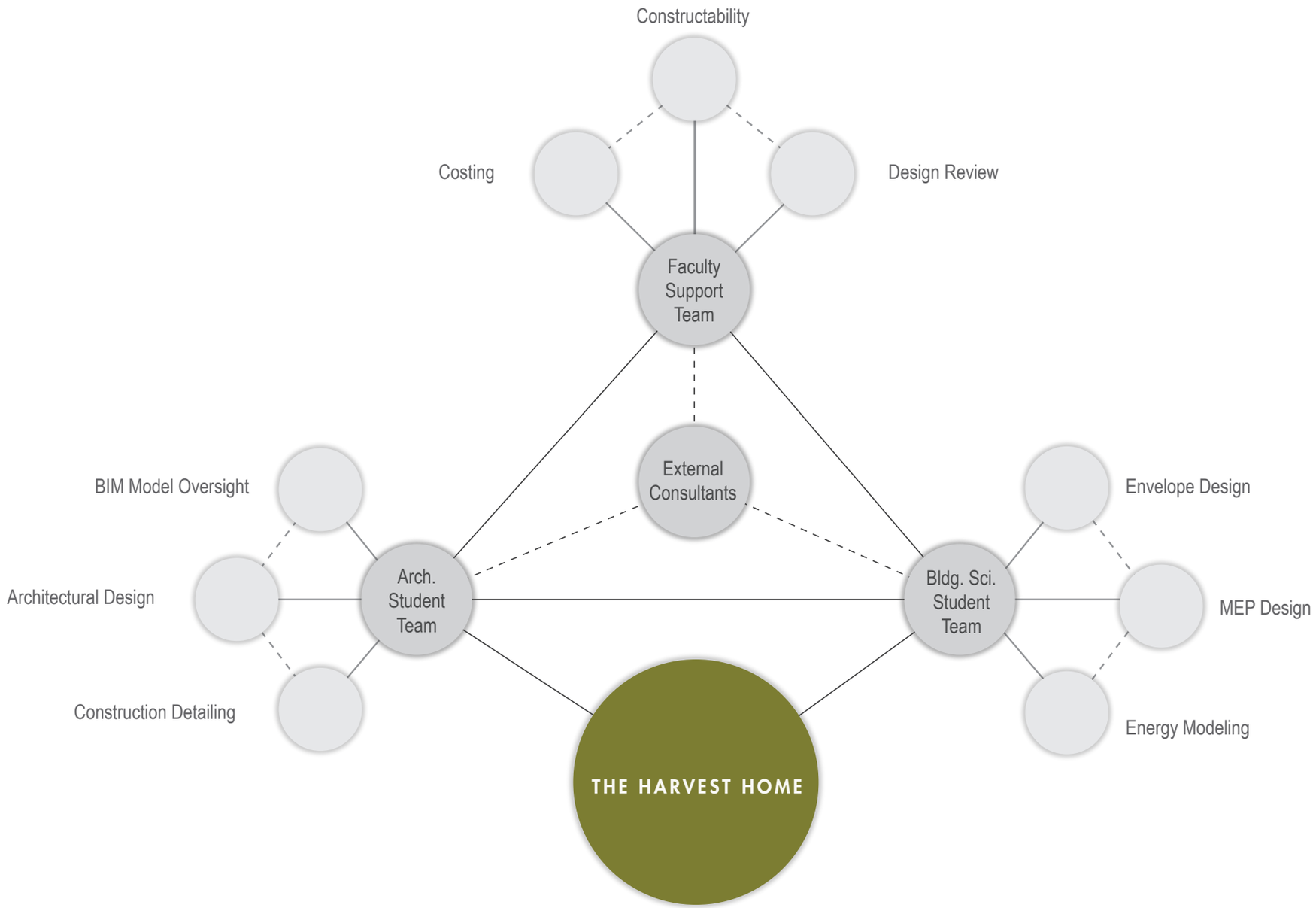
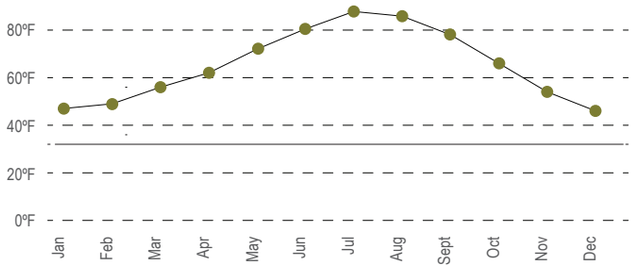
THE HARVEST HOME

U.S. DEPARTMENT OF ENERGY
CHALLENGE HOME STUDENT DESIGN COMPETITION

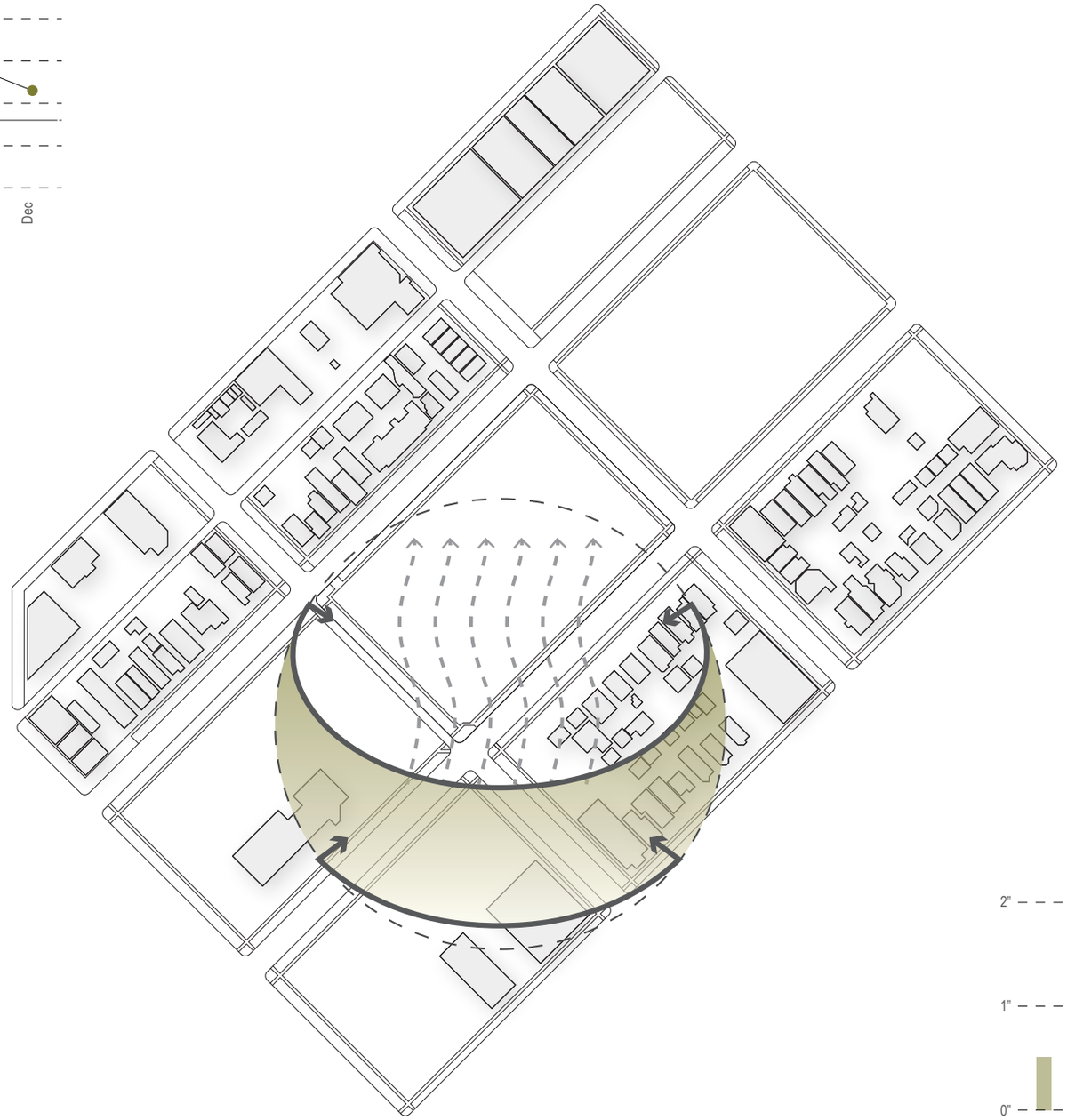

Constructability
Costing
Design Review
Faculty Support Team
External Consultants
BIM Model Oversight
Architectural Design
Construction Detailing
Arch. Student Team
Bldg. Sci. Student Team
Envelope Design
MEP Design
Energy Modeling
THE HARVEST HOME

Aerial View to South West

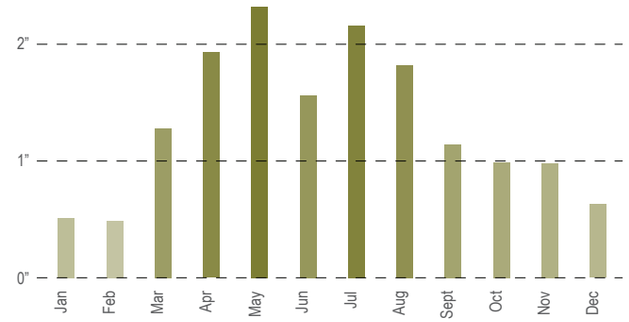
Area Plan - Existing



Monthly Average Temperature



Area Plan - Solar Orientation & Prevailing Winds



Monthly Average Precipitation

Design a cost-effective response allowing the average Denver family to purchase, operate and maintain a sustainable home.

Incorporate flexible interior and exterior spaces capable of accommodating a variety of familial scenarios.

Meet or exceed the requirements and standards outlined for certification by the Passive House Institute United States (PHIUS+).

Create a net-zero ready home with the potential of operating completely independent of municipal servicing.

Employ traditional construction methods coupled with readily available on-the-market materials, finishes, equipment and appliances..

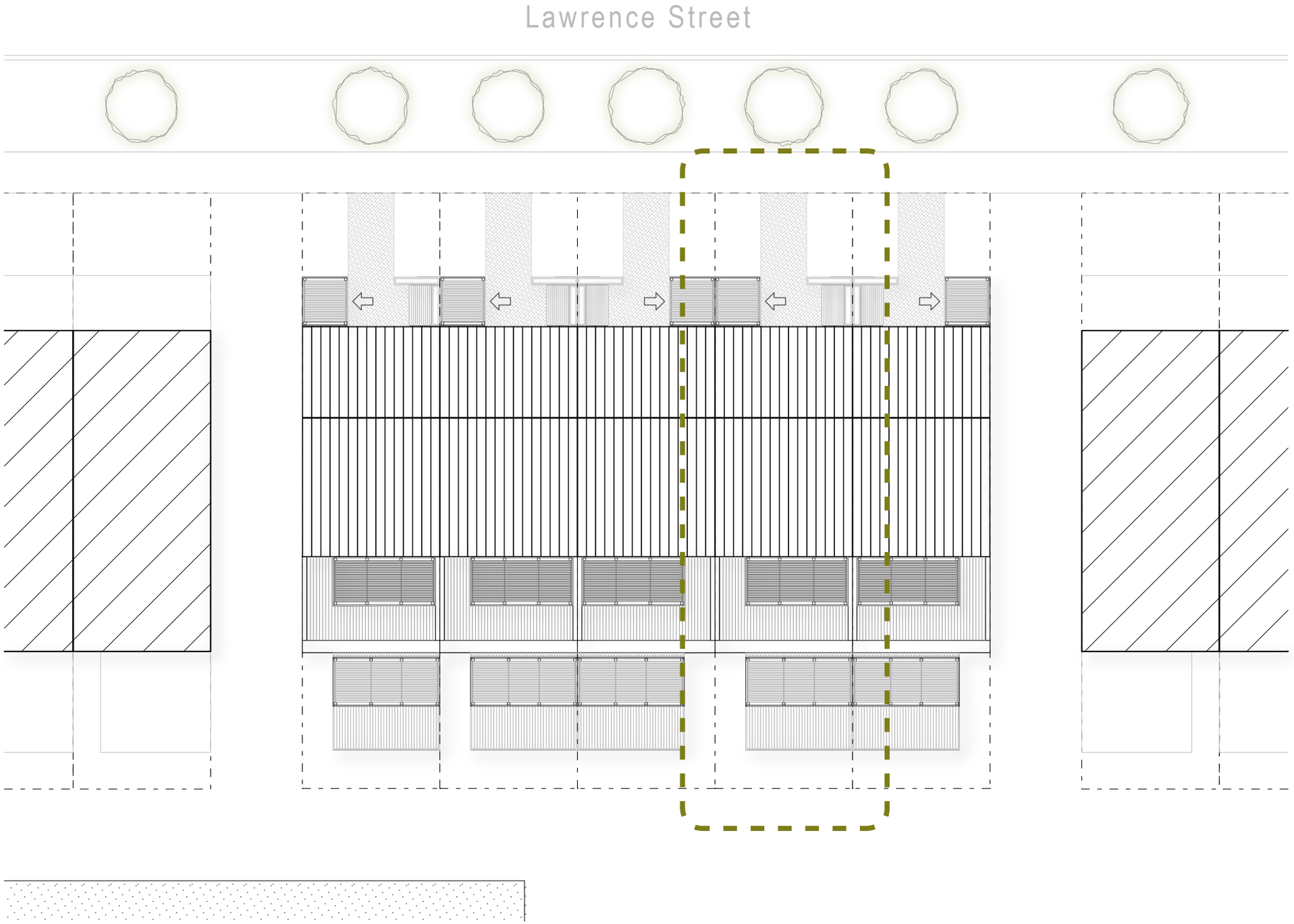
Incorporate open concept space planning capable of hosting a variety of functions within the modest sized floor plate.

Design the building envelope to be air-tight and thermal bridge free throughout.

Consider the building as a direct derivative of the natural context allowing for rain water collection and optimal passive solar gains.

Frontage at Lawrence Street

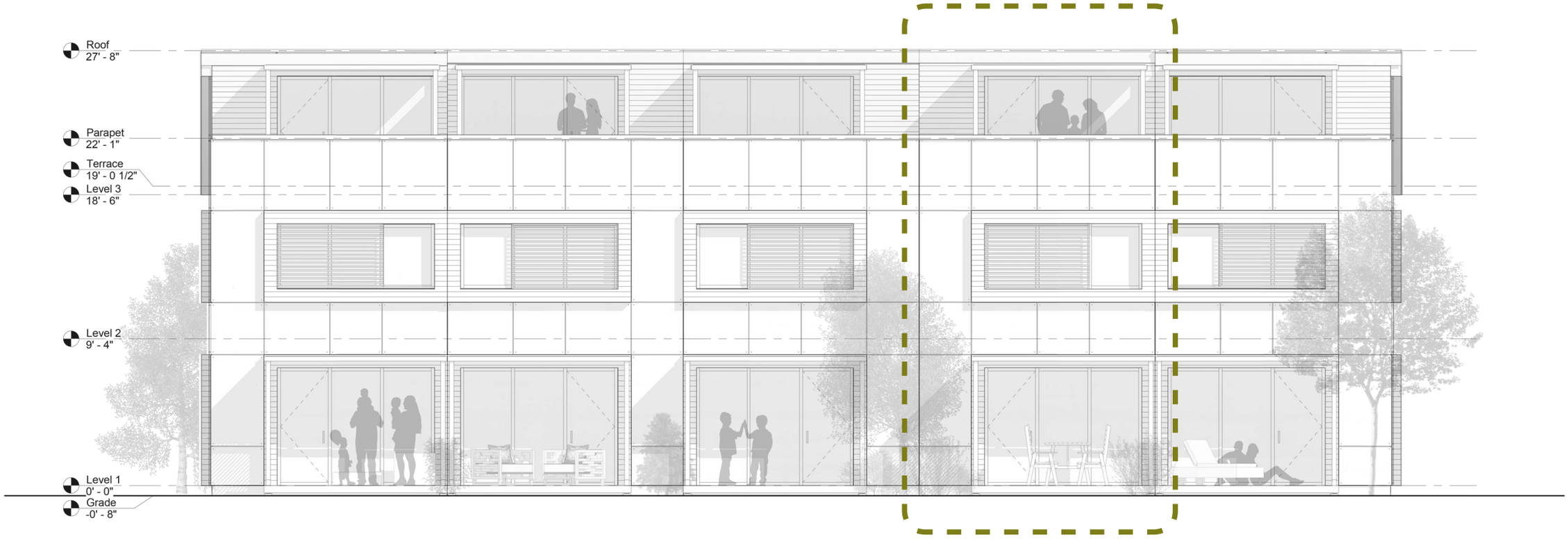
Area Plan - Proposed



Site Plan - Proposed

Row Elevation - North

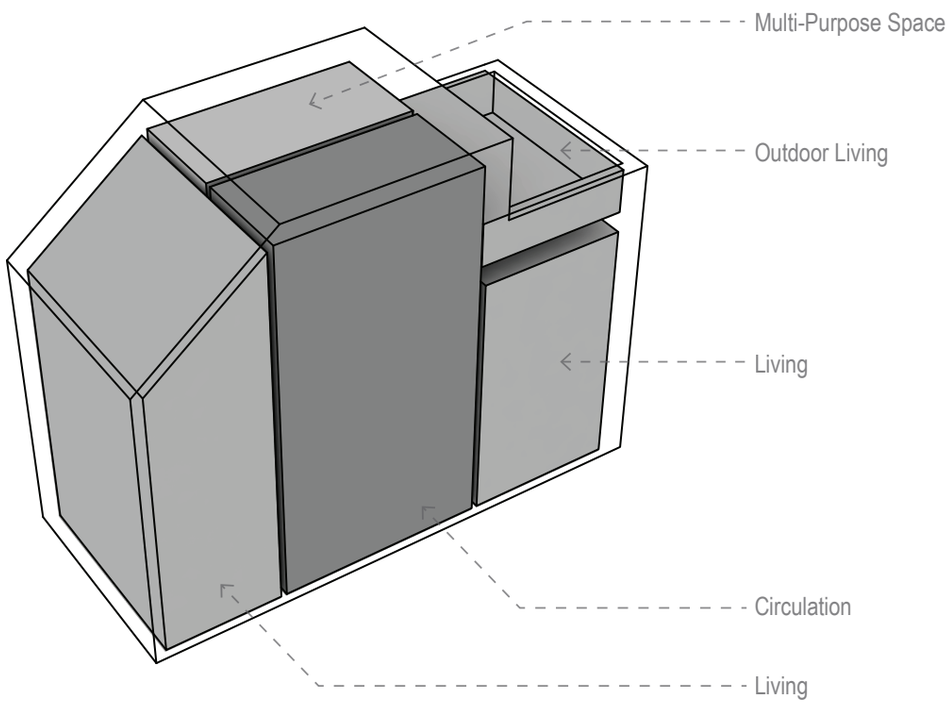
0 2 5 10 ft



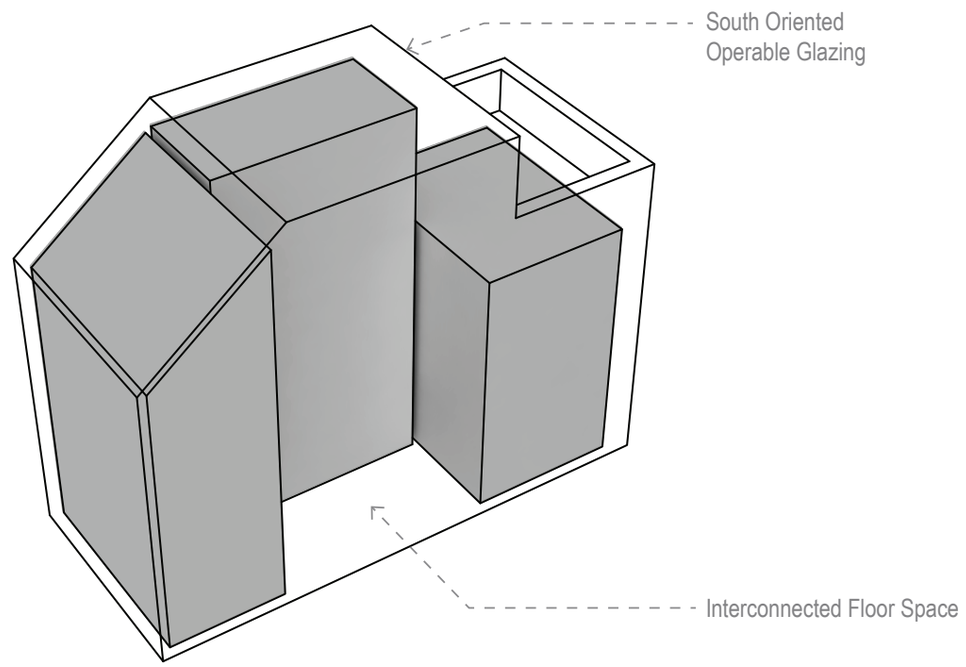
Row Elevation - South

0 2 5 10 ft

CONCEPTUAL MASSING

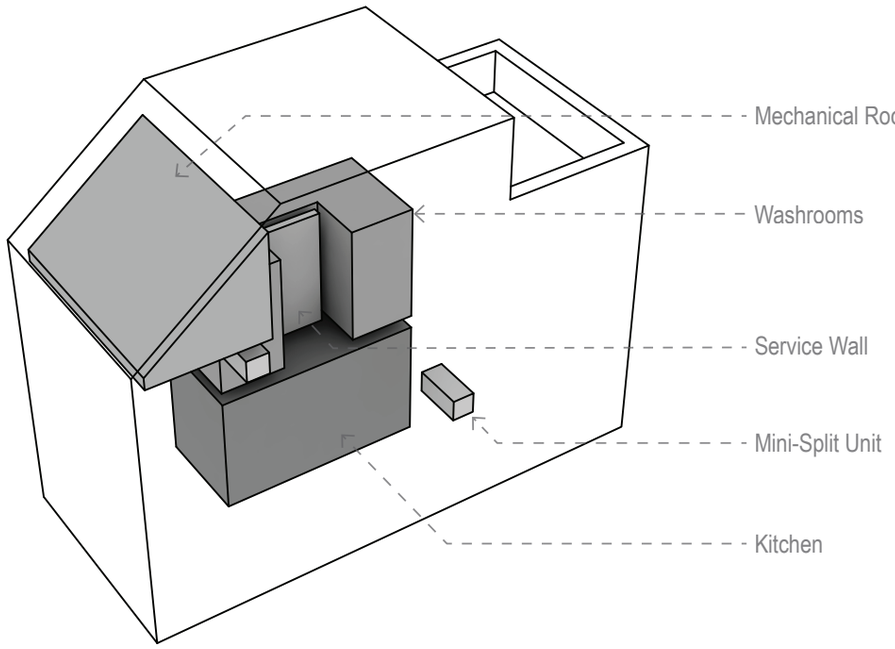


Interior Program Massing

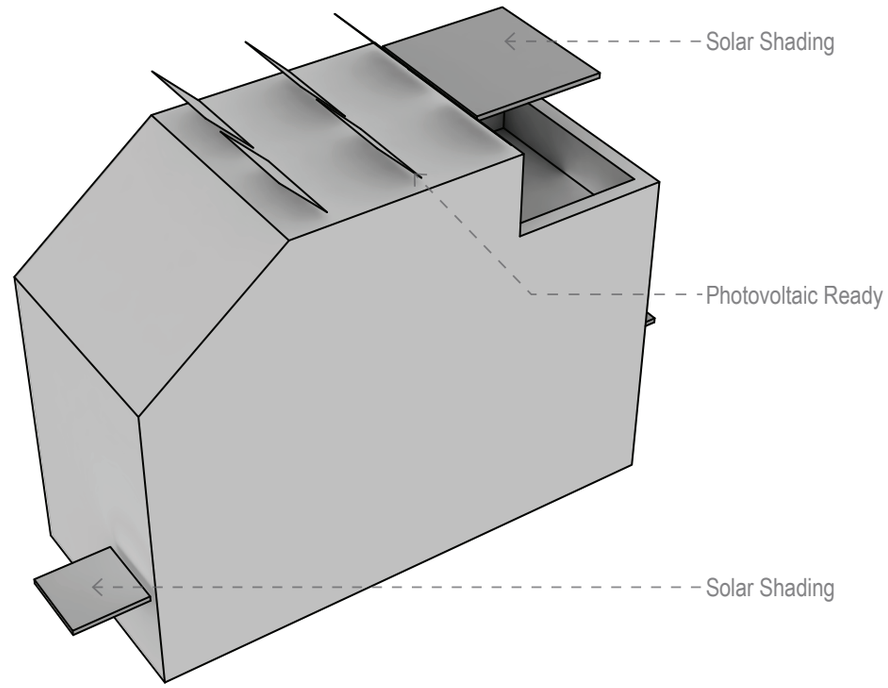


Central Stair

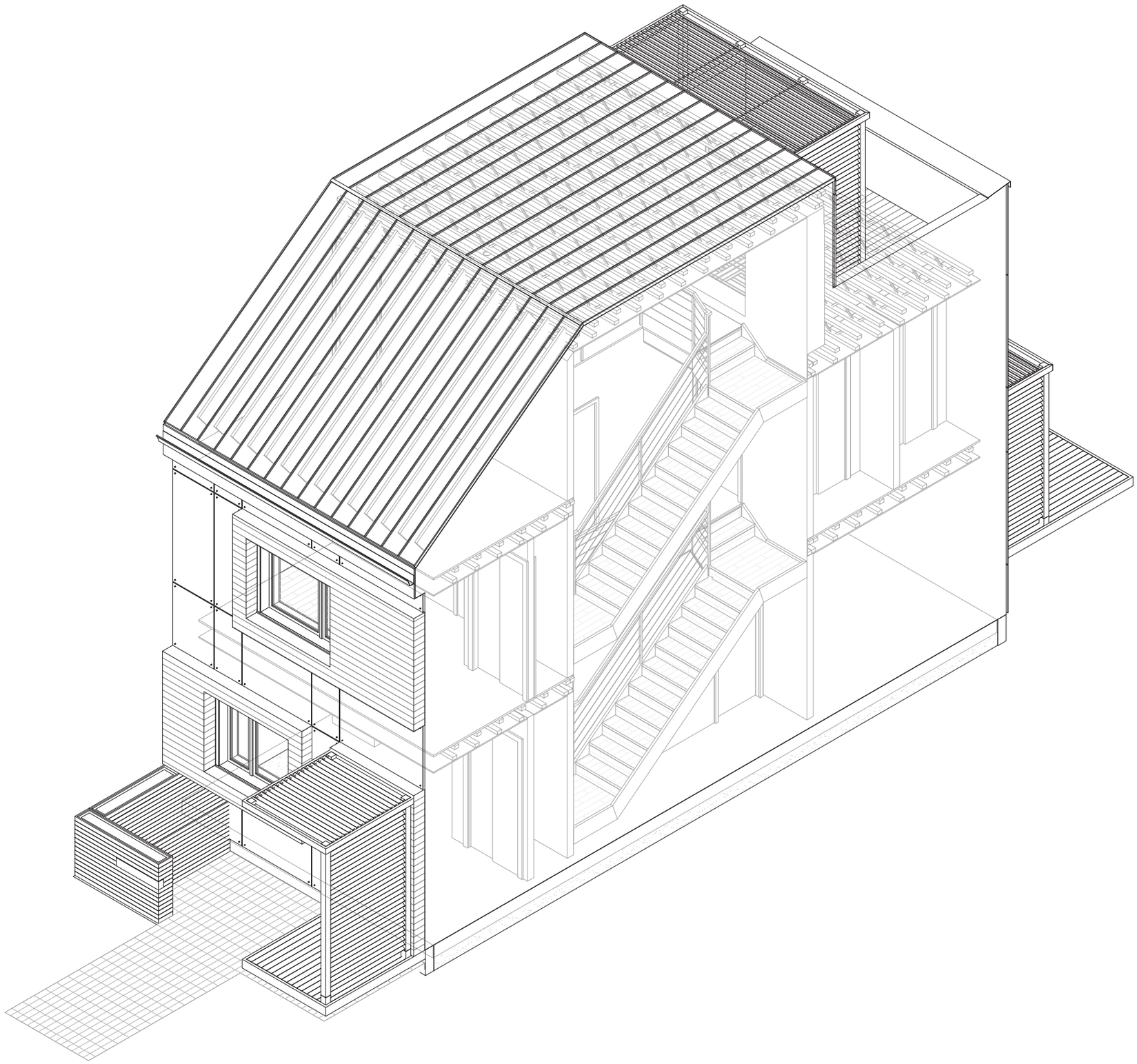
CONCEPTUAL MASSING



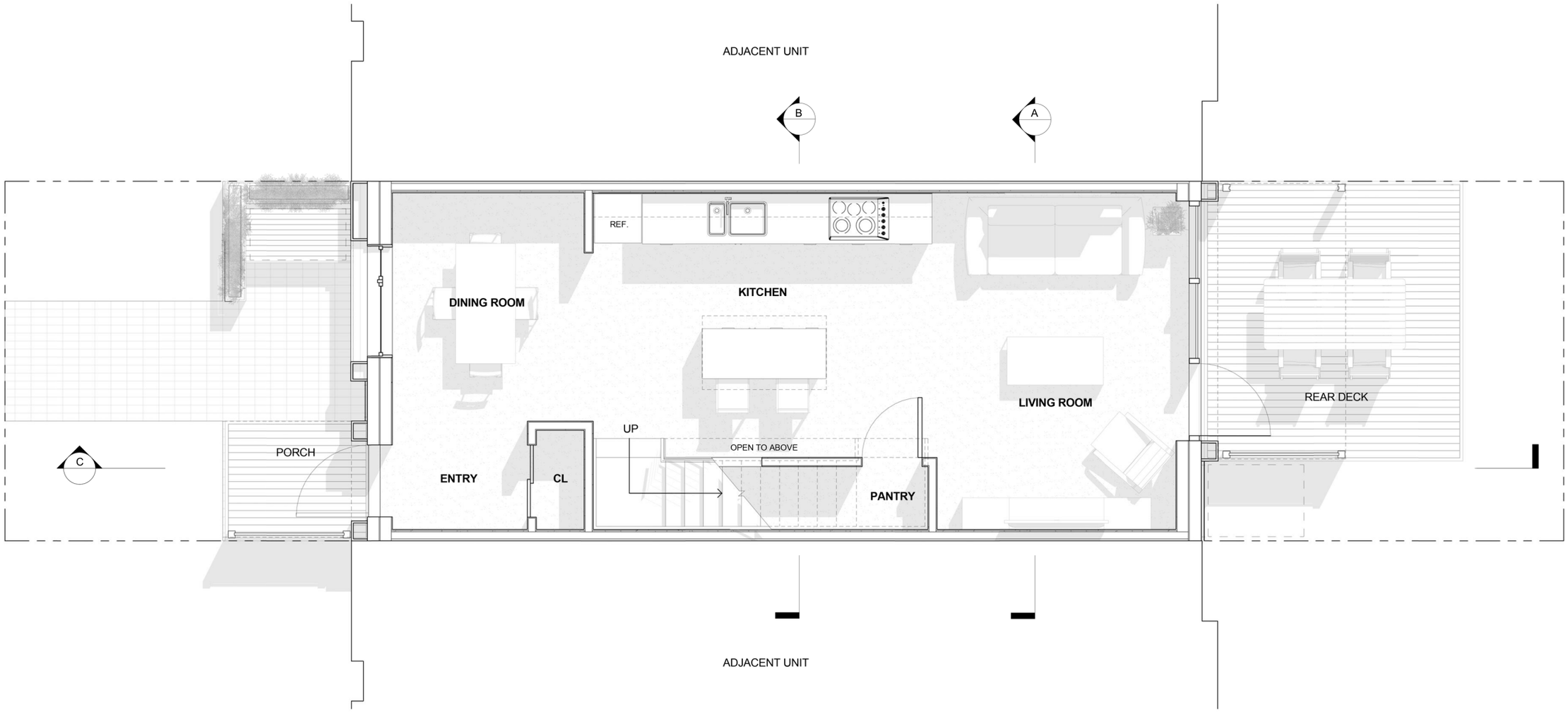
Building Services



Polar Shading & PV Orientation

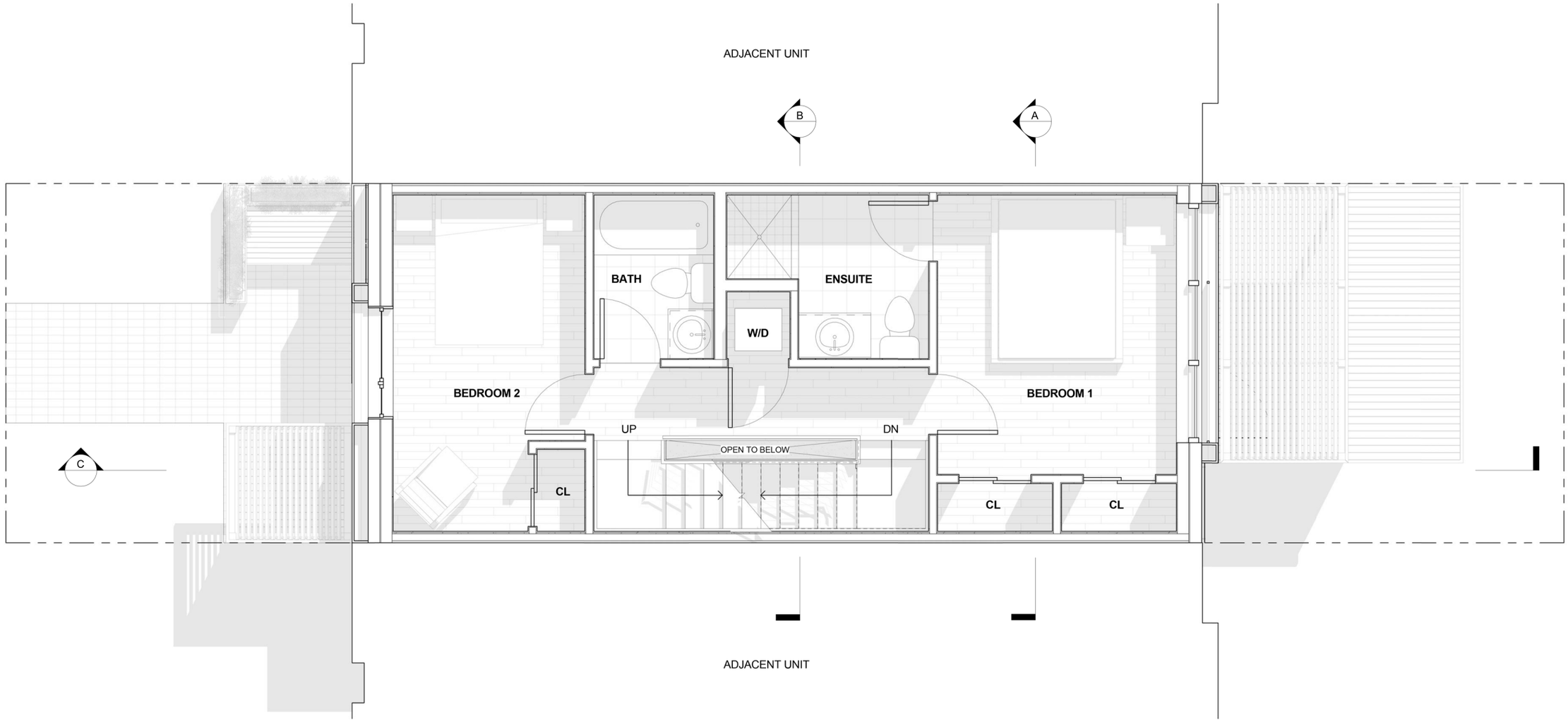


Building Axonometric



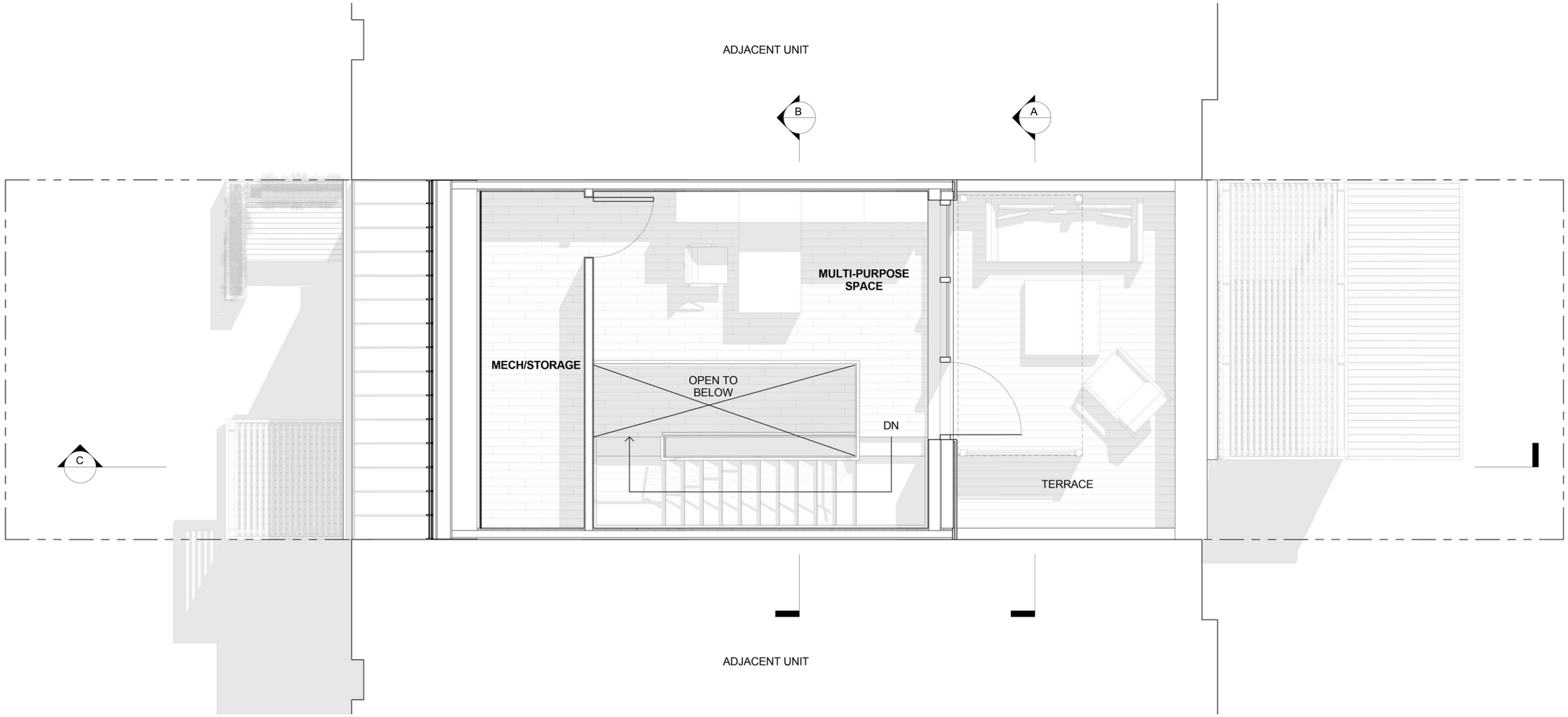
Floor Plan - Level One

0 2 5 10 ft

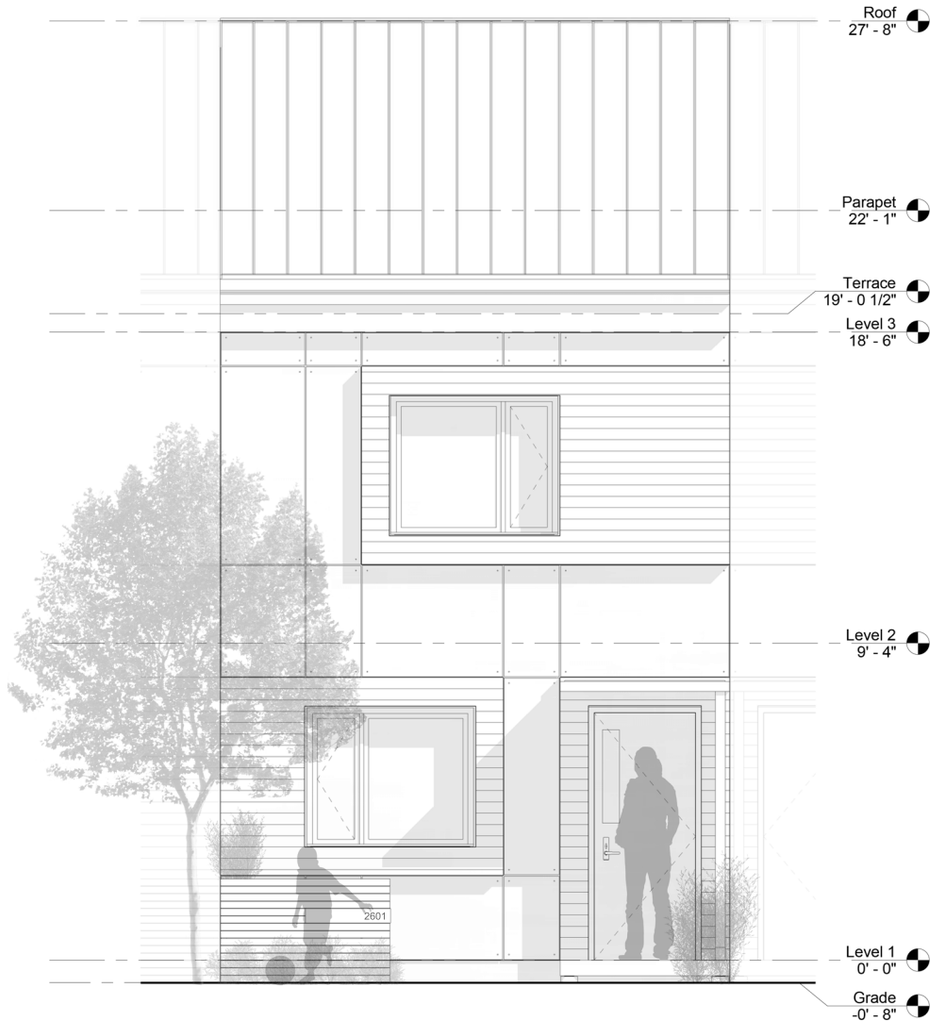


Floor Plan - Level Two

0 2 5 10 ft

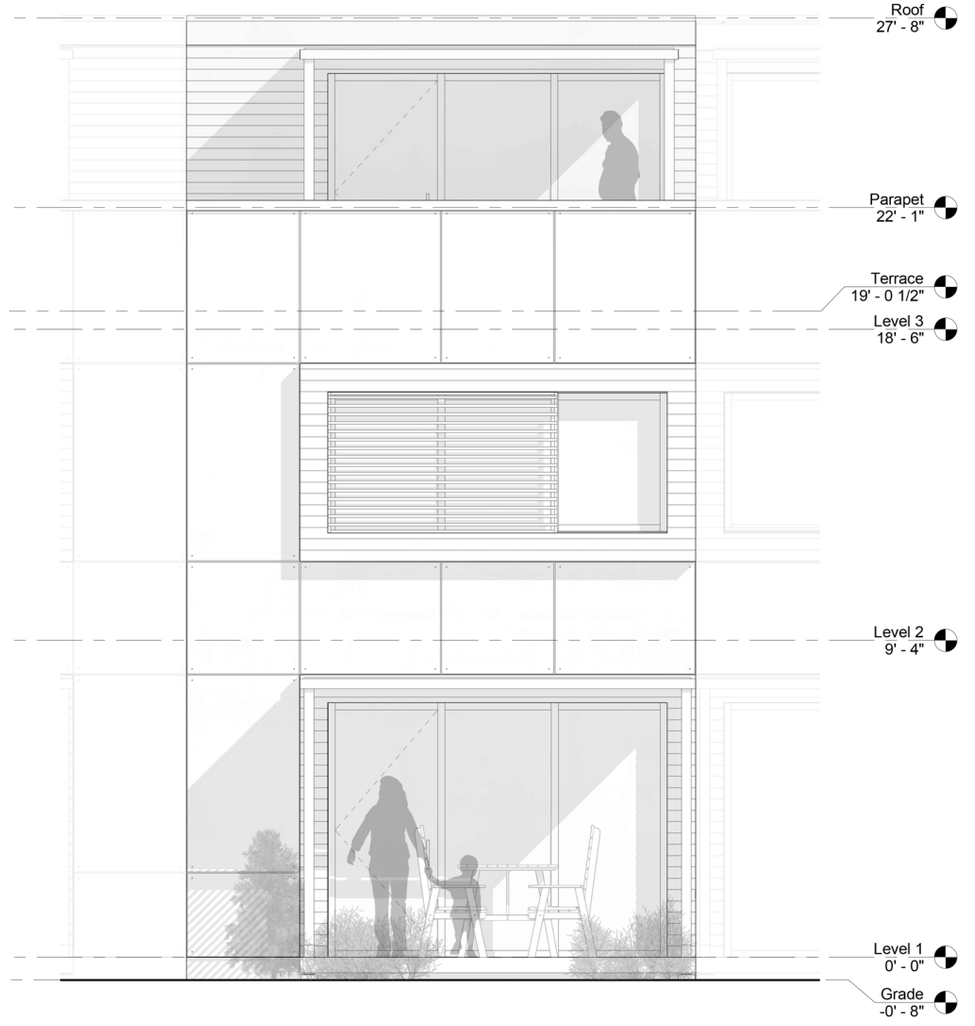


Floor Plan - Level Three



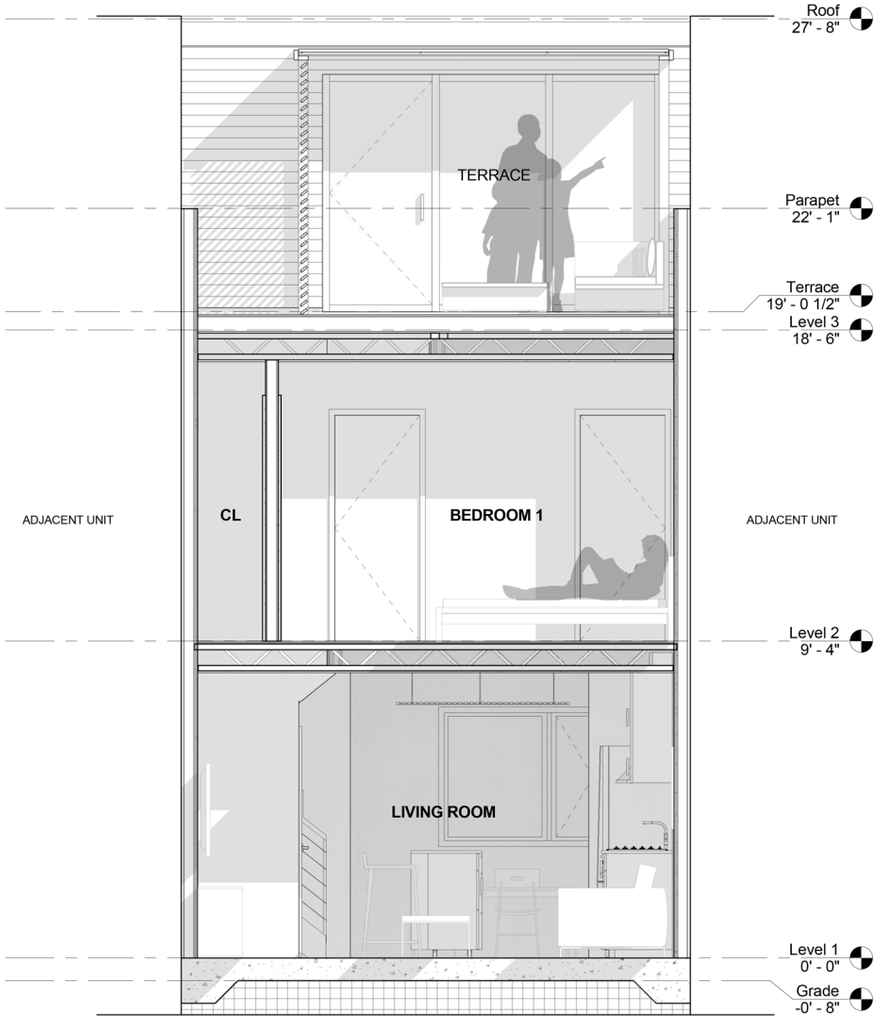
Unit Elevation - North

0 2 5 10 ft

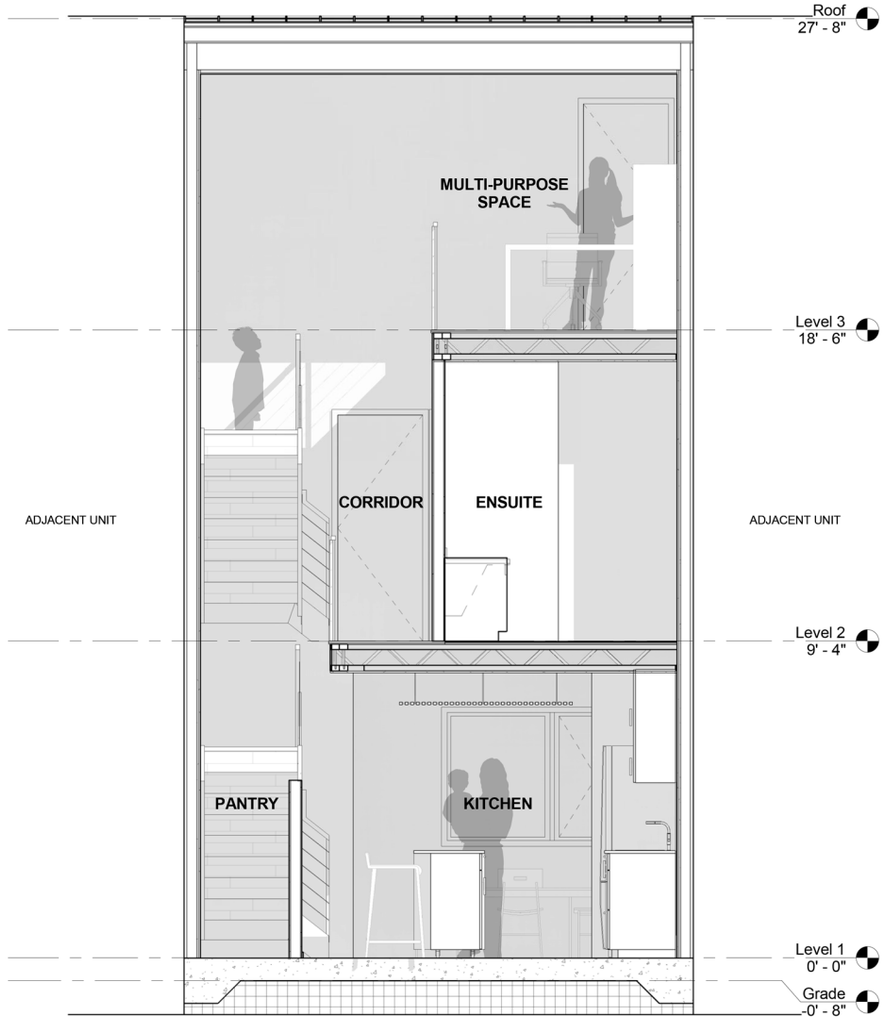


Unit Elevation - South

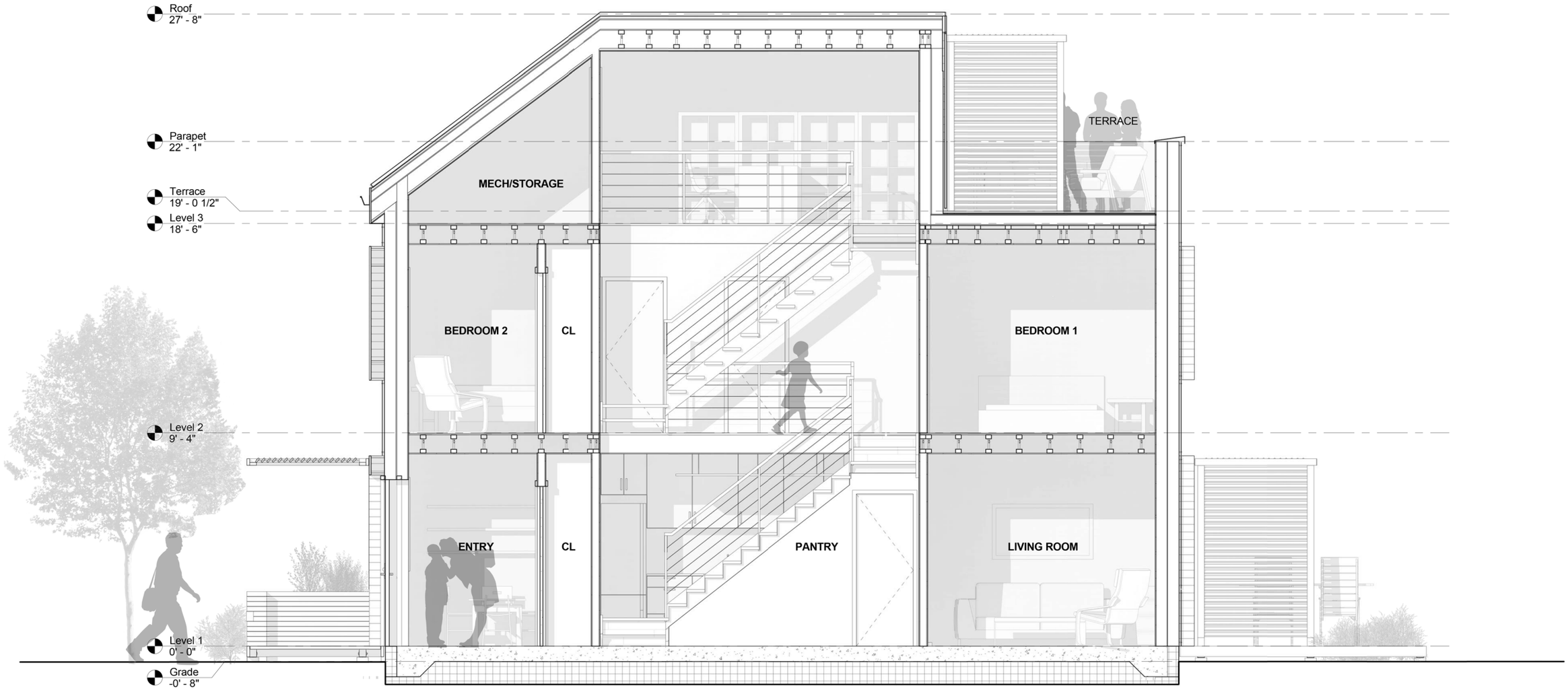
0 2 5 10 ft



Building Section - A



Building Section - B

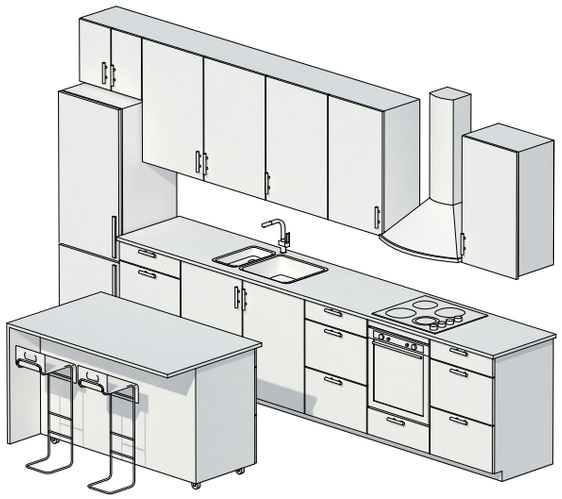


Building Section - C

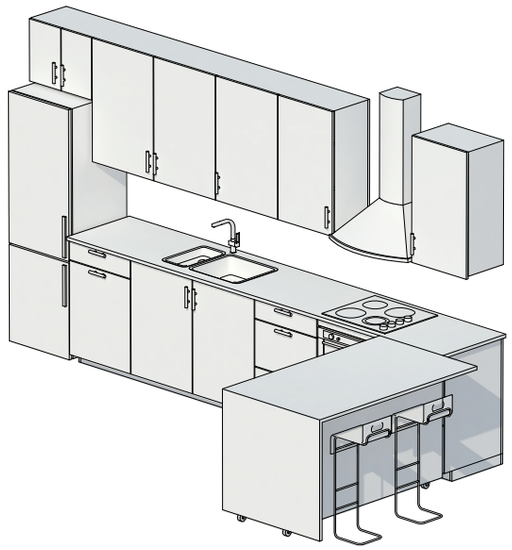
0 2 5 10 ft

Kitchen Toward Rear

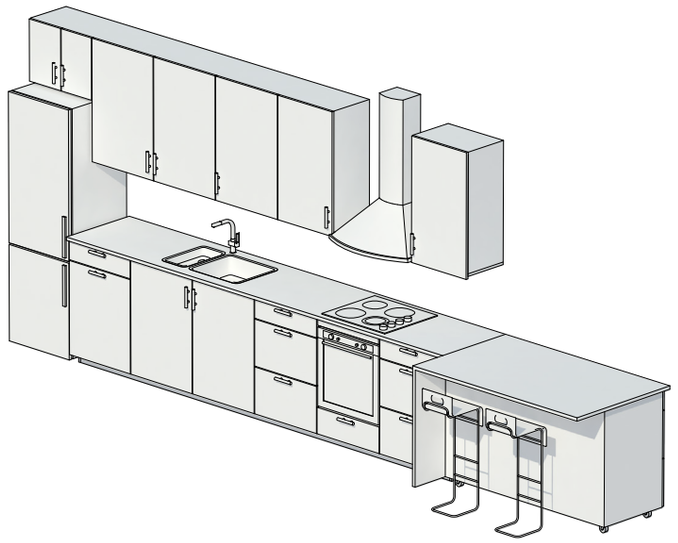
THE FLEXIBLE WORKSPACE



Centralized Island



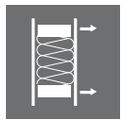
Peninsula Counter



Work Surface Extension

Second Level Gallery Stair

ENVELOPE DESIGN STRATEGIES



Eliminate thermal bridging across the entire envelope through external insulation.

Ensure an air tight envelope to limit undesired air infiltration.

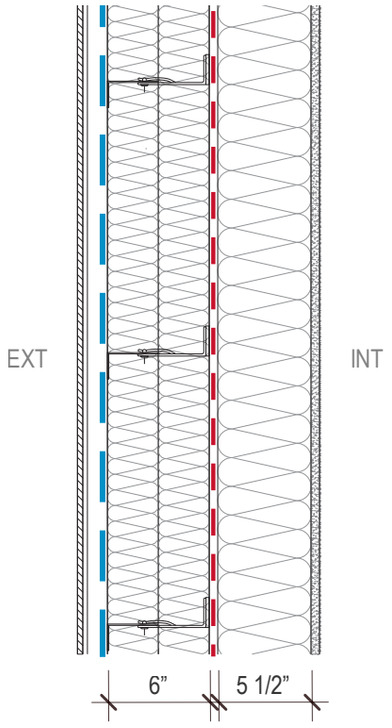
Employ a rain screen approach to drain bulk water and ventilate envelope layers.

Control solar gains through optimized glazing distribution.

Design envelope to a be highly durable using simplistic construction materials and methods.

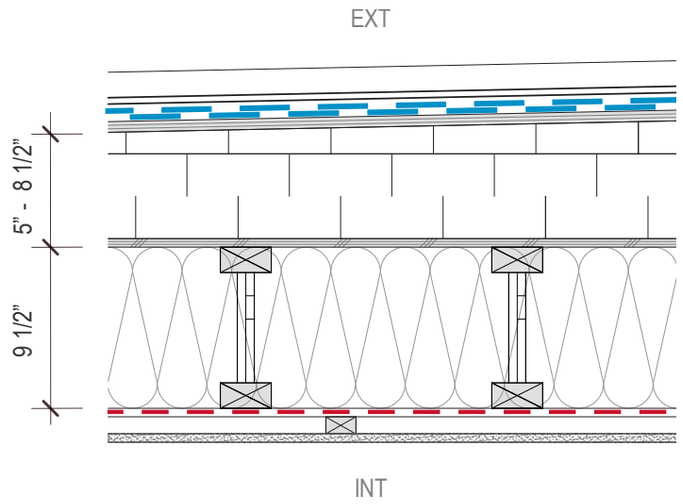
Optimize interior thermal comfort through appropriate insulation and air sealing details.

ENVELOPE ASSEMBLIES



Vertical Wall Assembly (R-44)

Fibre Cement “Ecoclad” Panel
1” Air Cavity
Tyvek Weather Barrier
2 Layers - 3” Roxul Rigid Insulation (R-25.8)
1/2” Zip System Air Barrier / Vapor Retarder
2 x 6” Structural Stud Wall (16” O/C)
5-1/2” Blown Cellulose Insulation (R-21)
1/2” Gypsum Wall Board
Zero VOC Paint Finish



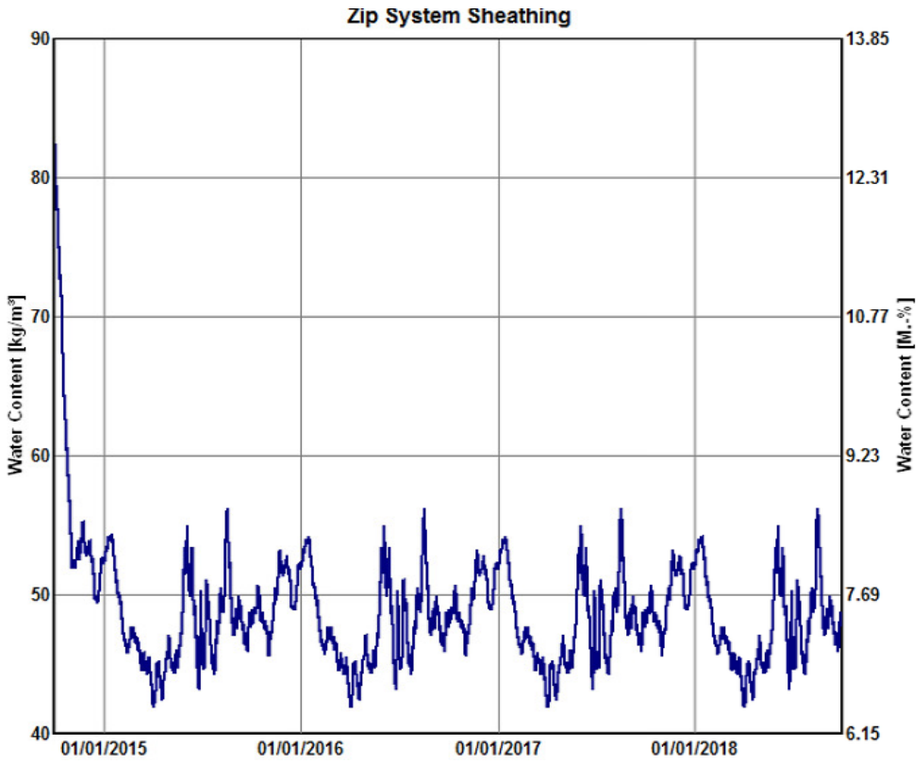
Roof Assembly (R-56)

Standing Seam Metal Roof
1” Air Cavity
2 Layers - 15lb. Roofing Felt
5/8” Plywood Sheathing
EPS Rigid Insulation (R-20)
1/2” Plywood Sheathing
2 x 10” Wood Joists (16“ O/C)
9-1/2” Blown Cellulose Insulation (R-33.25)
1/2” Zip System Air Barrier / Vapor Retarder
1” Wood Furring
5/8” Gypsum Wall Board Type X
Zero VOC Paint Finish

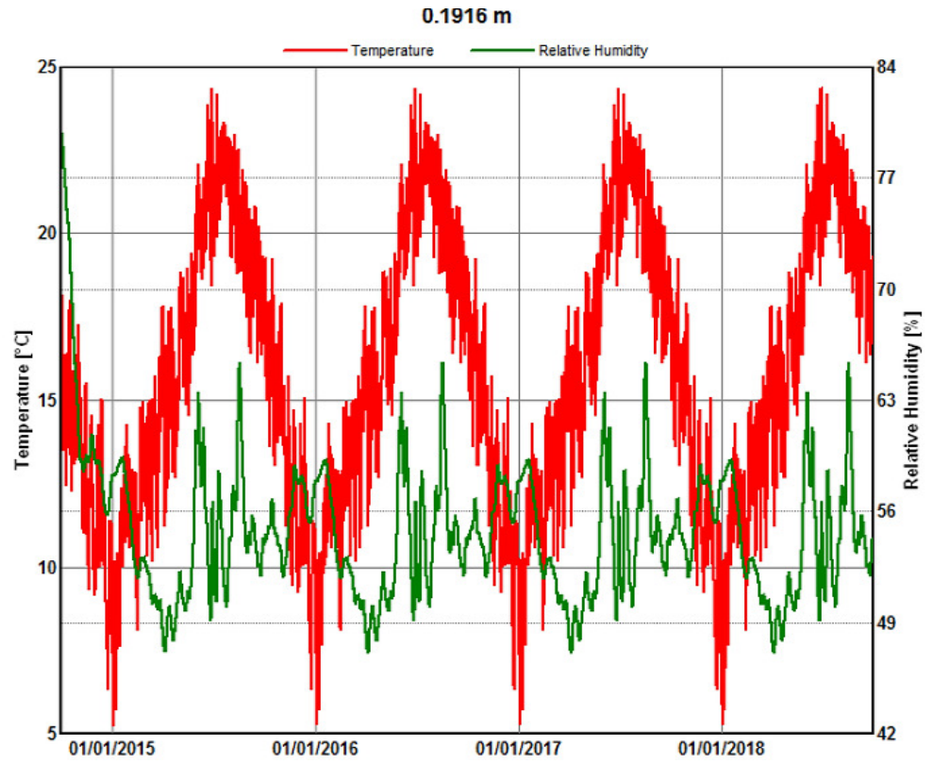
Moisture Barrier

Air Barrier / Vapor Retarder

HYGROTHERMAL ANALYSIS

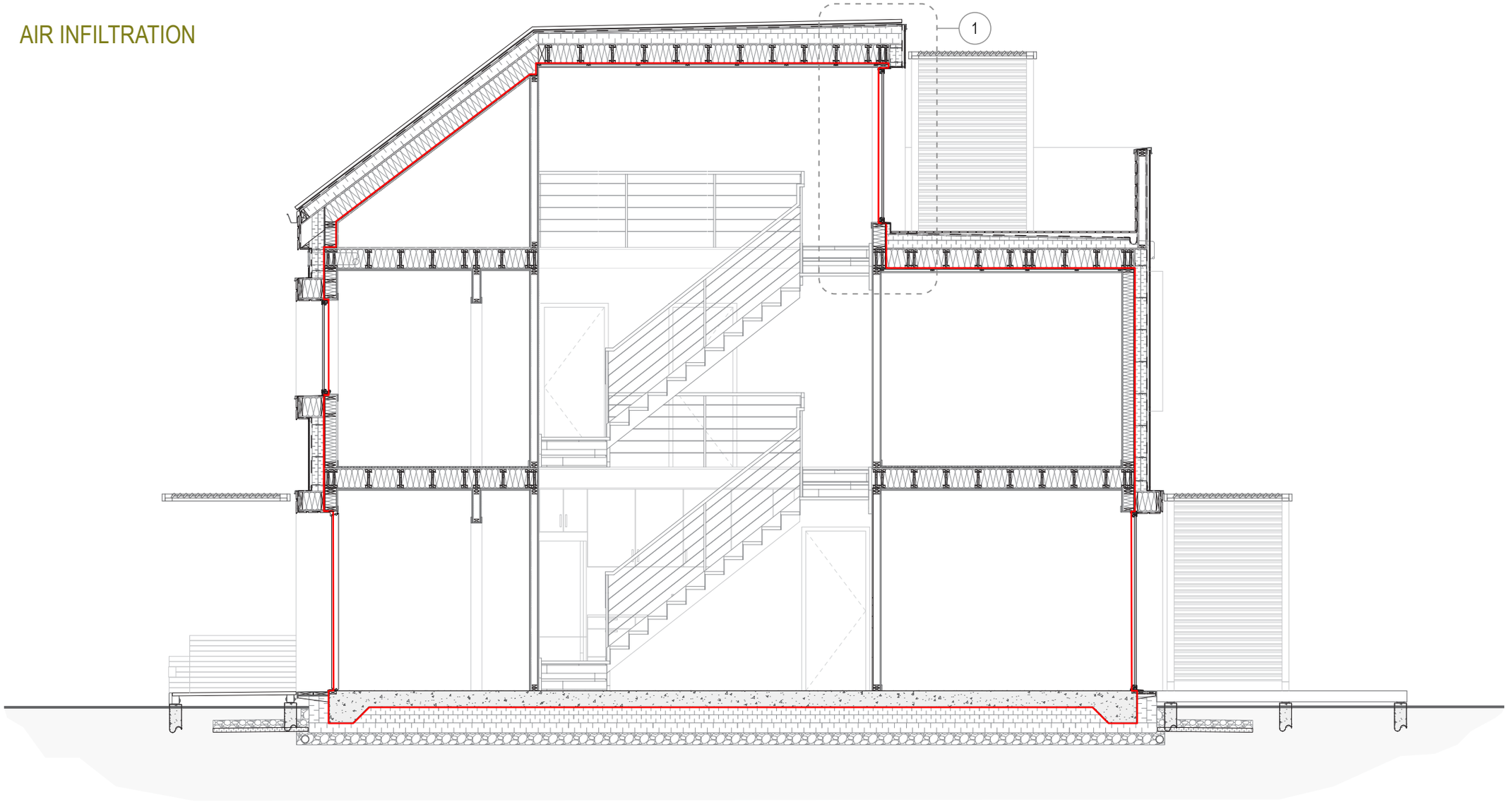


Exterior Sheathing Moisture Content



Exterior Sheathing Temperature & Relative Humidity

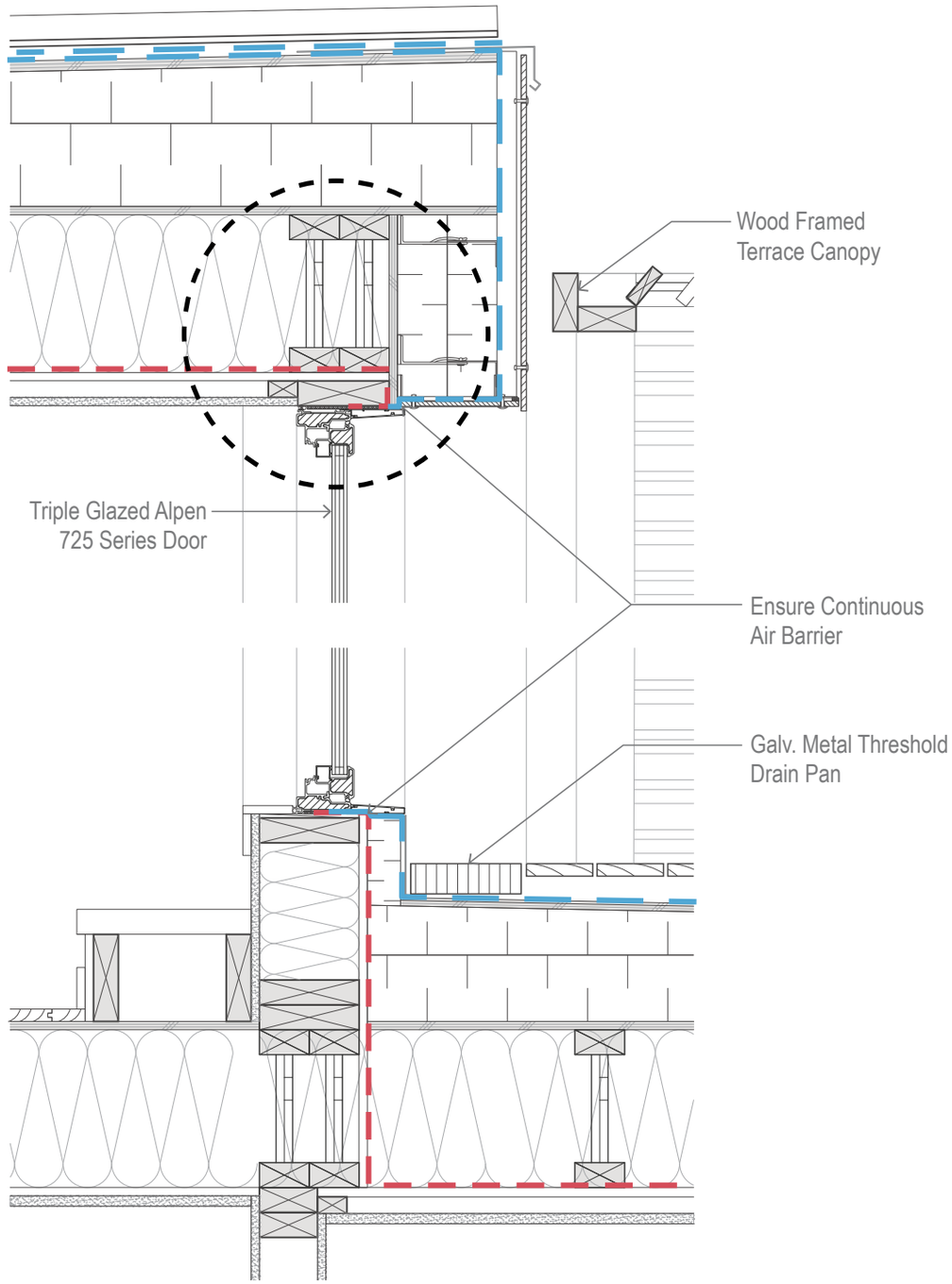
AIR INFILTRATION



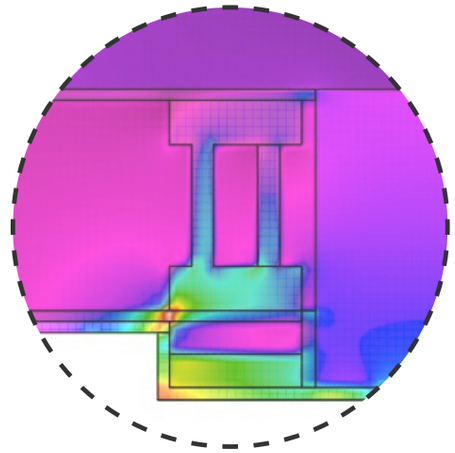
Detail Section

0 2 5 10 ft

THERMAL BRIDGING



Section Detail - Third Level Terrace Door



THERM Analysis

Moisture Barrier

Air Barrier / Vapor Retarder

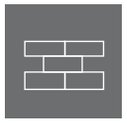
INDOOR AIR QUALITY & VENTILATION STRATEGIES

Eliminate airborne pollutants within through exceptional filtration of circulated and fresh air supply.

Incorporate mechanical ventilation systems to circulate and ventilate interior air.

Minimize noise generation and travel throughout the home.

Reduce, drain and control moisture within the building envelope.



Specify materials and finishes with low volatile organic compounds (VOCs).

Control supply and exhaust air to and from the home to ensure superior quality interior air.

Mitigate radon infiltration from surrounding soil.

SPACE CONDITIONING STRATEGIES

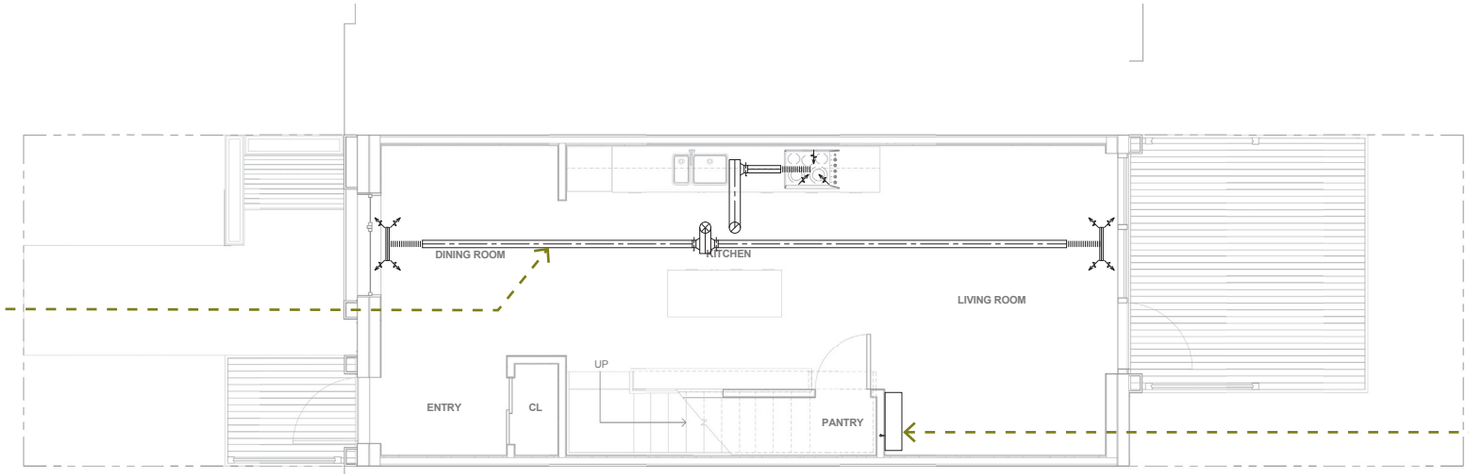
Appropriately size the mechanical system to meet the volumetric heating requirements.

Minimize operational costs throughout the mechanical system's entire life cycle.

Employ a consistent energy supply source throughout all home systems.

Minimize residual heat loss in duct runs and exhaust air.

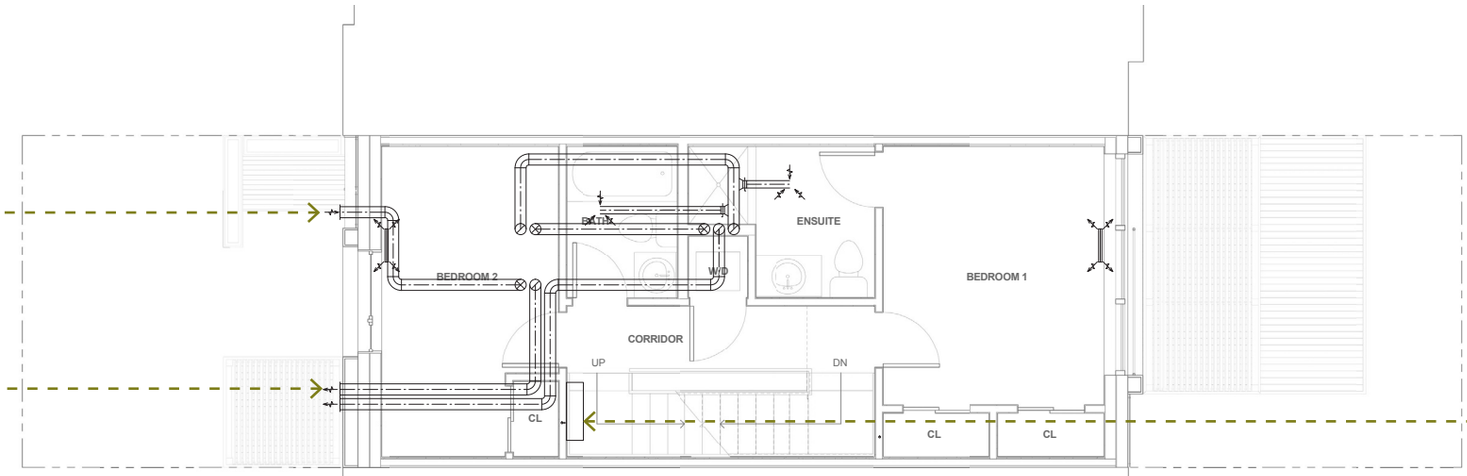
Ventilation Ductwork



Mitsubishi Mini-Split Heat Pump

Mechanical Plan - Level One

Supply Air

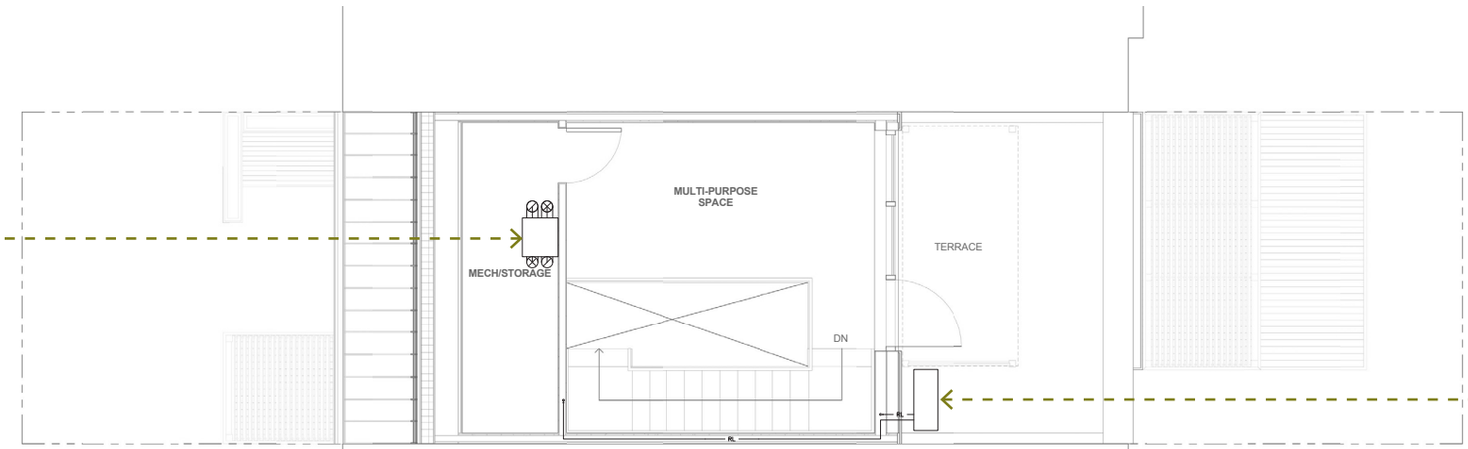


Exhaust Air

Mitsubishi Mini-Split Heat Pump

Mechanical Plan - Level Two

UltimateAir RecoupAerator ERV



Condensing Unit

Mechanical Plan - Level Three

DOMESTIC HOT WATER STRATEGIES

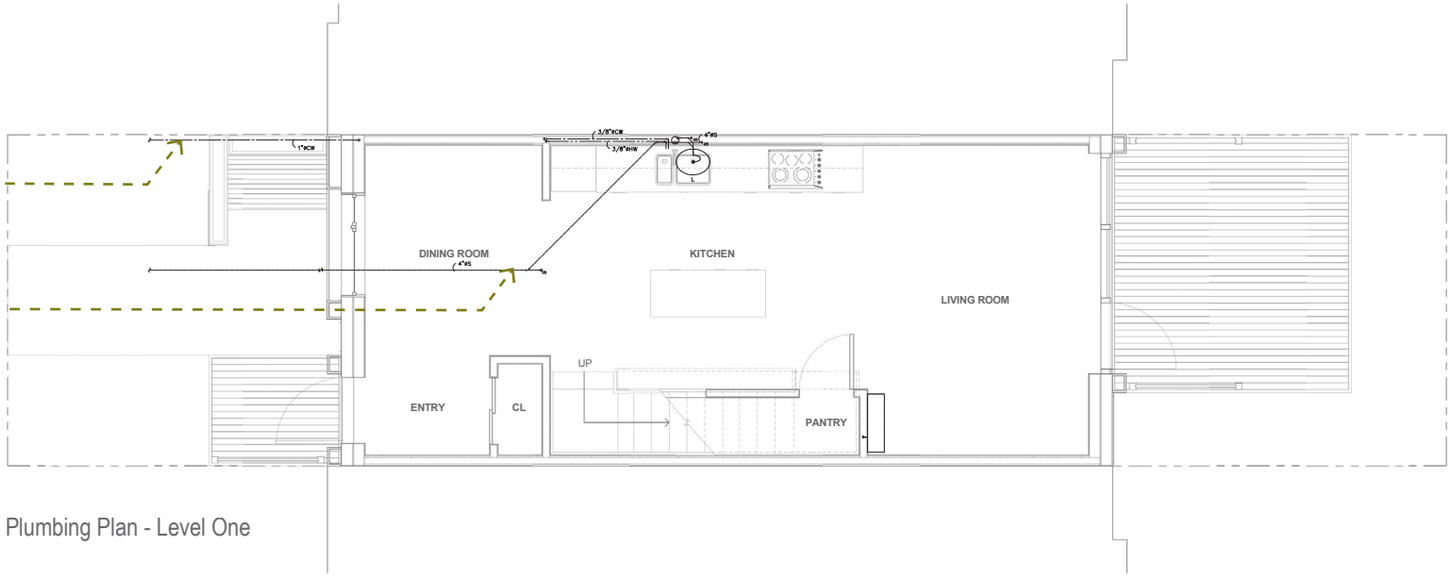
Utilize the same energy source as the HVAC system.

Minimize operational costs throughout the mechanical system's entire life cycle.

Eliminate the potential for standing water heat loss.

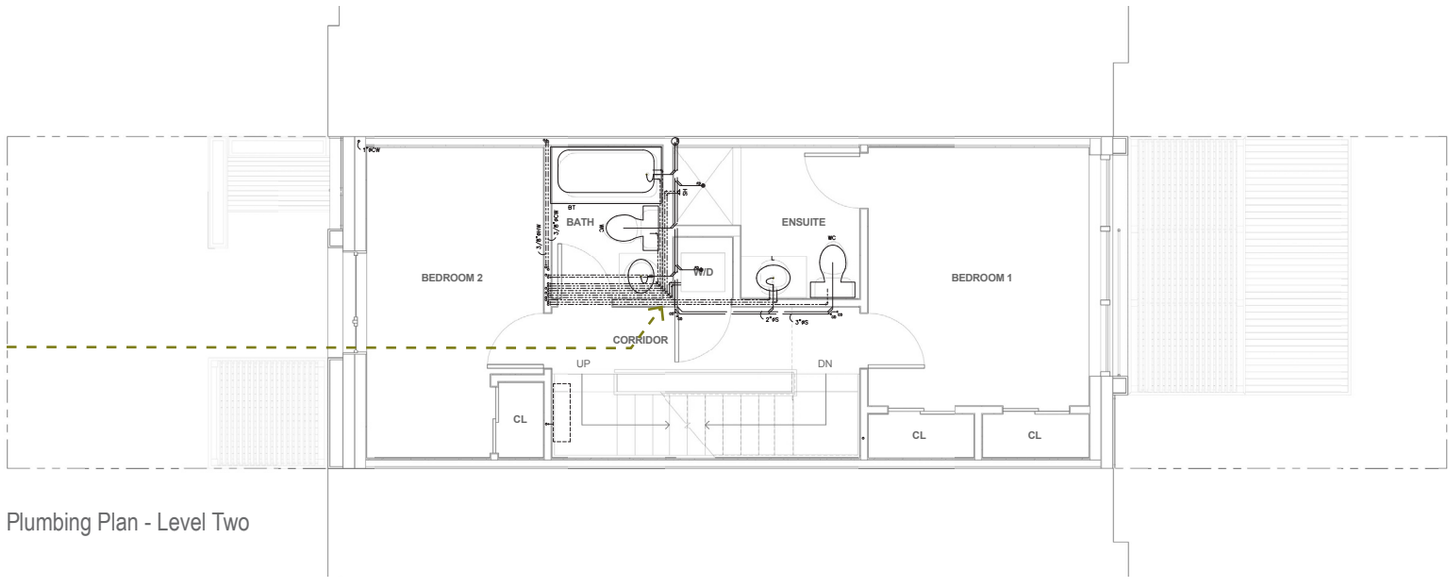
Sanitary Connection

Water Main Connection



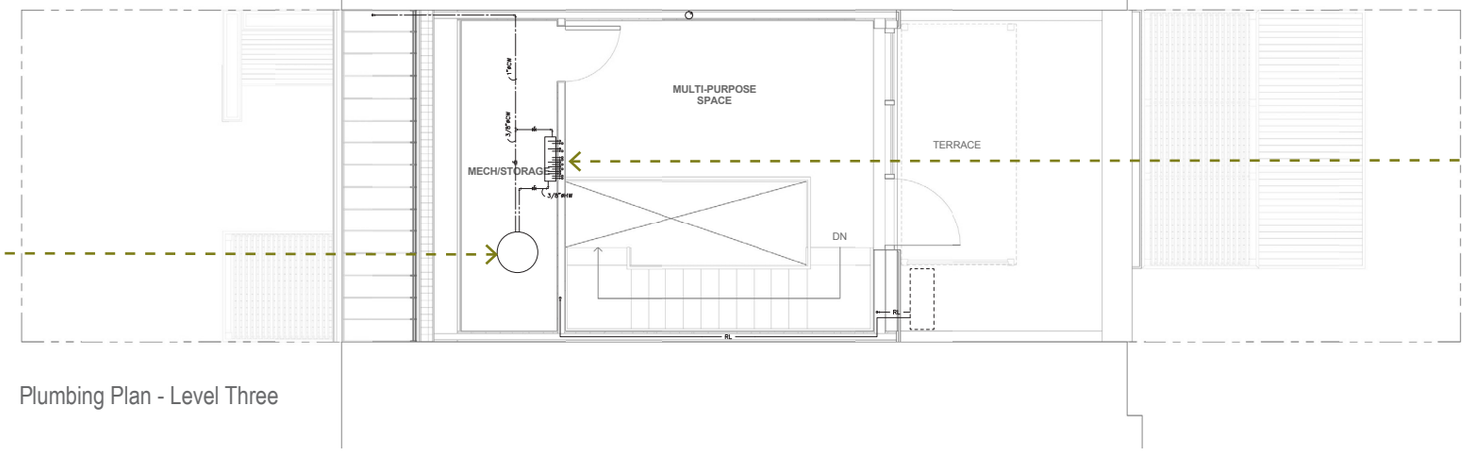
Plumbing Plan - Level One

Centralized Plumbing Stack



Plumbing Plan - Level Two

Hybrid Hot Water Heater



Plumbing Plan - Level Three

Home Run Manifold

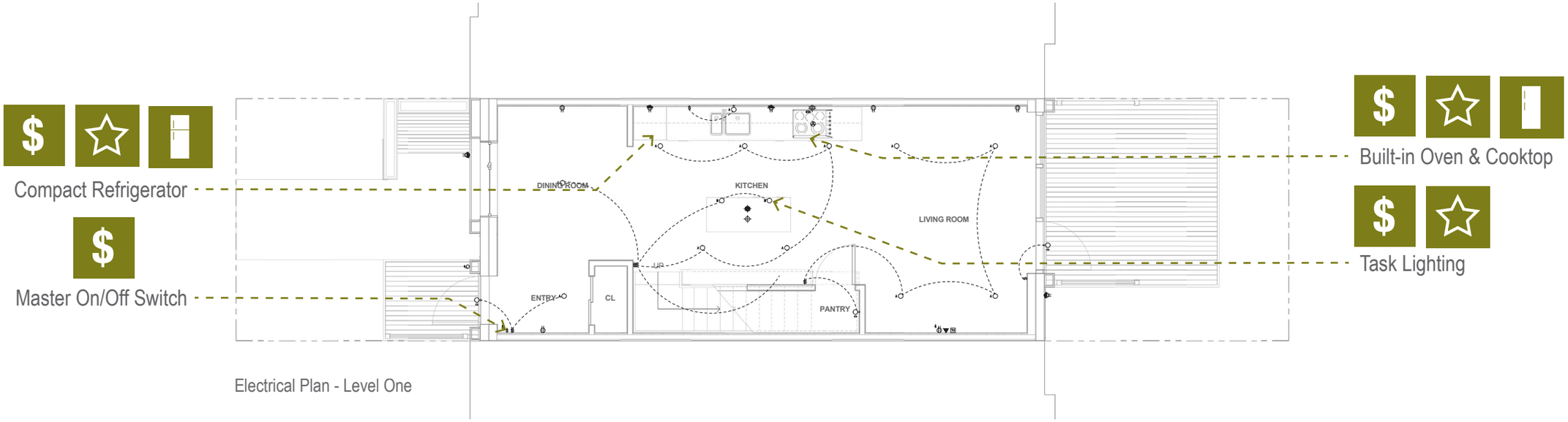
ELECTRICAL, LIGHTING & APPLIANCE STRATEGIES

Specify high efficiency fixtures and equipment to reduce annual energy consumption.

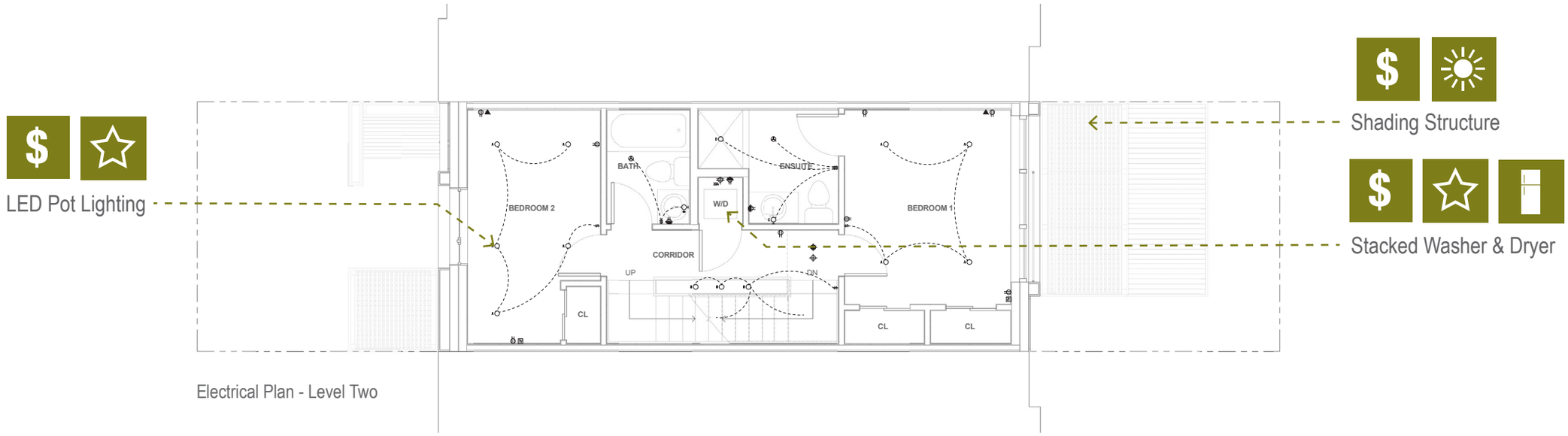
Minimize operational costs throughout the mechanical system's entire life cycle.

Specify compact appliances and equipment to alleviate space within the modest floor plate.

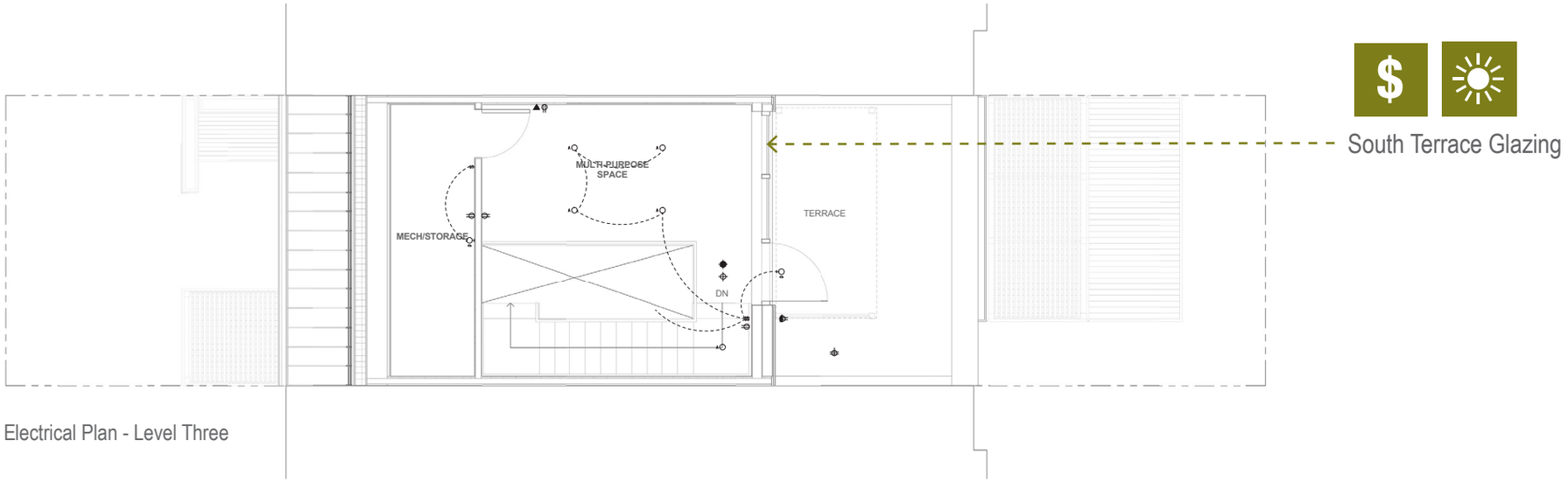
Maximize daylighting potential through the use of solar optimized glazing distribution.



Electrical Plan - Level One

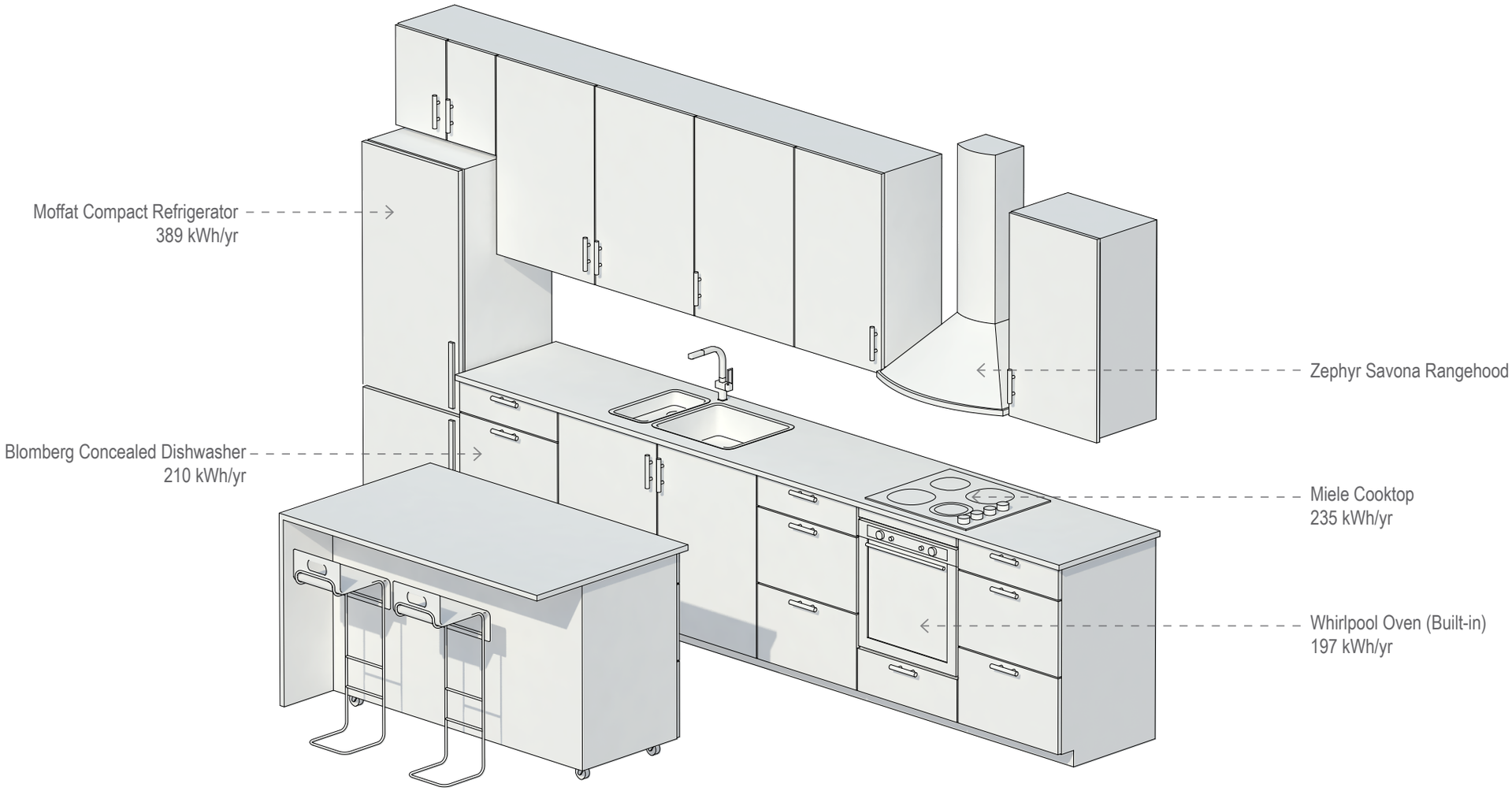


Electrical Plan - Level Two



Electrical Plan - Level Three

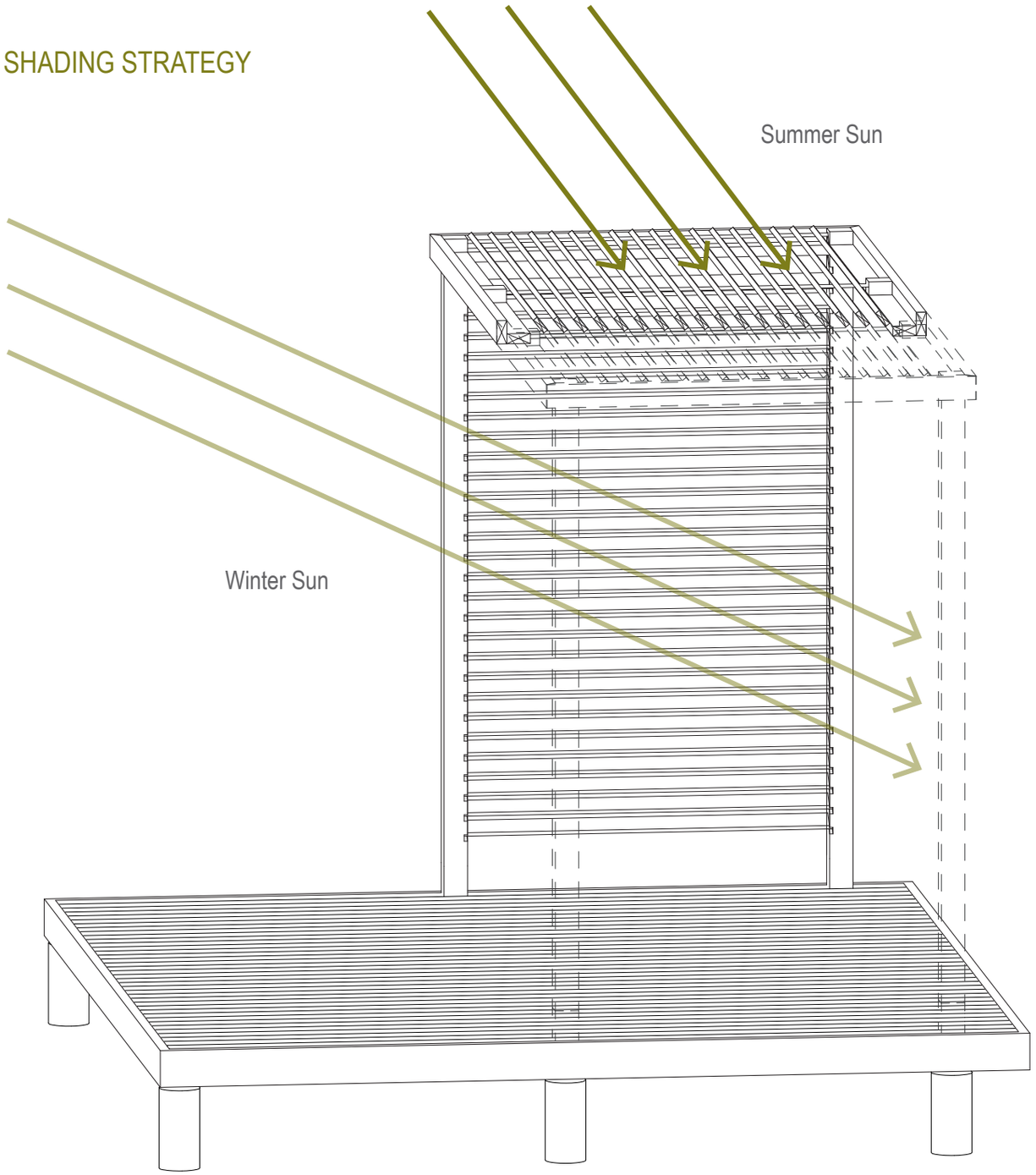
KITCHEN APPLIANCES



Annual Primary Energy Consumption **36.1 kWh/m² - yr**

Passive House Recommended **50.0 kWh/m² - yr**

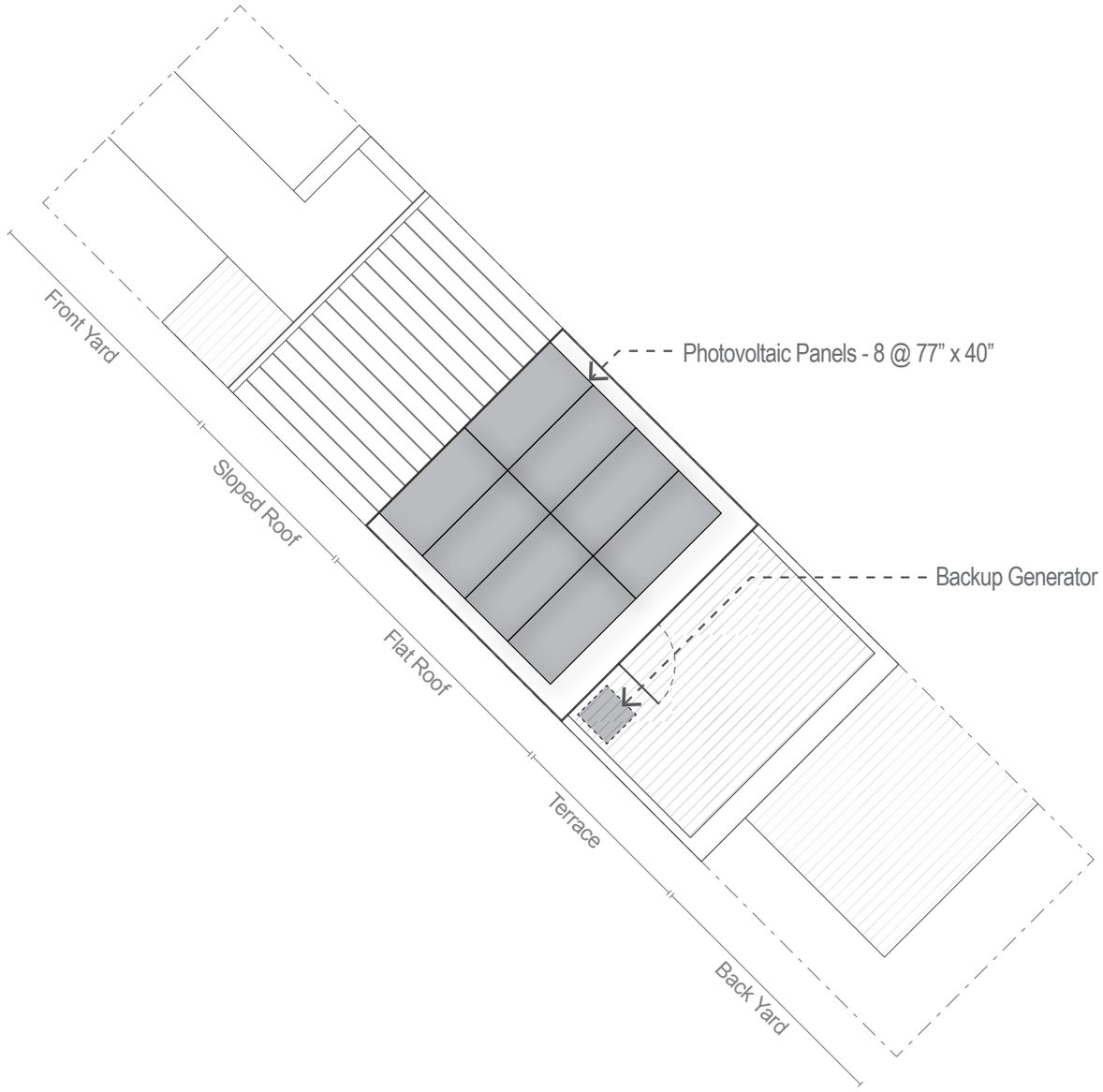
DAYLIGHTING & SHADING STRATEGY



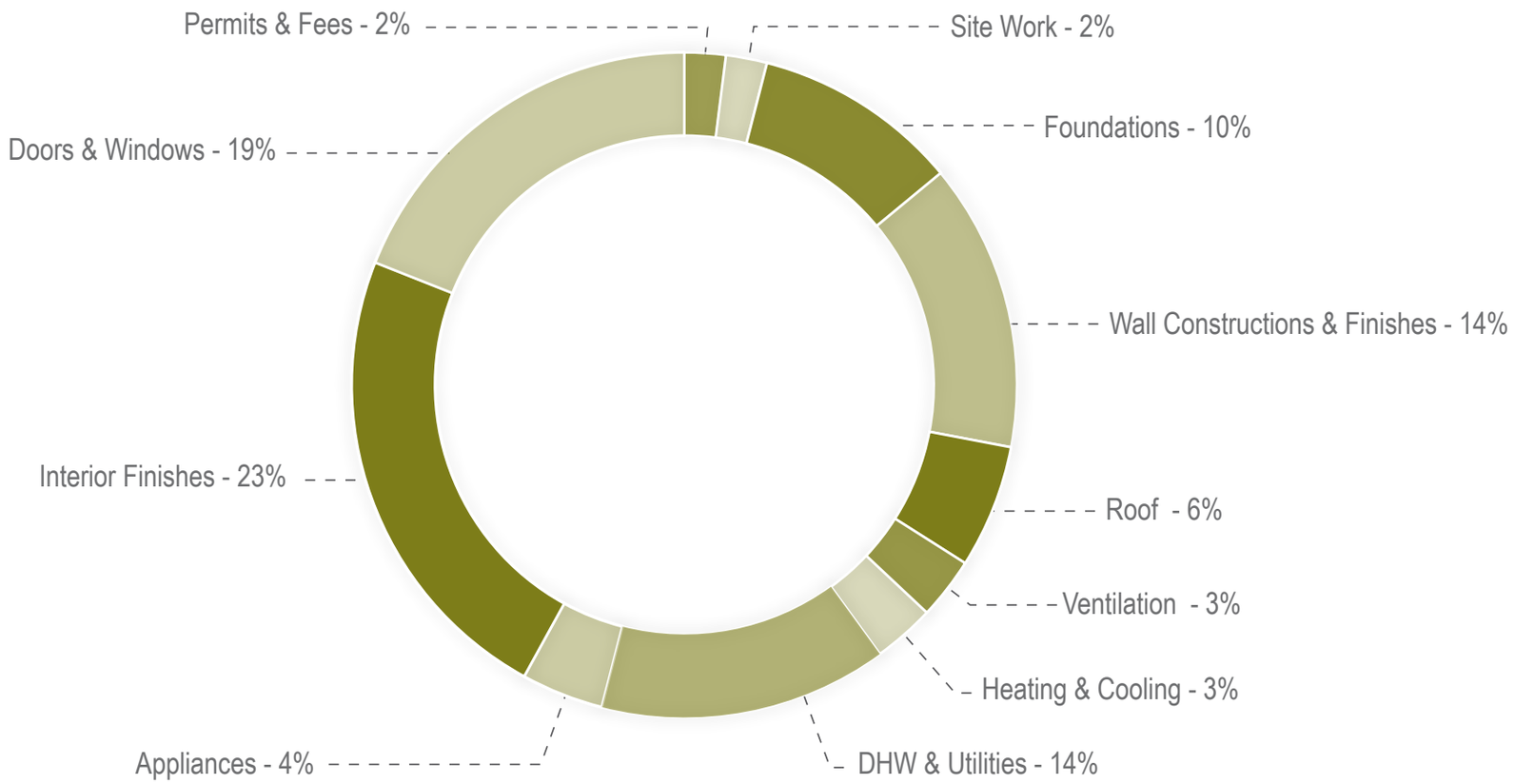
Solar Optimized Shading Canopies

PHOTOVOLTAIC INTEGRATION

Total Energy Consumption	3,800 kWh/yr
Total Energy Generation	3,010 kWh/yr
Total PV Capacity	2.4 kW
Gross Cost (Incl. Install & Tax Credit)	$7,622
Pay Back Period	10 yrs
Net Cash Flow - 25 yrs	$15,500

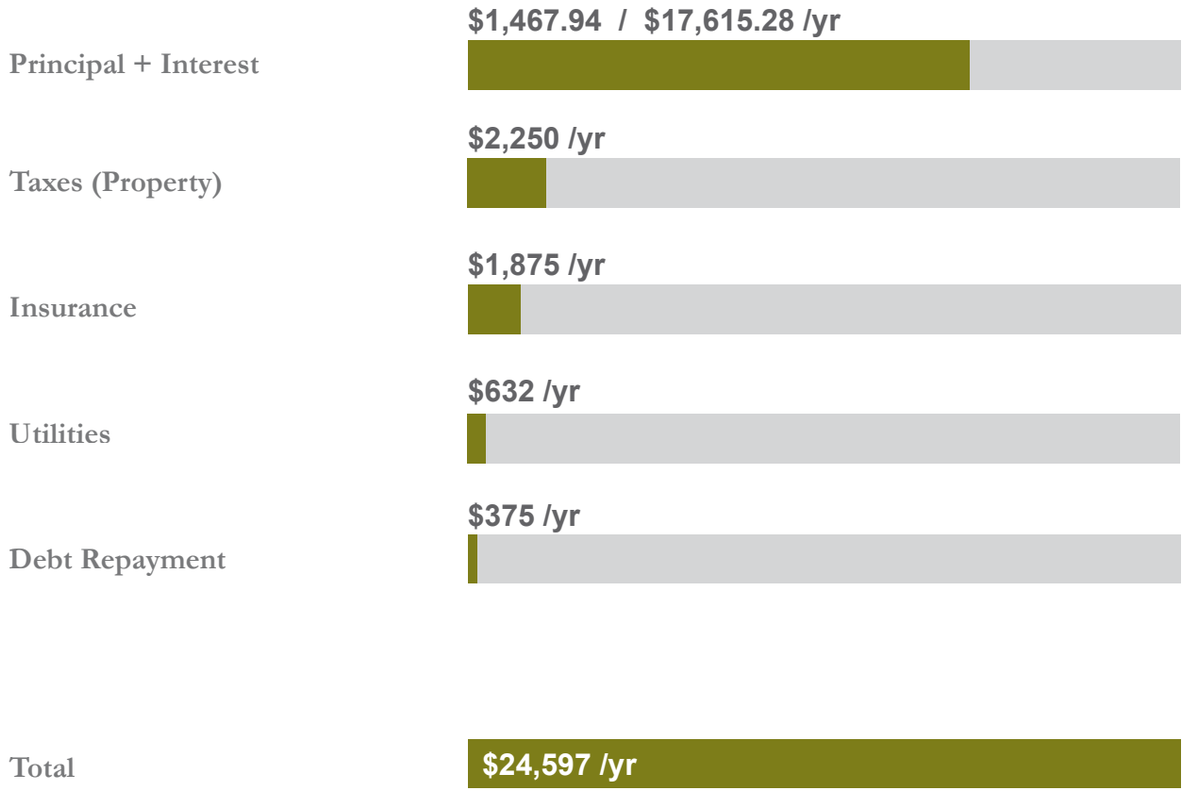


CONSTRUCTION COST ESTIMATE



Total Construction Cost	$181,000	Cost / ft²	$145	High Performance Premium	9.0%

AFFORDABILITY ANALYSIS - PITIU METHOD



AFFORDABILITY ANALYSIS - ANNUAL HOUSING EXPENSES

Median Family Income (MFI)
City of Denver

$75,000

Typical Housing Expenses (33%)

$25,000 /yr

Harvest Home

$24,597 /yr

Critical Components Replaced Twice in 30 years

$403 Net Annual Cash Flow

RATING SYSTEMS

PHIUS

Passive House Institute US

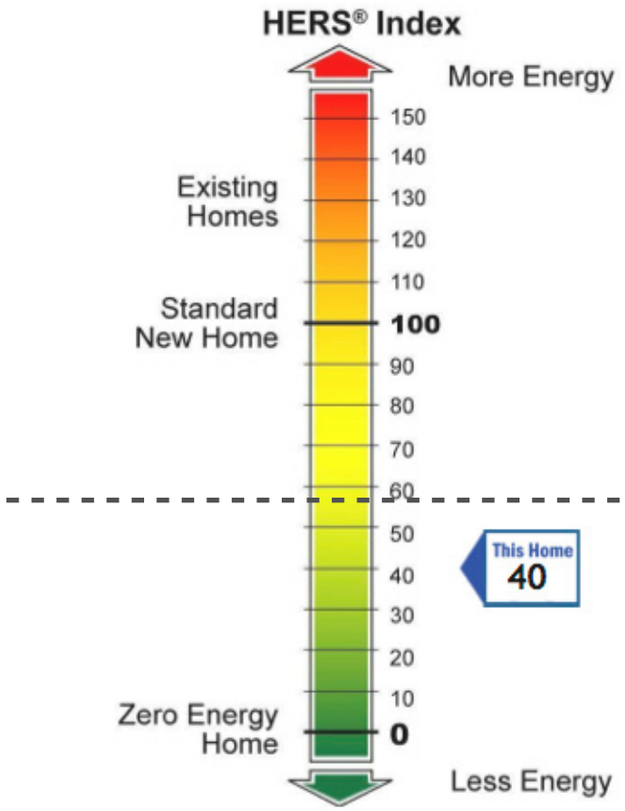
REM/Rate™ The Home Energy Rating Tool

U.S. GREEN BUILDING COUNCIL LEED USGBC®

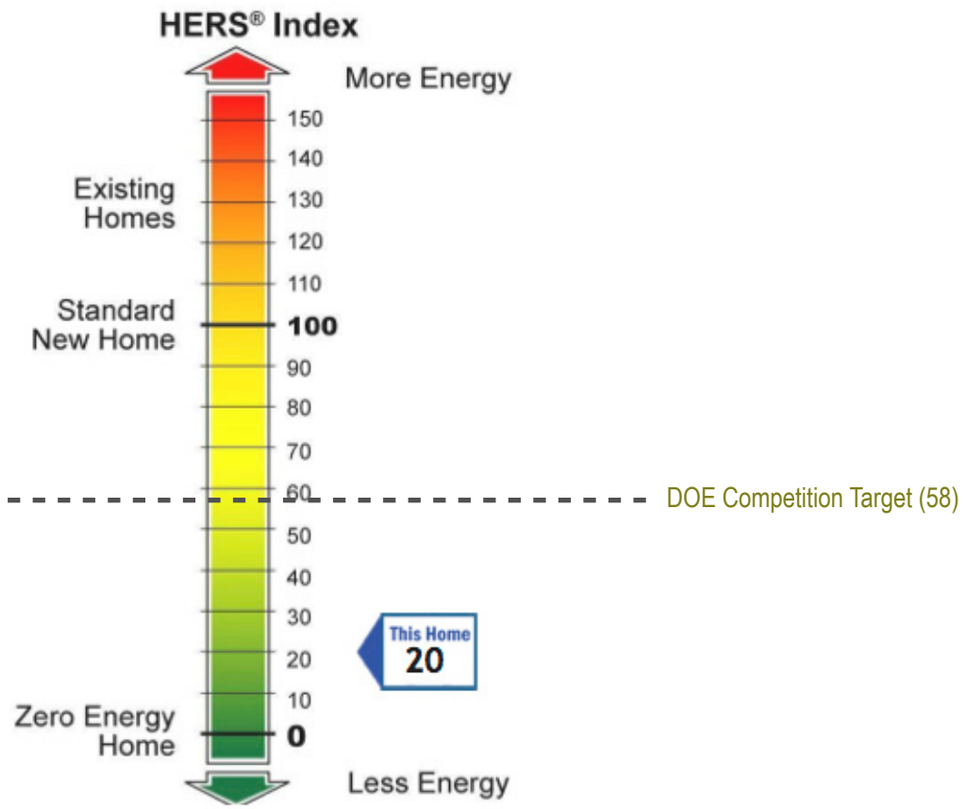
THE PASSIVE HOUSE STANDARD

	Heat Demand kBTU/ft² - yr	Cooling Demand kBTU/ft² - yr	Primary Energy Demand kBTU/ft² - yr
Passive House Standard	4.75	4.75	38
Harvest Home	2.4	1.74	37.82

HERS RATING - REM/RATE SOFTWARE

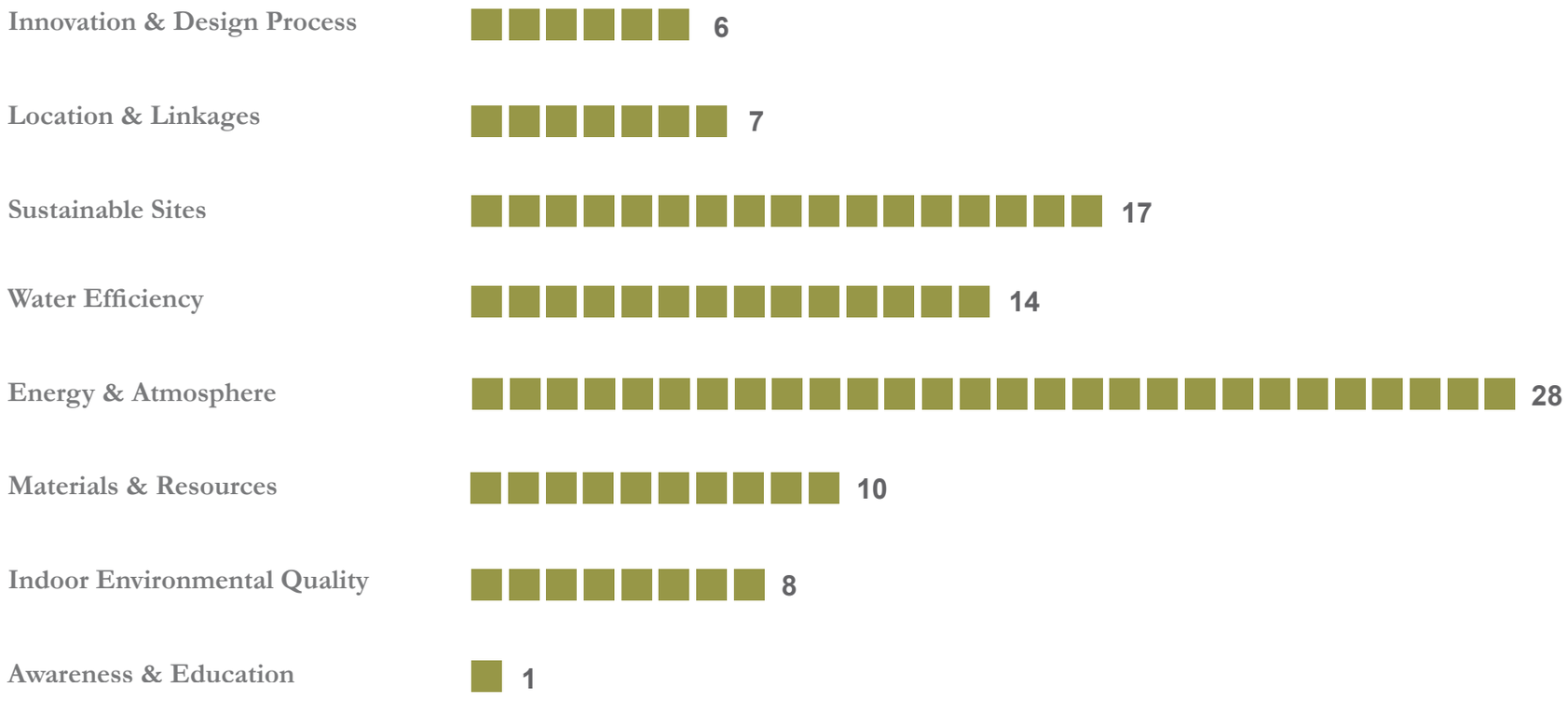


Harvest Home - Initial Construction

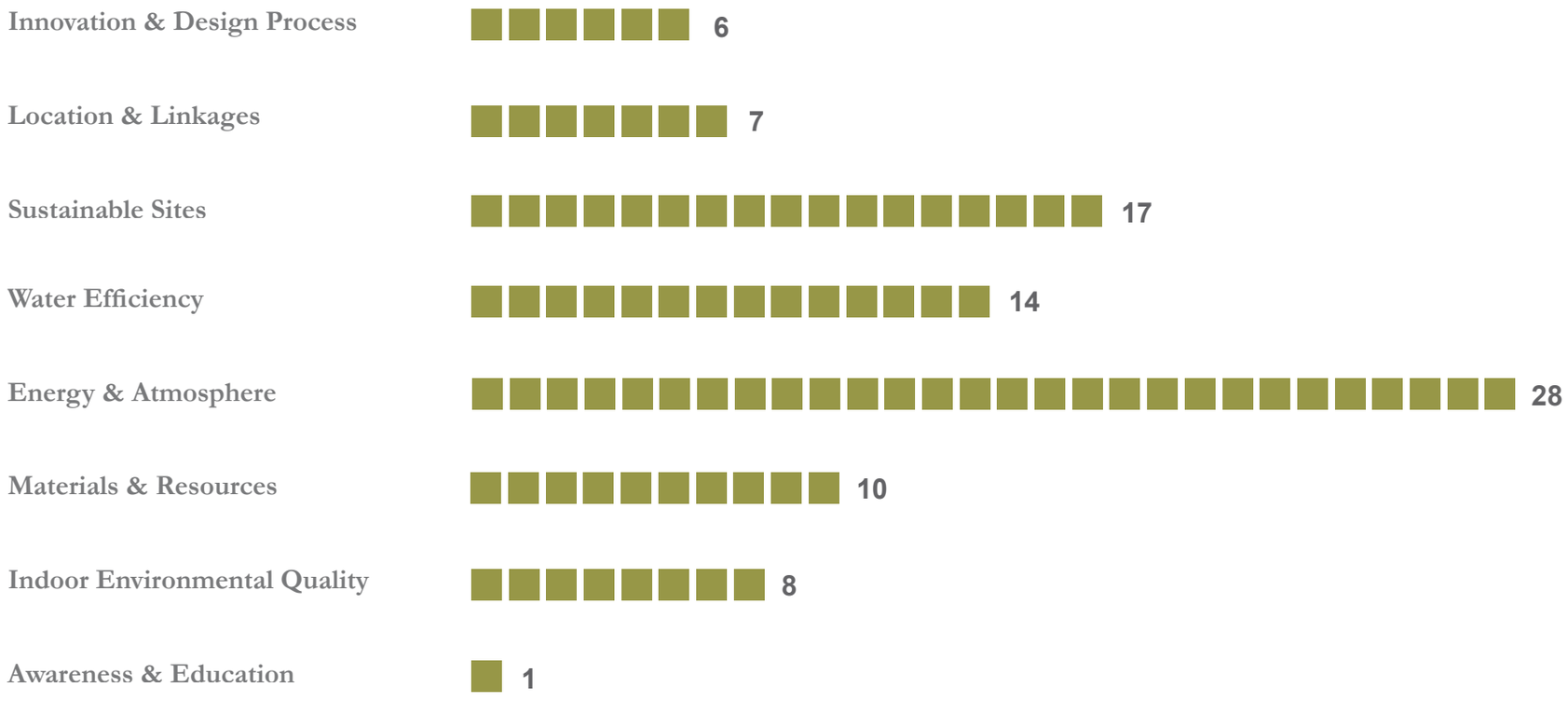


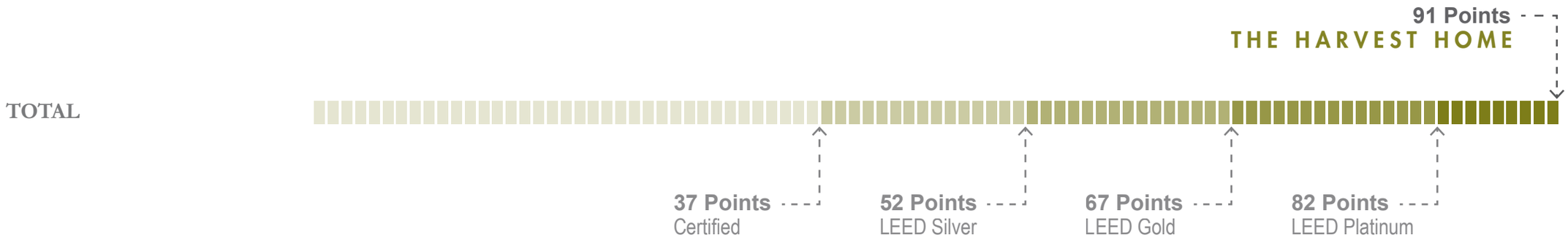
Harvest Home - On-site Photovoltaic Panels

LEED FOR HOMES



LEED FOR HOMES





	AVERAGE COLORADO RESIDENCE	THE HARVEST HOME
HERS Rating	100	40
Passive House U.S.	N/A	Certified
LEED Certification	N/A	Platinum - 91 pts
Annual Energy Consumption	102,000 kBTU/yr	23,600 kBTU/yr
Annual Heating + Cooling Cost	$1,551 /yr	$632 /yr
Gross Area	2,082 sf	1,175 sf
Construction Cost / ft^2	$120 - $300 /sf	$146 /sf

Third Level South Terrace

THE HARVEST HOME

RYERSON UNIVERSITY | TORONTO, CANADA