University of Minnesota

DOE “Race to Zero” Student Design Competition

University of Minnesota: Team OptiMN

Introduces the “IMPACT Home”

MULTI-DISCIPLINARY TEAM*

Residential Building Science

Collin Coltman
Matthew Dries
Maria Finsness
Tyler Kitzerow
Frank Peters
Peter Schneider
Kristel Spiegelberg
Cavan Wagg

Construction Management

Collin Coltman
Jose Aaron Cruz-Salinas
Kyle Holmes
Jackie Larson
Peter Schneider

Business & Marketing Education

Aaron Hanson

Master of Science Sustainable Design & Masters in Architecture

Laurel Johnston

Bioproducts & Biosystems Science, Engineering, & Management

Maria Fernanda Laguarda Mallo (PhD candidate)

* All 14 team members successfully completed their building science coursework

EXCELLENT PARTNERS

Urban Homeworks
Minneapolis, MN
Affordable Housing Developer

- Builder of communities
- Rebuilder of neighborhoods
- Providing equitable and dignified housing

URBAN HOMEWORKS

Residential Science Resources
Eagan, MN
Building Science Consultants

- Energy rating services
- Building science consulting
- Energy audits/assessments
- Utility program deployment

RSR residential science resources

MEET YOUR PRESENTERS

Laurel Johnston
Design Leader

Master of Science Sustainable Design & Masters in Architecture

I'm inspired by an ancient Native American proverb: "We do not inherit the earth from our ancestors, we borrow it from our children".

Peter Schneider
Envelope Leader

Residential Building Science & Technology & Construction Management

I enjoy finding new ways to make homes beautiful and high performing. I believe we can, and should build homes that lasts for generations.

Cavan Wagg
Systems Leader

Residential Building Science & Technology

I've enjoyed the experience that the DOE Race to ZERO competition has given me and plan to put that knowledge to work in the field after graduation.

Collin Coltman
Team Leader

Residential Building Science and Technology & Construction Management

I dream of building the sustainable, high performance homes of the future, but today.

SOCIAL GOALS | Site in North Minneapolis

- Hit hard by foreclosure crisis
- Struck by tornados in 2011
- Many vacant lots, including site
- Green Homes North: to build 100 energy-efficient homes on empty lots

DESIGN GOALS

Department of Energy's CHALLENGE
is to build a Zero Energy Ready Home

Urban Homeworks' MISSION
is to produce equitable, dignified, communities

Green Homes North INITIATIVE
is to revitalize North Minneapolis neighborhoods with affordable, sustainable, and quality homes

Team OptiMN's GOAL
is to design a home that makes an **IMPACT** on the community and environment by achieving all of the above

ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

URBAN HOMEWORKS

GreenHomes North

PERFORMANCE GOALS | DOE Climate Zone 6

Durable & Long-Lasting

ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

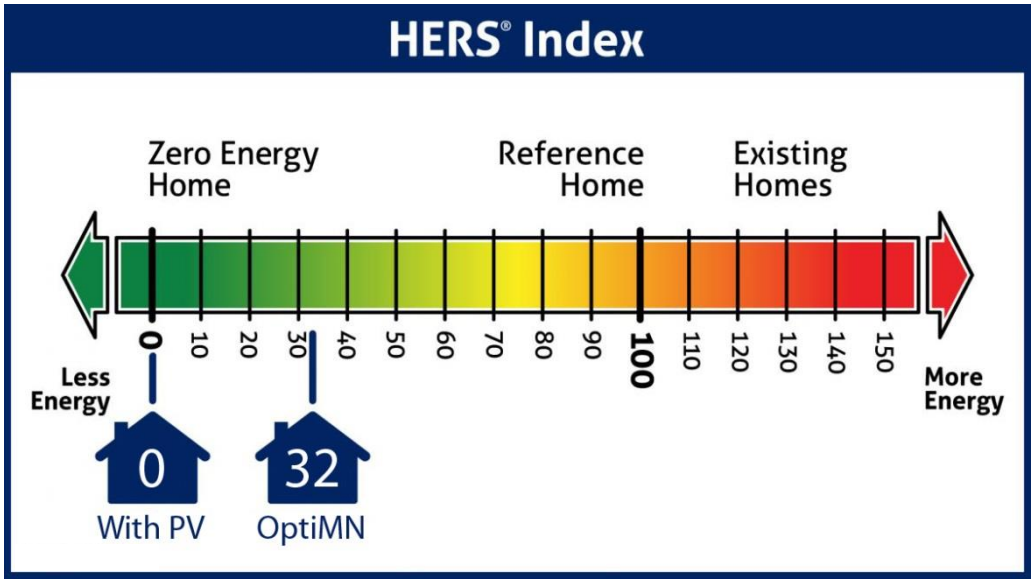
Fortified Home

FORTIFIED HOME

Indoor Air Quality

EPA Indoor airPLUS
QUALIFIED HOMES

Energy Efficient | Zero Energy Ready



Water Stewardship

WaterSense
Meets EPA Criteria
SM

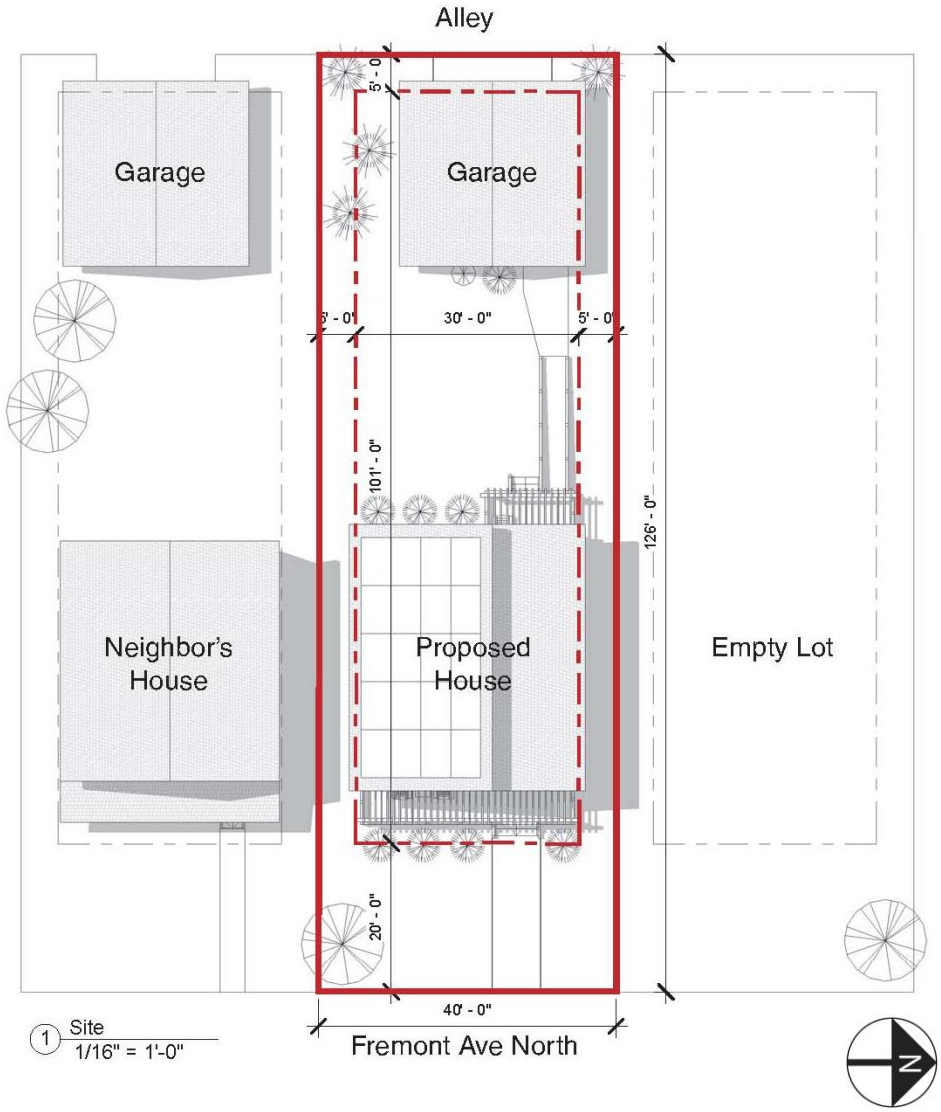
PERFORMANCE GOALS | Key Strategies

- ENERGY STAR appliances, fans, and windows
- WaterSense low-flow plumbing fixtures
- Native vegetation
- Harvesting rainwater with rain barrels
- LED light bulbs
- HardiePlank lap and shingle siding
- Low-VOC paints & finishes
- tenK solar panels
- Programmable thermostat
- Continuous ventilation system
- Engineered heating and cooling systems
- Whole house air exchanger
- Efficient sealed-combustion water heater
- Concrete with fly ash content
- Job site recycling of construction waste

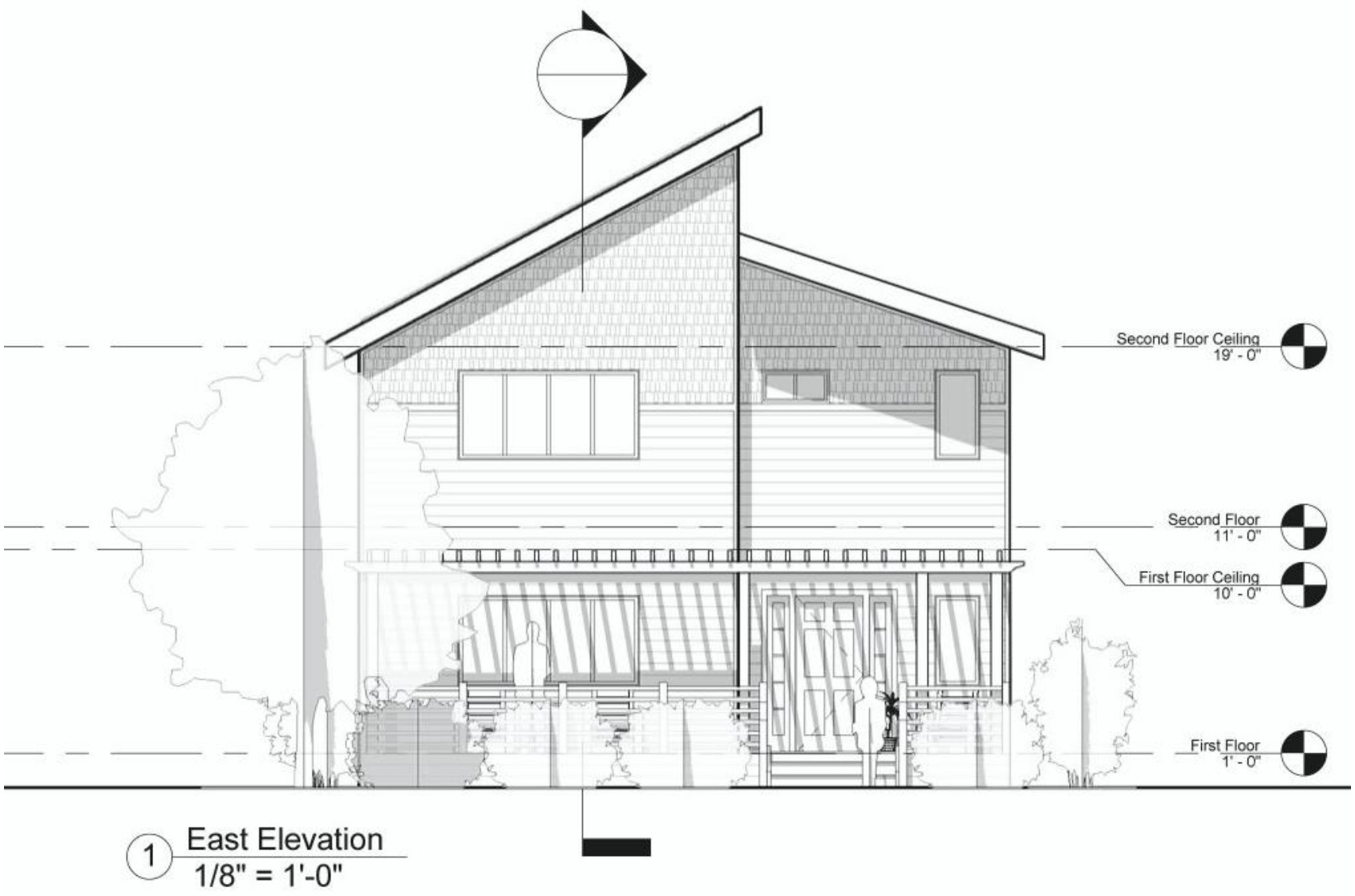
ARCHITECTURAL GOALS | Perspective from Fremont Ave

ARCHITECTURAL GOALS | Site Plan

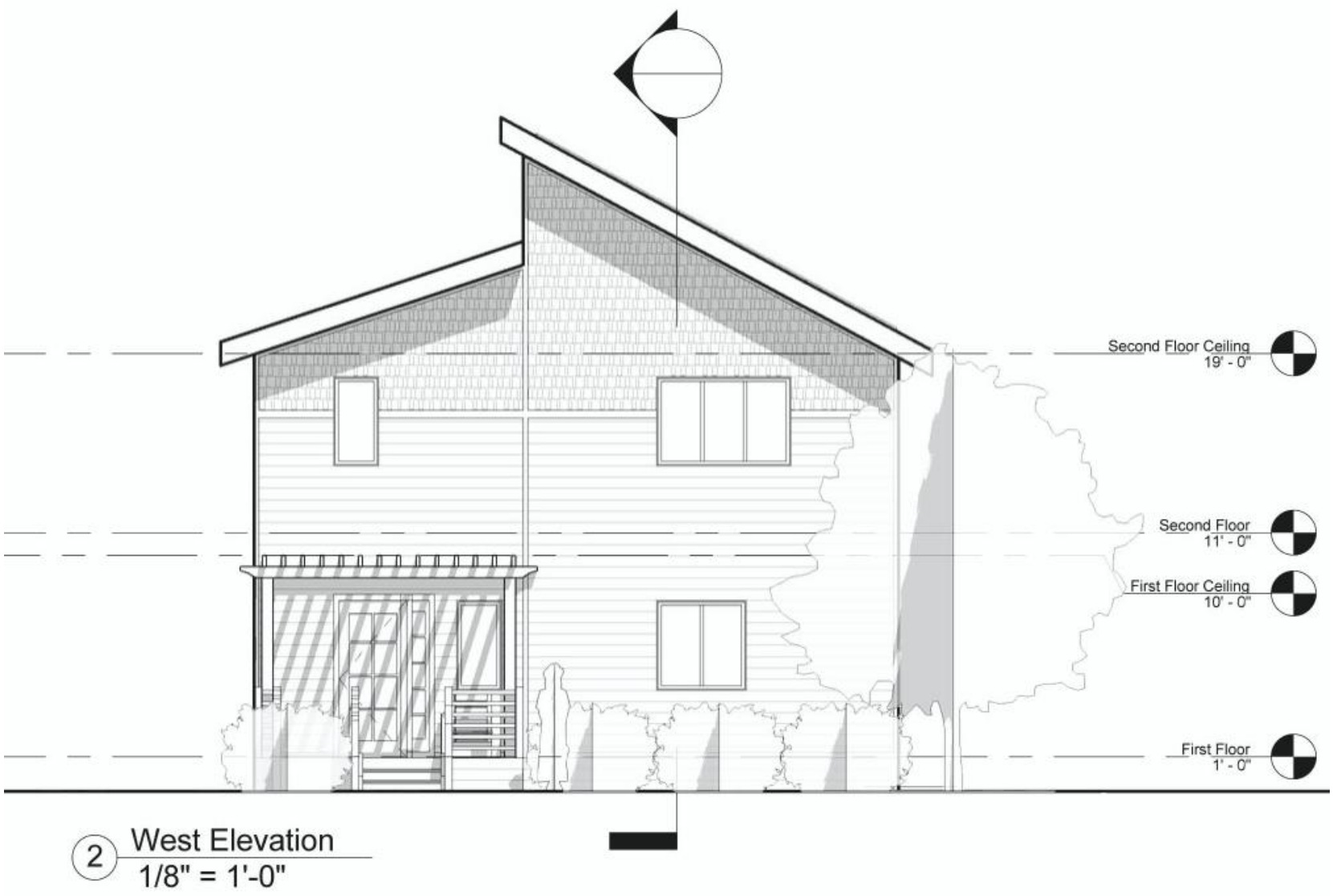
- Front faces East
- Longer side oriented South to take full advantage of the sun
- Most Minneapolis residential sites work perfect with this design because they face East or West
- Two-story design ensures better solar access



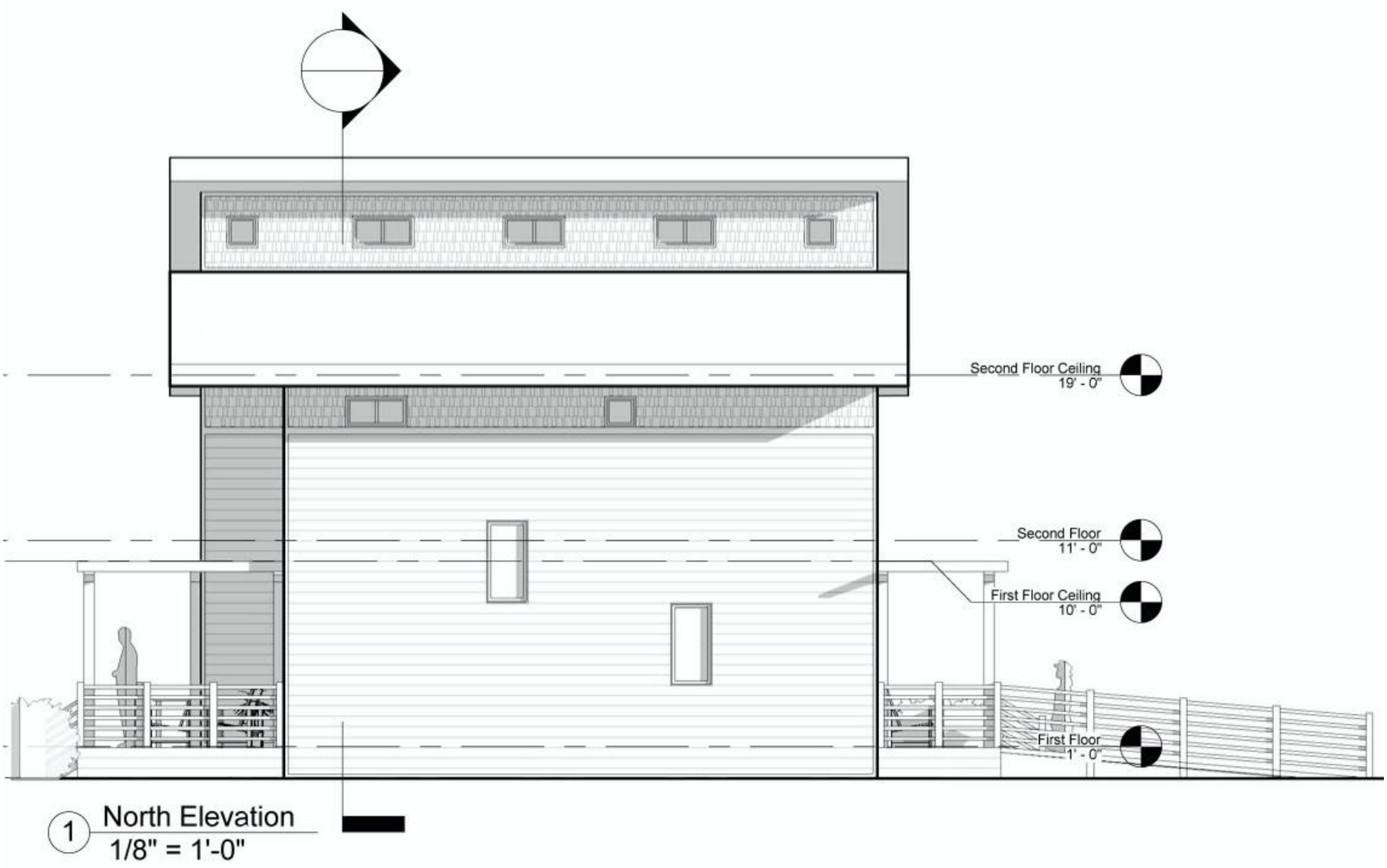
ARCHITECTURAL GOALS | East Elevation (front)



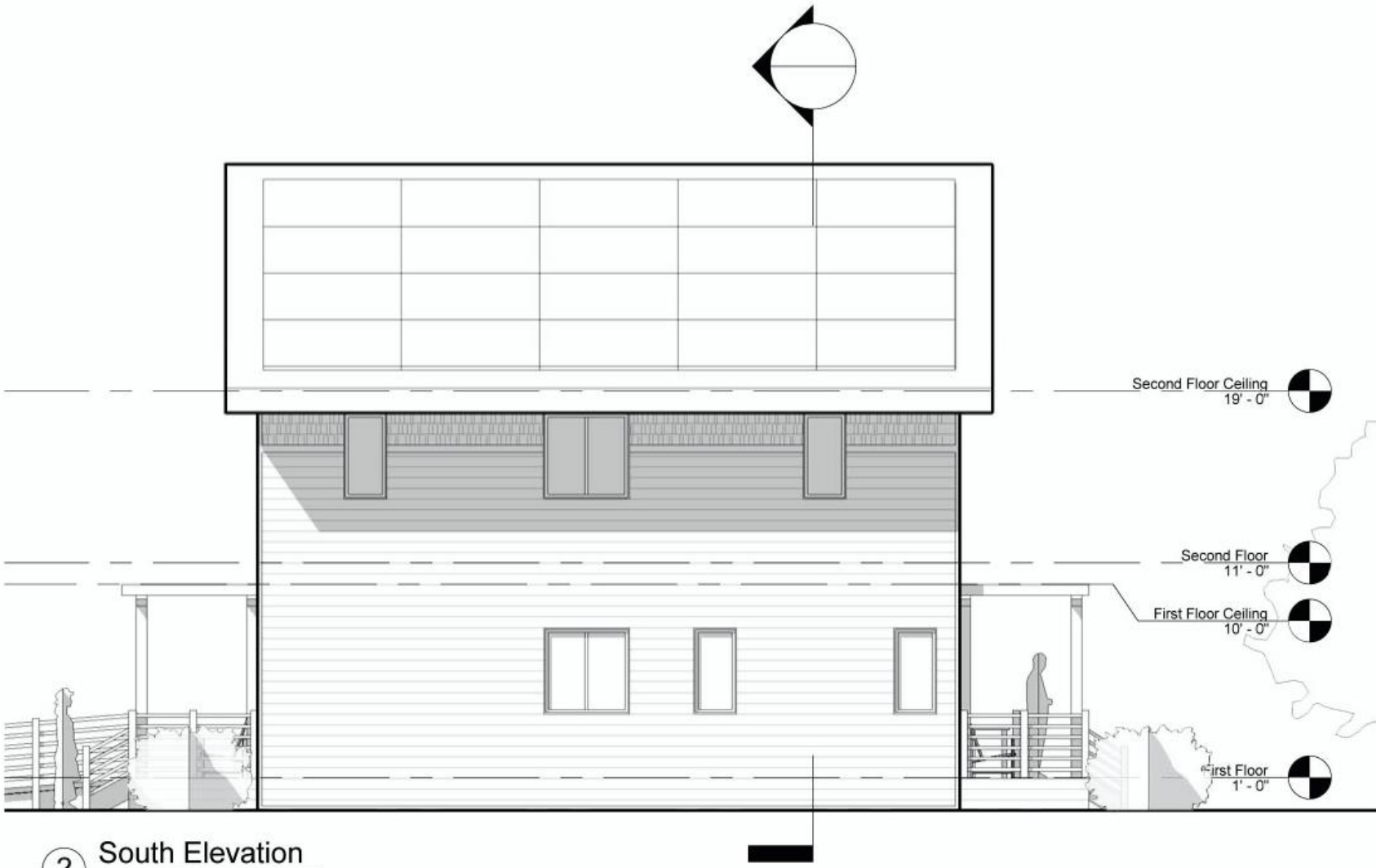
ARCHITECTURAL GOALS | West Elevation (back)



ARCHITECTURAL GOALS | North Elevation



ARCHITECTURAL GOALS | South Elevation



2 South Elevation
1/8" = 1'-0"

ARCHITECTURAL GOALS | Efficient & Flexible Space Planning

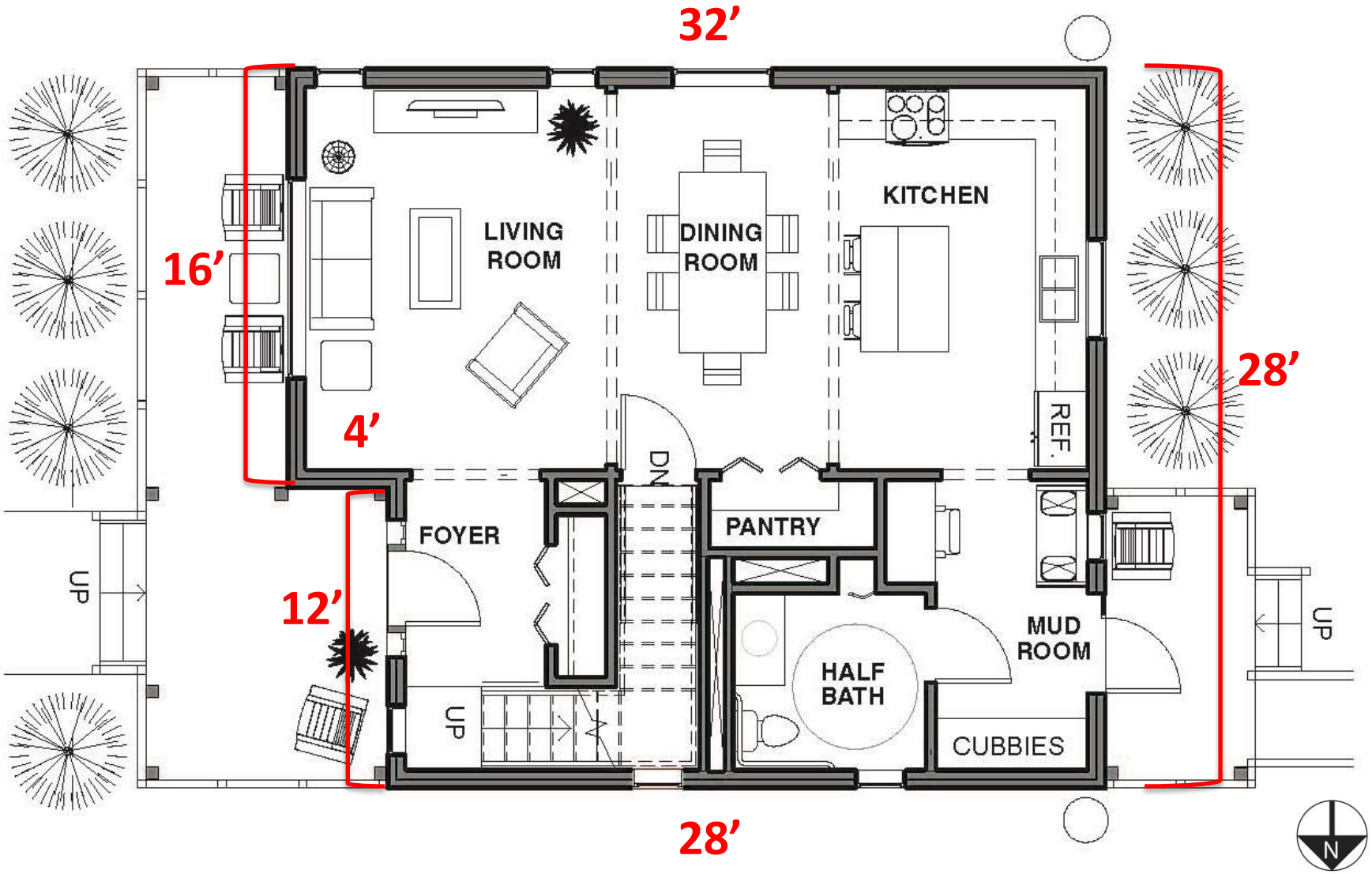
- Overall footprint **simple & compact**
- Finished **floor area = 1,696 sf**
  - Plus **848 sf** if lower level is finished
- **3 Bedrooms** (+2 in lower level)
- **1.5 Bathrooms** (+1 in lower level)
- **Two Zones**
  - **Living Spaces**
    - Living room, dining room, kitchen, & bedrooms
    - Take advantage of southern exposure & light from clerestory windows on second floor
  - **Support Spaces**
    - Foyer, stairs, mudroom, pantry, closets, laundry & bathrooms
    - Act as a buffer to the North

Second Floor Plan

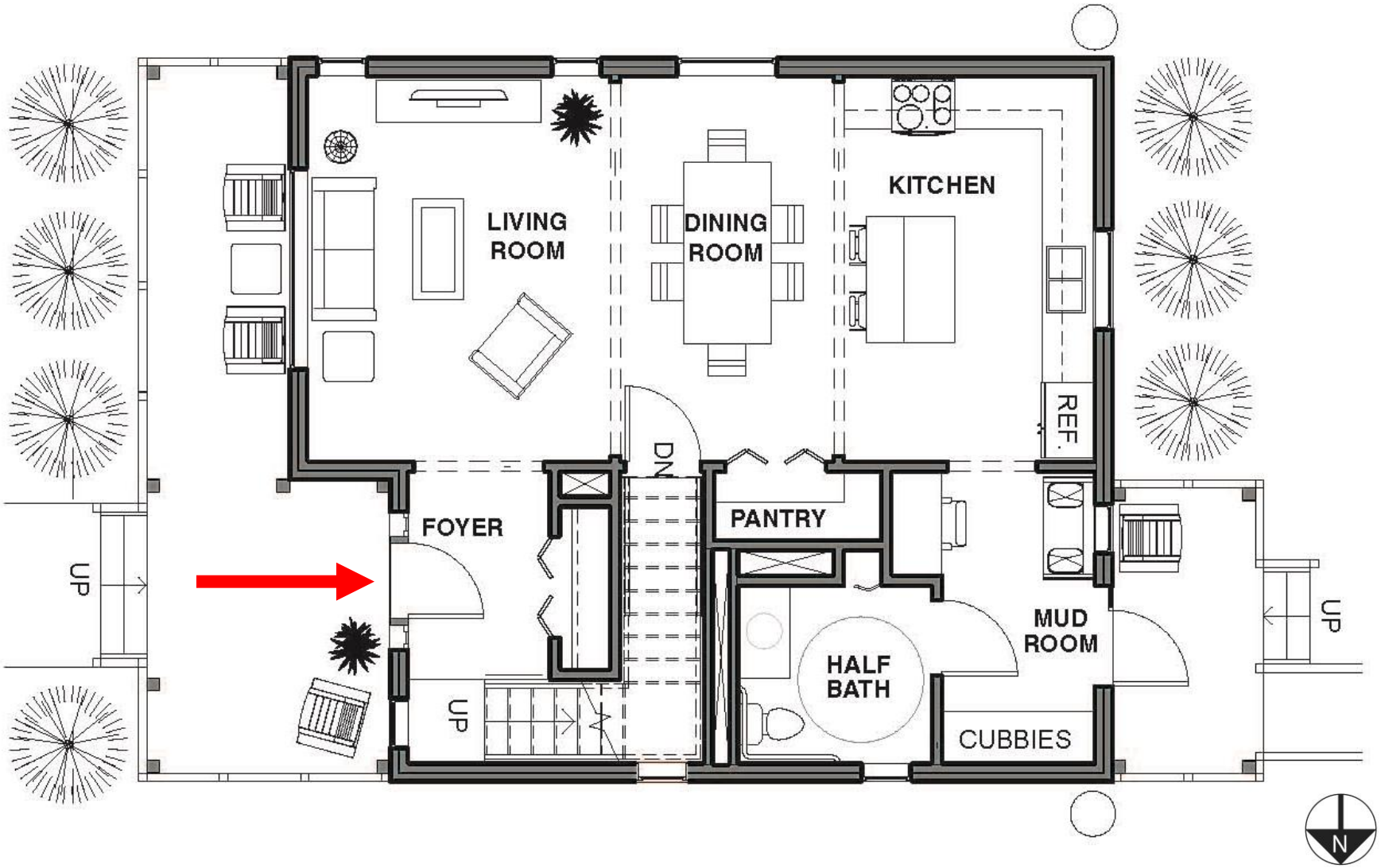
First Floor Plan

Space Use Diagram

ARCHITECTURAL GOALS | First Floor Plan



ARCHITECTURAL GOALS | First Floor Plan



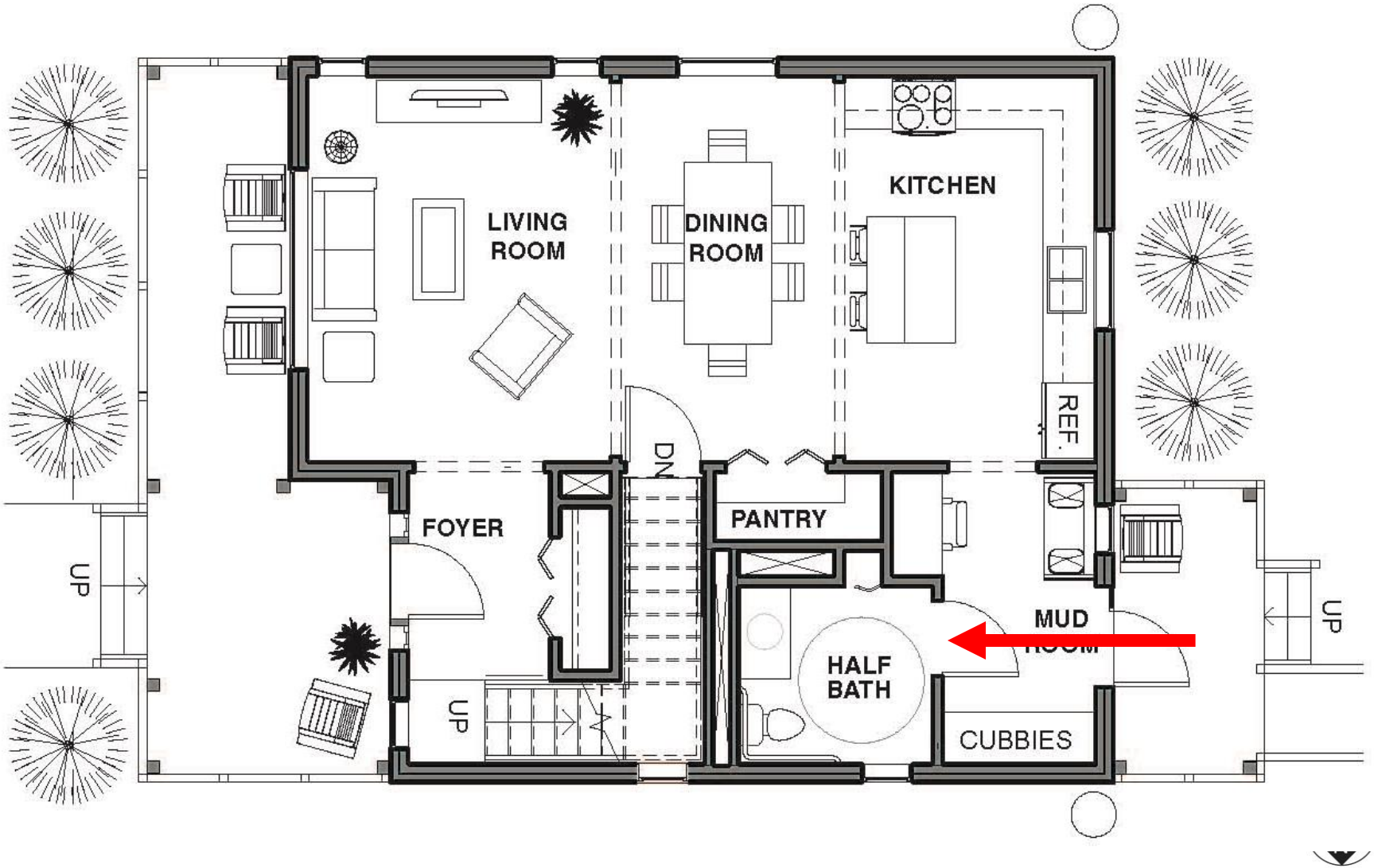
ARCHITECTURAL GOALS | First Floor Plan

ARCHITECTURAL GOALS | Perspective from Kitchen

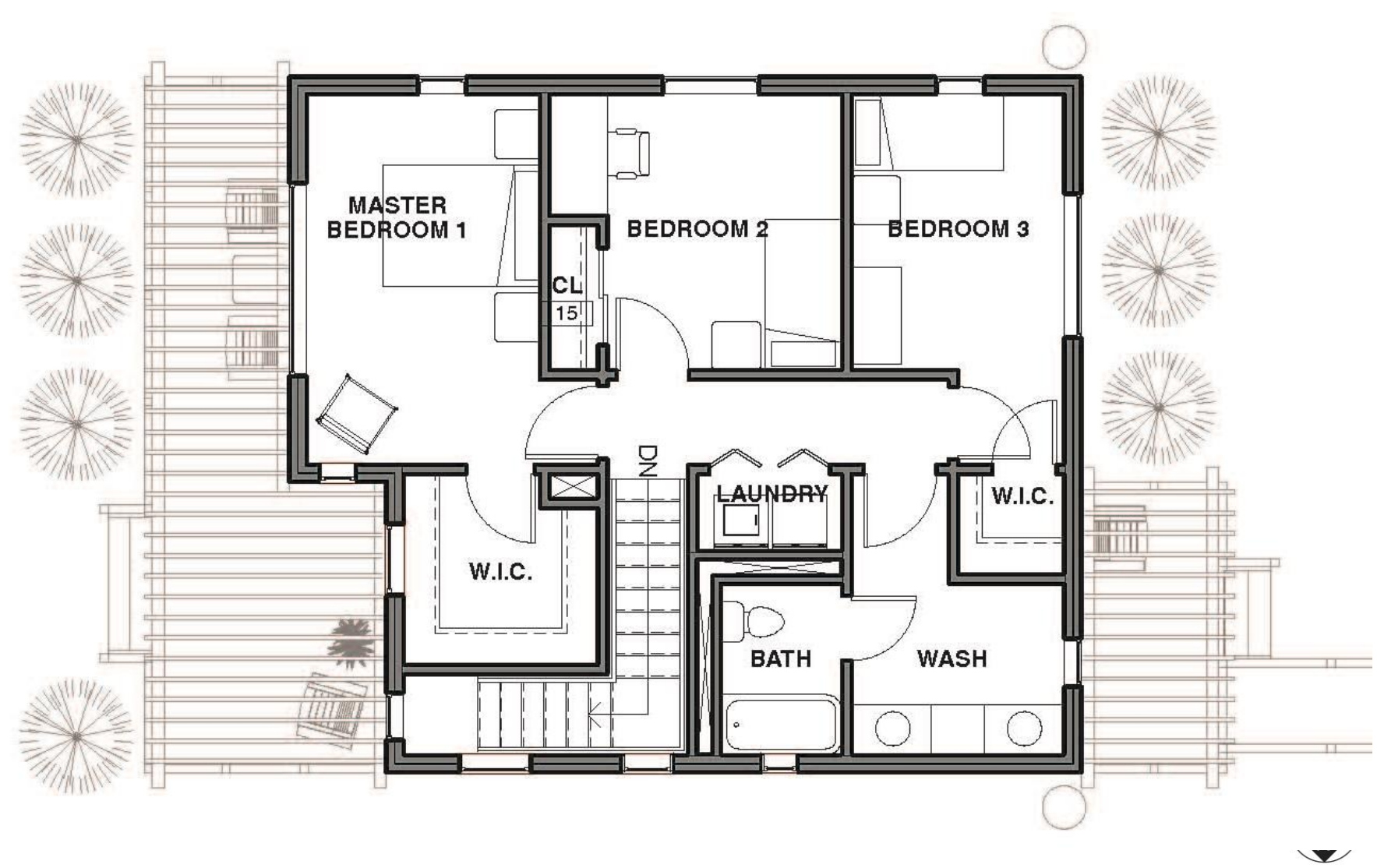
ARCHITECTURAL GOALS | First Floor Plan

ARCHITECTURAL GOALS | First Floor Plan

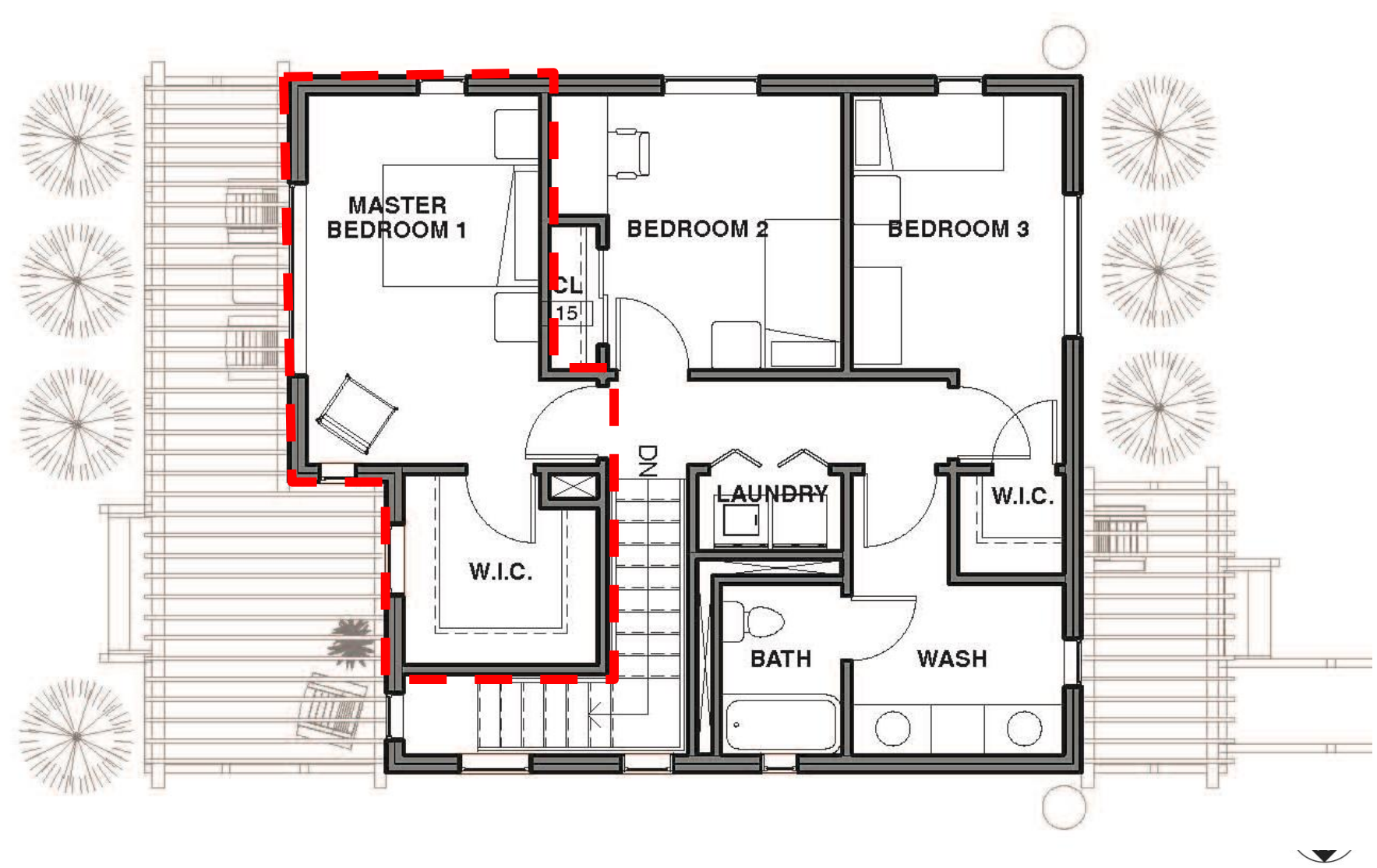
ARCHITECTURAL GOALS | First Floor Plan



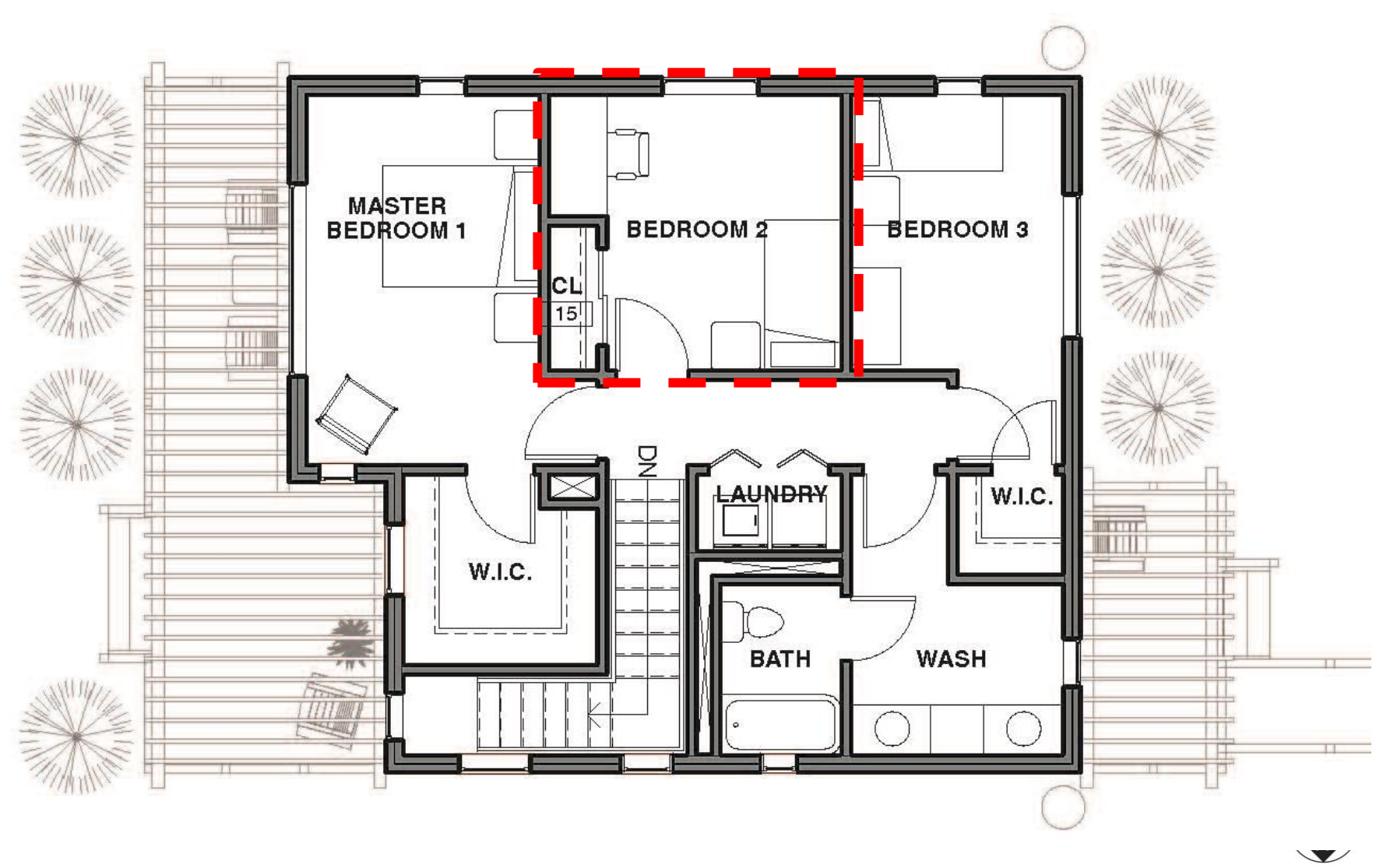
ARCHITECTURAL GOALS | Second Floor Plan



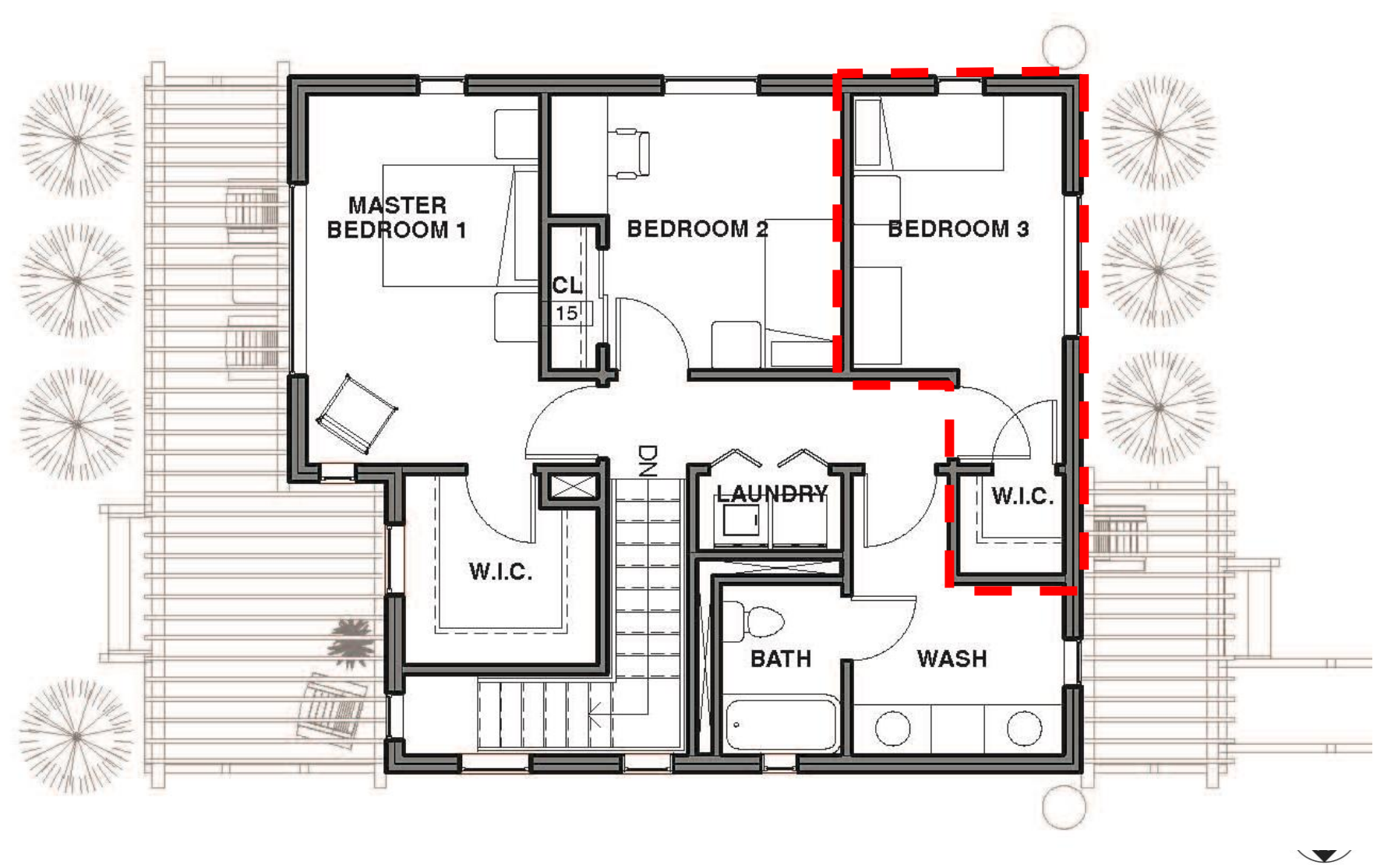
ARCHITECTURAL GOALS | Second Floor Plan



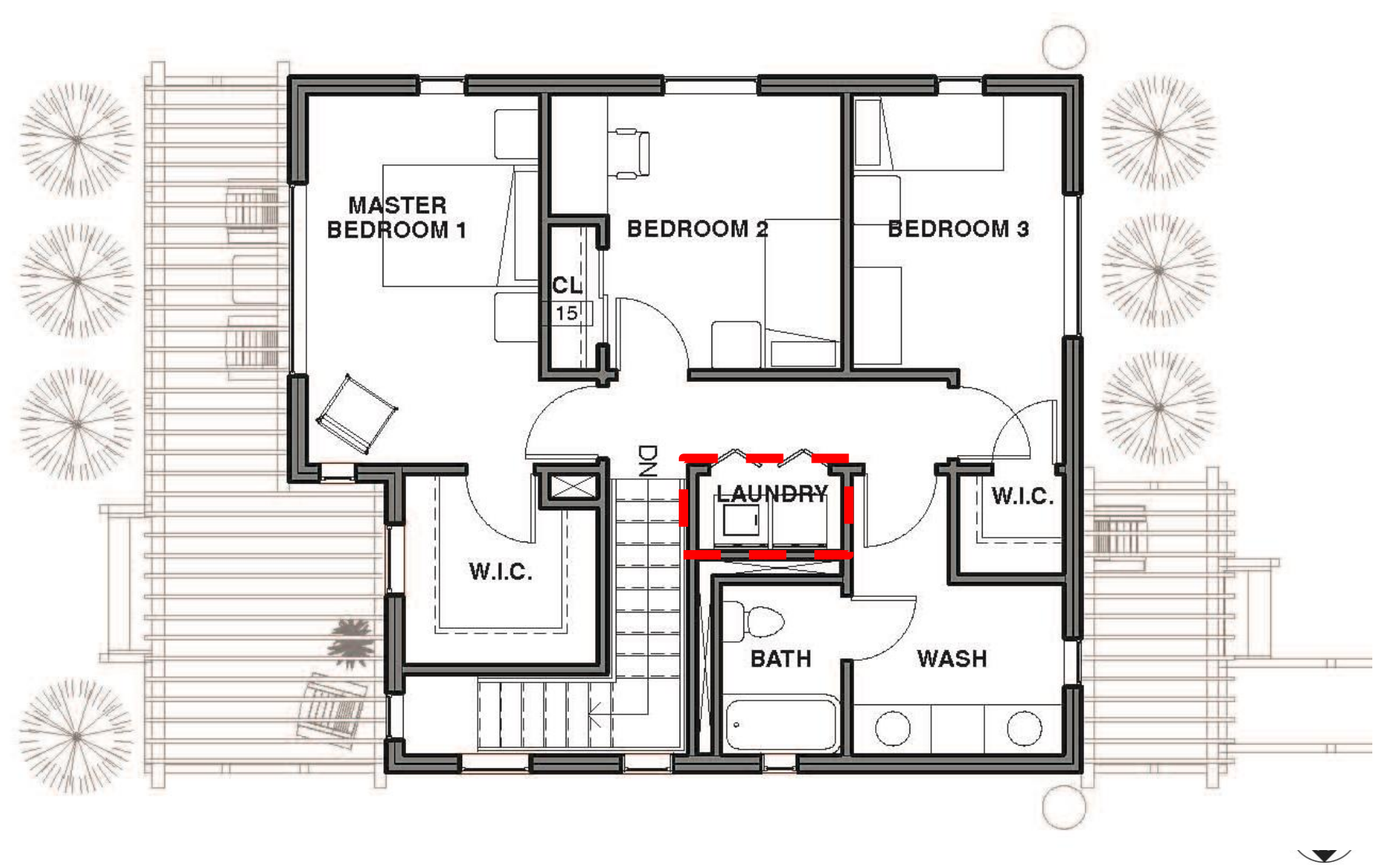
ARCHITECTURAL GOALS | Second Floor Plan



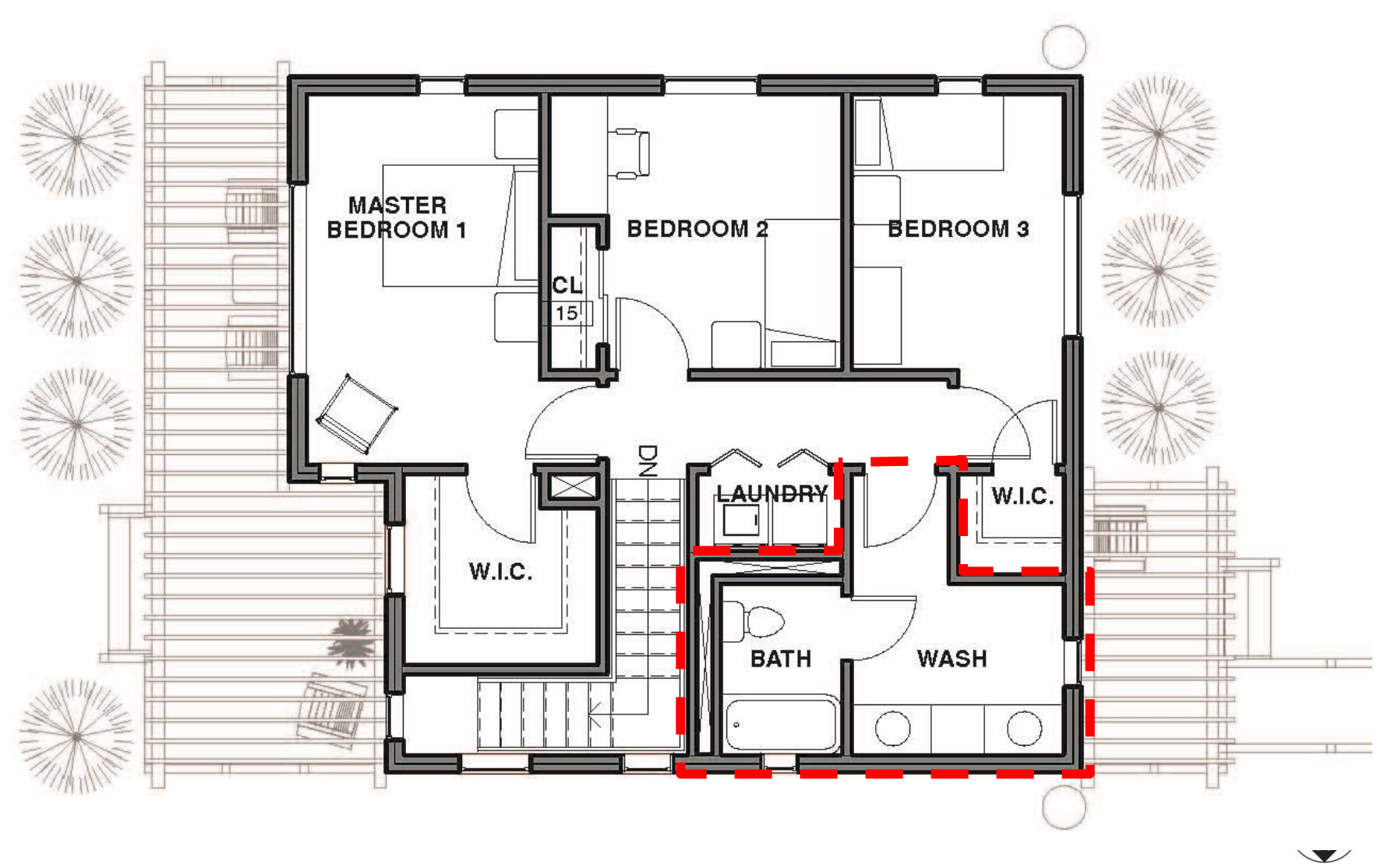
ARCHITECTURAL GOALS | Second Floor Plan



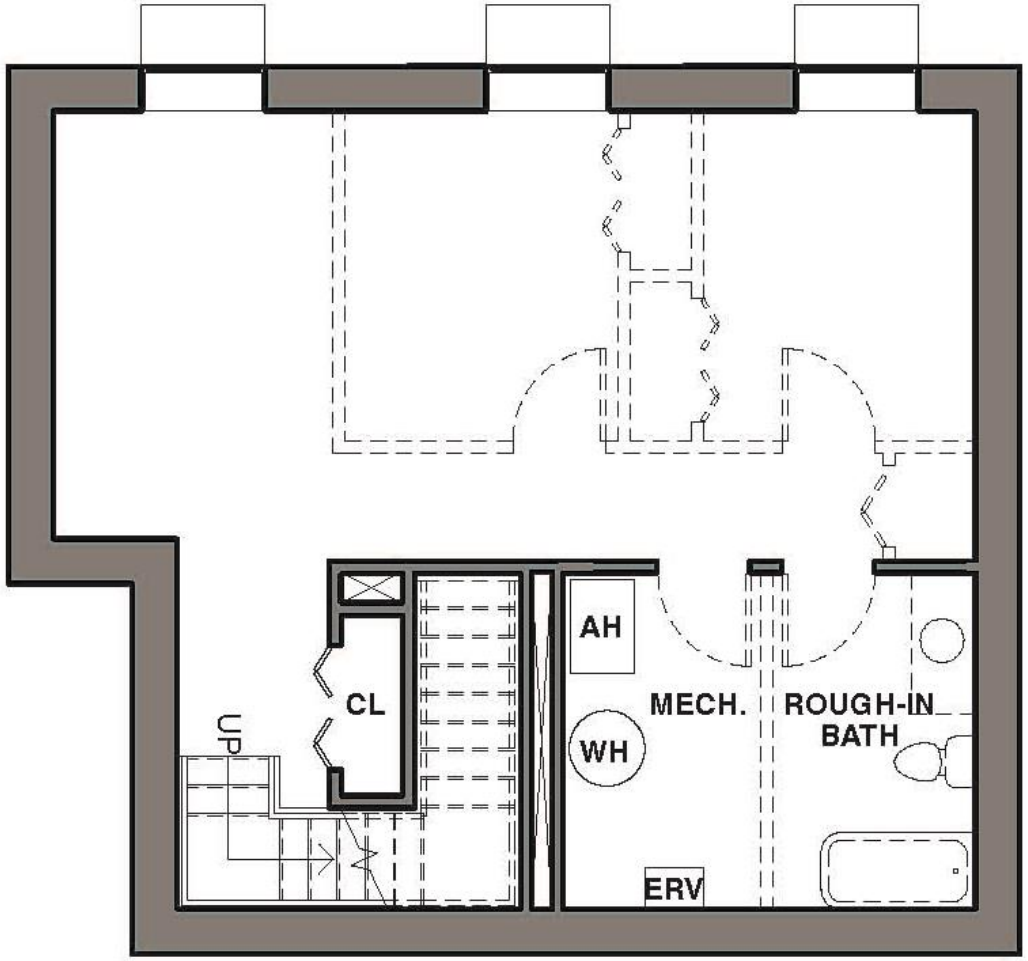
ARCHITECTURAL GOALS | Second Floor Plan



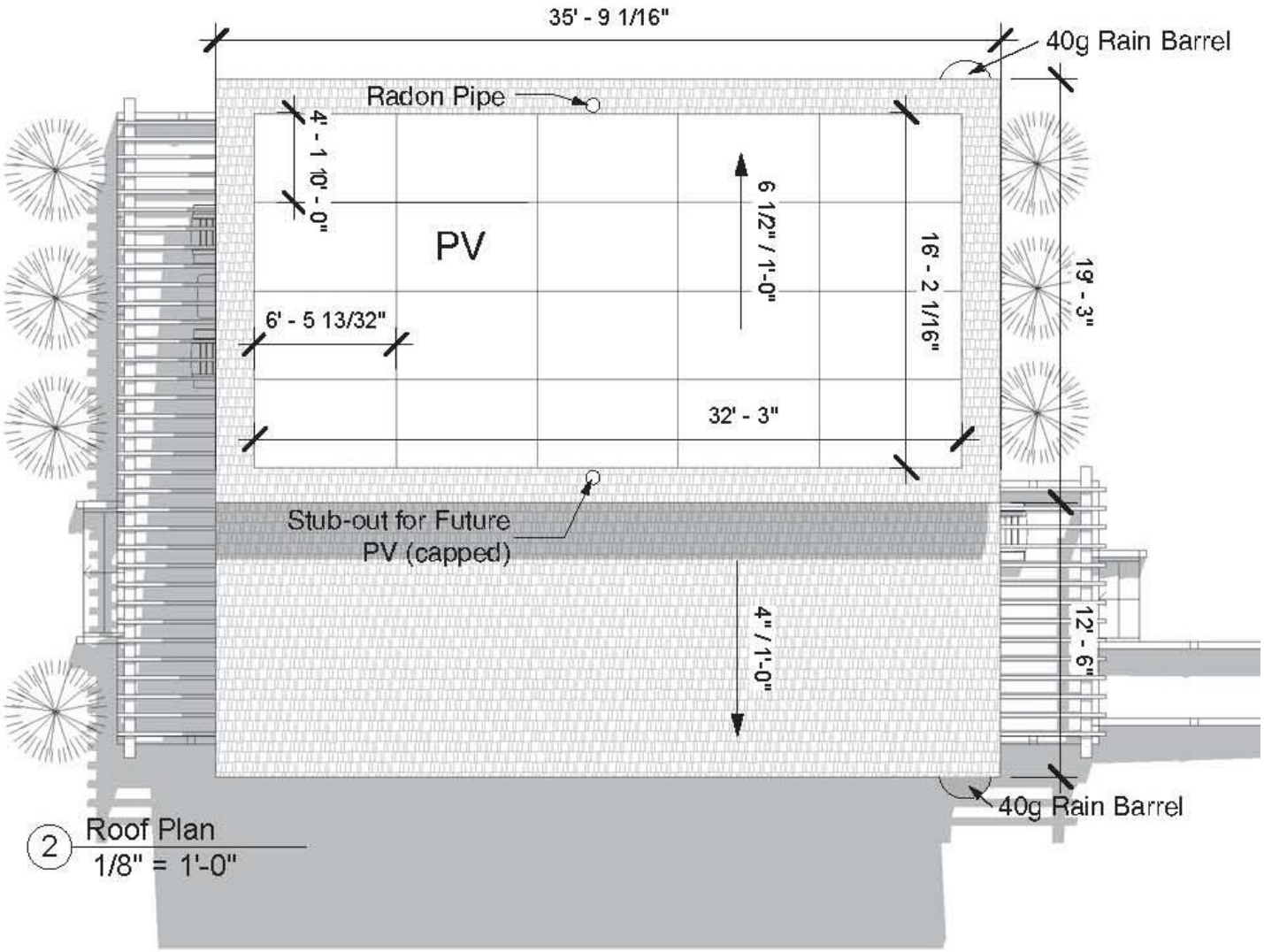
ARCHITECTURAL GOALS | Second Floor Plan



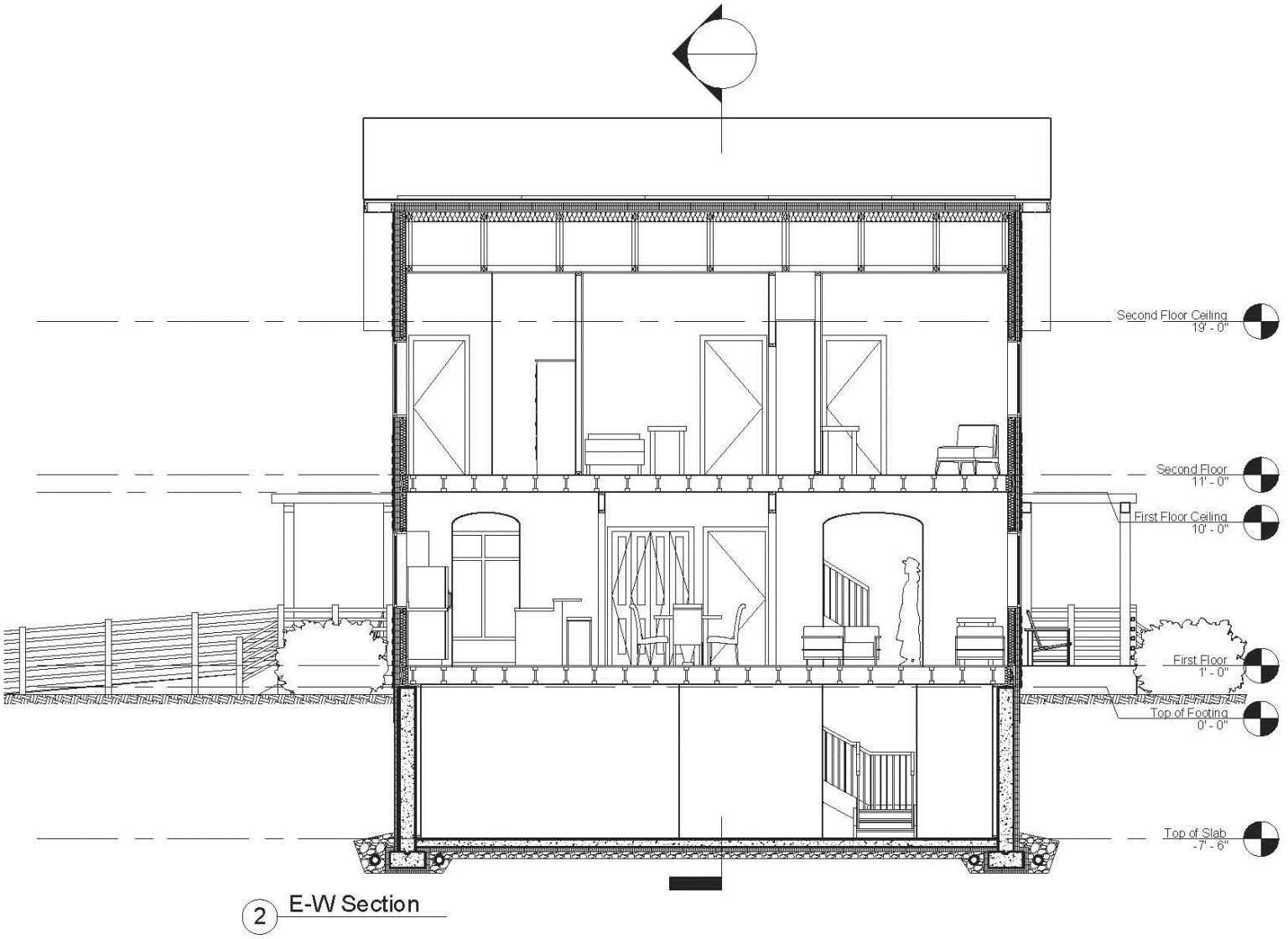
ARCHITECTURAL GOALS | Lower Level Plan



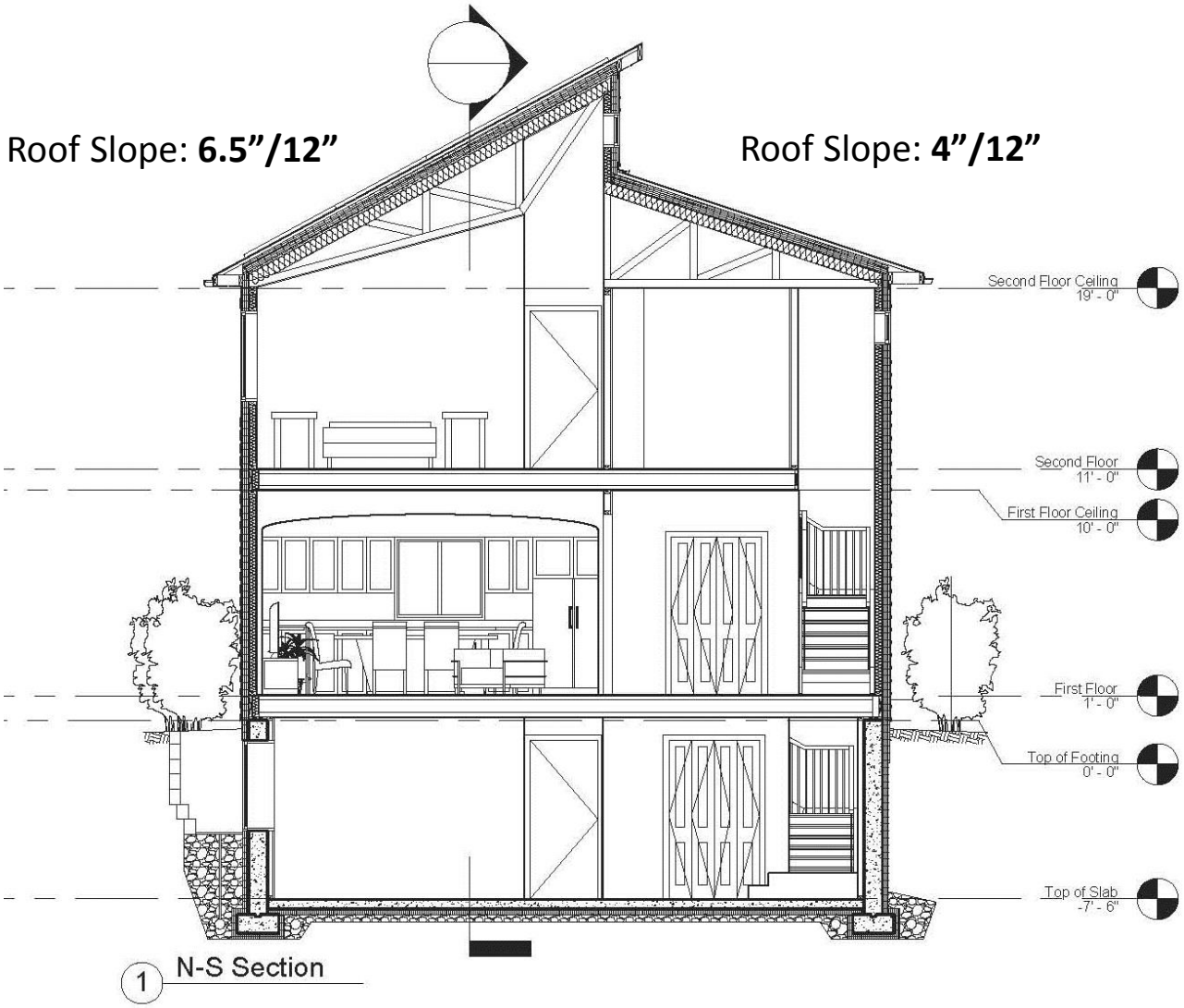
ARCHITECTURAL GOALS | Roof Plan



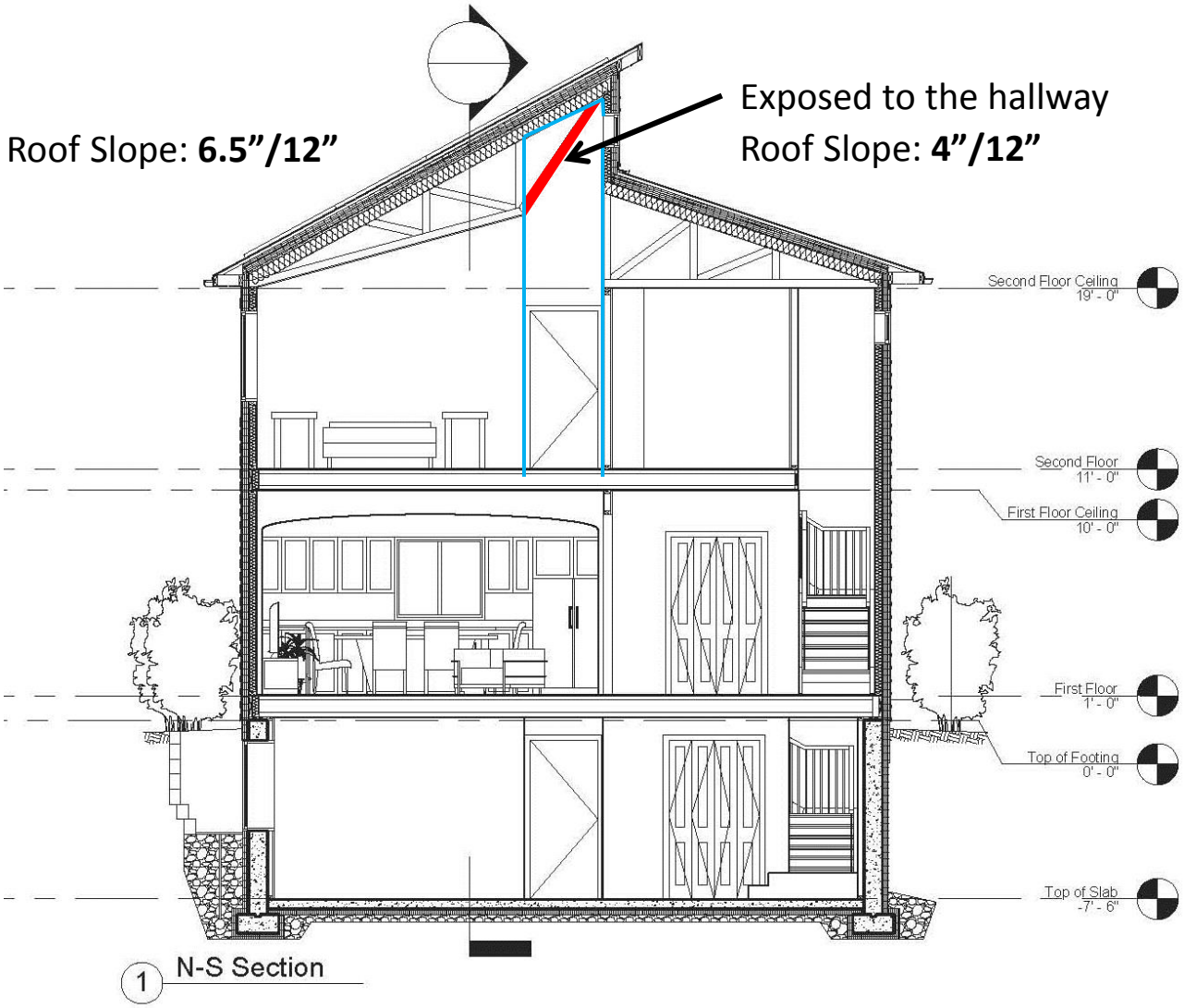
ARCHITECTURAL GOALS | East – West Section



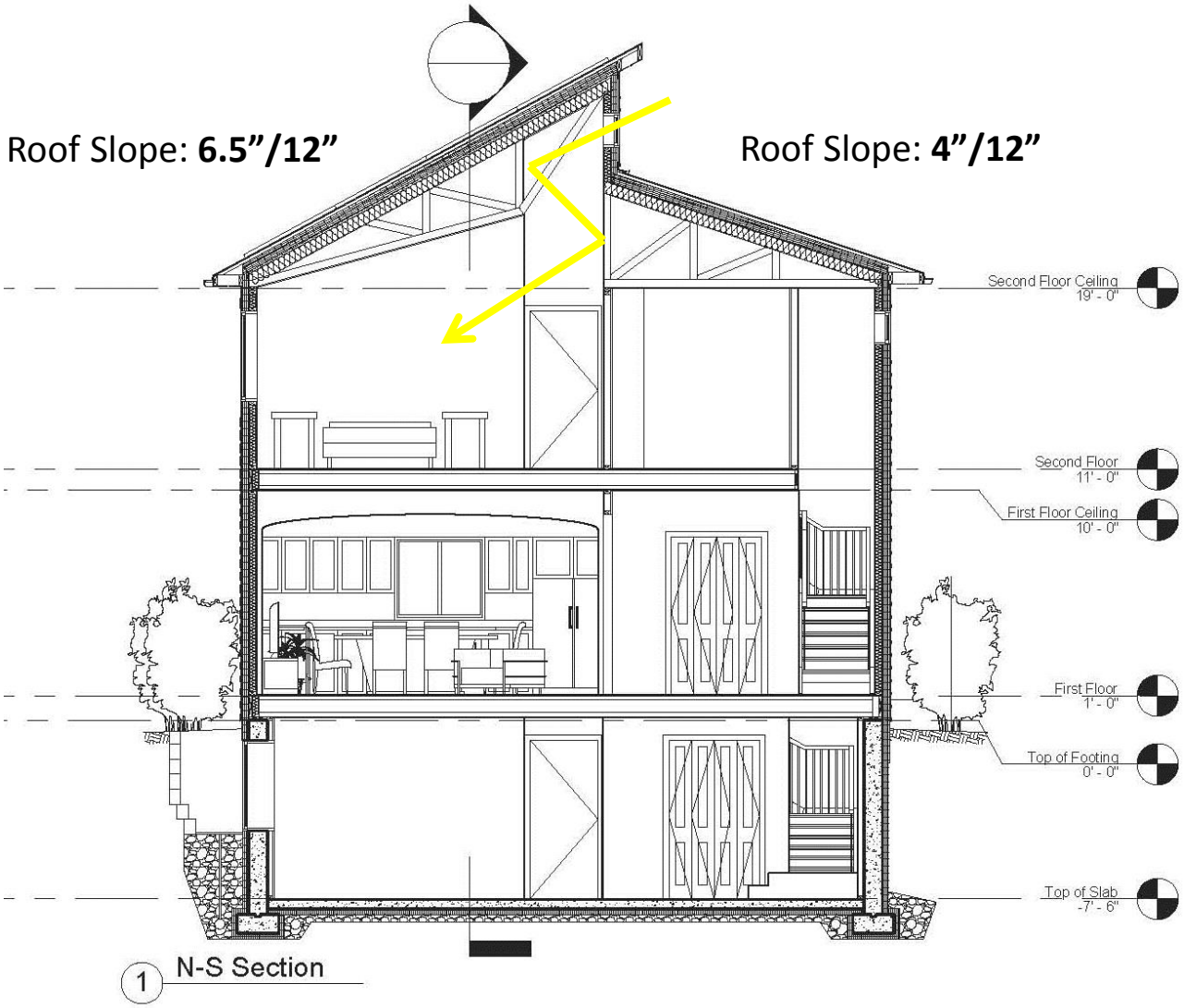
ARCHITECTURAL GOALS | North – South Section



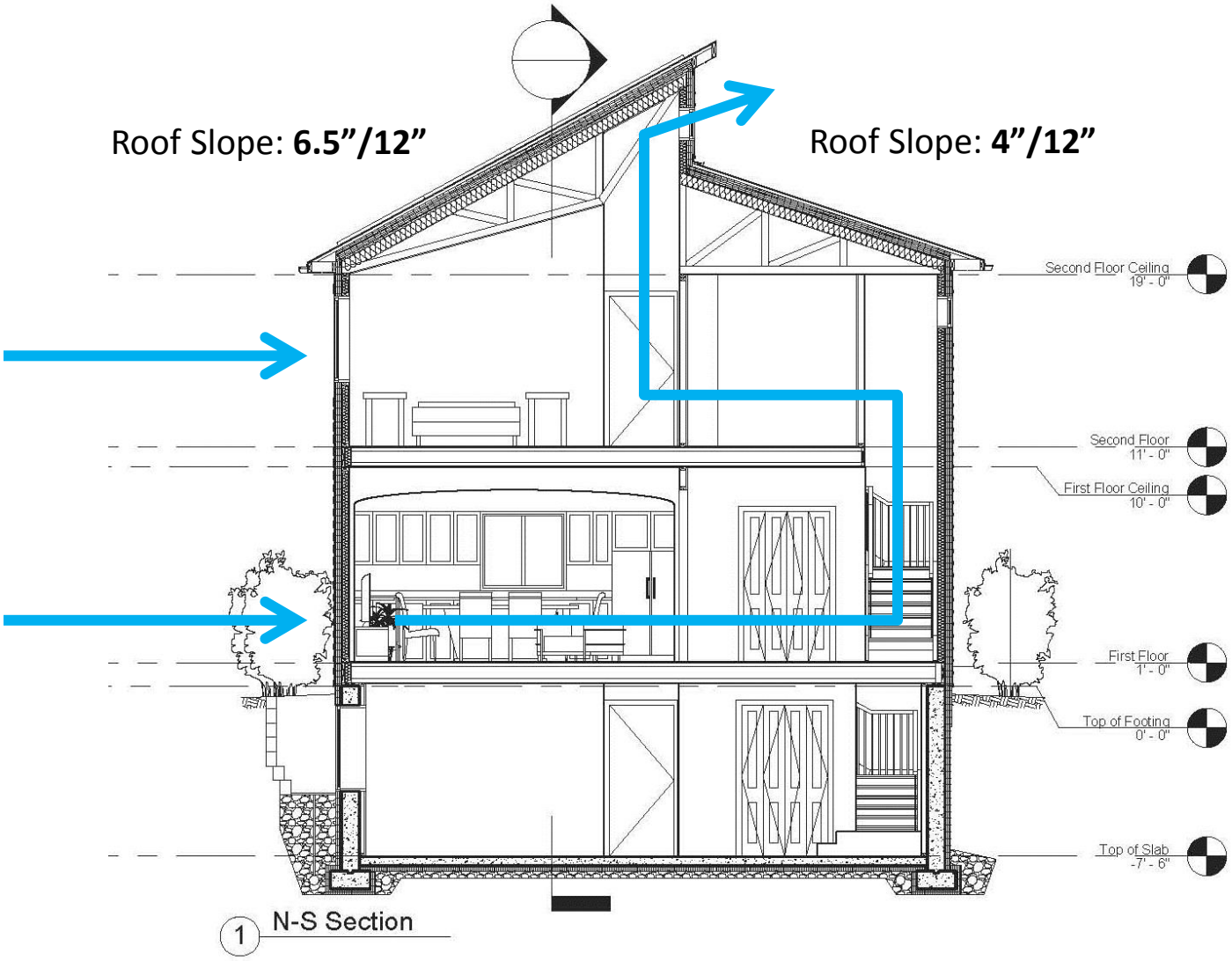
ARCHITECTURAL GOALS | Exposed Beam in Hallway



ARCHITECTURAL GOALS | Clerestory Natural Daylight



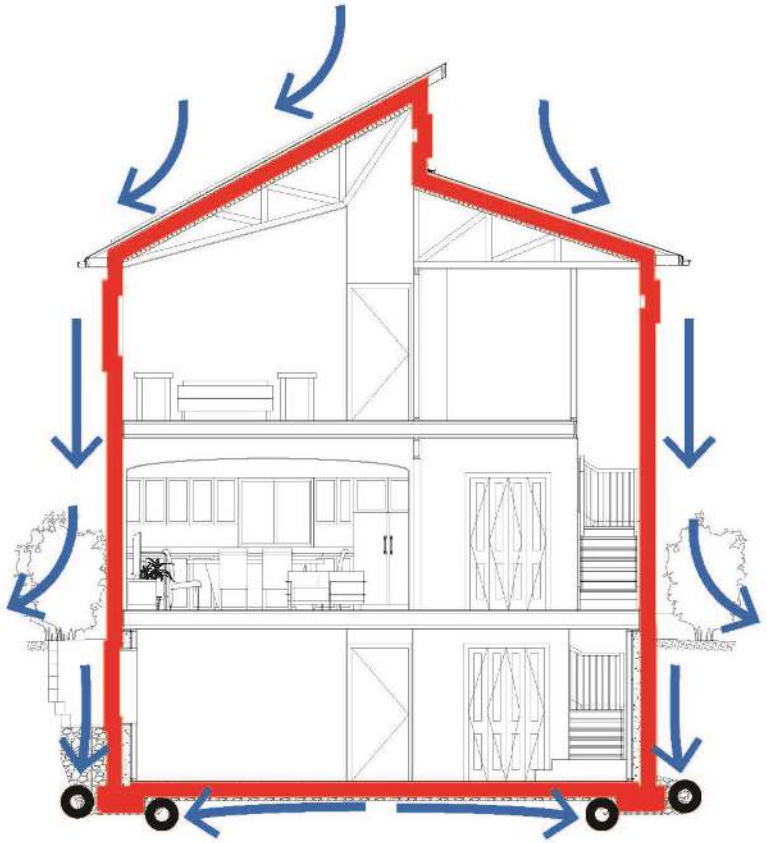
ARCHITECTURAL GOALS | Clerestory Natural Ventilation



Heat Management

Air Management

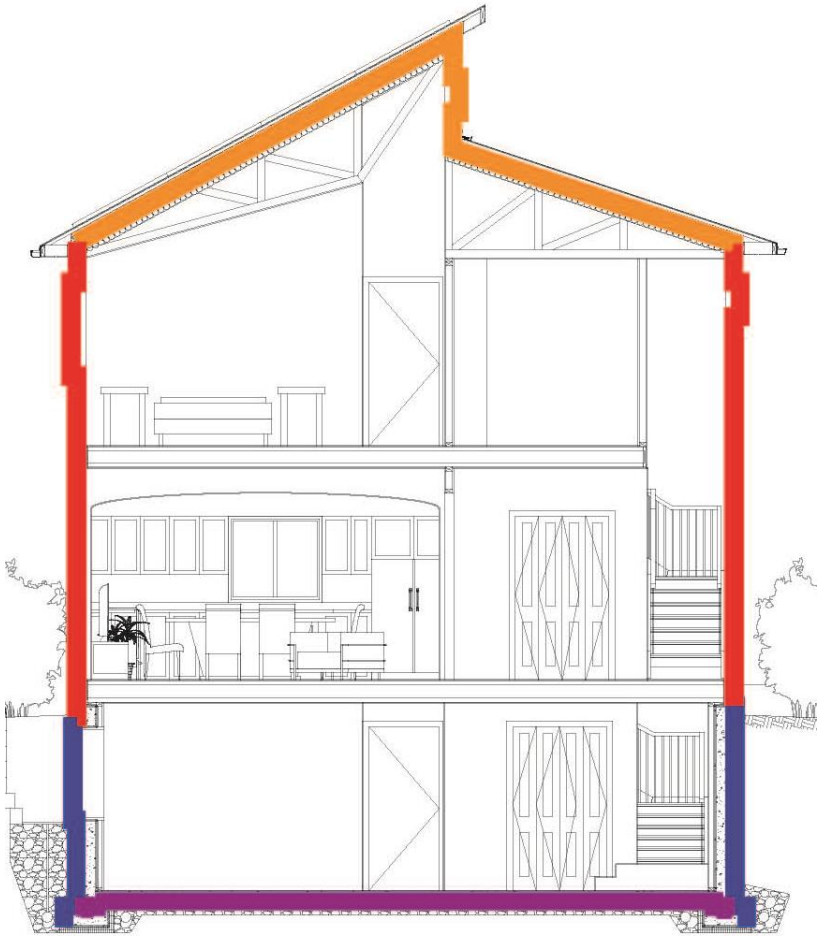
Moisture Management



ENVELOPE | Control Layers

Detailed attention to maintain critical **control layers** for all enclosure components

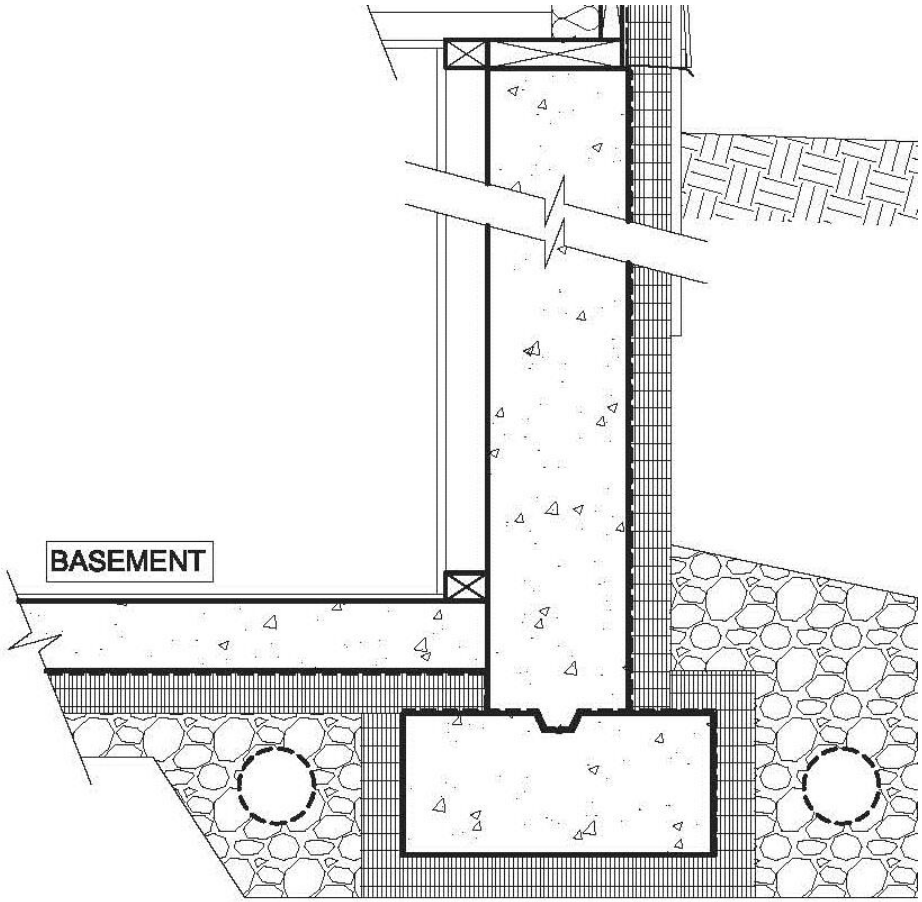
- Continuous **air** and **water** management system
  - **Orange**: W.R. Grace Perm-a-Barrier
  - **Red**: Huber ZIP sheathing system
  - **Blue**: Foundation waterproofing
  - **Purple**: Cross-laminated polyethylene membrane
- Optimal **thermal** insulation with minimal thermal bridging
- Deliberate **vapor** control strategy to limit wetting and enhance drying



Integrity of Control Layers

Thermal Control

- **Slab Insulation**
  - R-10
- **Footing Insulation**
  - R-10
- **Foundation Wall Insulation**
  - R-15



Moisture Control

- Capillary breaks
- Waterproof membrane
- Gravel bed and drain pipe
- Sealed sump basket

Thermal Control

- **Slab Insulation**
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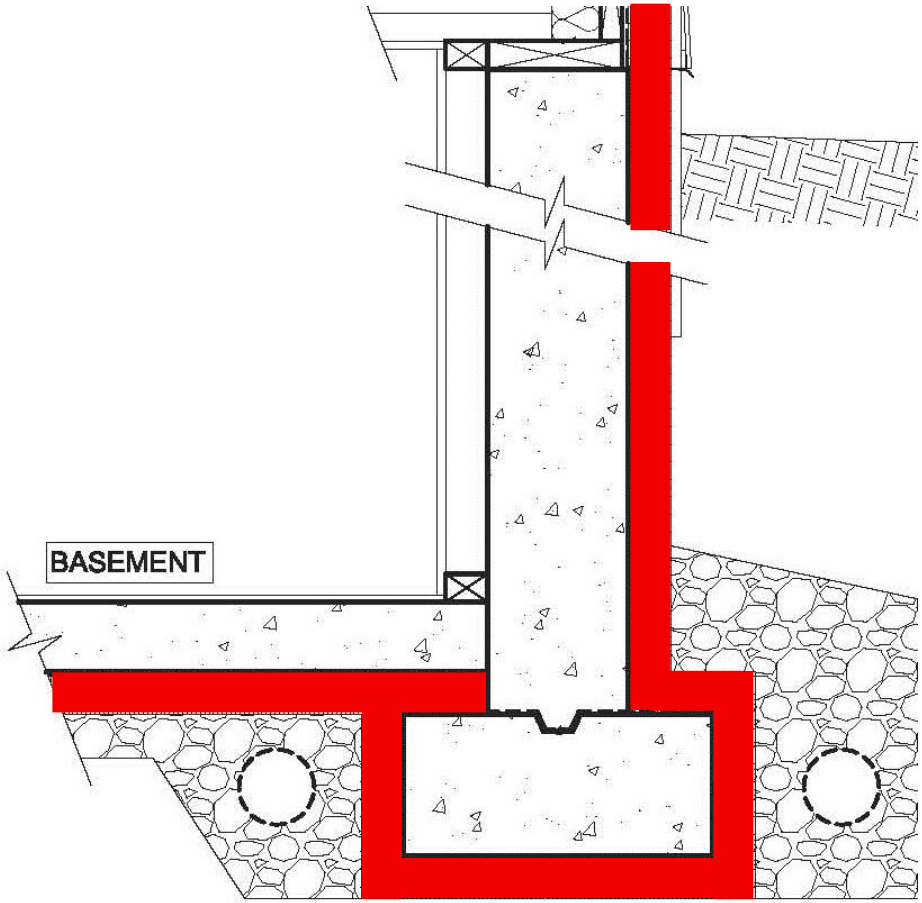

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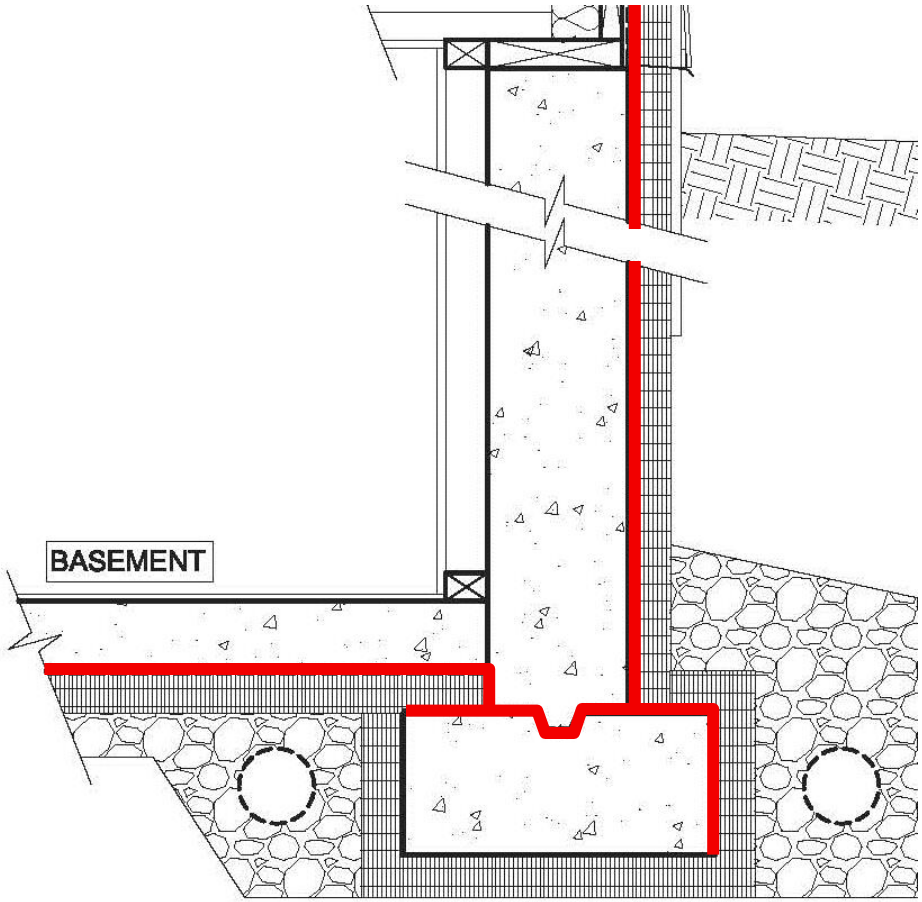
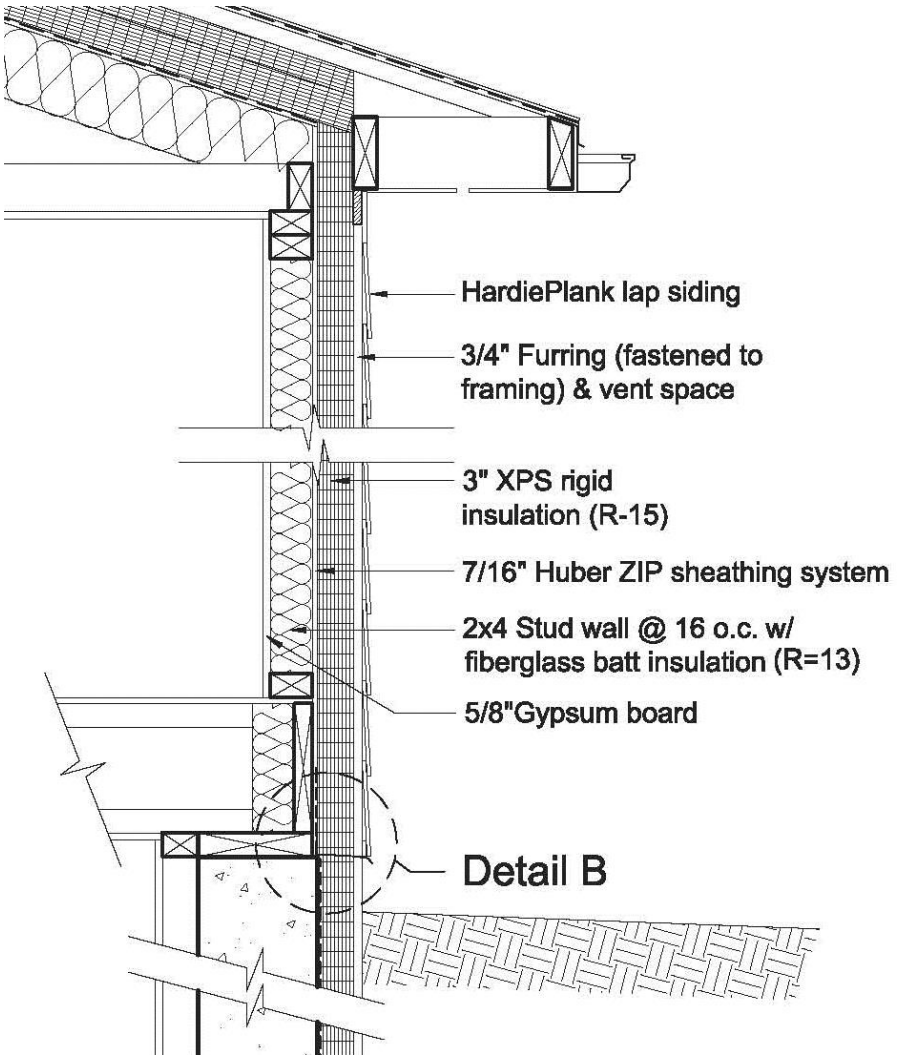


Moisture Control

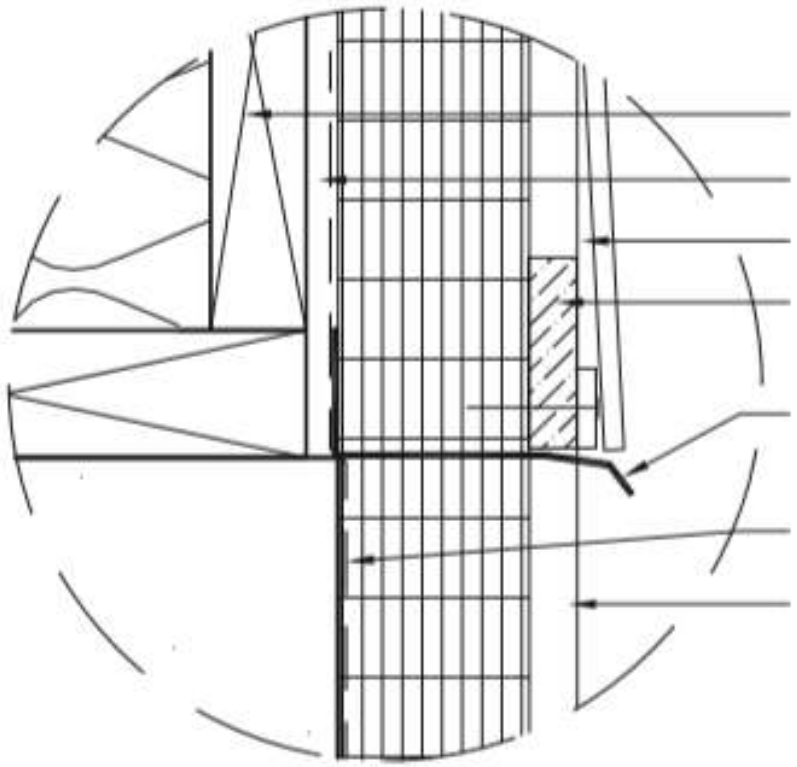
- Capillary breaks
- Waterproof membrane
- Gravel bed and drain pipe
- Sealed sump basket

OptiMN Wall

- **Hybrid Wall Insulation**
  - R-32
  - 50/50 ratio
- **Rim Joist**
  - R-32
- **Zip Panel & Tape**
  - Moisture control
  - Air barrier



ENVELOPE | Detail B Flashing



1 1/8" TJ composite rim board

7/16" Huber ZIP sheathing system

HardiePlank lap siding

Cor-a-Vent siding vent & insect screen

Metal flashing to ZIP w/ flashing tape

Foundation water proofing

3/4" Groundbreaker protection board (extends 12" below grade)

DETAIL B: Flashing Detail | Scale 3" = 1'-0"

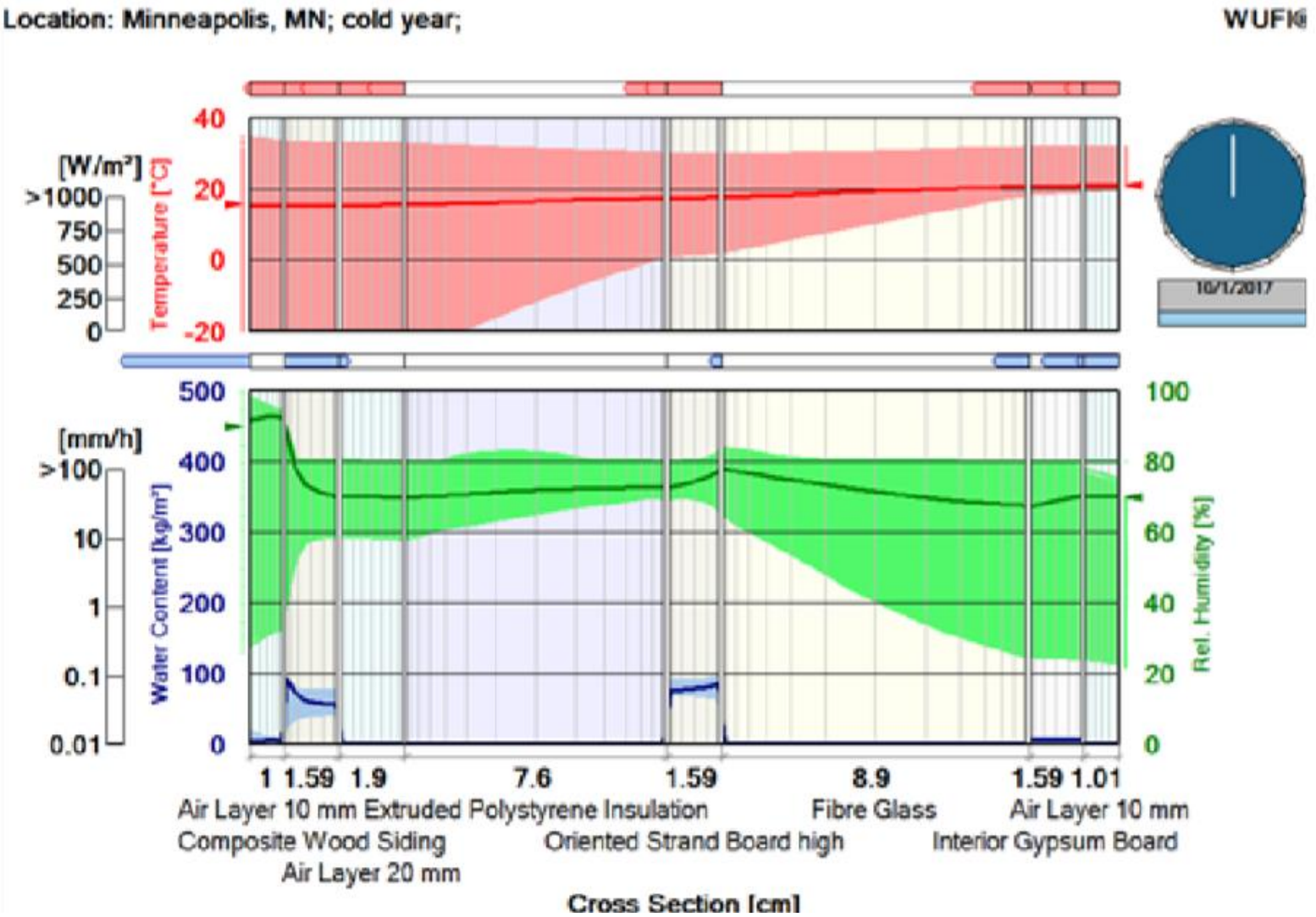
Modified Glaser Method for January: Confirms Limited Condensation Potential

	January Wall								
Layer		R Value	M(Perm)	$R_{v,i}$	T (°F)	P_{sat}(psi)	P_w(PSI)	RH%	Delta T	Delta P Drop
	Indoor				68.0	0.33927	0.10178	30.00		
Interior Air Film		0.68	160	0.0063					1.09925	0.00028
					66.9	0.32777	0.10150	30.97		
Gypsum		0.45	35.2	0.0284					0.72744	0.00127
					66.2	0.31662	0.10024	31.66		
R-13 Fiberglass		13	33.71	0.0297					21.01504	0.00132
					45.2	0.14755	0.09891	67.04		
Zip Panel		0.62	18.67	0.0536					1.00226	0.00239
					44.2	0.14205	0.09652	67.95		
3" XPS		15	0.8	1.2500					24.24812	0.05574
					19.9	0.05049	0.04078	80.79		
Air Space		1	240	0.0042					1.61654	0.00019
					18.3	0.04584	0.04060	88.57		
Hardie Board		1	4.27	0.2342					1.61654	0.01044
					16.7	0.04213	0.03016	71.57		
Exterior Air Film		0.17	1000	0.0010					0.27481	0.00004
	Exterior				16.4	0.04241	0.03011	71.00		

Modified Glaser Method for July: Confirms Limited Condensation Potential

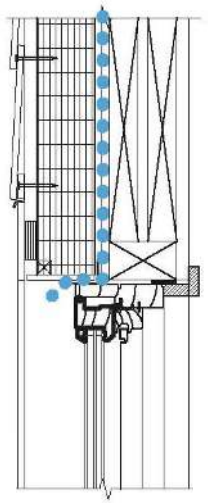
	July Wall								
Layer		R Value	M(Perm)	$R_{v,i}$	T (°F)	P_{sat}(psi)	P_w(PSI)	RH%	Delta T	Delta P Drop
	Indoor				75.0	0.43015	0.21508	50.00		
Interior Air Film		0.68	160	0.0063					0.03409	-0.00021
					75.0	0.43015	0.21528	50.05		
Gypsum		0.45	35.2	0.0284					0.02256	-0.00095
					74.9	0.42873	0.21623	50.44		
R-13 Fiberglass		13	33.71	0.0297					0.65163	-0.00099
					74.3	0.42024	0.21723	51.69		
Zip Panel		0.62	18.67	0.0536					0.03108	-0.00179
					74.3	0.42024	0.21902	52.12		
3" XPS		15	0.8	1.2500					0.75188	-0.04181
					73.5	0.40895	0.26083	63.78		
Air Space		1	240	0.0042					0.05013	-0.00014
					73.5	0.40895	0.26096	63.81		
Hardie Board		1	4.27	0.2342					0.05013	-0.00783
					73.4	0.40734	0.26880	65.99		
Exterior Air Film		0.17	1000	0.0010					0.00852	-0.00003
	Exterior				73.4	0.40732	0.26883	66.00		

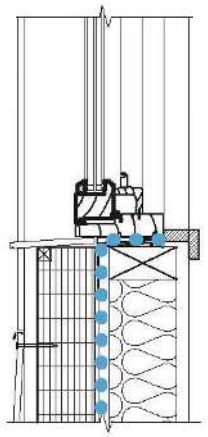
ENVELOPE | WUFI Analysis



Window Details Matter

- Selected an affordable, high-performance, double-pane, low-e window (SilverLine)
  - U = 0.27
  - SHGC = 0.20
- Installation details are critical
  - Pan flashing before installation
  - Integration to ZIP sheathing air and water control system

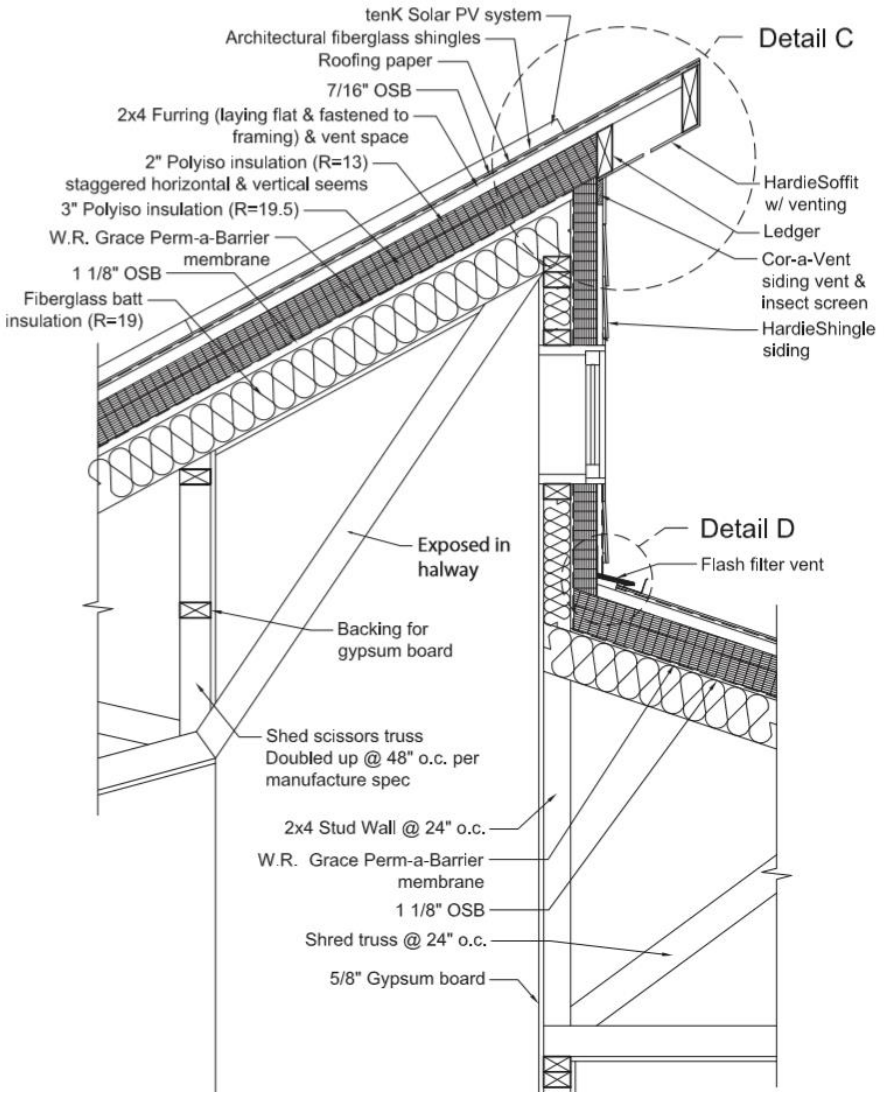




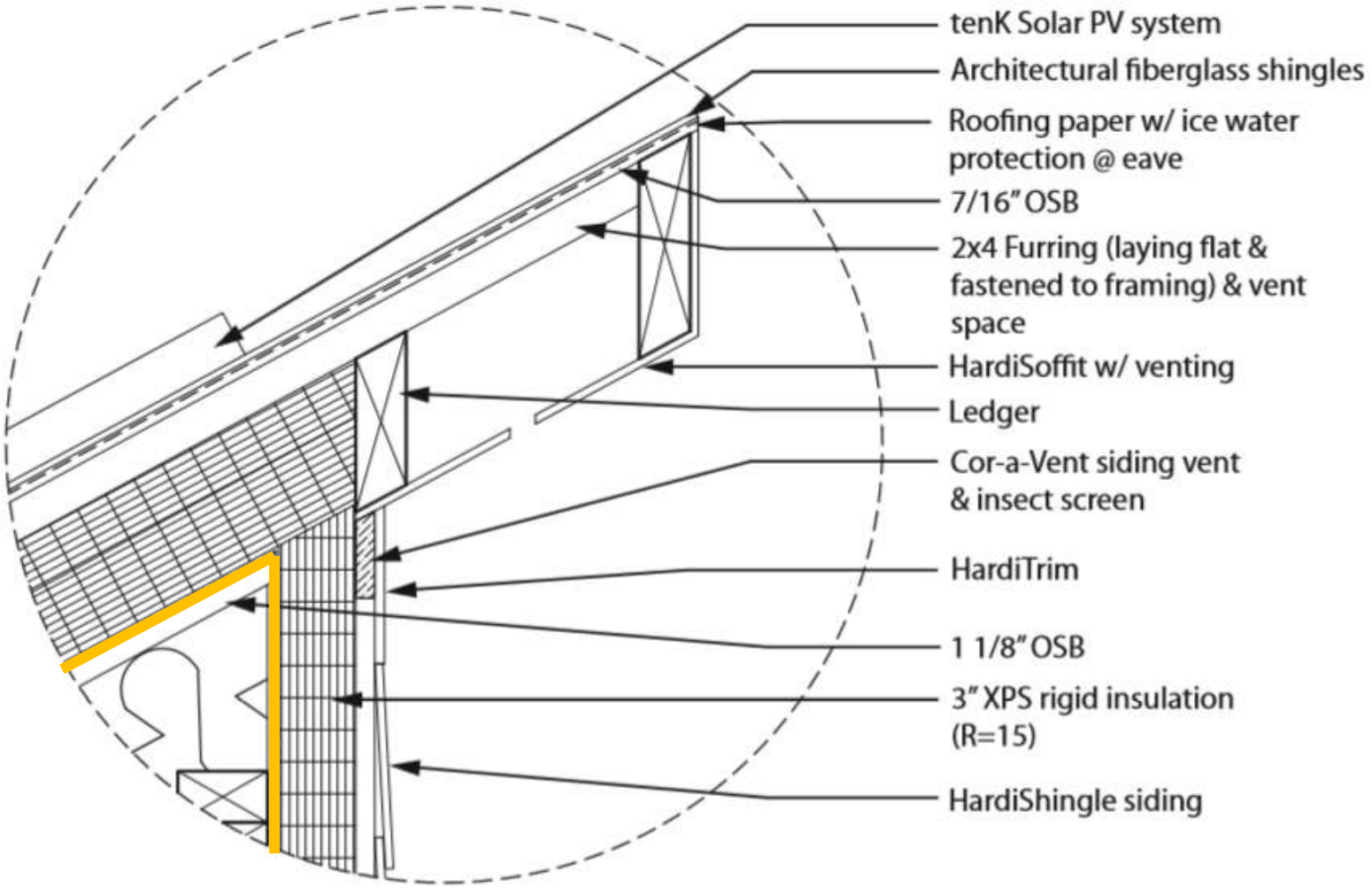
Drainage Plain

OptiMN Roof

- **Truss Roof System**
  - South = shed scissor truss
  - North = shed (or half) truss
- **Hybrid Insulation**
  - R-53
  - 60/40 ratio
- **Material Selection**
  - Integrity of water and air management system

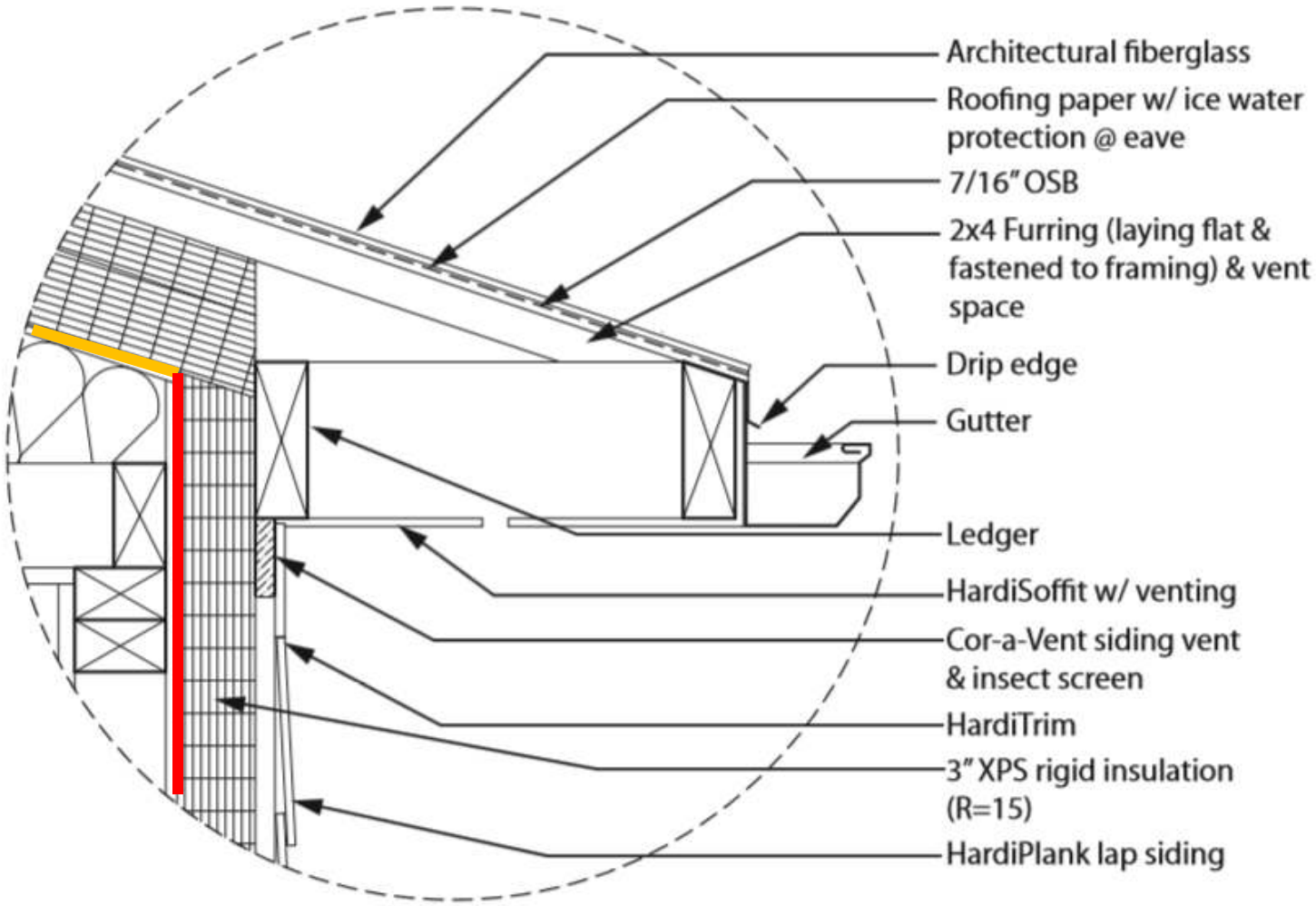


ENVELOPE | Detail C



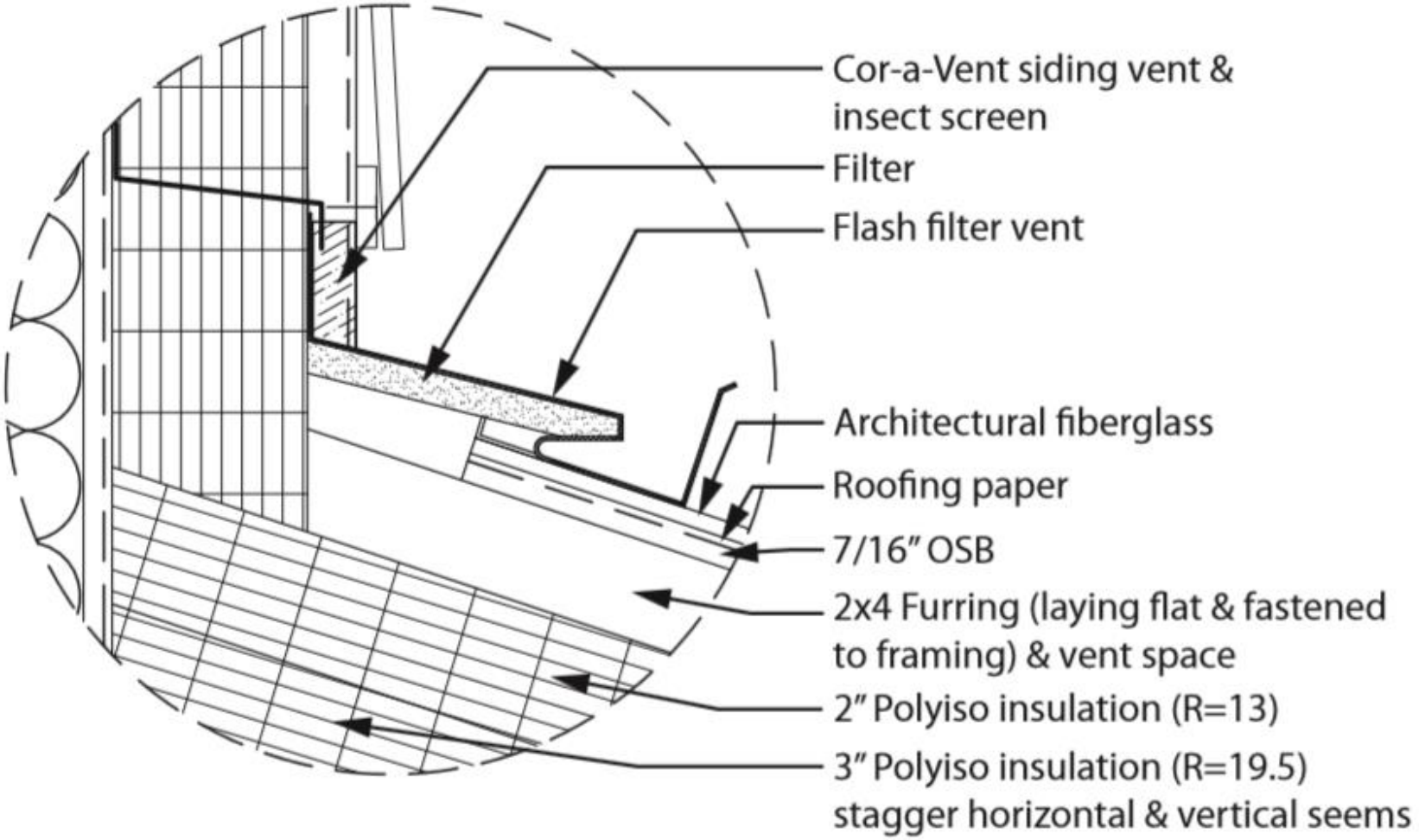
DETAIL C: Overhang Over Clerestory | Scale 1 1/2" = 1'-0"

ENVELOPE | Detail A



DETAIL A: North Overhang | Scale 1 1/2" = 1'-0"

ENVELOPE | Detail D



DETAIL D: Clerestory Roof Connection | Scale 3" = 1'-0"

SYSTEMS | Goals

- Comprehensive and integrated approach for indoor air management
- Space conditioning (heating, cooling, dehumidification, filtration, fresh air distribution) system that can provide:
  - high efficiency
  - low cost
  - exceptional comfort
  - healthy air
  - simple operation & maintenance
- Developed with Building America research and resources as a guide

	REMRate	Manual J
Heating Load [Kbtu/hr]	20.2	22.8
Cooling Load [KBtu/hr]	10.3	14.5

Exceptional Annual Energy Cost (before PV)

- Heating = $282
- Cooling = $38
- Water Heating = $97

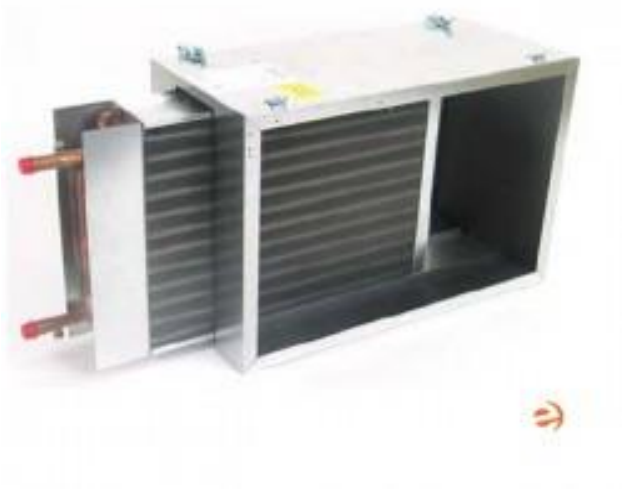
MANUAL J8$_{AE}$ • SUMMARY REPORT					
Project		Mfg. Equipment Sensible Heat Ratio		0.75	ACCA Manual D CFM
		Manual Overide Entry for Design CFM		500	
Room Name	HEAT LOSS	HTG CFM	HEAT GAIN	CLG CFM	
ML Mud room	1250	31	802	37	37
ML Bathroom	431	11	155	7	11
ML Kitchen	1218	30	768	35	35
ML Dining	946	23	371	17	23
ML Family Room	2067	51	1525	70	70
ML Entrance & Stairwell	2339	58	1470	68	68
UL Bathroom	996	25	516	24	25
UL M Bedroom & Hallway	3095	77	2255	104	104
UL Bed #2	845	21	648	30	30
UL Bed #3	1619	40	1367	63	63
LL Bath	808	20	60	3	20
LL Mechanical	367	9	151	7	9
LL Lounge & Stairs	2283	56	259	12	56
LL Fut. Bedroom #4	829	21	259	12	21
LL Fut. Bedroom #5	1122	28	259	12	28
Room Envelope Totals	20214	500	10864	500	

SYSTEMS | Manual J Summary Report

Total Area	Construction Components	HEAT LOSS		HEAT GAIN	
309	Windows & Glass Doors	6749	29.62%	6963	53.29%
	Skylights				
40	Wood & Metal Doors	556	2.44%	179	1.37%
2169	Above Grade Walls	5402	23.71%	700	5.36%
	Partition Walls				
918	Below Grade Walls	3382	14.84%		
721	Ceilings	1046	4.59%	775	5.93%
	Partition Ceilings				
	Passive Floors				
	Exposed Floors				
	Slab Floors				
850	Basement Floors	1033	4.53%		
	Partition Floors				
	Infiltration	2302	10.10%	202	1.54%
	Internal Gains			2120	16.23%
	Duct Loss & Gain	140	0.62%	71	0.55%
	Ventilation	2177	9.55%	349	2.67%
	Blower Heat Gain			1707	13.06%
	Total Sensible	22788	100.00%	13065	100.00%
	Total Latent			1439	
	Total Cooling Load			14504	

Polaris Condensing Water Heater & Unico M2430 2 Ton Hot Water Coil

- 95% CAE
- 120°F Operating Temp.
- Flow Rate: 4 GPM

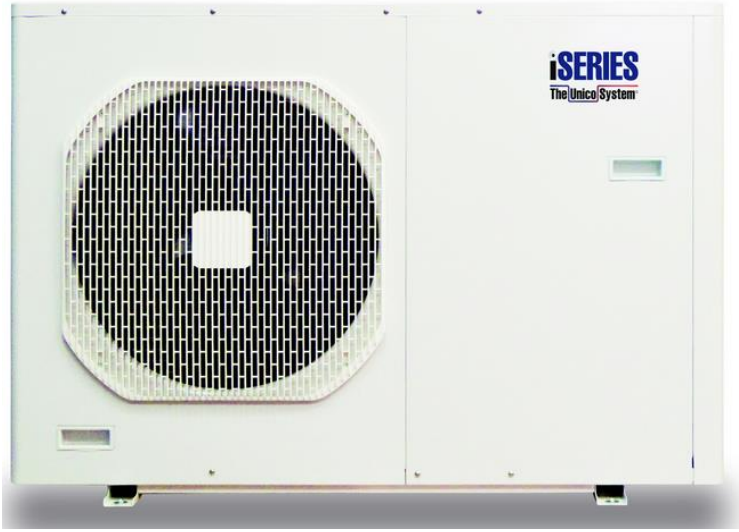


Green Series M2430 Compact Air Handler

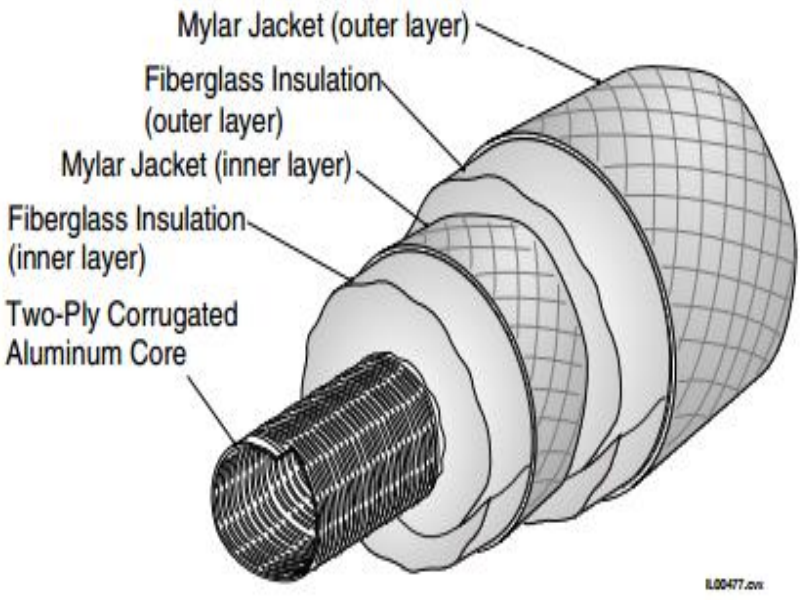
- ECM blower

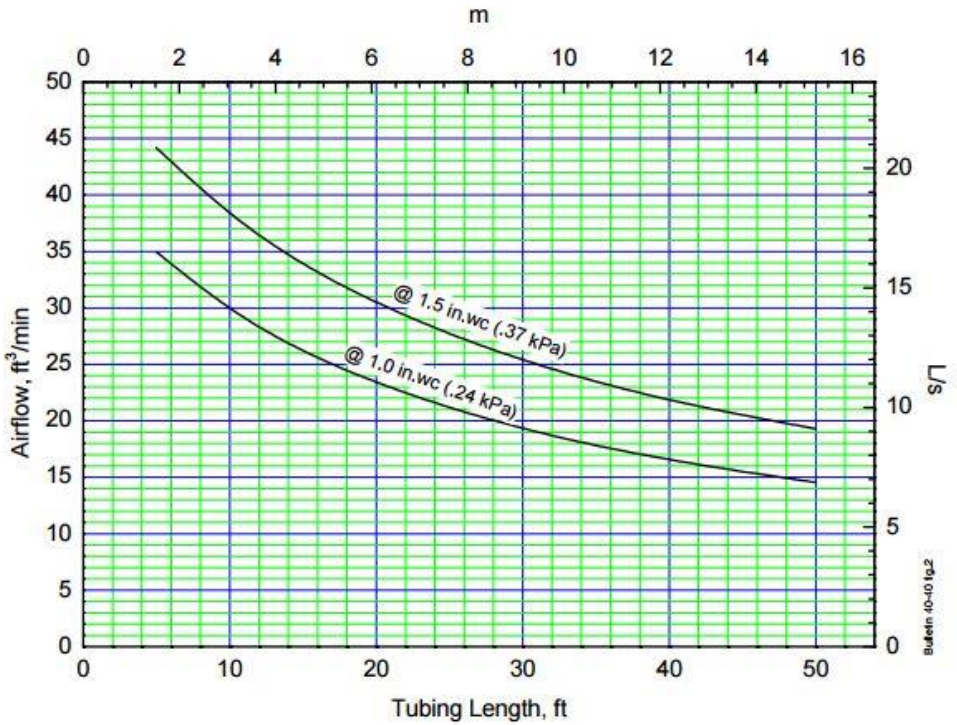
I-Series IS24G065 Outdoor Inverter Heat Pump (IS24G065)

- SEER 14+



SYSTEMS | Distribution Fully-Ducted Supply System





Design Airflow: 500 CFM

Supply Duct Number	Length from Plenum (ft)	Airflow Capacity (cfm) @1.5 in. wc	Room or Zone
1	22	29	LL Lounge
2	16	33	LL stairs
3	11	38	LL Bedroom 1
4	21	30	LL Bedroom 2
5	16	33	LL Bathroom
6	13	35	LL Mechanical
7	17	33	Front Entrance & stairs
8	10	38	Front Entrance & Stairs
9	20	30	Living Room
10	19	31	Living Room
11	16	33	Kitchen
12	24	28	Mud Room
13	18	32	ML Bathroom
14	30	25	Master Bedroom
15	28	26	Master Bedroom
16	15	34	Hallway
17	18	32	Hallway
18	18	32	UL Bedroom 1
19	25	27	UL Bedroom 2
20	13	35	UL Bathroom
21	4	44	UL Bathroom

Compact, simplified central return system to reduce ductwork and cost

- A centrally-located, dedicated return grille on each floor
- An additional high return grille in the second floor clerestory
- All spaces with doors have transfer grilles

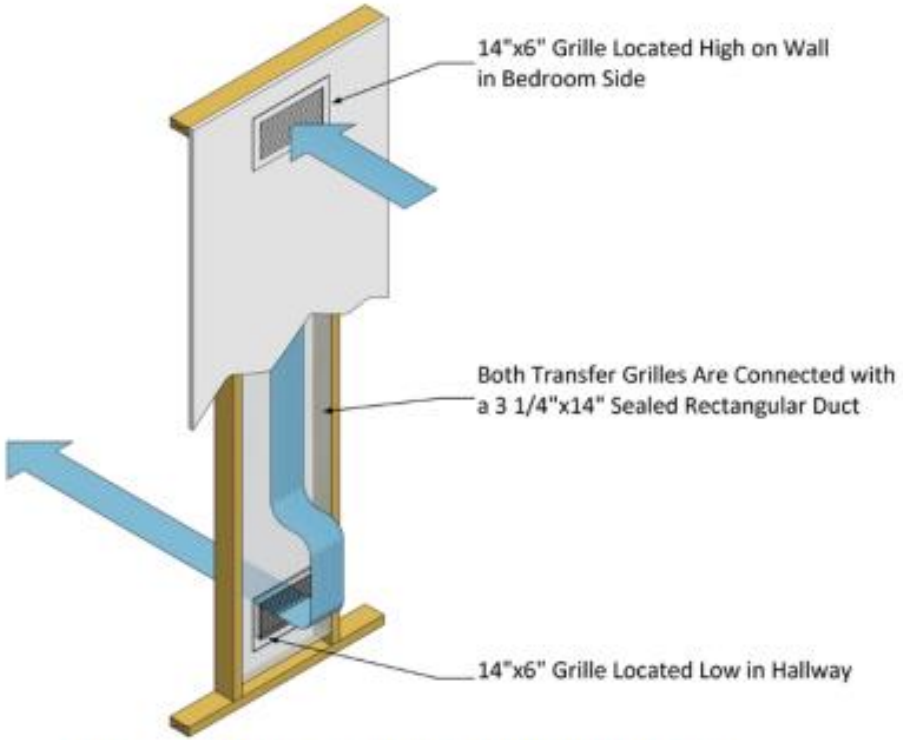
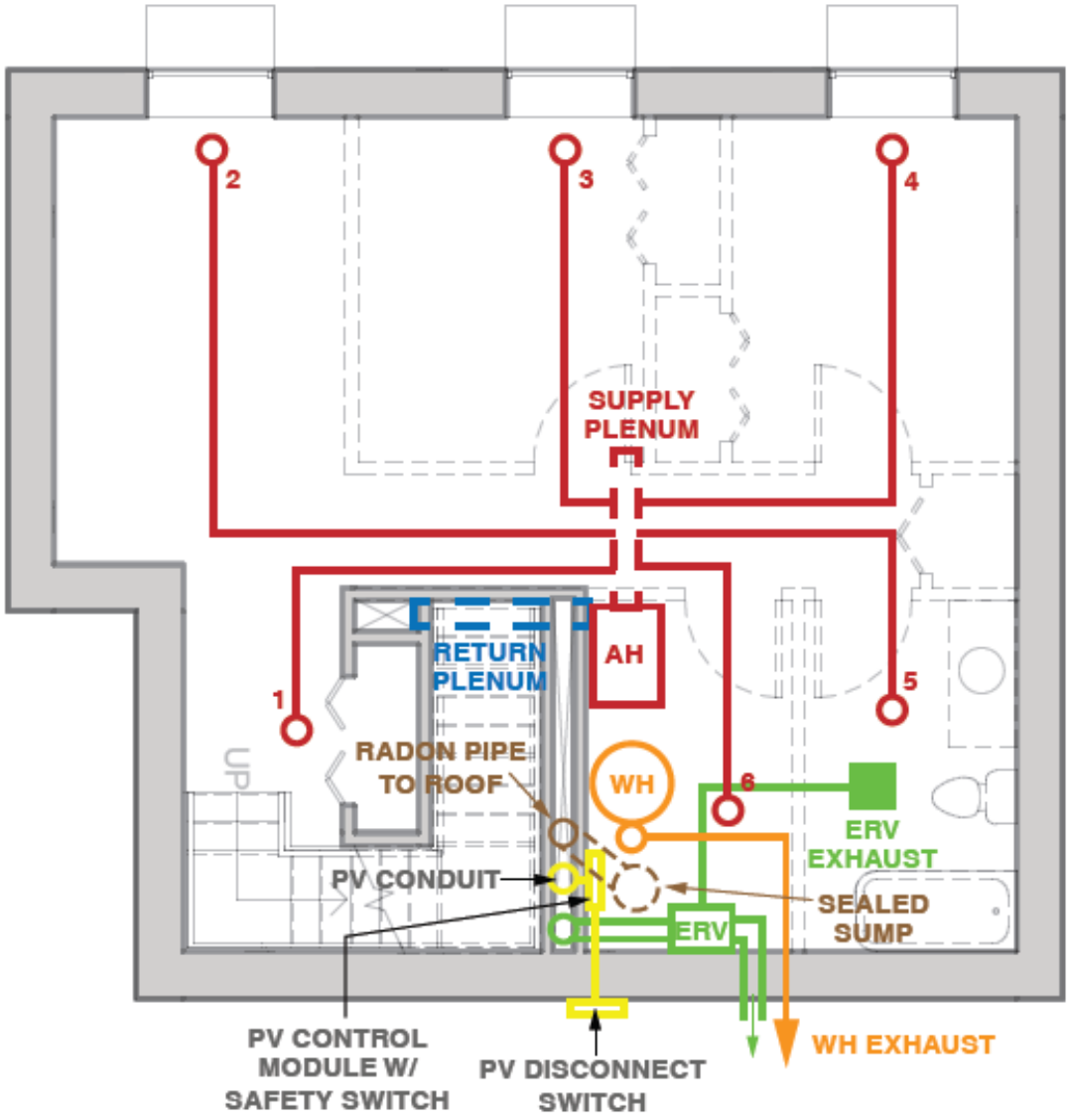
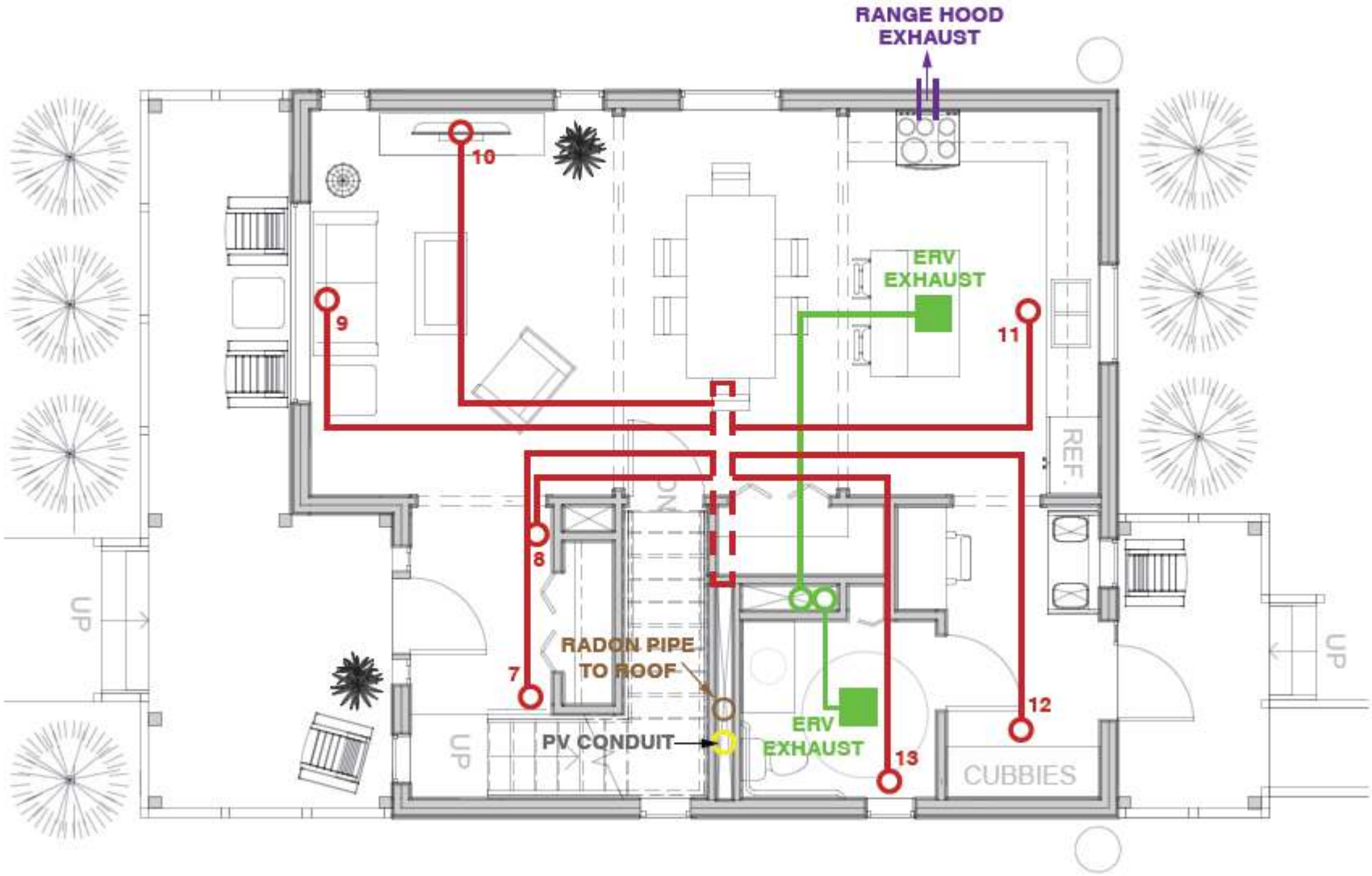


Figure 16. High/low through-the-wall transfer grille

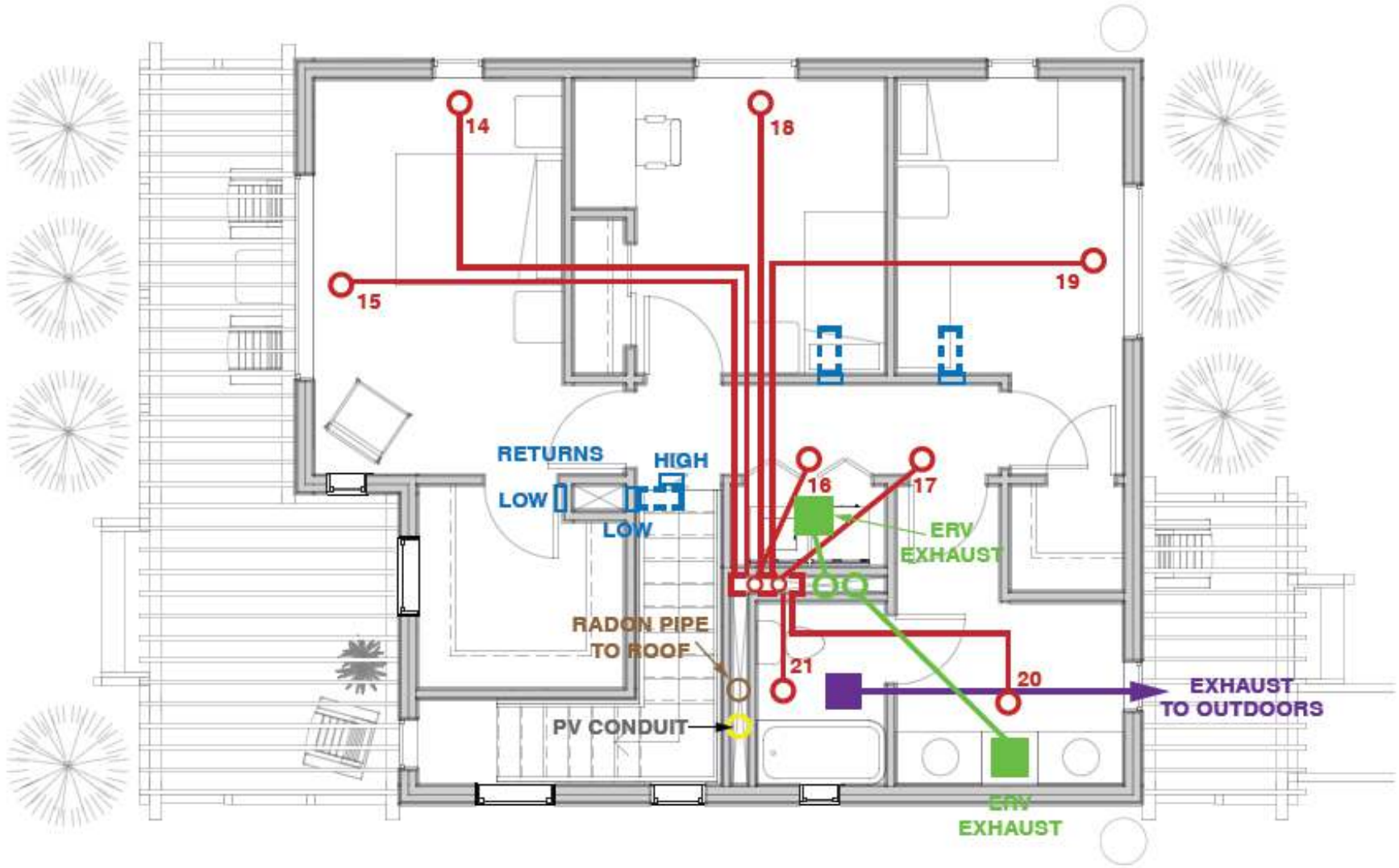
SYSTEMS | Lower Level Mechanical Plan



SYSTEMS | First Floor Mechanical Plan



SYSTEMS | Second Floor Mechanical Plan



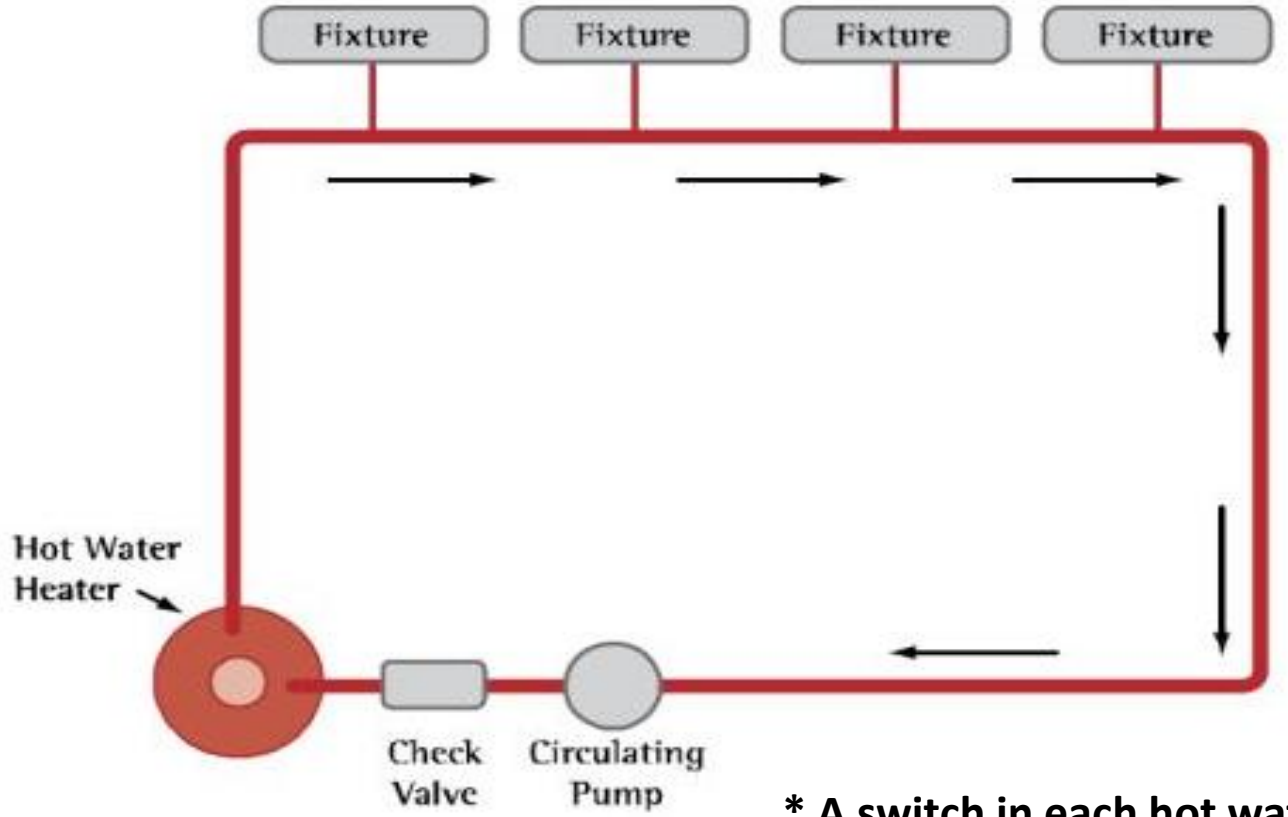
Hot Water Goals

- Minimize cold water wasted waiting for hot water to arrive
- Limit hot water that remains unused in the pipes
- Comply with EPA WaterSense specifications
- High-efficiency, sealed combustion, condensing water heater

Polaris High-Efficiency Water Heater

- 96% thermal efficiency
- 100,000 Btu/hour input
- 34 gallon capacity
- 1% standby losses

SYSTEMS | Demand Recirculation Pump & Loop



*** A switch in each hot water use area initiates the recirculation pump**

SYSTEMS | Hot Water Delivery System Calculations

Hot Water Delivery System Calculations

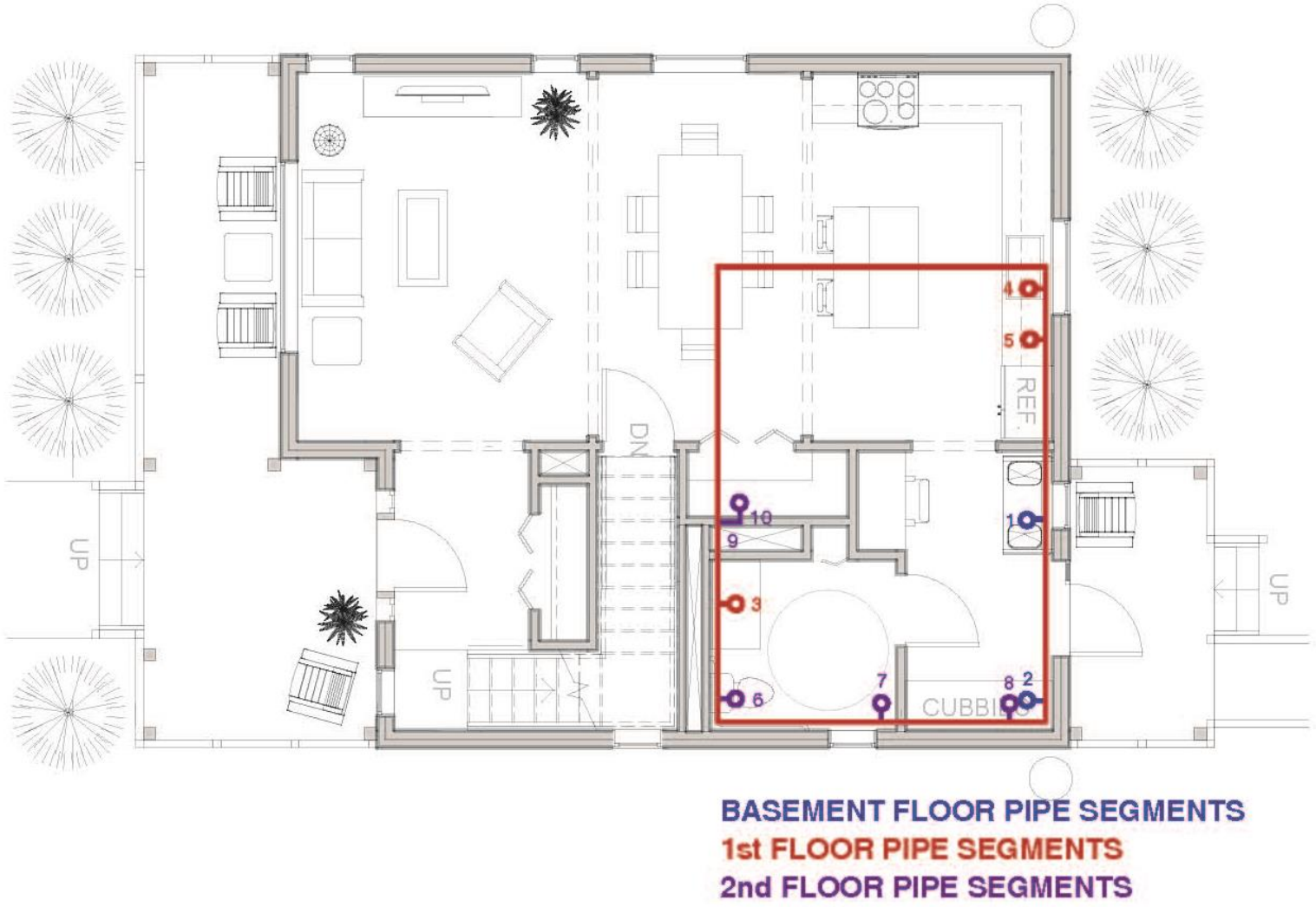
Demand-Initiated Recirculation System Using CVPC SCH 40 Tubing

Fixture	Pipe Segment	Pipe Diameter [in]	Water Capacity [oz/ft]	Pipe Length [ft]	Water Volume [gal]
basement bathroom	Drop from Loop	1/2	1.89	6.5	0.096
	1	1/2	1.89	1.5	0.022
				Total Hot Water Volume [gal]	**0.118**
				Hot Water Wait Time [sec]	**4.7**
basement bathtub	Drop from Loop	1/2	1.89	6	0.089
	2	1/2	1.89	1.5	0.022
				Total Hot Water Volume [gal]	**0.111**
				Hot Water Wait Time [sec]	**3.0**
1st Floor half	Drop from Loop	1/2	1.89	3.5	0.052
	3	1/2	1.89	1.5	0.022
				Total Hot Water Volume [gal]	**0.074**
				Hot Water Wait Time [sec]	**3.0**
1st Floor kitchen sink	Drop from Loop	1/2	1.89	3.5	0.052
	4	1/2	1.89	1.5	0.022
				Total Hot Water Volume [gal]	**0.074**
				Hot Water Wait Time [sec]	**2.0**
1st floor dishwasher	Drop from Loop	1/2	1.89	3.5	0.052
	5	1/2	1.89	1.5	0.022
				Total Hot Water Volume [gal]	**0.074**
2nd floor tub and shower	Drop from Loop	1/2	1.89	12.5	0.185
	6	1/2	1.89	1.5	0.022
				Total Hot Water Volume [gal]	**0.207**
				Hot Water Wait Time [sec]	**6.2**

Fixture	Pipe Segment	Pipe Diameter [in]	Water Capacity [oz/ft]	Pipe Length [ft]	Water Volume [gal]
2nd Floor Bath Sink 1	Drop from Loop	1/2	1.89	12.5	0.185
	7	1/2	1.89	1.5	0.022
				Total Hot Water Volume [gal]	**0.207**
				Hot Water Wait Time [sec]	**8.3**
2nd Floor Bath Sink 2	Drop from Loop	1/2	1.89	12.5	0.185
	8	1/2	1.89	1.5	0.022
				Total Hot Water Volume [gal]	**0.207**
				Hot Water Wait Time [sec]	**8.3**
2nd Floor Clothes Washer	Drop from Loop	1/2	1.89	12.5	0.185
	9	1/2	1.89	1	0.015
	10	1/2	1.89	1.5	0.022
				Total Hot Water Volume [gal]	**0.221**

1. Assumes a bathroom sink faucet flow rate of 1.5 gpm: the maximum flow rate for WaterSense labeled bathroom sink faucets
2. Assumes a kitchen facuet flow rate of 2.2 gpm: the maximum flow rate for WaterSense labeled kitchen sink faucets
3. Assumes a showerhead flow rate of 2.0 gpm: the maximum flow rate for WaterSense labeled showerheads.

SYSTEMS | Demand Recirculation Hot Water Distribution

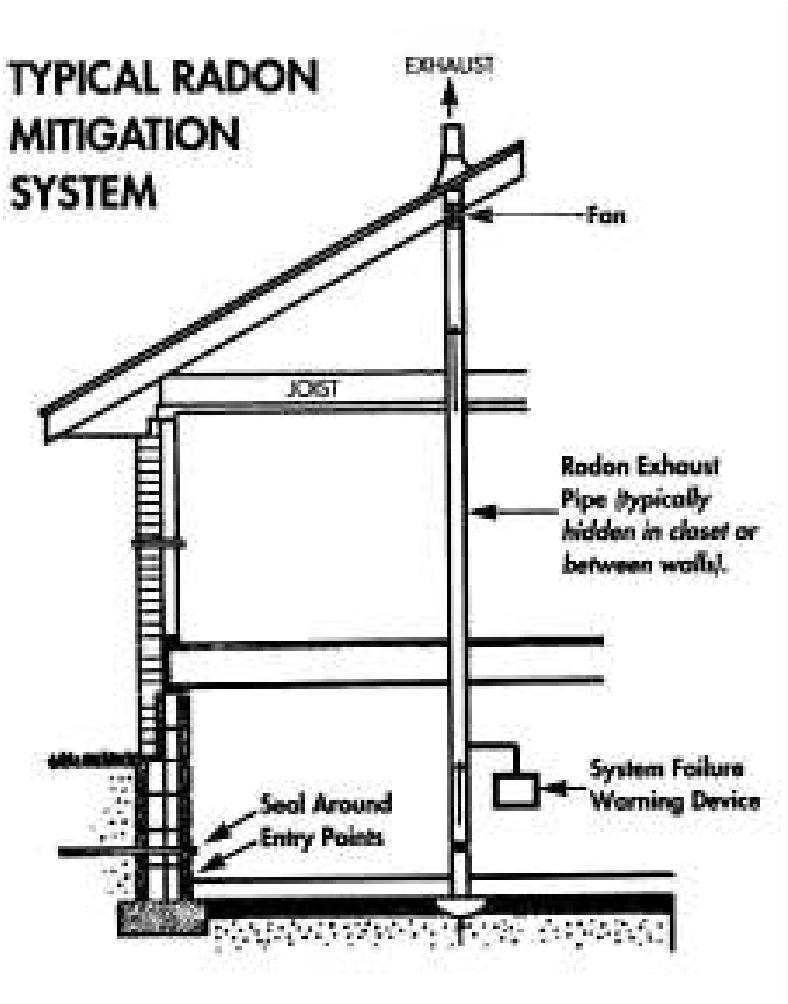


3-Step Indoor Air Quality Strategy

- **Avoid pollutant sources**
  - combustion pollutants
  - radon reduction strategies
  - VOCs, lead, etc.
  - avoidance of garage contaminants
- **Ensure point-source removal**
- **Provide fresh air distribution**

INDOOR AIR QUALITY | Radon/VOC/Particulate Reduction

- Active sub-slab depressurization system to mitigate soil gases
- Material selection following EPA's Indoor AirPLUS to minimize indoor emissions
- Use of hard surface flooring to mitigate particulate loading



INDOOR AIR QUALITY | Whole House & Fresh Air Filtration

Better

Filtered Airborne Contaminants

POLLEN | PET DANDER | DUST/LINT | DUST MITE | MOLD SPORES | SMOG | ODOR*

	Particle Size Removal	Arrestance	Dust-Spot Efficiency Percent	Typical Applications	Most Common Air Filter Type
MERV 9	-	> 90%	40 - 45%	Better Residential Better Commercial Buildings Hospital Laboratories	Bag Filters Pleated Filters Rigid Style Box Filters
MERV 10	-	> 95%	50 - 55%		
MERV 11	-	> 95%	60 - 65%		
MERV 12	-	> 95%	70 - 75%		

INDOOR AIR QUALITY | Ventilation Rates

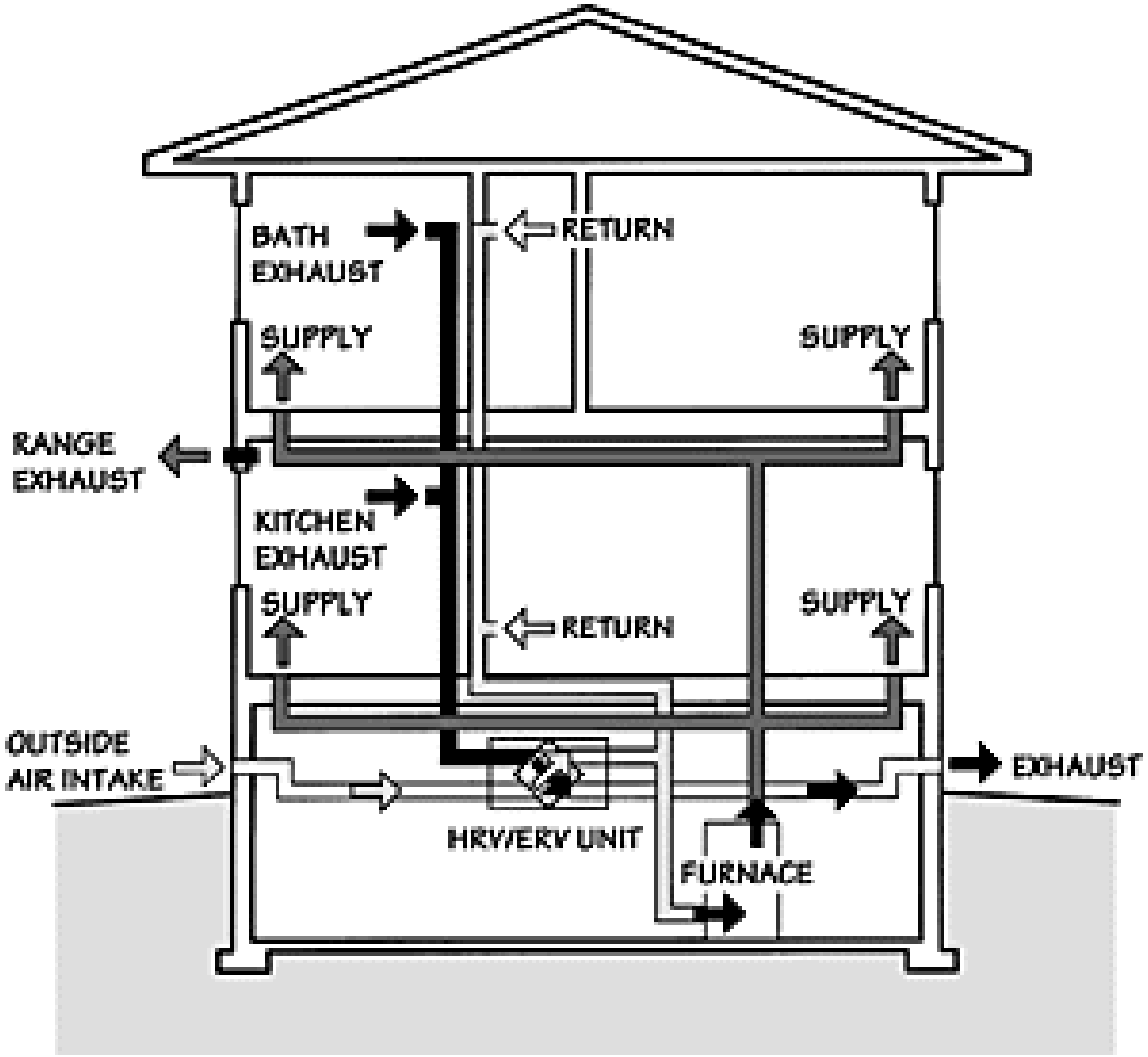
ASHRAE 62.2 2013		
# BR.	5	3
Sq. Ft.	2544	2544
Total Required Ventilation	121.32	106.32

ASHRAE 62.2 2010		
# BR.	5	3
Sq. Ft.	2544	2544
Total Required Ventilation	70.44	55.44

MN Energy Code 2015		
# BR.	5	3
Sq. Ft.	2544	2544
Total Required Ventilation	140.88	110.88
Total Cont. Required	70.44	55.44

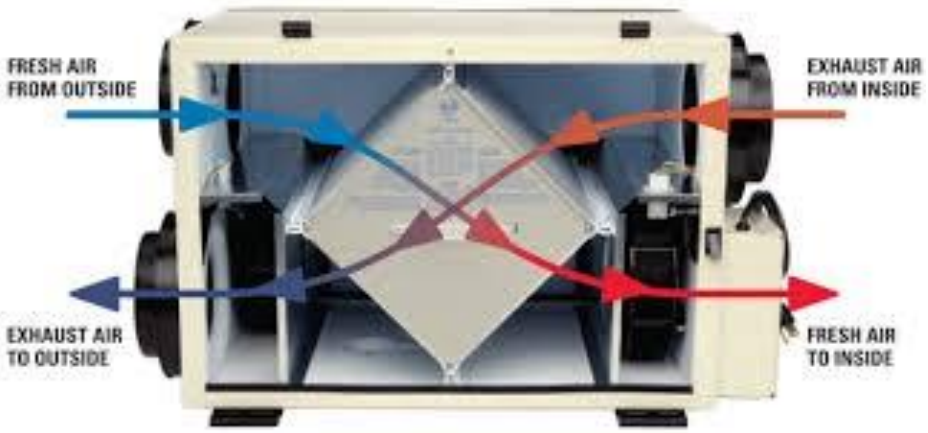
MN Energy Code 2015	3 BR		5 BR	
	Cont.	Total	Cont.	Total
* From Table @ 2000-2500 sq ft.	55	100	70	140
* From Table @ 2500-30000 sq ft.	60	120	75	150

INDOOR AIR QUALITY | Balanced Source-Point Ventilation



Venmar ERV Duo 2.0

- 70% SRE
- 60-120 CFM



Source Point CFM (continuous/high)

- 2nd Floor Bathroom = 10-20 cfm
- 2nd Floor Laundry = 10-20 cfm
- 1st Floor Half-Bath = 20-40 cfm
- 1st Floor Kitchen = 10-20 cfm
- Lower Level = 10-20 cfm

Dedicated Exhaust Fans

- Due to high use and pollutant potential a dedicated exhaust fan is being used in:
- Primary bath
  - Mitigate odors and humidity
- Kitchen range
  - Manage gases and particulates
  - Large area for improved capture efficiency

Panasonic FV-08VKM3

- 50 cfm intermittent

Ispira Venmar IU600ES

- 160 cfm intermittent

ENERGY PERFORMANCE | OptiMN Impact Home

- **REM/Rate Model**
  - **Meets** DOE ZERH
  - HERS Index = **32**
  - ENERGY STAR Rating of **5 Star Plus**
  - Estimated Annual Energy Cost = **$1,124**

ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

Annual Load	MMBtu/yr
Heating	29.9
Cooling	6.4
Water Heating	10.8

Annual Consumption	MMBtu/yr
Heating	32.0
Cooling	1.5
Water Heating	11.4
Lights & Appliances	19.0
Photovoltaics	-0.0
Total	**63.8**

Annual Energy Cost	$/yr
Heating	282
Cooling	38
Water Heating	97
Lights & Appliances	500
Photovoltaics	-0
Service Charges	204
Total	**1121**

Design Loads	kBtu/hr
Space Heating	20.2
Space Cooling	10.3

Utility Rates	
Electricity	Xcel Energy Elec
Gas	Xcel Energy Gas

DRAFT

ENERGY PERFORMANCE | OptiMN Impact Home with PV

- **REM/Rate Model**
  - **Meets** DOE ZERH
  - HERS Index = **0**
  - ENERGY STAR Rating of **5 Star Plus**
  - Estimated Annual Energy Cost = **$124**

ZERO ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

Annual Load	MMBtu/yr
Heating	29.9
Cooling	6.4
Water Heating	10.8

Annual Consumption	MMBtu/yr
Heating	32.0
Cooling	1.5
Water Heating	11.4
Lights & Appliances	19.0
Photovoltaics	-37.8
Total	**26.0**

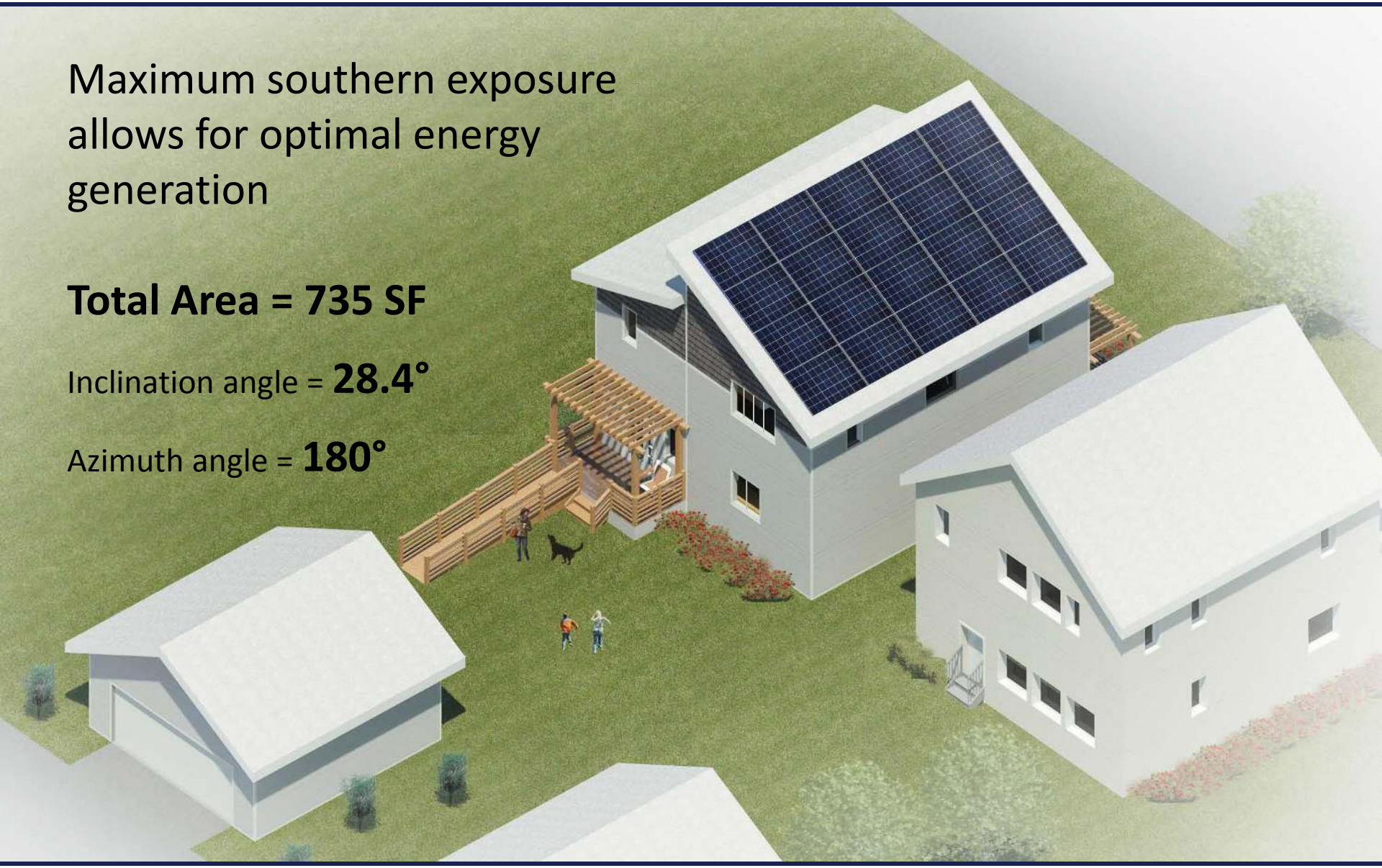
Annual Energy Cost	$/yr
Heating	282
Cooling	38
Water Heating	97
Lights & Appliances	500
Photovoltaics	-997
Service Charges	204
Total	**124**

Design Loads	kBtu/hr
Space Heating	20.2
Space Cooling	10.3

Utility Rates	
Electricity	Xcel Energy Elec
Gas	Xcel Energy Gas

DRAFT

PHOTOVOLTAIC SYSTEM | Aerial View



PHOTOVOLTAIC SYSTEM | Solar Array Analysis

- tenK is Minnesota made, allowing for a Made in Minnesota rebate for 10 years
- Model XT-A 410W system utilizes parallel architecture, a redundant inverter bus, and polycrystalline cells
- 20 - 410 watt panels
- Maximum power generation of 8.2 kW
- Cost before rebates = $41,000
- Cost after federal tax credit = $28,700
- Annual energy savings = 10,337 kWh
- At $0.10/KWh, the PV system will save approximately $1,034 per year
- HERS Score with PV = 0

ten K SOLAR

PHOTOVOLTAIC ARRAY | Costs & Payback

Year	KWh Produced	MiM Rebate	Annual PV savings	Total Annual Savings	Annual Payback ($)
0	11,086	$2,772	$1,033	$3,805	24896
1	11,086	$2,590	$1,138	$3,728	21168
2	11,086	$2,421	$1,140	$3,560	17607
3	11,086	$2,262	$1,142	$3,404	14203
4	11,086	$2,114	$1,144	$3,258	10945
5	11,086	$1,976	$1,145	$3,121	7824
6	11,086	$1,847	$1,147	$2,994	4830
7	11,086	$1,726	$1,149	$2,875	1955
8	11,086	$1,613	$1,150	$2,763	-808
9	11,086	$1,508	$1,151	$2,659	-3466
10	11,086	$1,409	$1,153	$2,562	-6028

- kWh production was given by NREL calculator using local weather data and assumed to be constant
- PV information can be found in energy analysis
- **Made in Minnesota (MIN) rebate** is given for 10 years & awarded for using local MN solar panels
- **Payback** is in **year 8**

LIGHTING | Annual Electricity Cost Comparison

LED Lights						Incandescent Lights	
FIXTURE	Units	LED Watt	Hours/Day	Total Watt/Day	Total kWh/year	Watts/Unit	Total kWh/year
Track Lighting	1	16	8	128	46.72	65	189.8
Island Lighting	1	60	8	480	175.2	65	189.8
Ceiling Lights							
(Bed 1)	1	16.92	3	50.76	18.5274	65	71.2
(Bed2)	1	16.92	5	84.6	30.879	65	118.6
(Bed3)	1	16.92	3	50.76	18.5274	65	71.2
(Closets)	4	16.92	2	135.36	49.4064	65	189.8
(Foyer)	2	16.92	5	169.2	61.758	65	237.3
(Hall)	1	16.92	5	84.6	30.879	65	118.6
(Bath)	3	16.92	4	203.04	74.1096	65	284.7
(Living/Dining)	2	16.92	8	270.72	98.8128	65	379.6
Sconce Fixture	2	13	12	312	113.88	65	569.4
Vanity Fixtures	3	13	4	156	56.94	65	284.7
Wall-Mounts	2	11.6	12	278.4	101.616	100	876.0
				Total	**877.2556**		**3580.65**
				Cost ($/kWh)	**$0.10**		**$0.10**
				Total ($/yr)	**$87.73**		**$358.07**

Total Savings ($/yr) **$270.34**

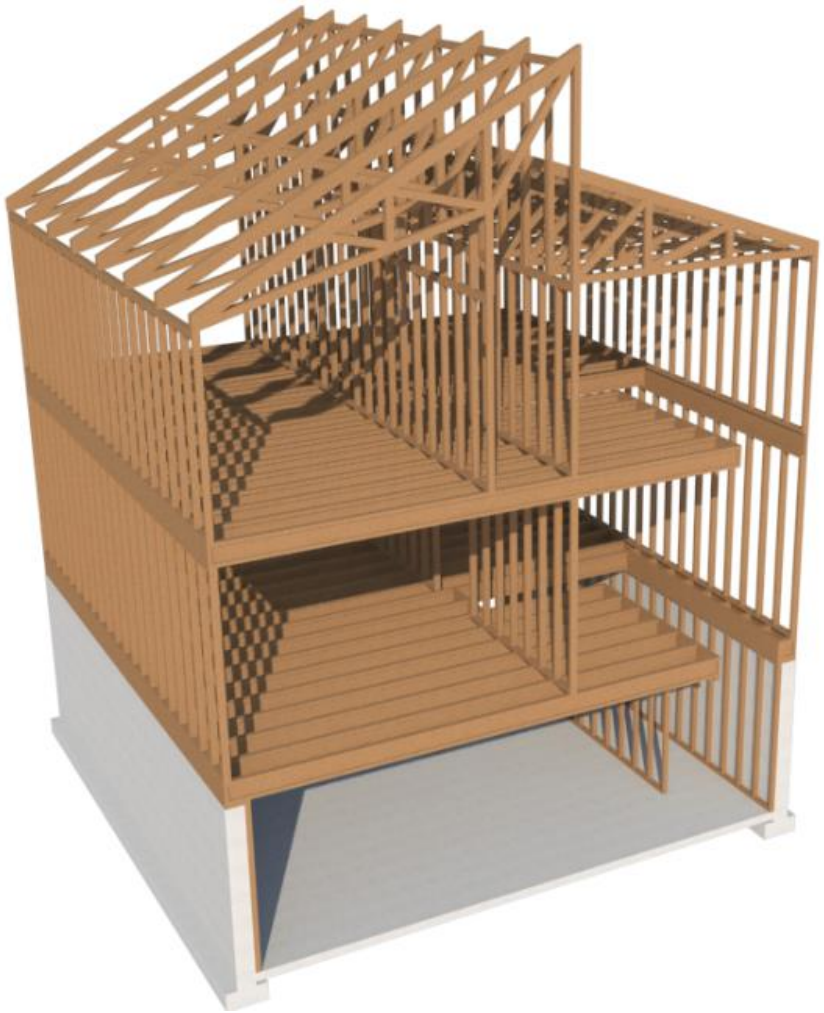
APPLIANCE CHOICE | Balancing Cost & Performance

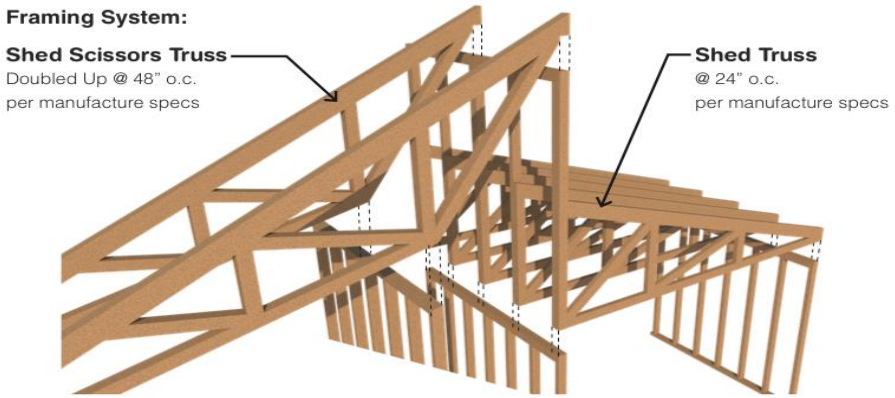
Ventless washer-dryer combo for ZERO impact on house pressure during operation

Efficient fan motors for air handler, ERV, bath fan, and range hood

ENERGY STAR rated appliances and fans

CONSTRUCTABILITY | Familiar Systems & Materials





Approachable and Appropriate Construction Materials and Methods

- Simplified shape in 4’ modules
- Use of traditional framing techniques
- Use of prefabricated roof trusses
- Use of readily accessible building materials
- Simplified duct and hot water systems
- A “Construction Quality Management Plan” for unique and sequence sensitive details

FINANCIAL FRAMEWORK | Meeting Competition Standards

	Annual	Monthly
Medium Family Income (MFI)	$63,900	$5, 325
Home Ownership Affordability	$24,282	$1,650.75
Utility Costs	$1, 121	$93
Property Tax	$1, 917	$108
Insurance	$780	$92
Mortgage Insurance	$1, 598	$133.13
Down Payment	$62,369	
Monthly Household Debt	$320	$26.63
Amount Available for Mortgage Payment	$18,547	$1,546

Monthly Payment of Opti-MN House **$1,264**

What can the Homeowner Afford?

- **Using a median family income (MFI) of $63,900 for a family of four, which is 80% of Hennepin County's MFI of $82,300**
- Utility costs found by REM/Rate estimates
- **Down Payment** is paid in year 1, and is calculated to be **20% of home's value**

82% of what the family of four can afford

FINANCIAL FRAMEWORK | Meeting UHW Needs

	Annual	Monthly
Medium Family Income (MFI)	$63,900	$5,325
Home Ownership Affordability	$24,282	$1,650.75
Utility Costs	$1, 121	$93
Property Tax	$1, 296	$108
Insurance	$780	$92
Mortgage Insurance	$1,600	$90
Down Payment	$7,600	
Monthly Household Debt	$320	$26.63
Amount Available for Mortgage Payment	$14,894	$1,241.13

Monthly Payment of Opti-MN House with Special Financing **$731.65**

What can the Homeowner Afford?

- **Using the maximum median family income of $63,900** Minnesota Housing Finance Agency as the cap for "Low income" category of mortgage products for first-time homebuyers
- Utility costs found by REM/Rate estimates
- **Down Payment is 5% of mortgage amount**

Well within reach of the future homeowner

PRELIMINARY COST ESTIMATE

Hard Cost Preliminary Cost Estimate

- **$226,800 or $133 per ft²**

$318,900 TOTAL project cost after adding the competition 40.6% for soft costs

Green Homes North Example

PRELIMINARY COST ESTIMATE

Preliminary Budget			
Line Item	**Base Model Cost**	**Opti-MN House Cost**	**Cost/SF**
Site Preparation			
Lot Cost	$5,000.00	$5,000.00	$2.22
Utility Connections	$7,800.00	$8,827.05	$3.47
Concrete	$20,500.00	$23,199.29	$9.12
Misc. Prep Costs	$13,500.00	$15,277.58	$6.01
Subtotal Prep Costs	**$46,800.00**	**$52,303.91**	
General Construction			$0.00
Framing	$27,501.00	$21,098.09	$12.23
Windows and Doors	$8,694.80	$10,294.80	$3.87
Insulation	$12,604.00	$12,418.59	$5.61
Drywall	$2,784.45	$2,160.72	$1.24
Misc. General Construction Costs	$2,278.15	$2,831.87	$1.01
Subtotal General Construction	**$53,862.40**	**$48,804.07**	

PRELIMINARY COST ESTIMATE

Preliminary Budget			
Line Item	**Base Model Cost**	**Opti-MN House Cost**	**Cost/SF**
Interior Finishing			
Finish Carpentry	$14,098.25	$10,636.40	$6.27
Tile Work	$1,430	$1,078.86	$0.64
Flooring	$10,345	$7,804.77	$4.60
Painting	$3,000	$2,263.35	$1.33
Misc. Interior Painting Costs	$1,500	$1,131.67	$0.67
Punch List	$2,000	$1,508.90	$0.89
Subtotal Interior Finishes	**$32,373.25**	**$24,423.95**	
Exterior Finishes			
Exterior Cladding	$6,455	$7,304.95	$2.87
Porches	$3,300	$3,3734.52	$1.47
Landscaping Improvements	$1,500	$1,697.51	$0.67
Misc. Exterior Finishing Costs	$100	$113.17	$0.04
Subtotal Exterior Finishes	**$11,355**	**$12,850.14**	
Garage Construction	$12,885	$12,885	

PRELIMINARY COST ESTIMATE

Preliminary Budget			
Line Item	**Base Model Cost**	**Opti-MN House Cost**	**Cost/SF**
Roofing			
Roofing	$5,662.44	$11,815.77	$2.52
Gutters	$1,120	$844.98	$0.50
Subtotal Roofing	**$6,782.44**	**$12,660.75**	
Electrical Systems			
Lighting Package	$2,250	$2,946.26	$1.00
Electrical Labor	$7,395	$8,368.72	$3.29
Subtotal Electrical Systems	**$9,645**	**$11,314.98**	
Plumbing Systems			
Plumbing Fixtures	$2,000	$3,908.90	$0.89
Plumbing Labor	$13,000	$9,807.83	$5.78
Misc. Plumbing Systems Costs	$250	$188.61	$0.11
Subtotal Plumbing Systems	**$15,250**	**$13,905.34**	

PRELIMINARY COST ESTIMATE

Preliminary Budget			
Line Item	**Base Model Cost**	**Opti-MN House Cost**	**Cost/SF**
HVAC Systems			
Heating and Cooling	$14,000	$10,600	$6.23
Ventilation	$1,100	$1,544.84	$0.49
Subtotal HVAC Systems	**$15,100**	**$12,144.84**	
Energy Conservation			
Appliances	$2,700	$2,595	$1.20
Subtotal Energy Conservation	**$2,700**	**$2,595**	
Other			
General Requirements	$8,830	$9,992.67	$3.93
Builder's Profit	$2,849.72	$3,224.95	$1.27
Overhead	$7,064	$7,994.14	$3.14
Warranty Accrual	$1,500	$1,697.51	$0.67
Subtotal Other	**$20,243.72**	**$22,909.26**	
GRAND TOTAL	**$226,996.81**	**$226,797.24**	
5% Contingency		**$11,339.86**	

CONCLUSION | IMPACT Home by Team OptiMN

Department of Energy's CHALLENGE
to build a Zero Energy Ready Home

→ **HERS score of 32** without PV
HERS score of 0 with PV

Urban Homeworks' MISSION
to produce equitable, dignified, communities

Green Homes North INITIATIVE
to revitalize North Minneapolis neighborhoods
with affordable, sustainable, and quality homes

Team OptiMN's GOAL
is to design a home that makes an **IMPACT**
by achieving all of the above

Department of Energy's CHALLENGE
to build a Zero Energy Ready Home

Urban Homeworks' MISSION
to produce equitable, dignified, communities

An affordable house design that is larger, more flexible, and higher performance.

Green Homes North INITIATIVE
to revitalize North Minneapolis neighborhoods with affordable, sustainable, and quality homes

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Department of Energy's CHALLENGE
to build a Zero Energy Ready Home

Urban Homeworks' MISSION
to produce equitable, dignified, communities

Green Homes North INITIATIVE
to revitalize North Minneapolis neighborhoods with affordable, sustainable, and quality homes

→ **Giving new life to a vacant lot with a highly efficient home design for the future**

Team OptiMN's GOAL
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CONCLUSION | IMPACT Home by Team OptiMN

Department of Energy's CHALLENGE
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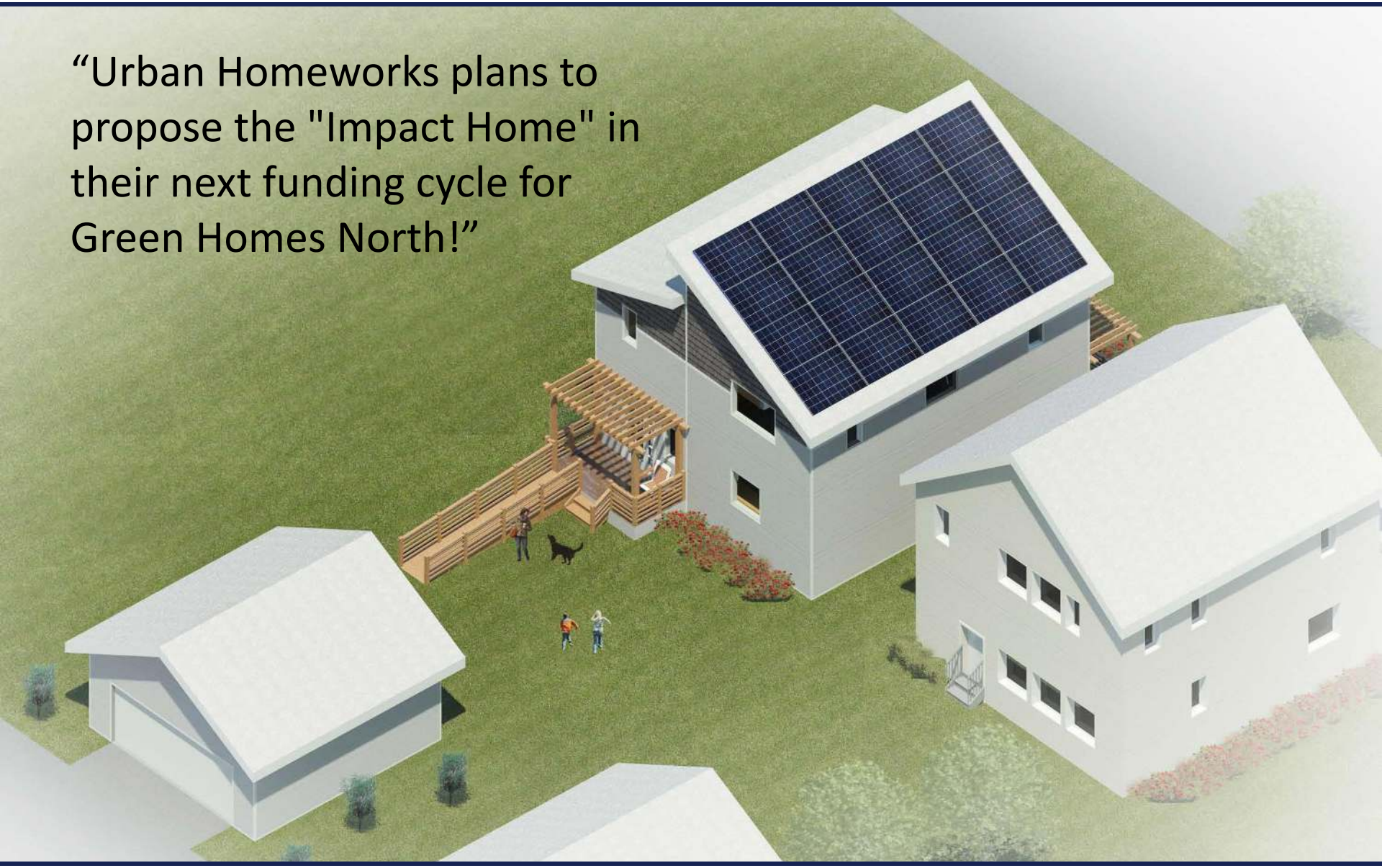
We successfully met these goals by creating an affordable, high-performance home that truly benefits the owner, the community, and the environment

CONCLUSION | And One Last Thing…



CONCLUSION | A Special Thank You from Team OptiMN

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