



appalachian
[In]sight



[In]visible House

Team Appalachian [In]sight



Management Team



Hazel Chang



Andrew Windham

Design Team



Ethan Gooch



Bahar Shir Khanloo

Systems Team



Rowan Parris



Ricky Bohlen

Construction Team



Abe Somers



Andrew Mackenzie

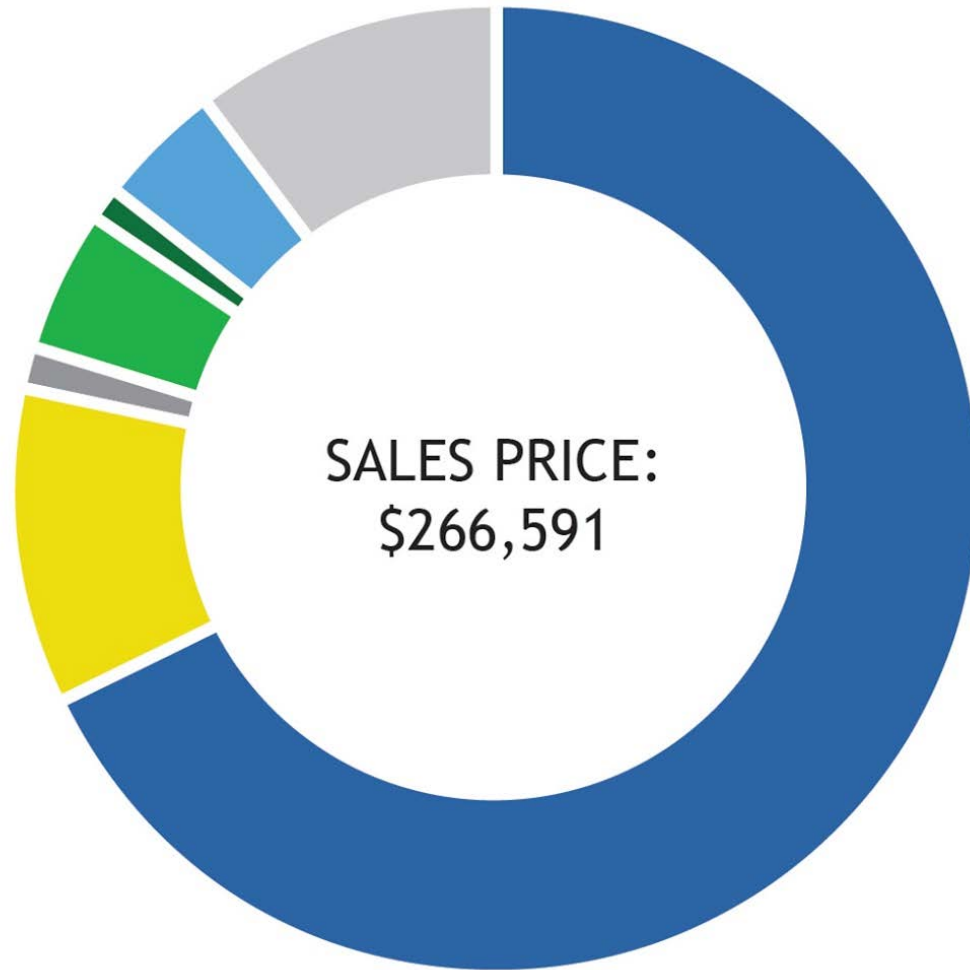
Industry Partners

- “Real life” project
- Schematic Review with Architects
- Tour of a zero-energy ready, mixed income neighborhood
- Market analysis with an Asheville realtor, Mary Love



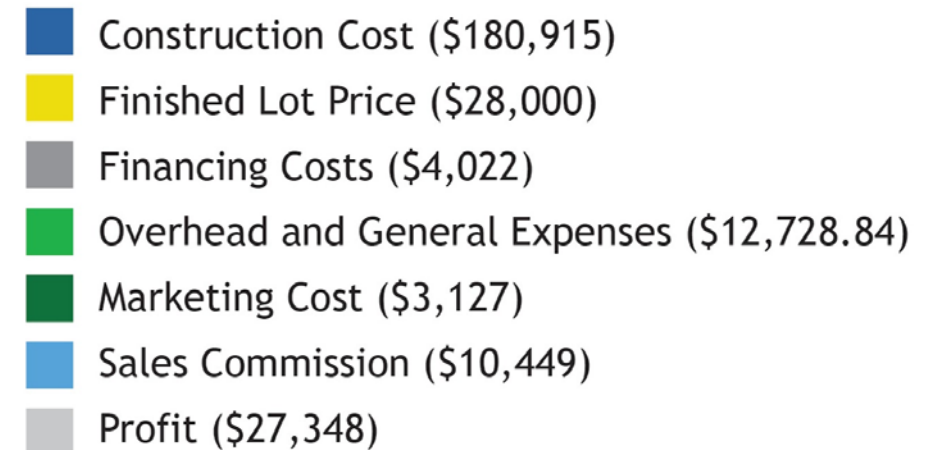
SAMSEL
ARCHITECTS

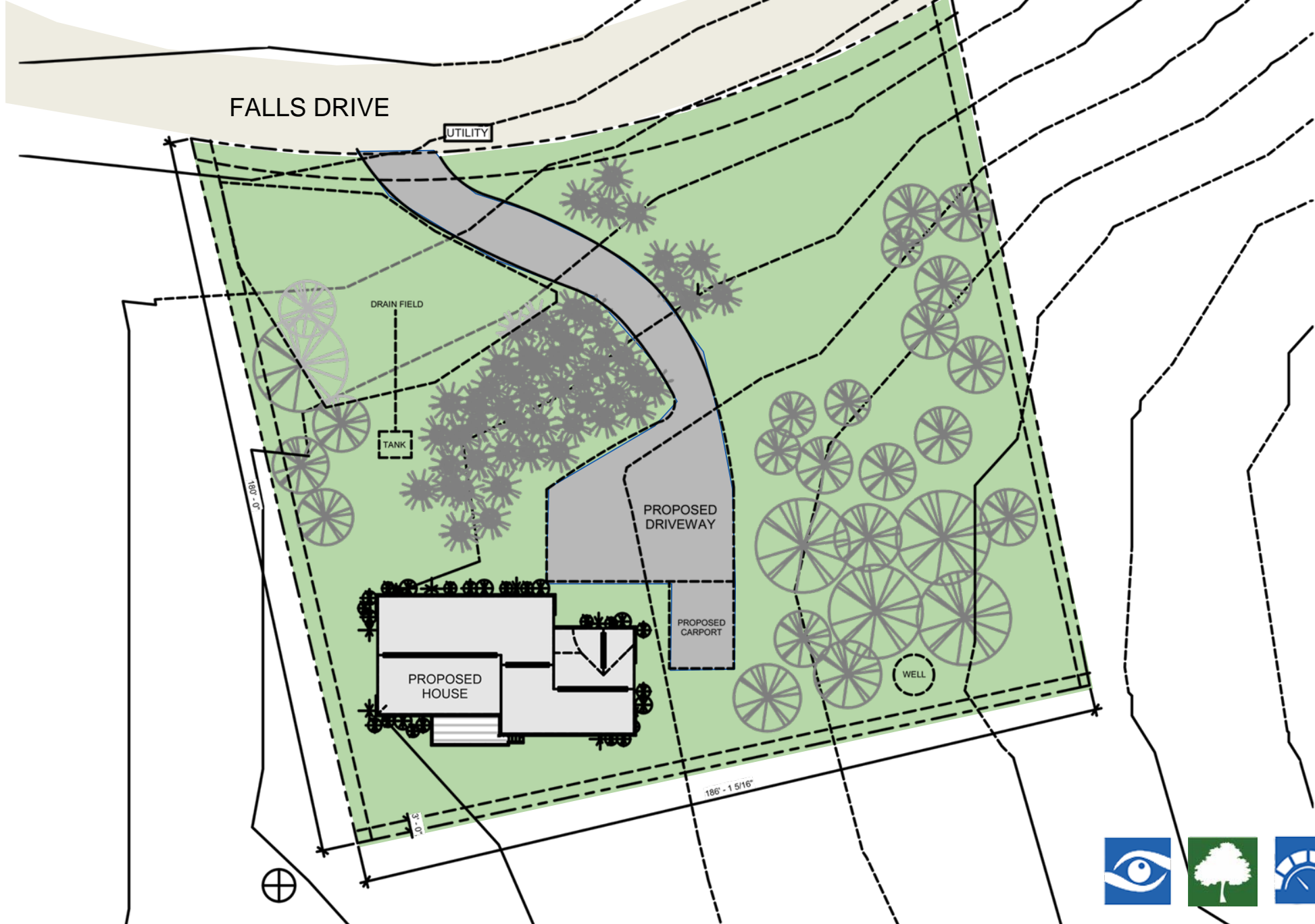




Target Market

- Retirees
- Young business professionals
- Small families







Panorama of Site



Existing Driveway



Neighbors to the SE



[In]visible house



Design Goals





Intentional Vision



- Stay hidden from neighbors
- Keep systems hidden until they need to be maintained
- Connect inside and outside





Conservation



- Design a house that reaches NZE with a 6.5 kW PV array
- Obtain ENERGY STAR, Indoor airPLUS, and WaterSense certifications
- Remain in the \$250K market





Performance



- Ensure clean and comfortable air is distributed throughout the house
- Have the potential to become an accessible design
- Maintain systems from within the home





Constructability



- Build upon proven construction assemblies
- Use negative space to add interest to a single story footprint
- Have a clear and documented plan for all major connections





Research-Based Innovation



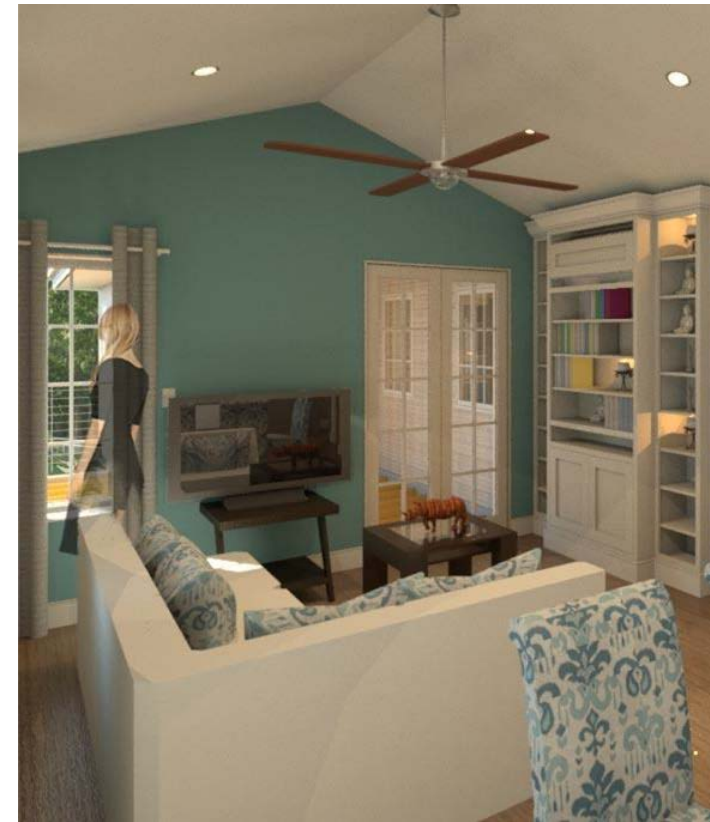
- Produce examples, data, and/or calculations to justify decisions
- Visit similar buildings to learn from experience
- Tackle new problems by understanding solved problems

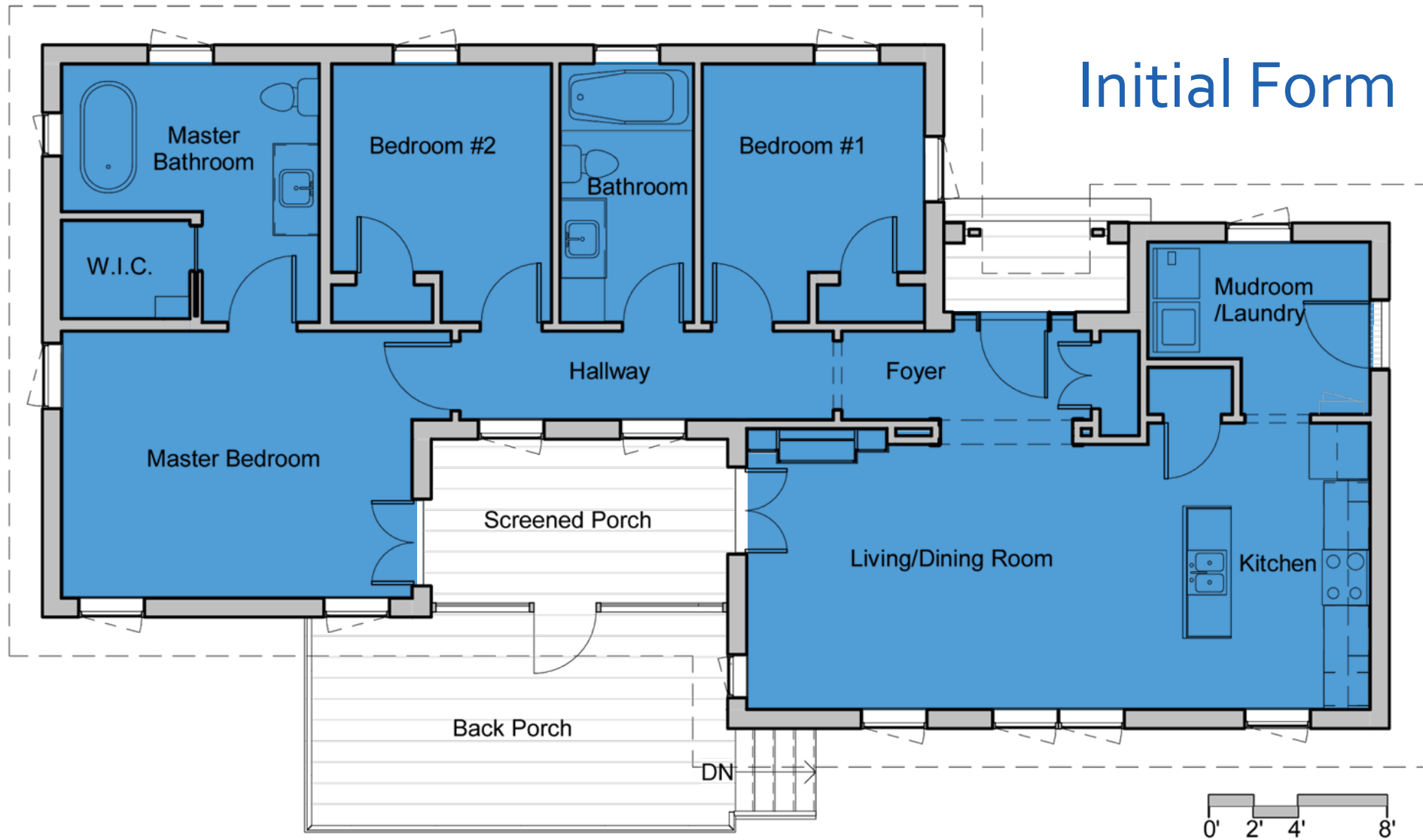




DESIGN

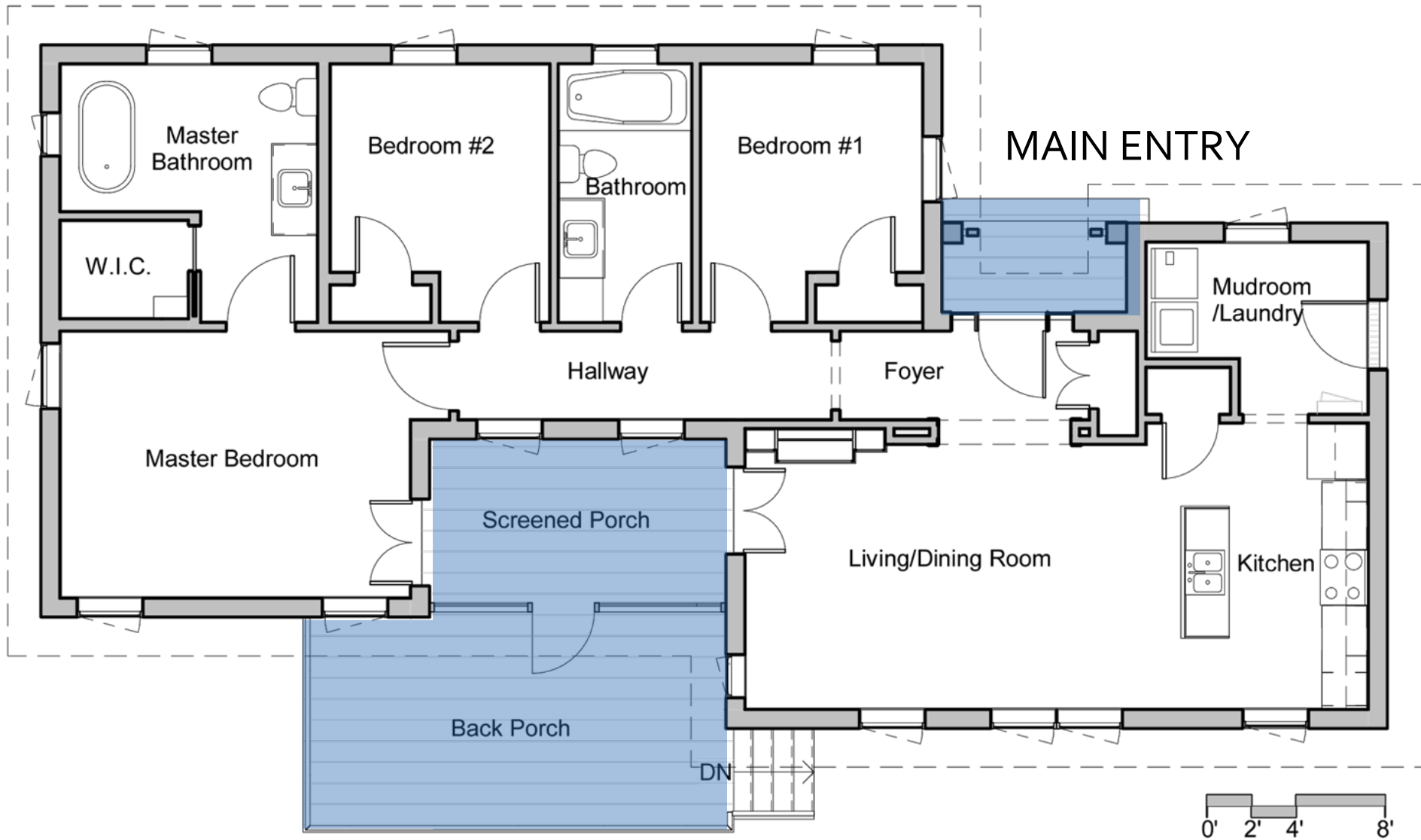
Ethan Gooch





Initial Form



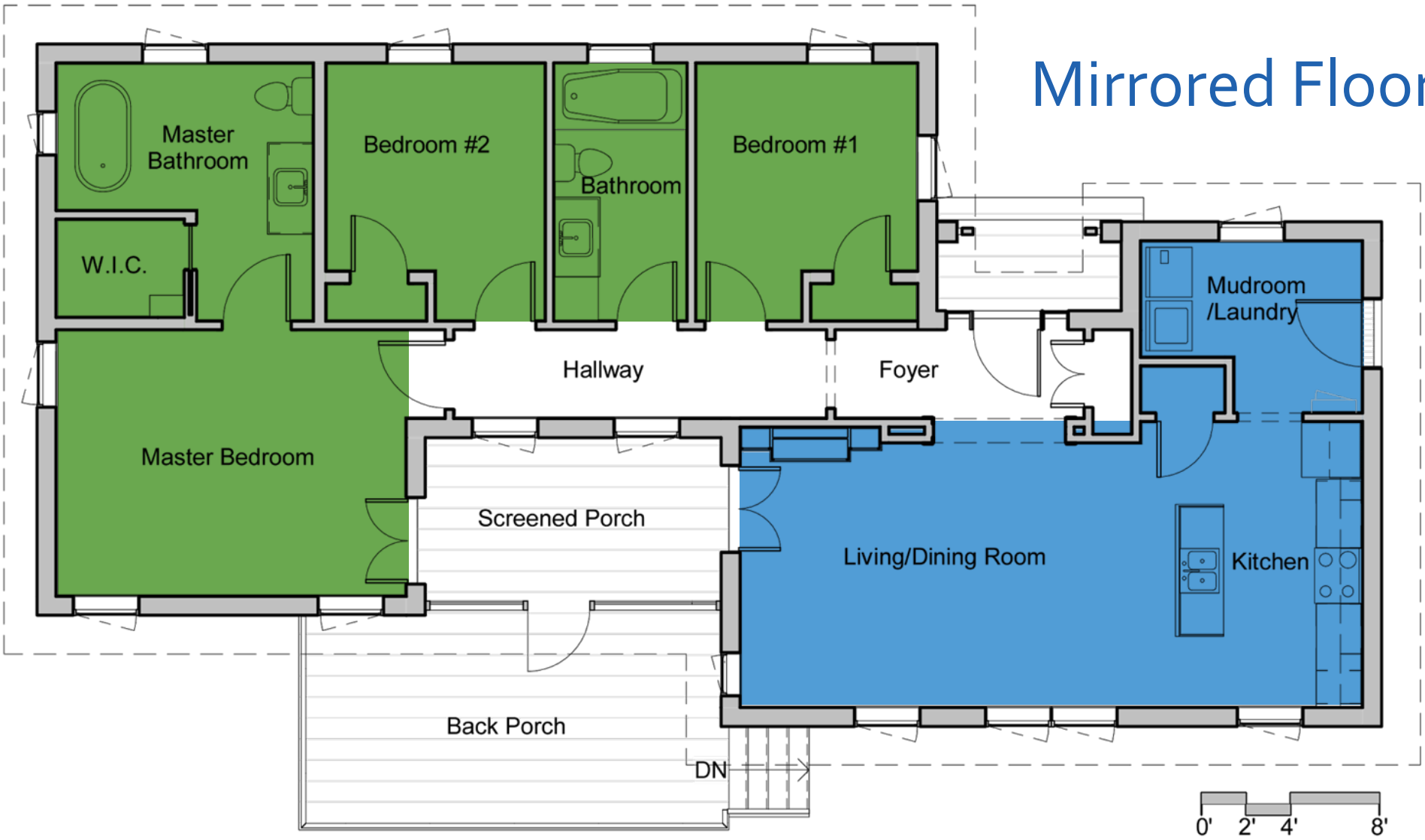


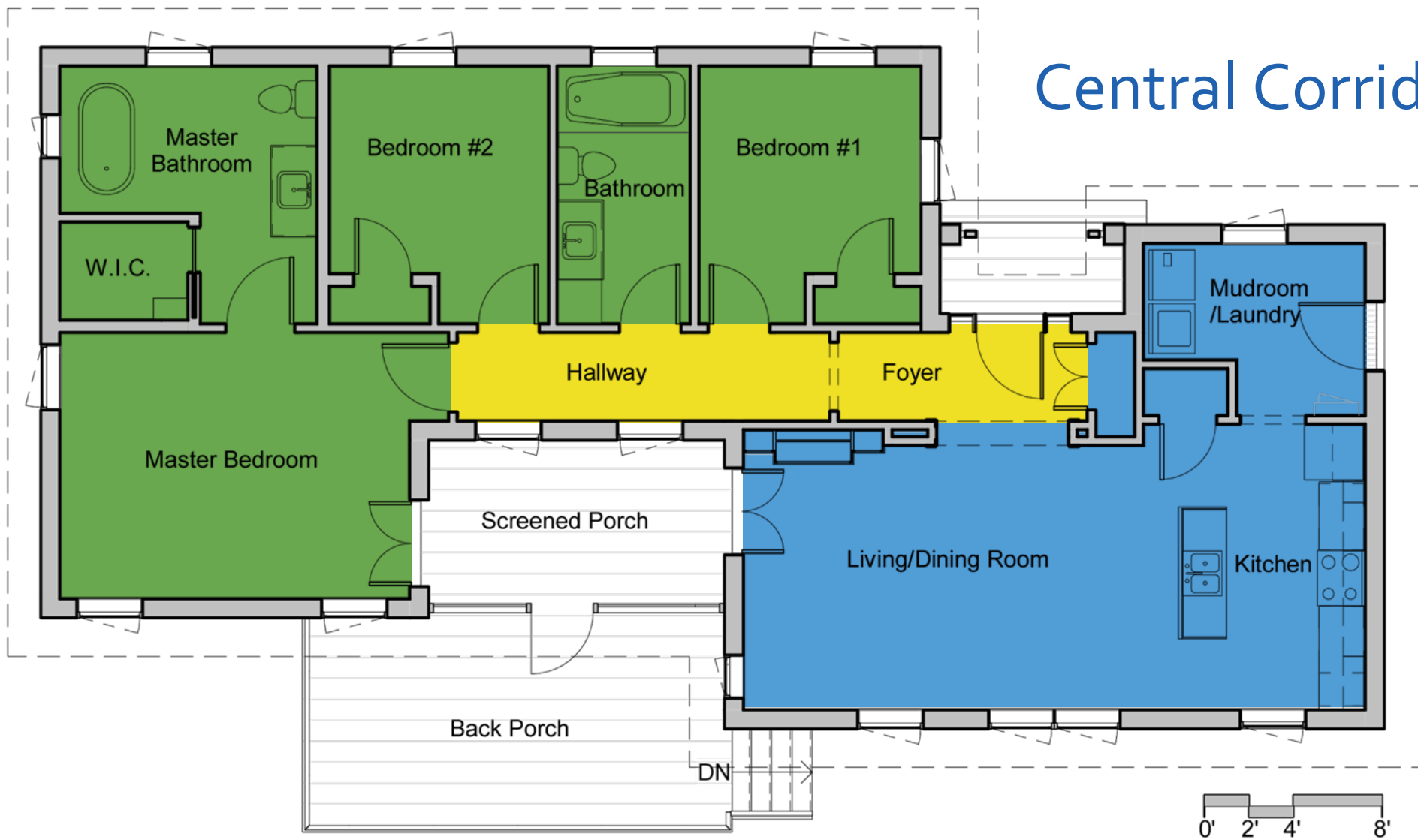
OUTDOOR ACCESS





Mirrored Floorplan



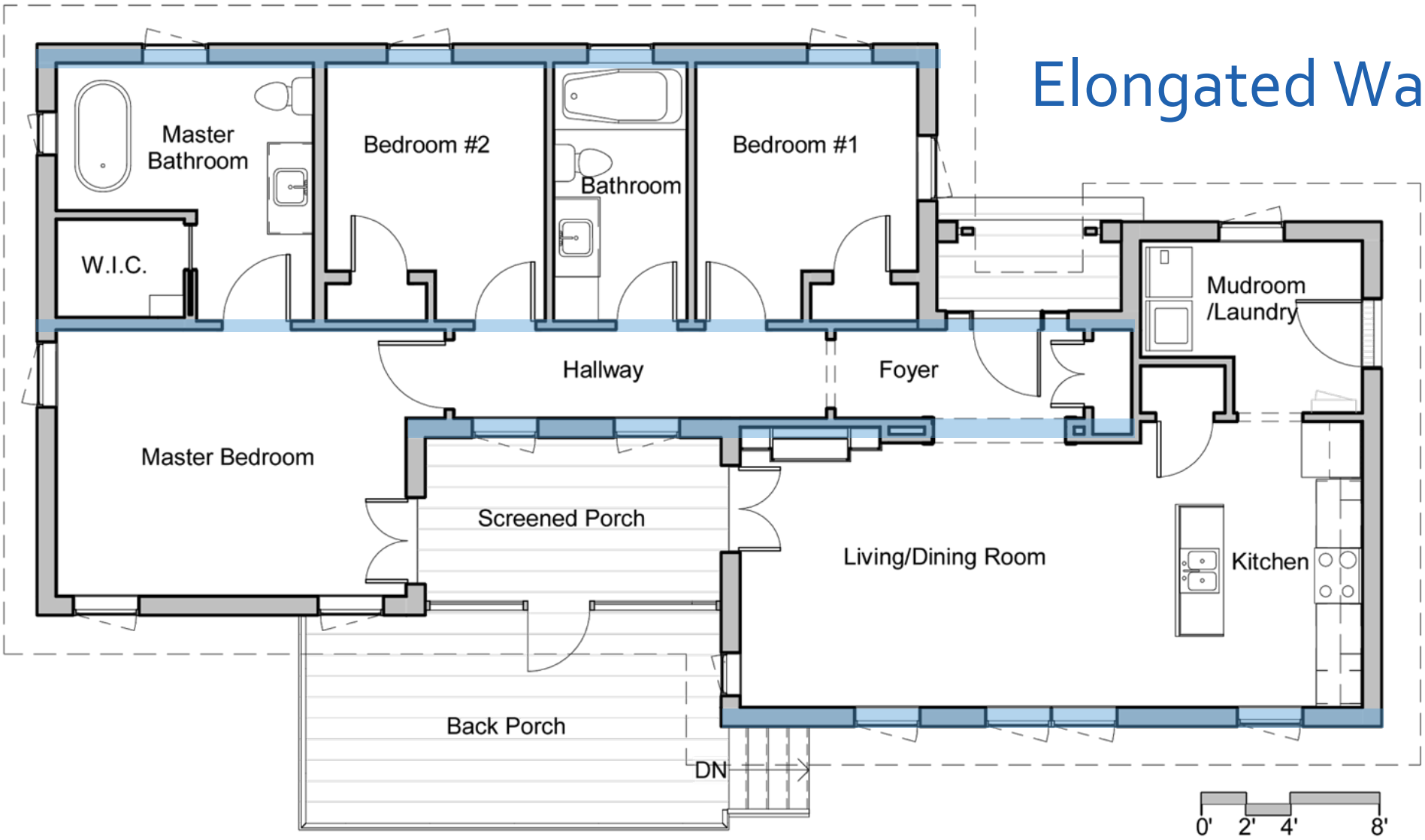


Central Corridor



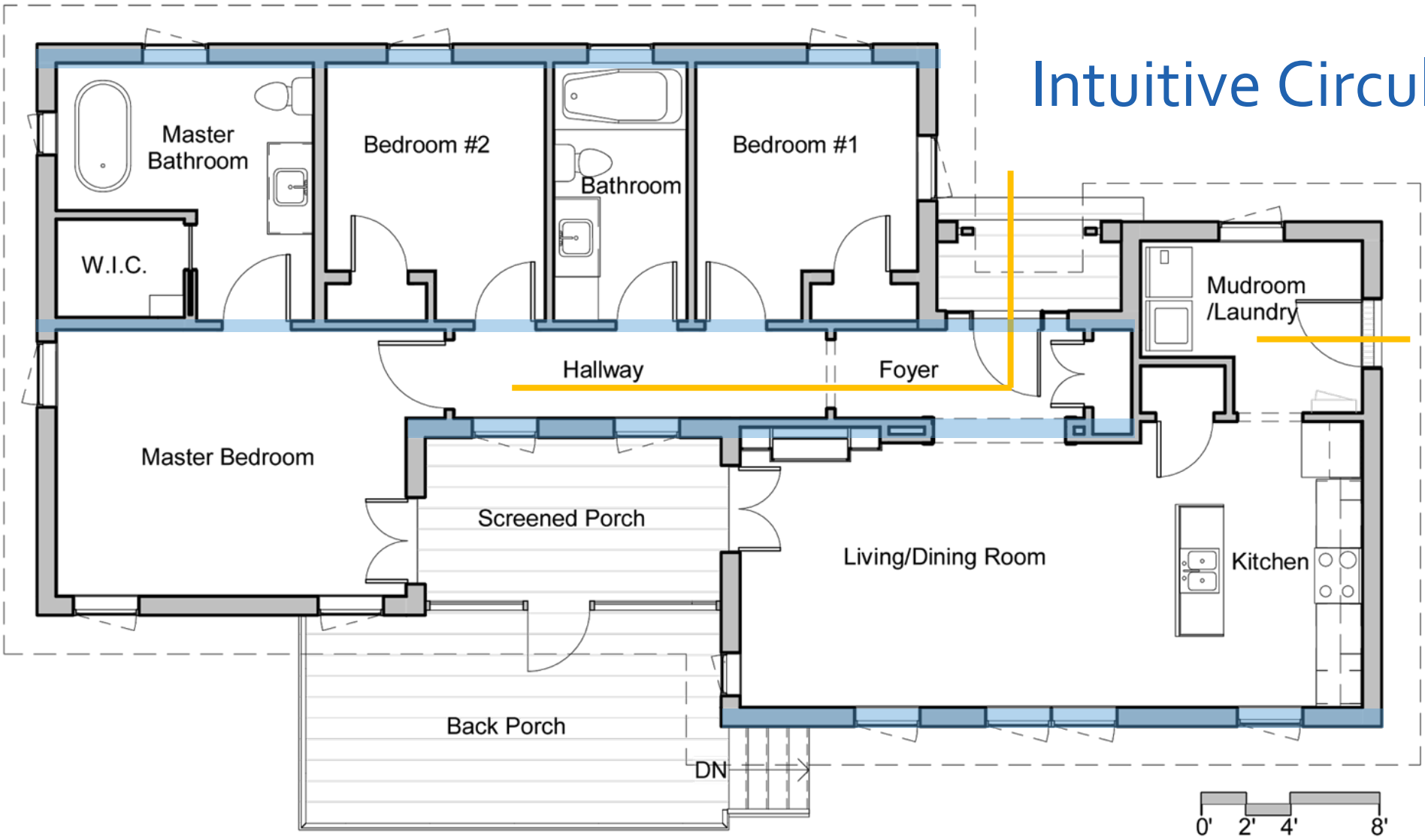


Elongated Walls



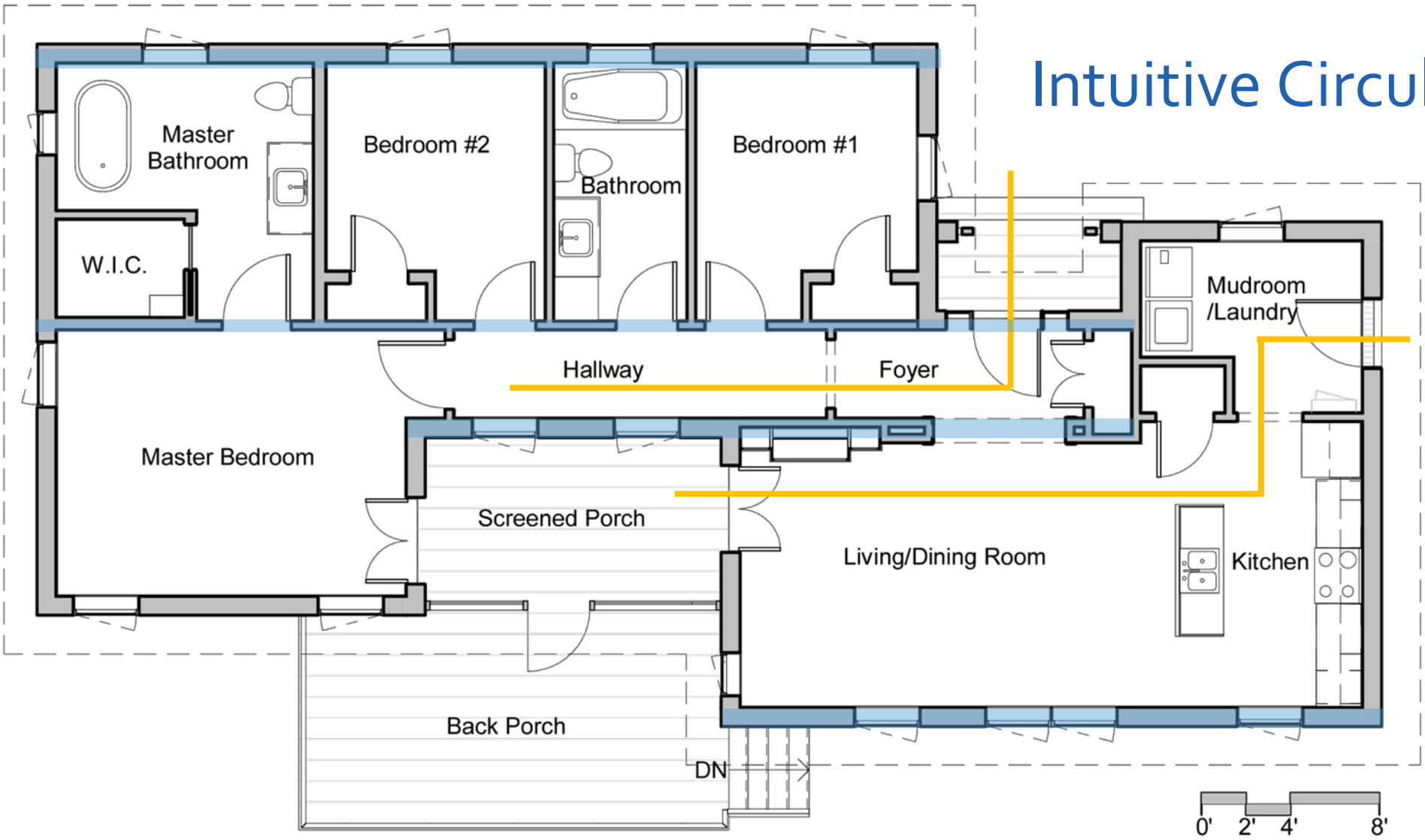


Intuitive Circulation



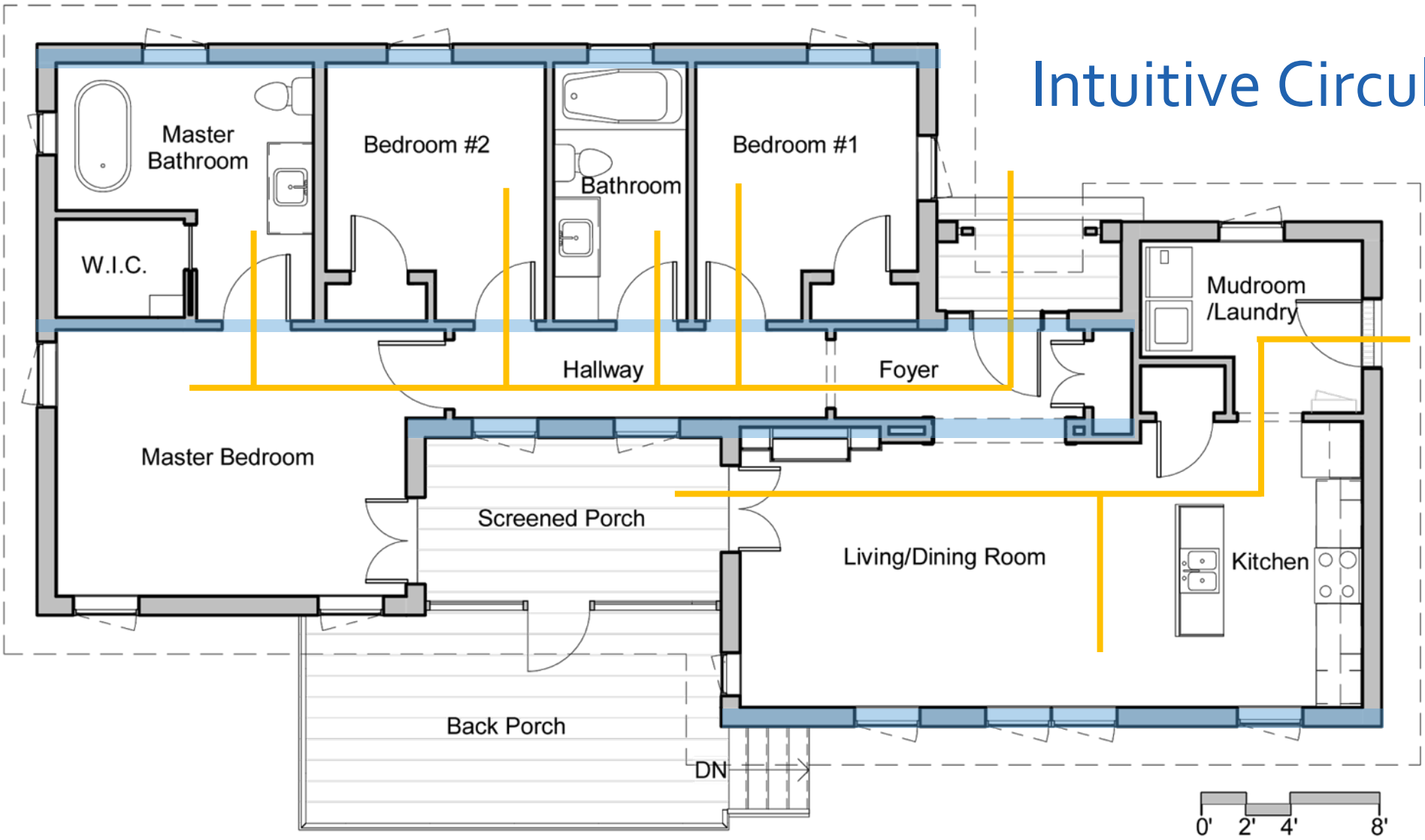


Intuitive Circulation



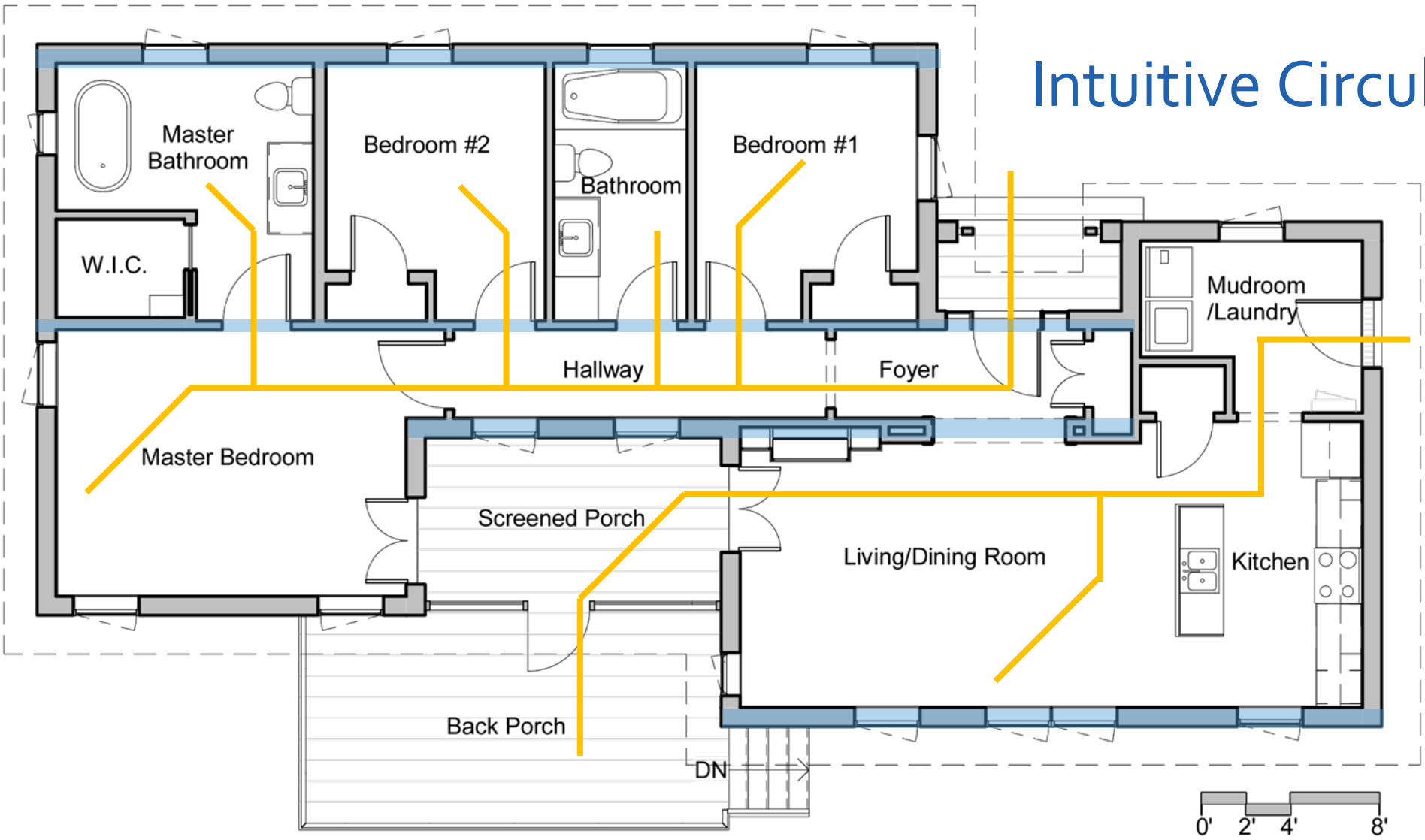


Intuitive Circulation



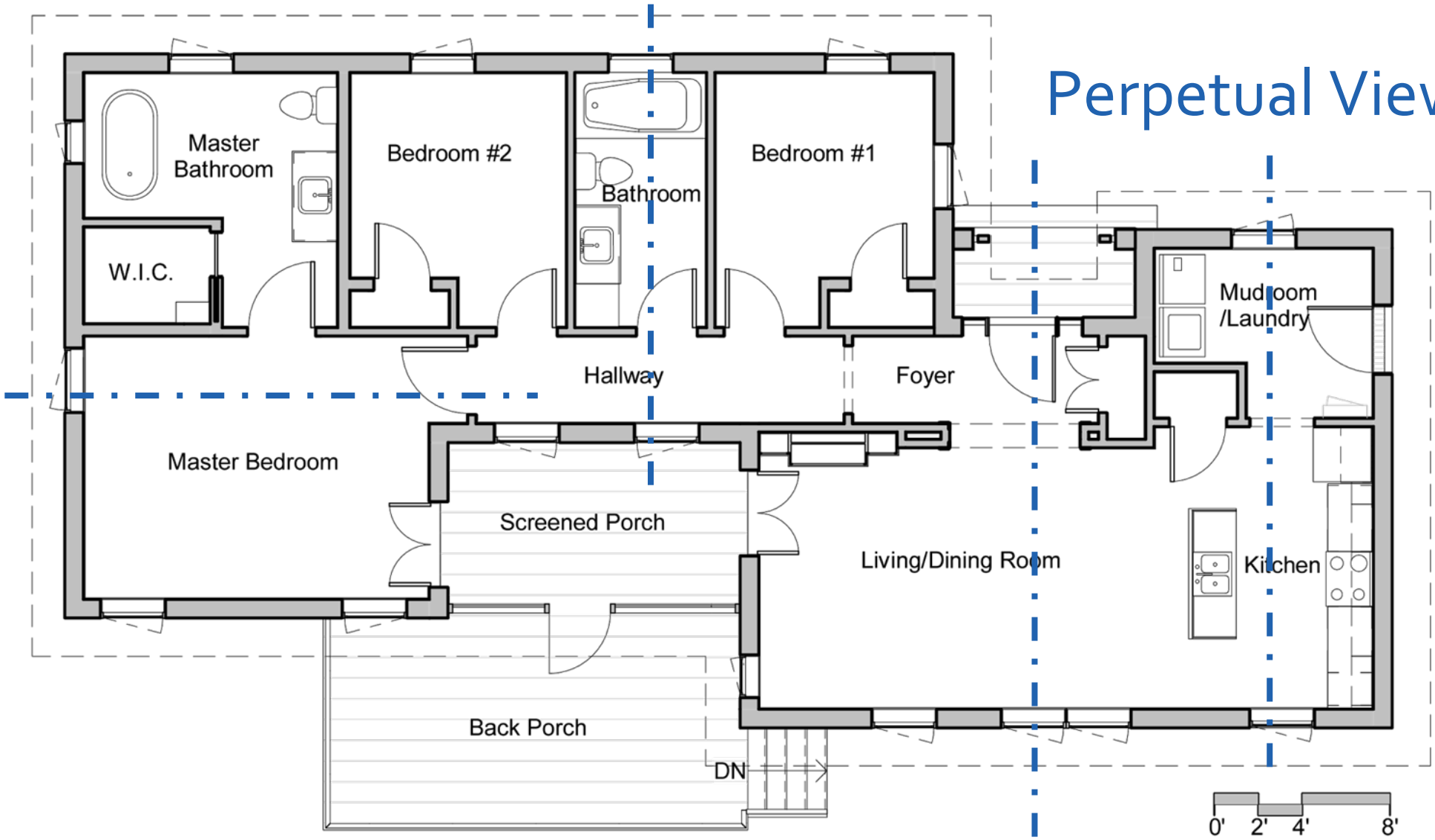


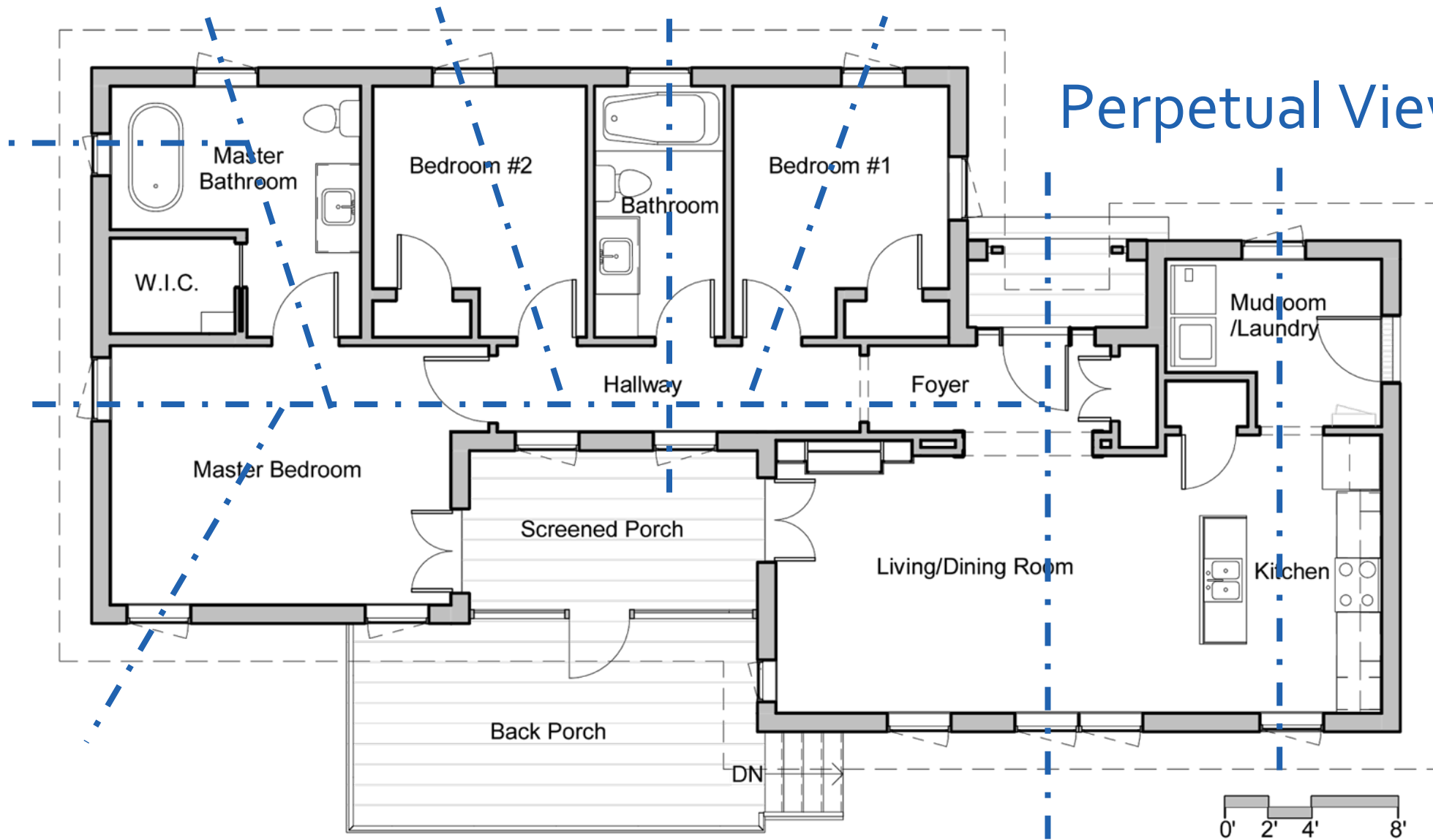
Intuitive Circulation



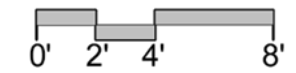


Perpetual Views





Perpetual Views





Landscaping





Landscaping

**Natural
Vegetation**



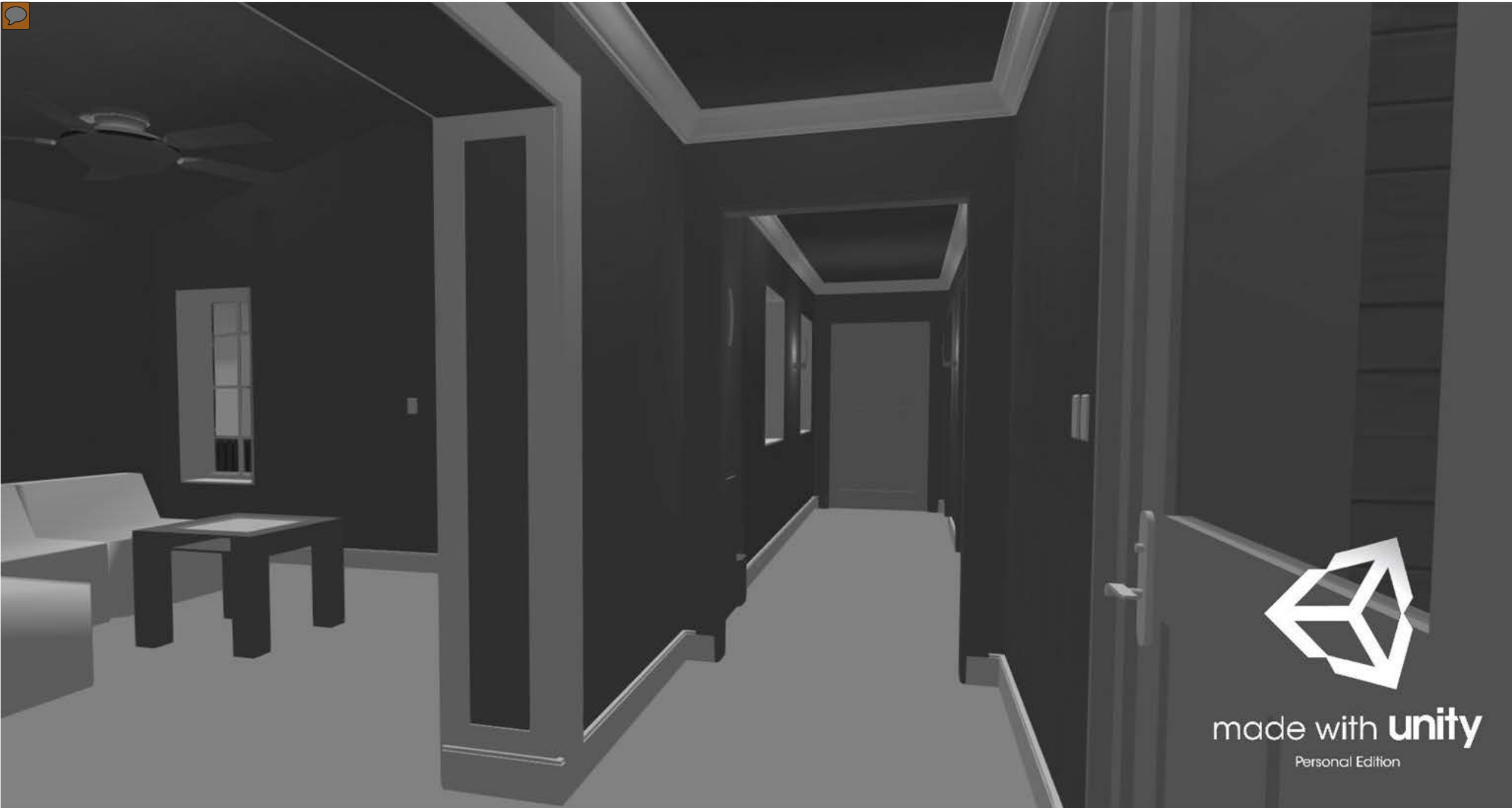


Landscaping

Firepit

Grand Reveal



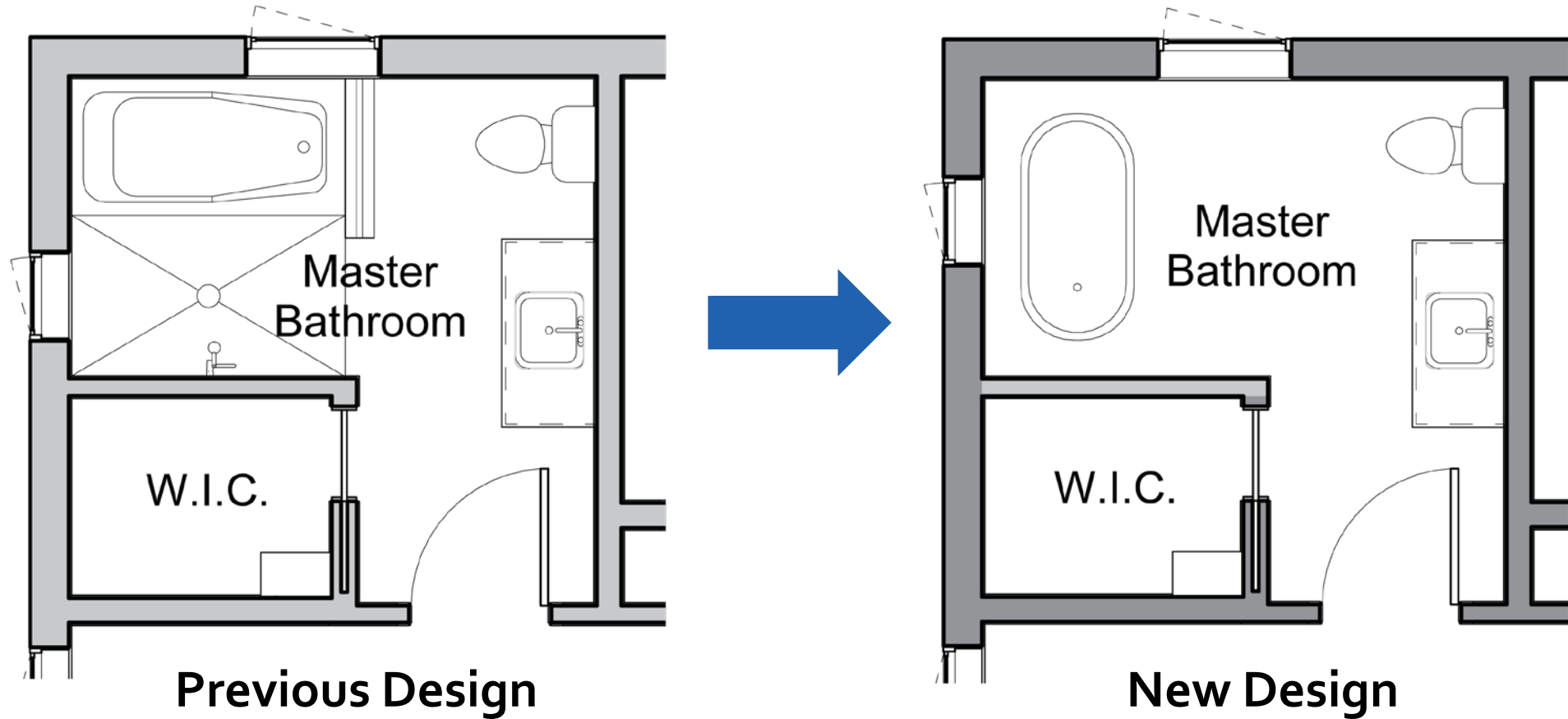


made with **unity**

Personal Edition

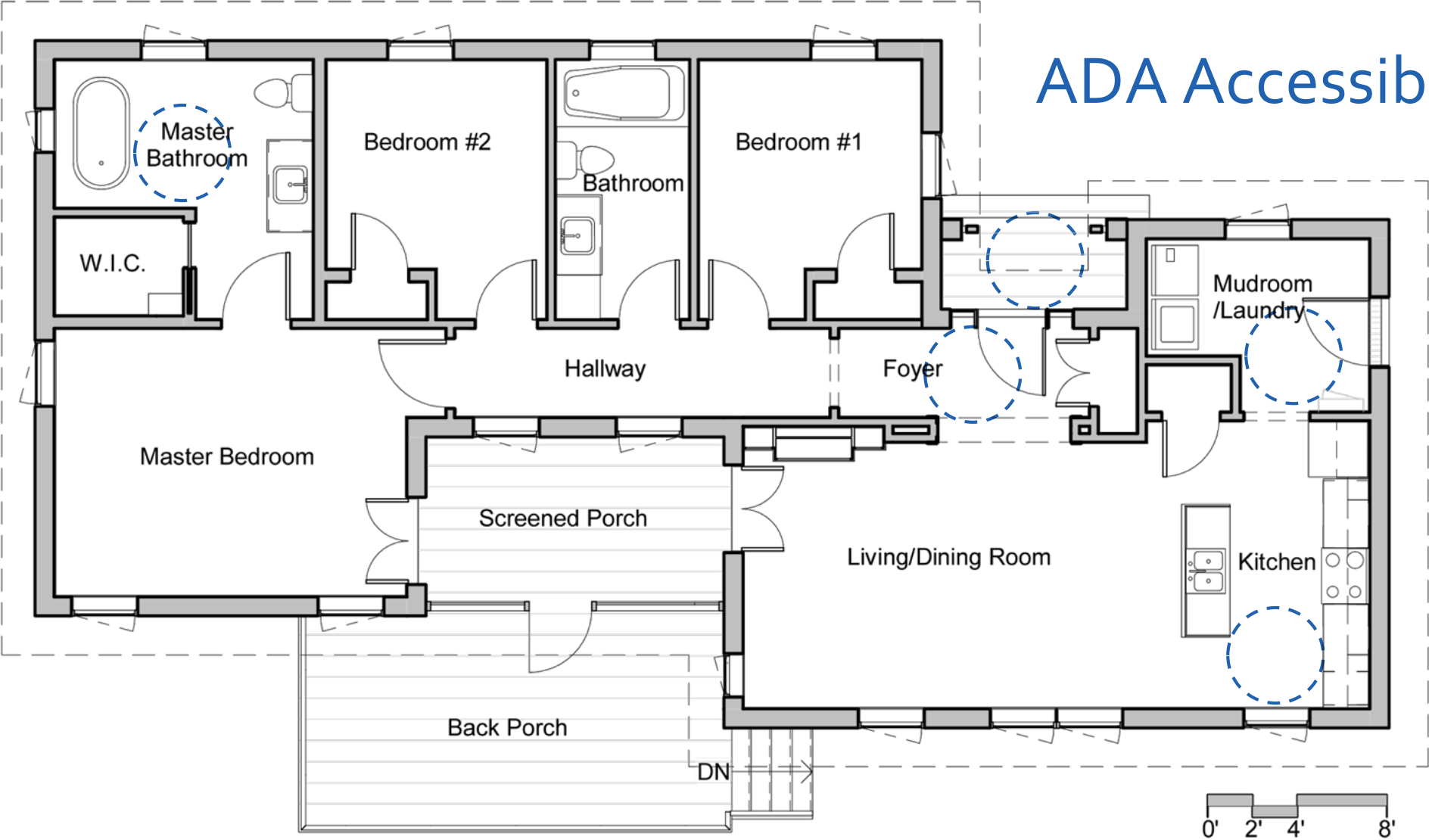


Master Bath Fix



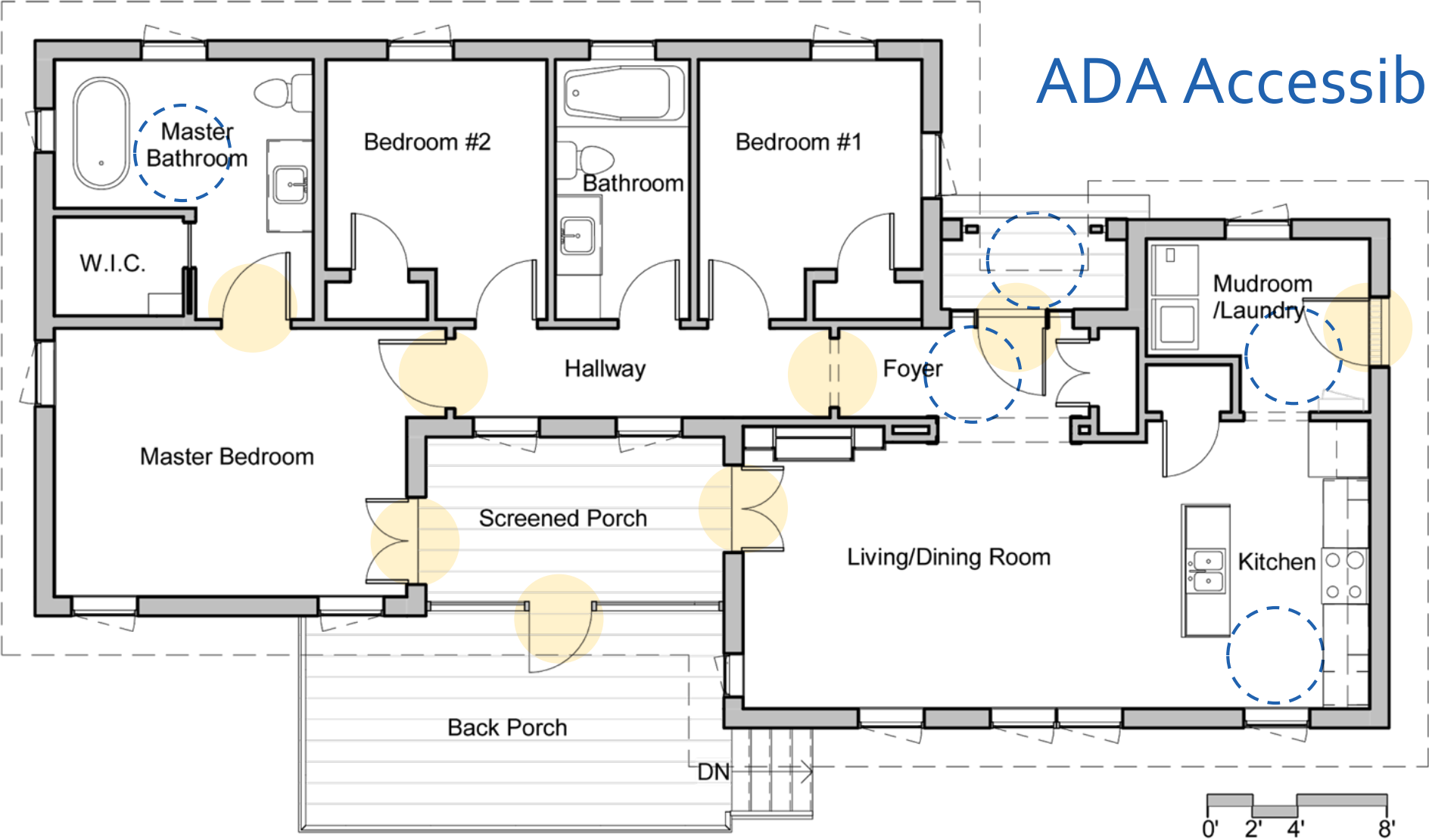


ADA Accessibility



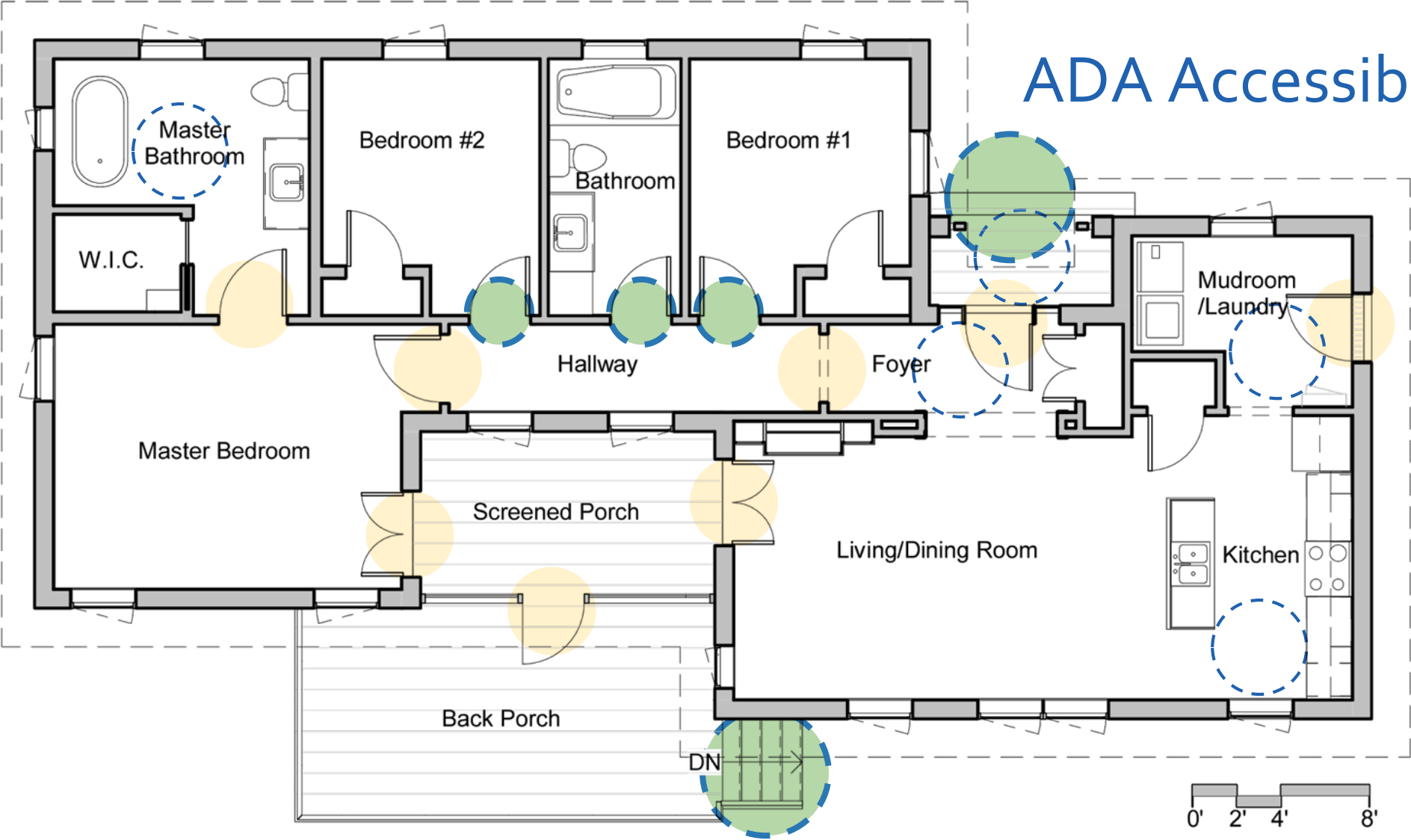


ADA Accessibility





ADA Accessibility









N



E



S



W





N



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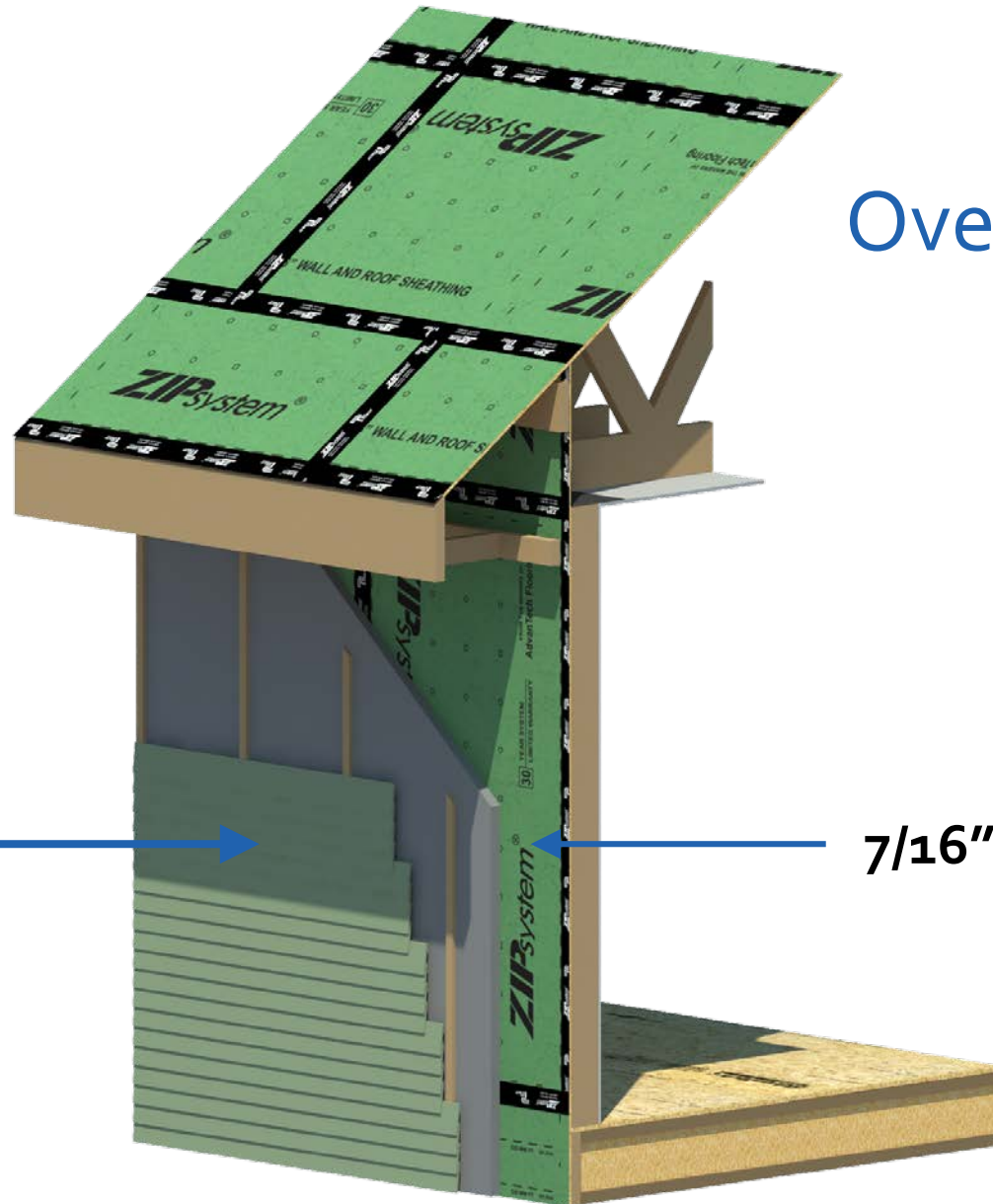
W





Overview of Assemblies

LP SmartSide
lap siding



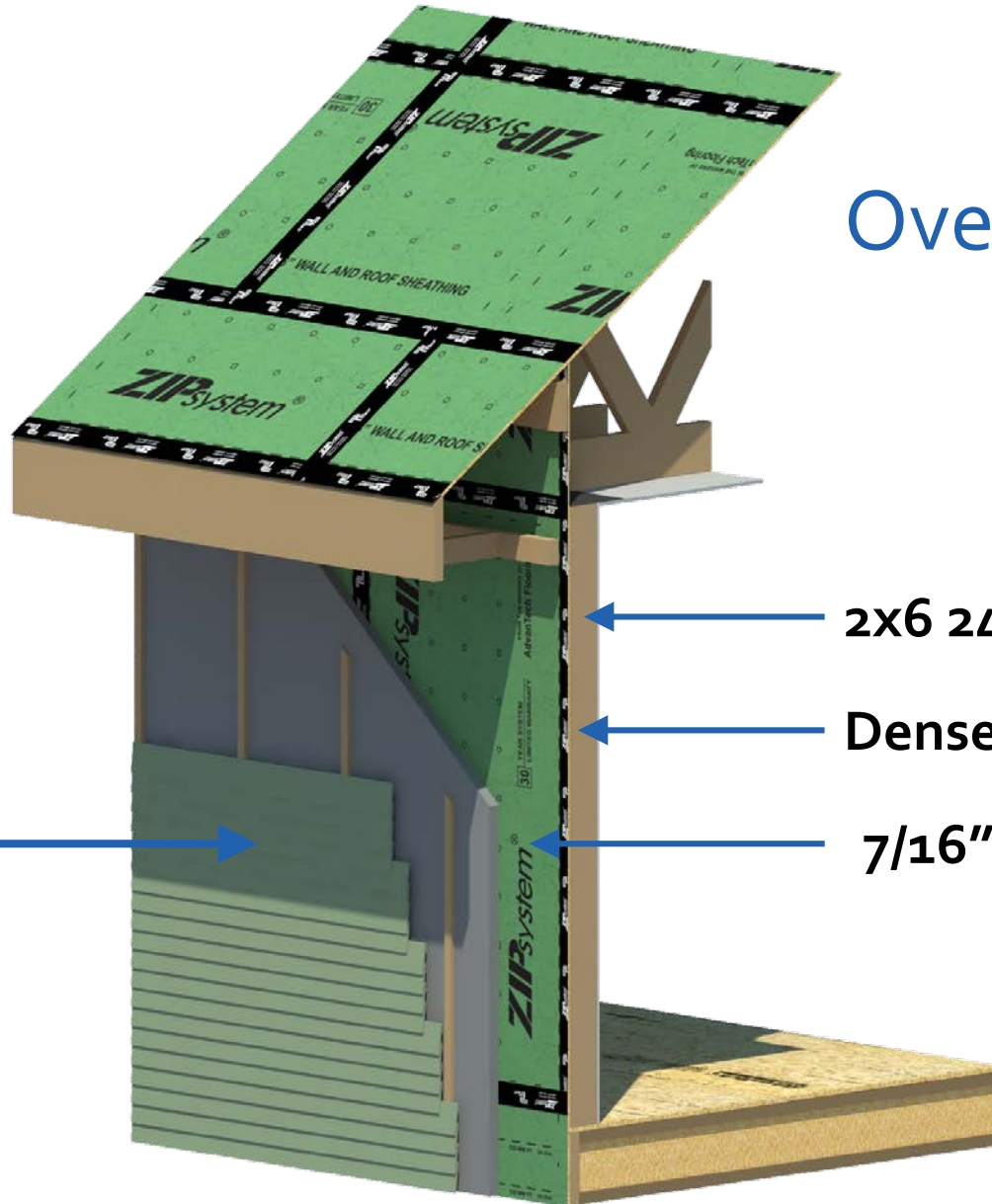
7/16" ZIP system





Overview of Assemblies

LP SmartSide
lap siding



2x6 24" o.c. studs

Dense-packed cellulose (R-22)

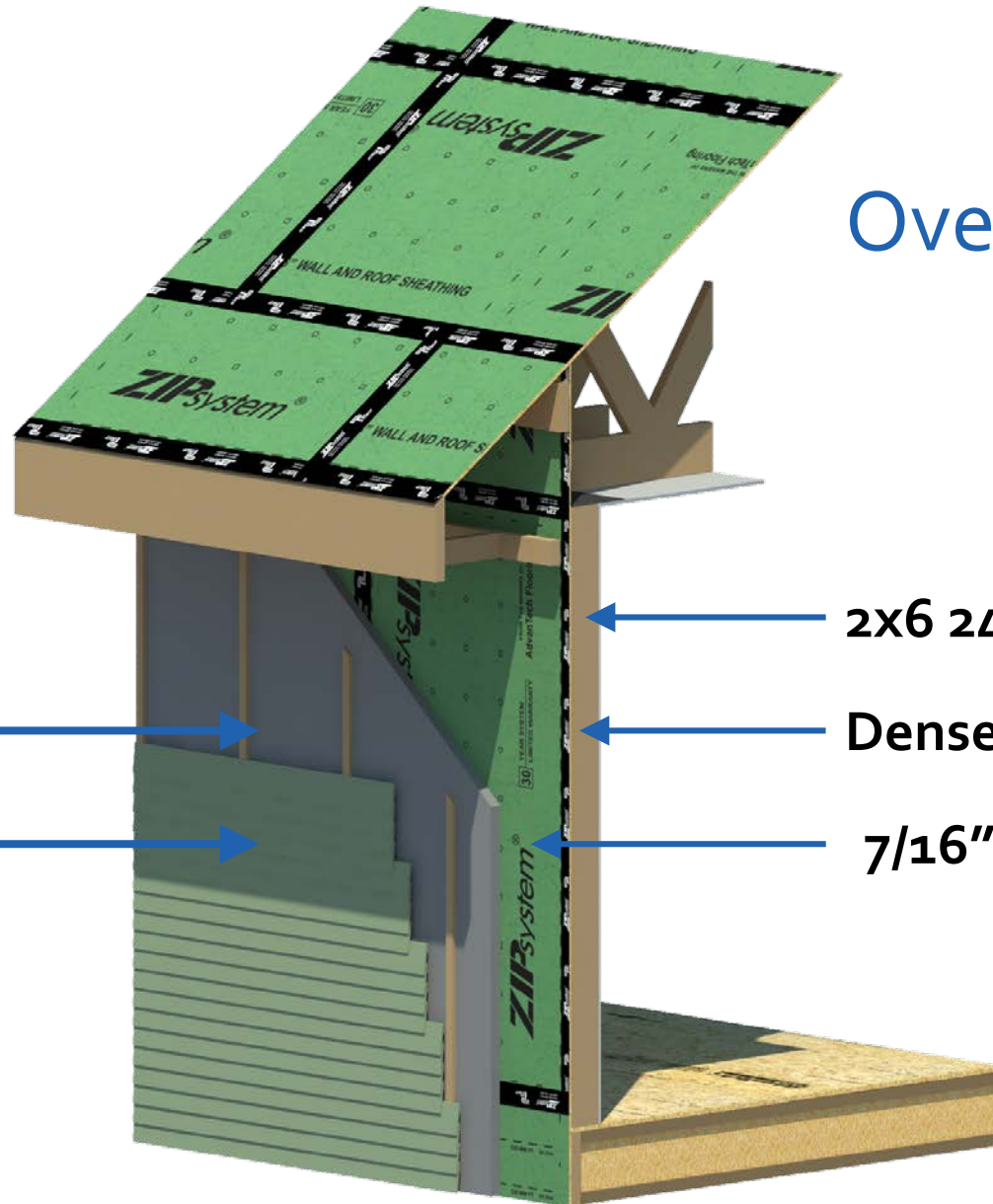
7/16" ZIP system





Overview of Assemblies

2" Neopor (R-9)
LP SmartSide
lap siding



2x6 24" o.c. studs

Dense-packed cellulose (R-22)

7/16" ZIP system





Overview of Assemblies

5/8" ZIP system



Raised heel truss roof framing



Loose-fill cellulose (R-50)



2x6 24" o.c. studs



2" Neopor (R-9)



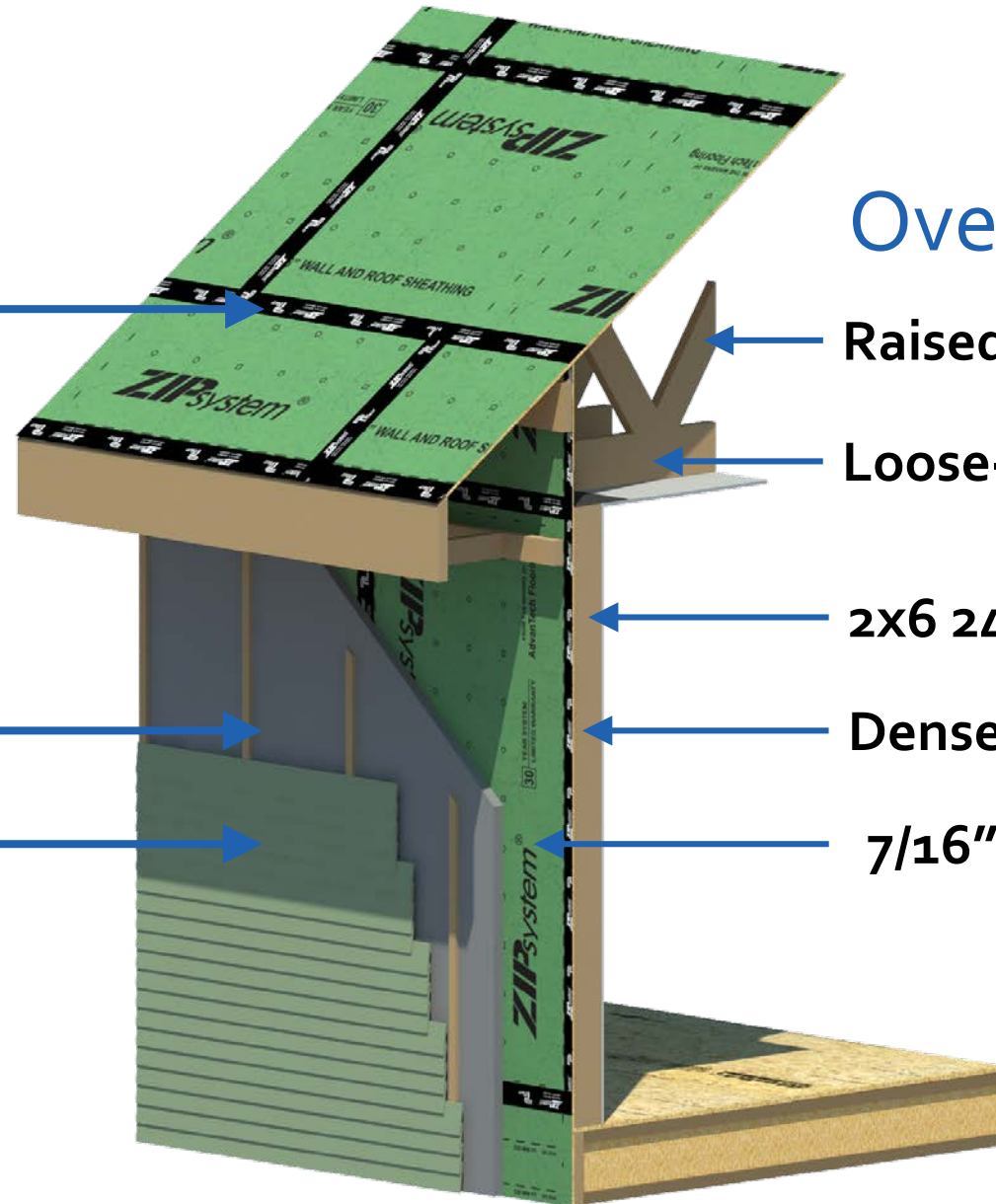
Dense-packed cellulose (R-22)

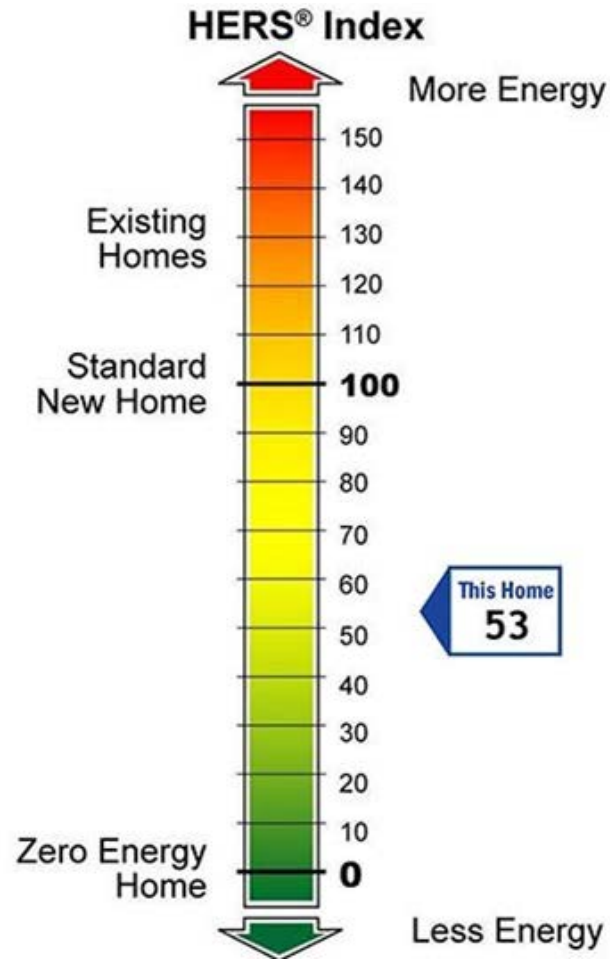


LP SmartSide
lap siding

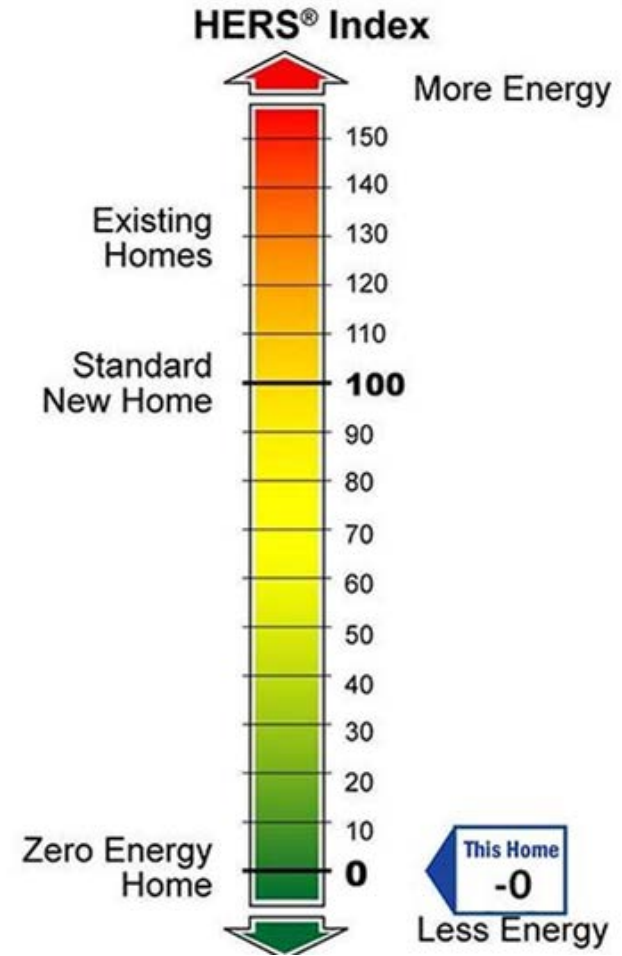


7/16" ZIP system





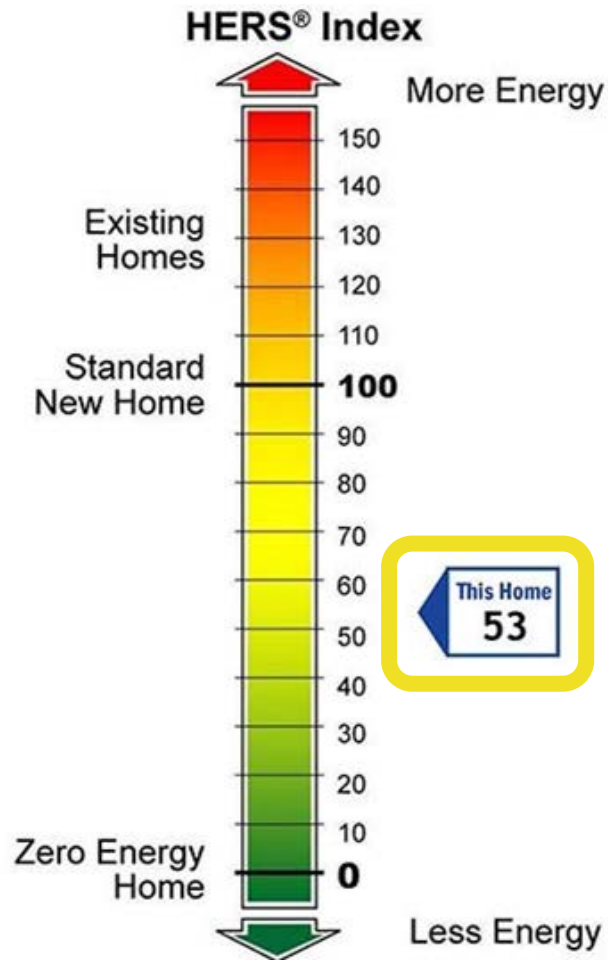
[In]visible without PV



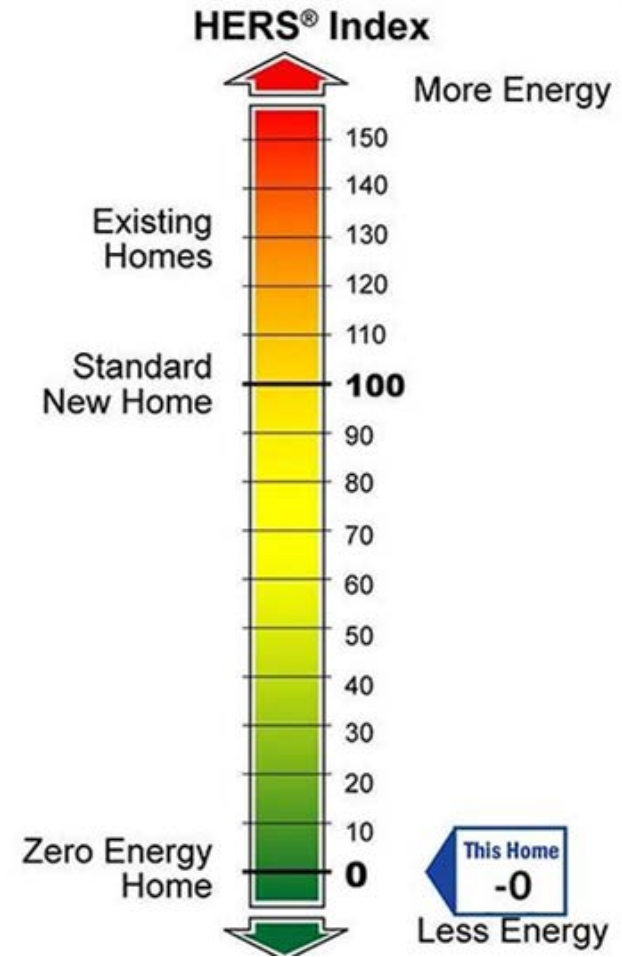
[In]visible with PV

Zero Energy Ready Summary





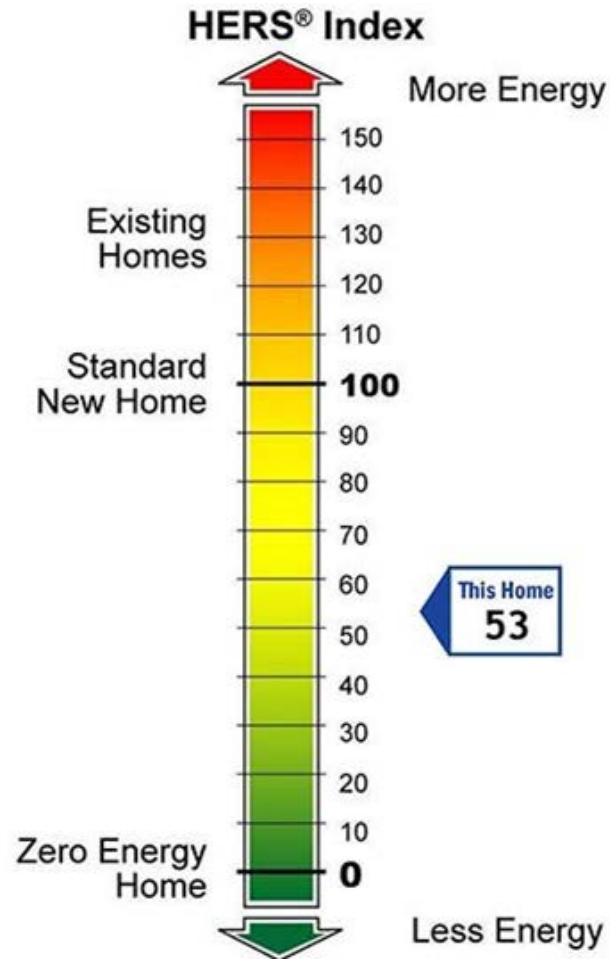
[In]visible without PV



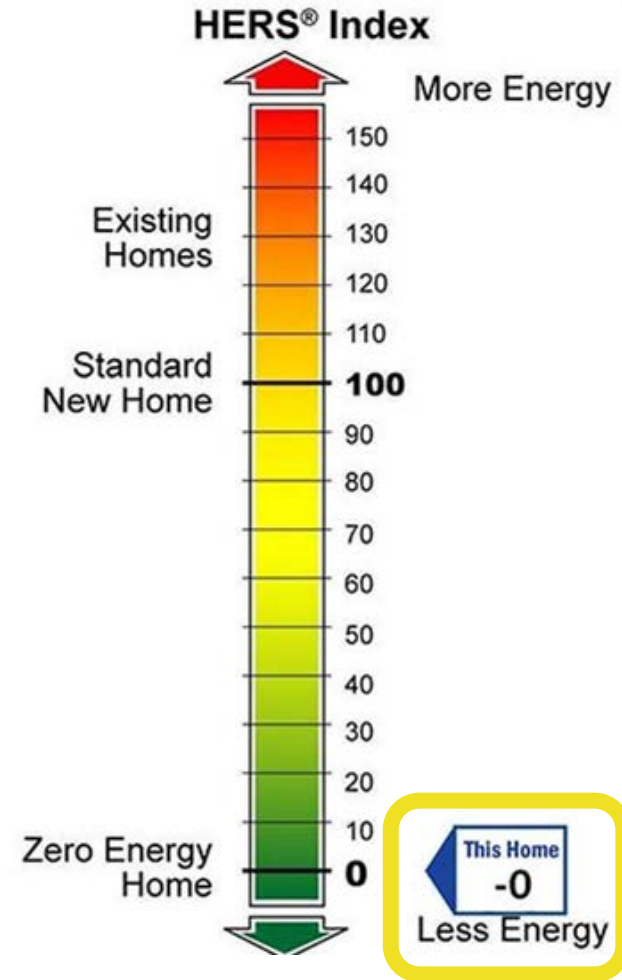
[In]visible with PV

Zero Energy Ready Summary





[In]visible without PV

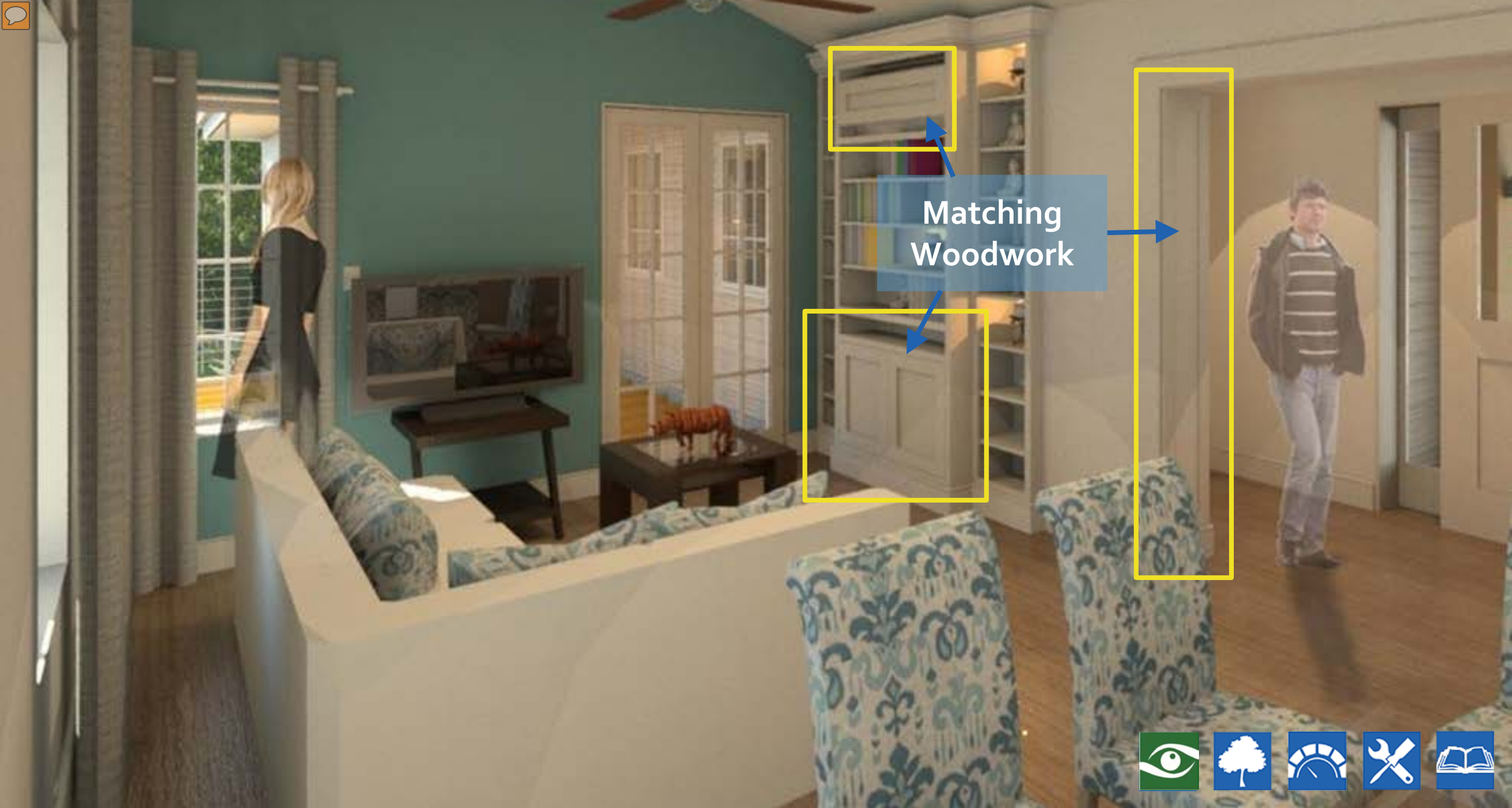


[In]visible with PV

Zero Energy Ready Summary







Matching Woodwork



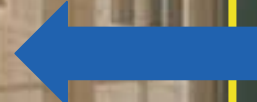
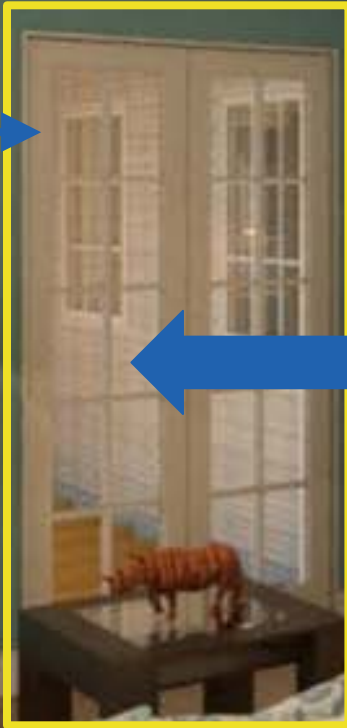


Hidden Mini-split





Outdoor
Access









Appliances / Materials

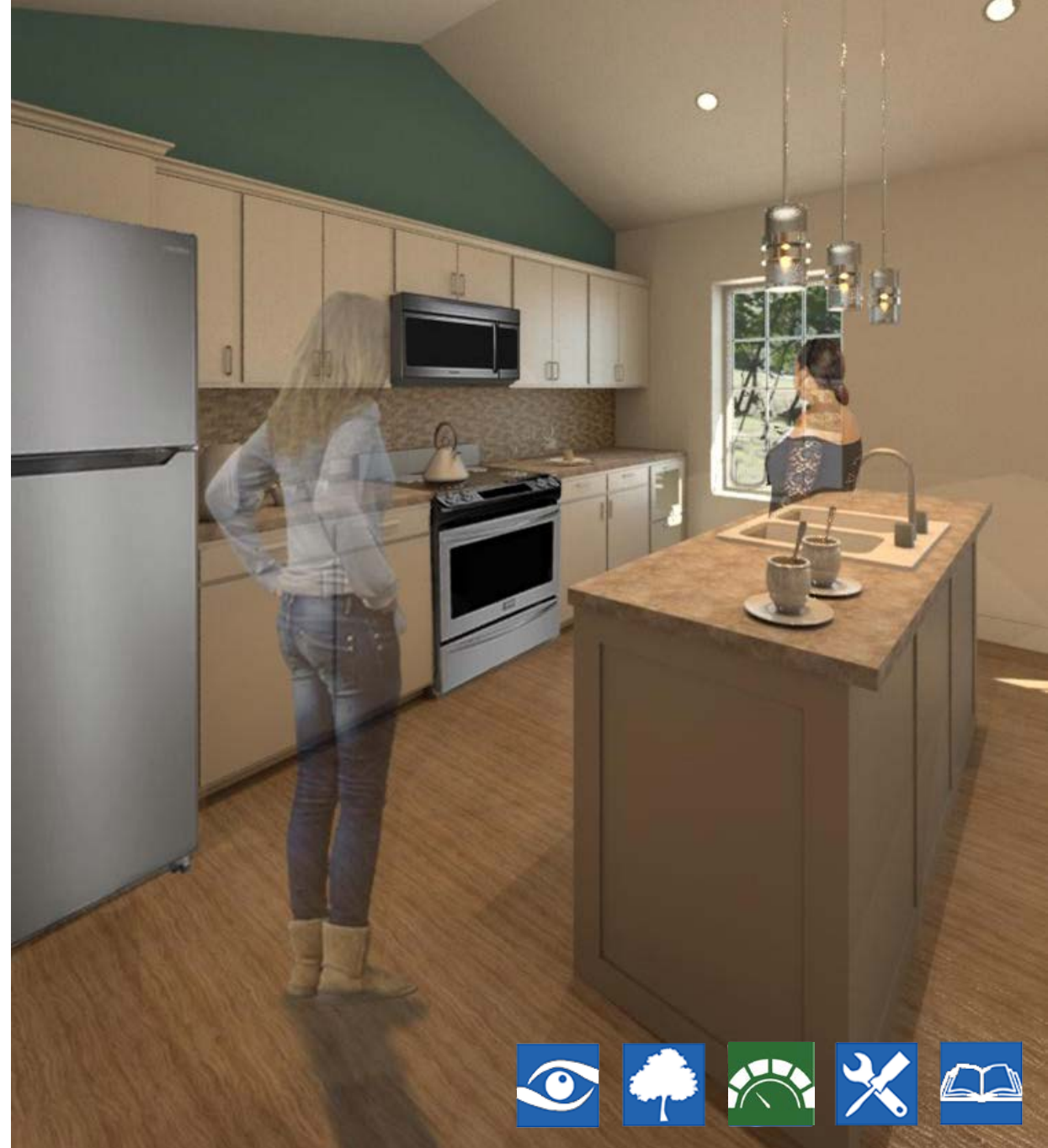


**ENERGY STAR
Approved**



IntelliBalance ERV

Finish Options	\$ per sq. ft.
Option #1	\$1.14/sq. ft.
Option #2	\$5.32/sq. ft.





SYSTEMS

Rowan Parris





Material/Finish	Low/ No-VOC	GREENGUARD Certified	KCMA Certified
Paint	✓	✓	
Wood Flooring	✓	✓	
Tile	✓	✓	
Countertops	✓	✓	
Baseboards	✓		
Crown Moulding	✓		
Window Casing	✓		
Cabinets	✓		✓
Gypsum Drywall	✓		



Indoor Air Quality

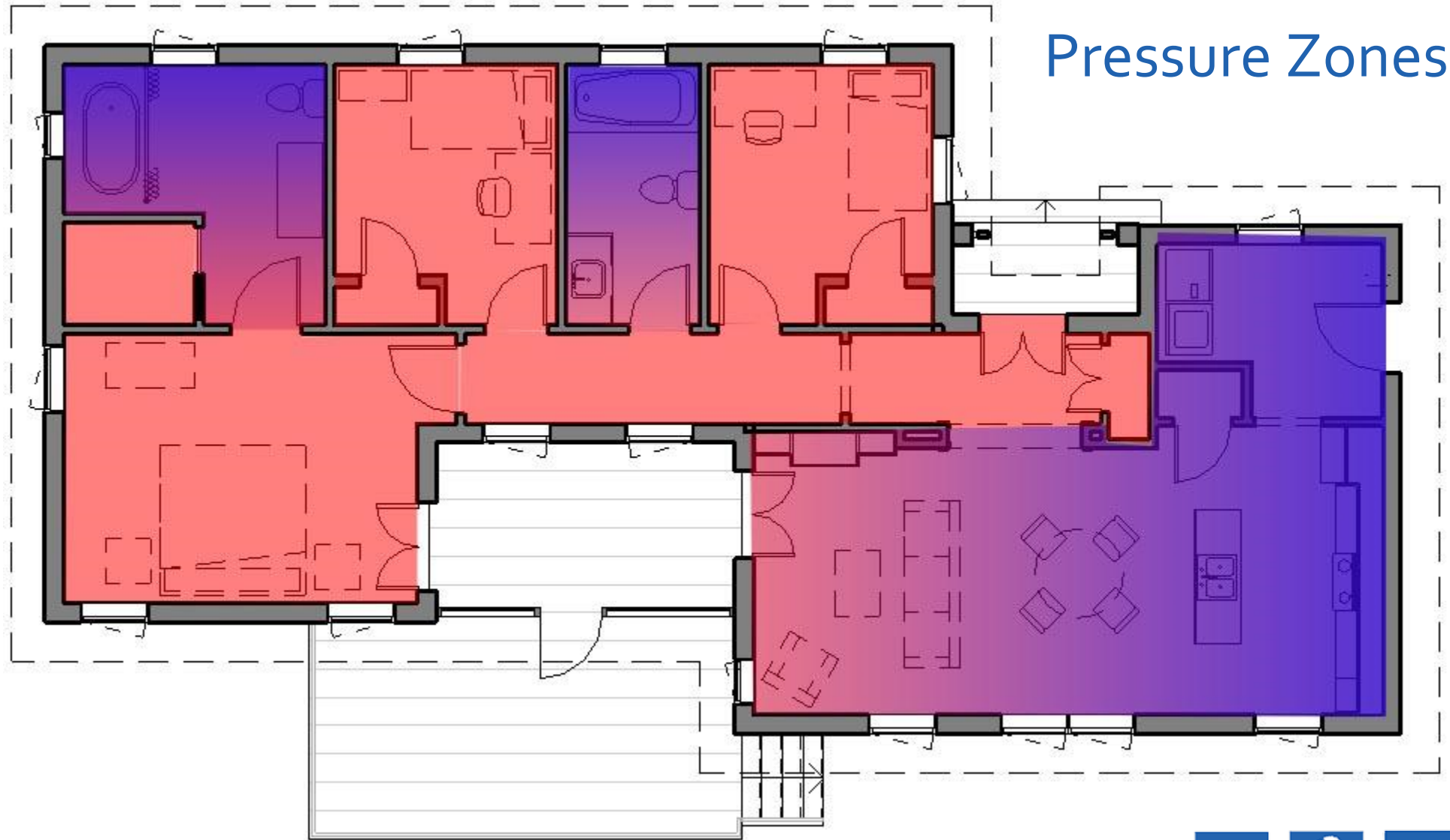


Ensure clean and fresh air



Meet Indoor airPlus requirements



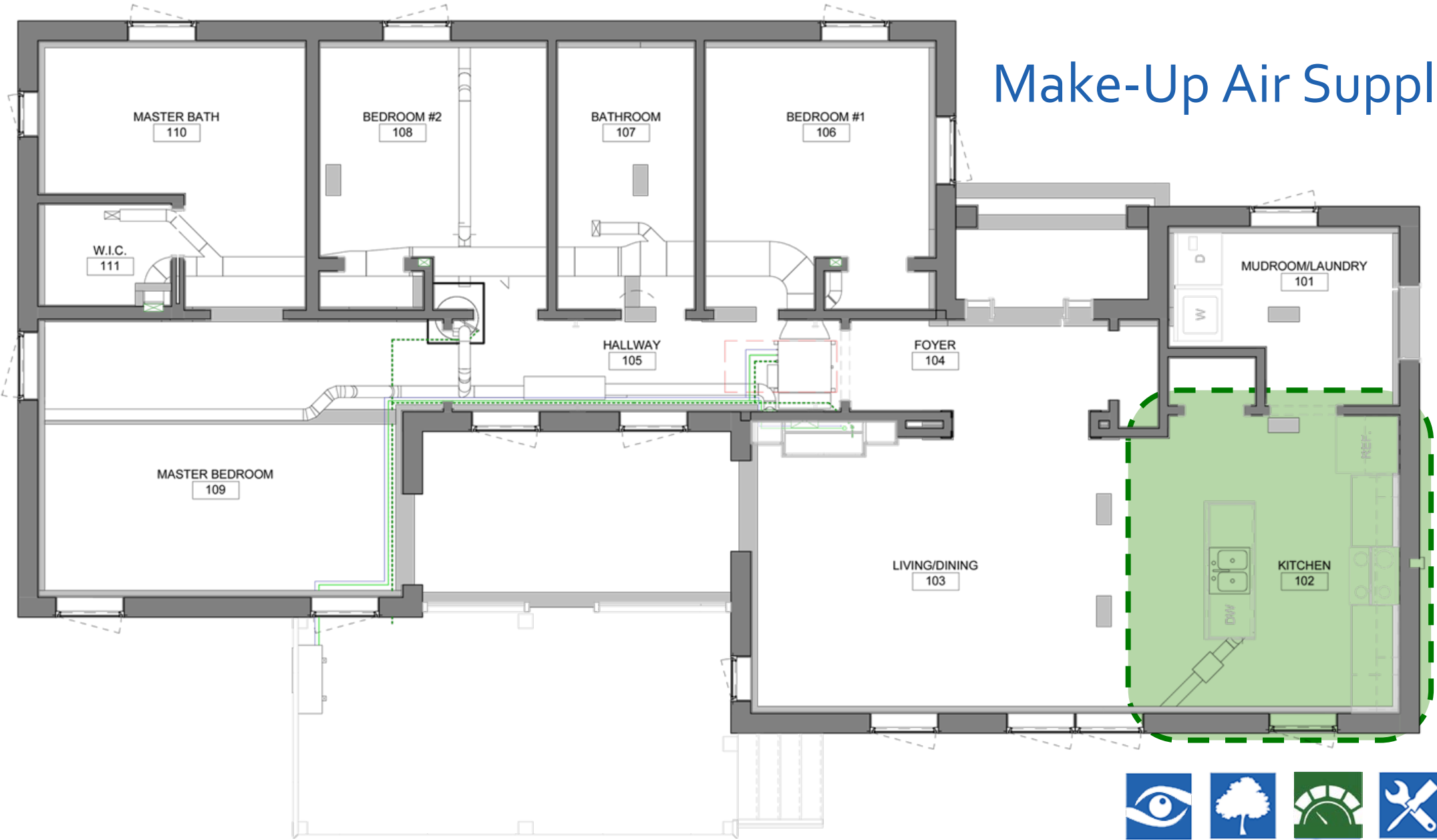


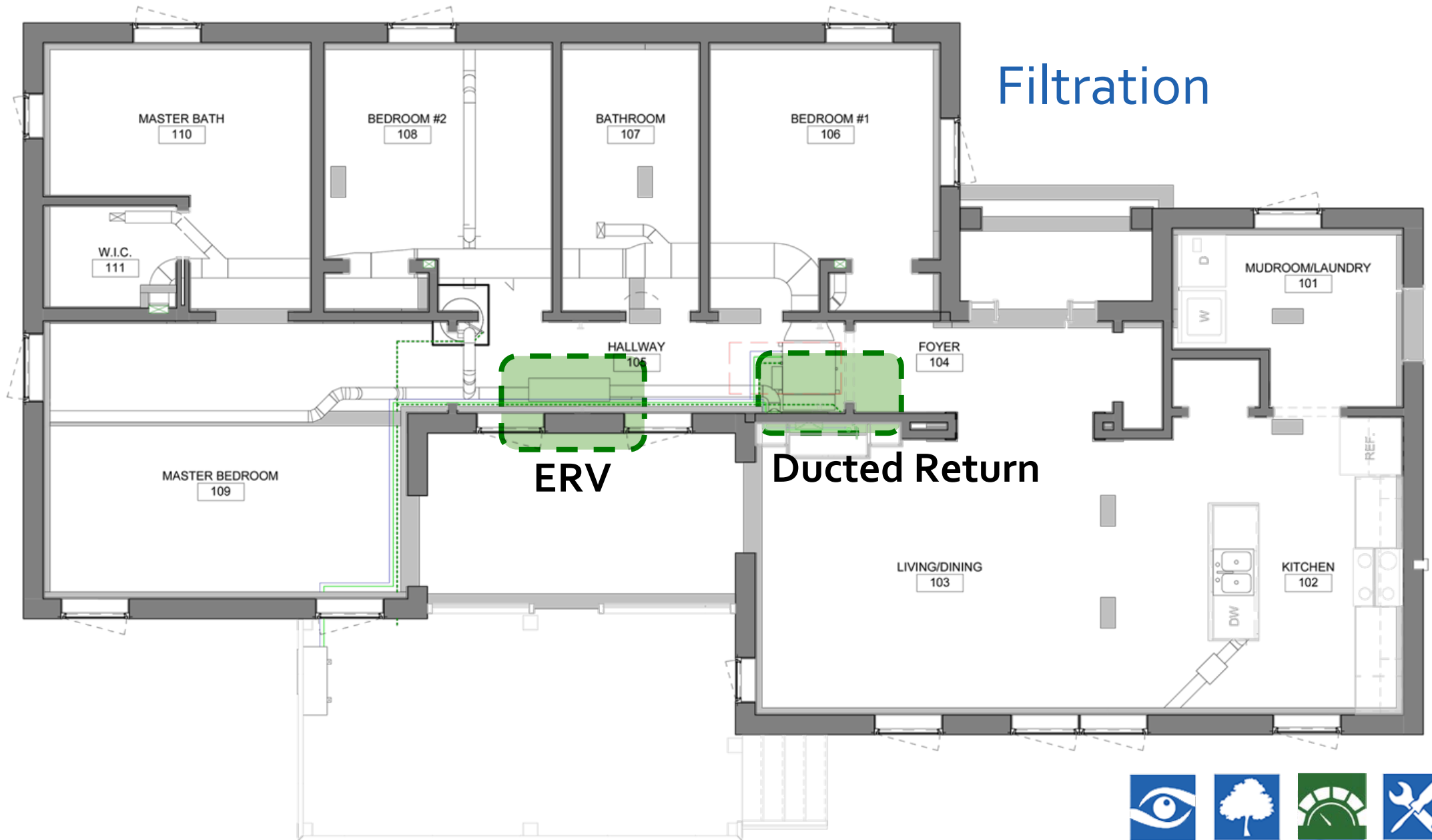
Pressure Zones





Make-Up Air Supply



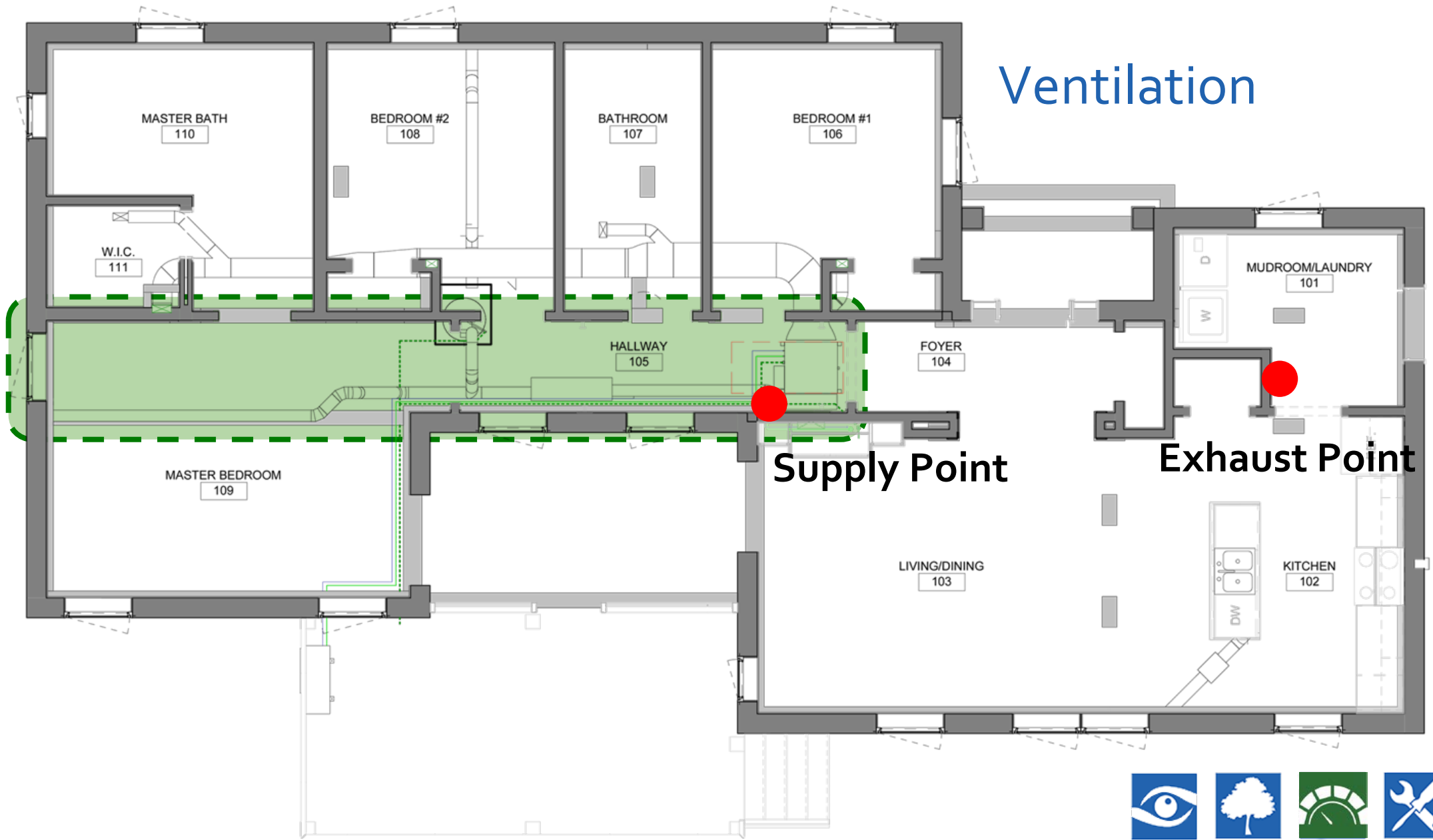


Filtration

ERV

Ducted Return



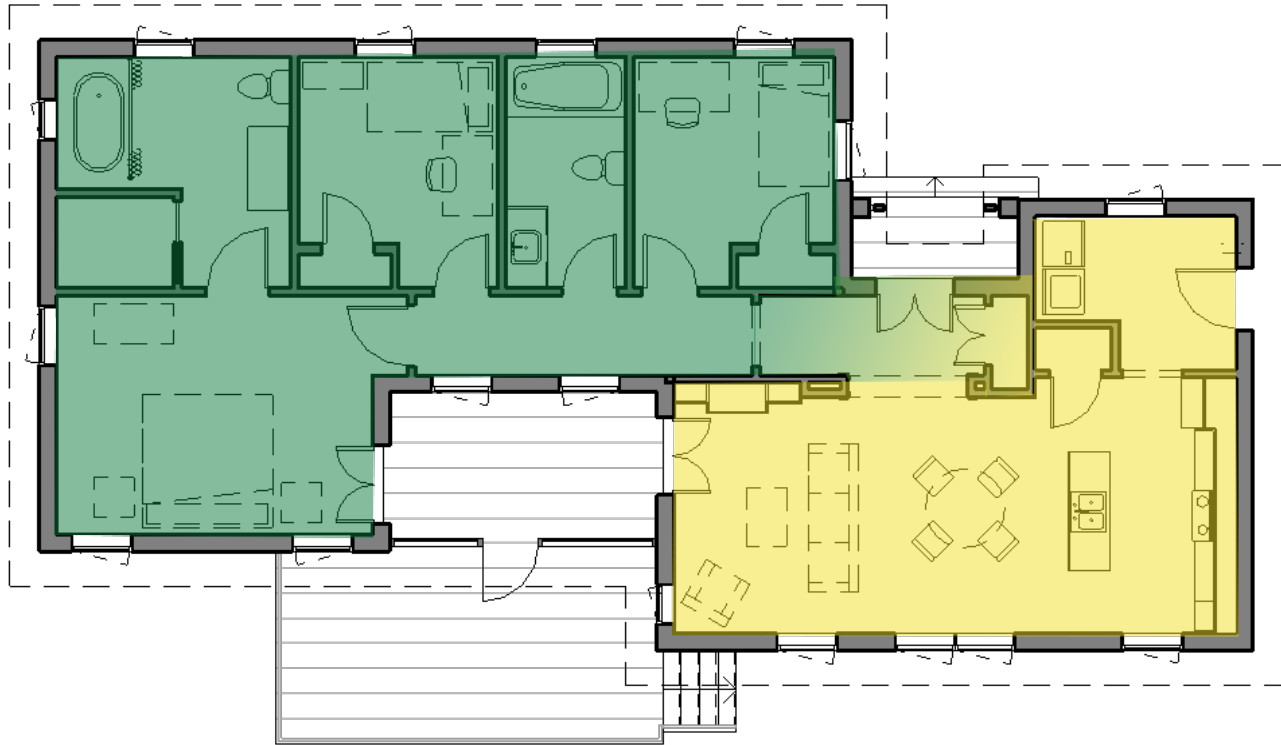


Ventilation

Supply Point

Exhaust Point





Mechanical



Keep systems hidden, yet accessible

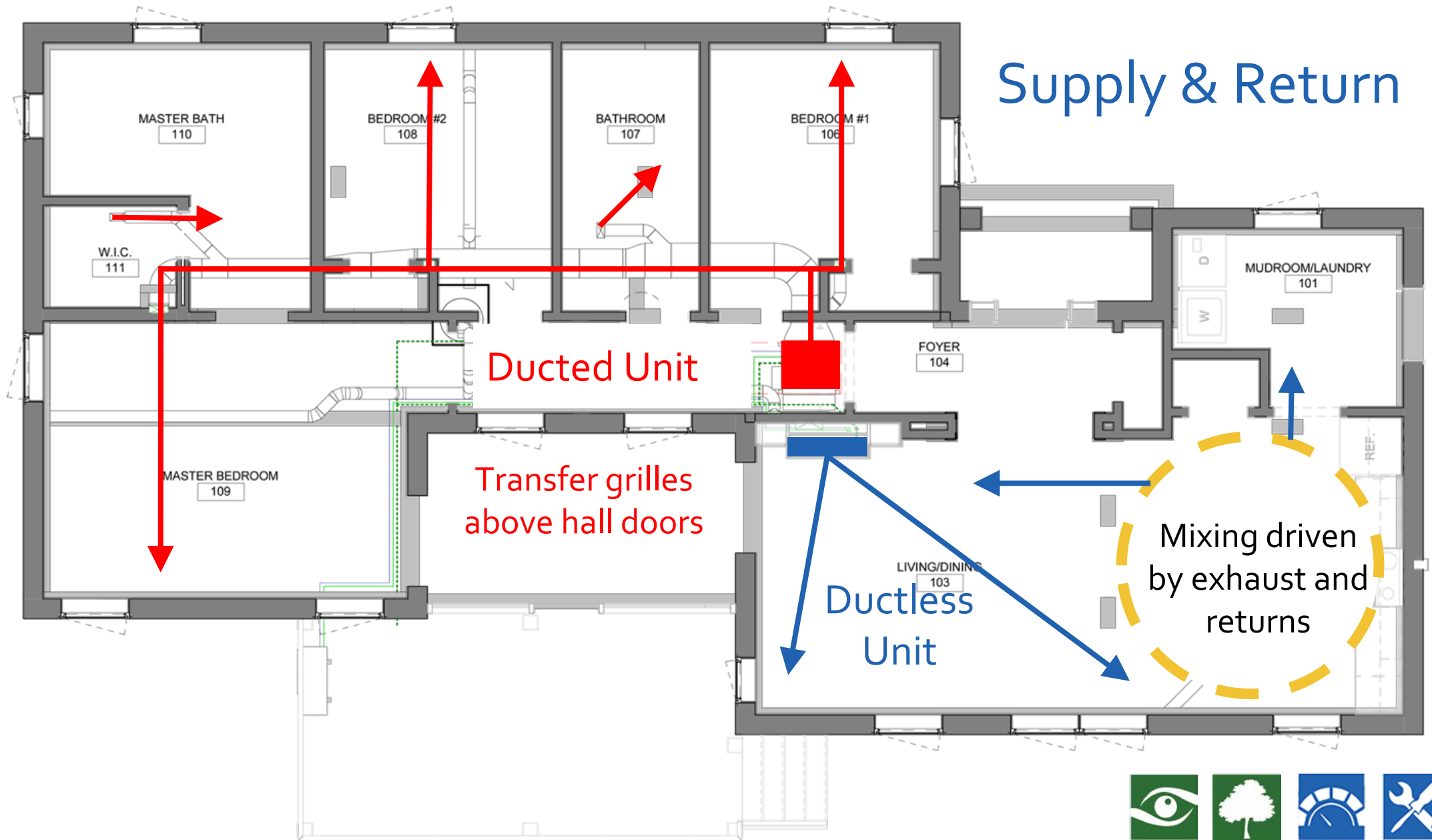


Meet ENERGY STAR requirements



Facilitate circulation and dehumidification







Load Calculations

BLOCK LOADS (BTUH)	
HEATING	COOLING
	(SENSIBLE + LATENT)
18,934	10,162 + 2,942

DUCT DESIGN	FLOWS (CFM)	SIZE
MBED	123	4"X13"
MBATH	56	4"X7"
BED1	66	4"X7"
BED2	54	4"X5"
BATH1	62	4"X5"
LIVING	170	DUCTLESS
KITCHEN	65	
MUD ROOM	36	

ZONE HEATING LOADS (BTUH)	
MBED	2841
MBATH	1694
BED1	1652
BED2	1190
BATH1	1618
LIVING	4406
KITCHEN	1535
MUD ROOM	1679
OTHER LOADS (BTUH)	
DUCT LOSSES	1228
INFILTRATION	3358
VENTILATION	2762





MSZ-FH09NA

Rated Sensible Heat Factor: 0.92



SEZ-KD09NA4R1.TH

Rated Sensible Heat Factor: 0.80

Dehumidification

- Localized exhaust fans near moisture sources
- ERV utilization to reduce incoming summer latent load
- Management of on/off deadband intervals for longer runtime





Distribution

- Use of forced and passive mixing to circulate through public spaces
- Option to install mudroom transfer fan if proven necessary





Electrical

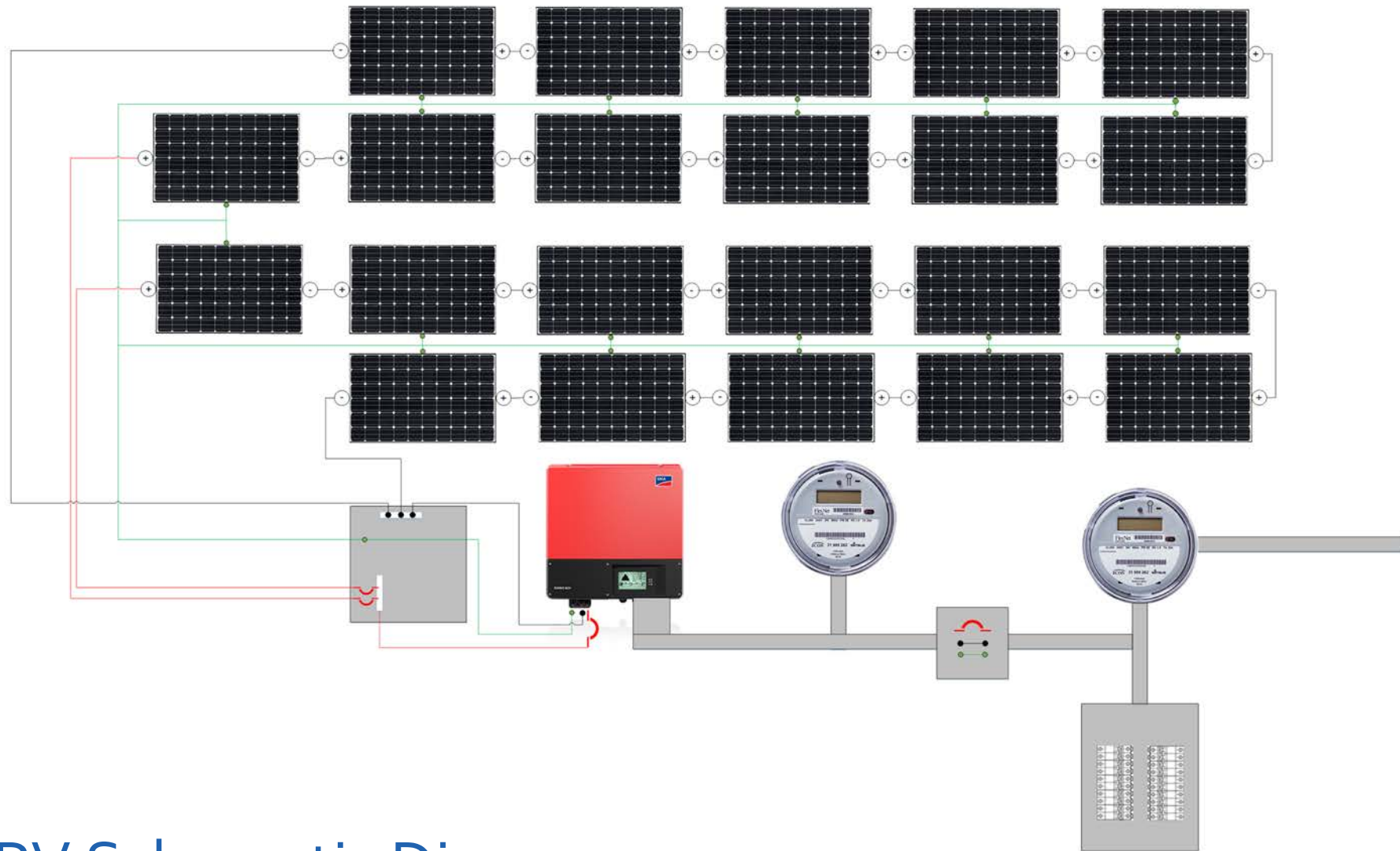


Meet ENERGY STAR requirements



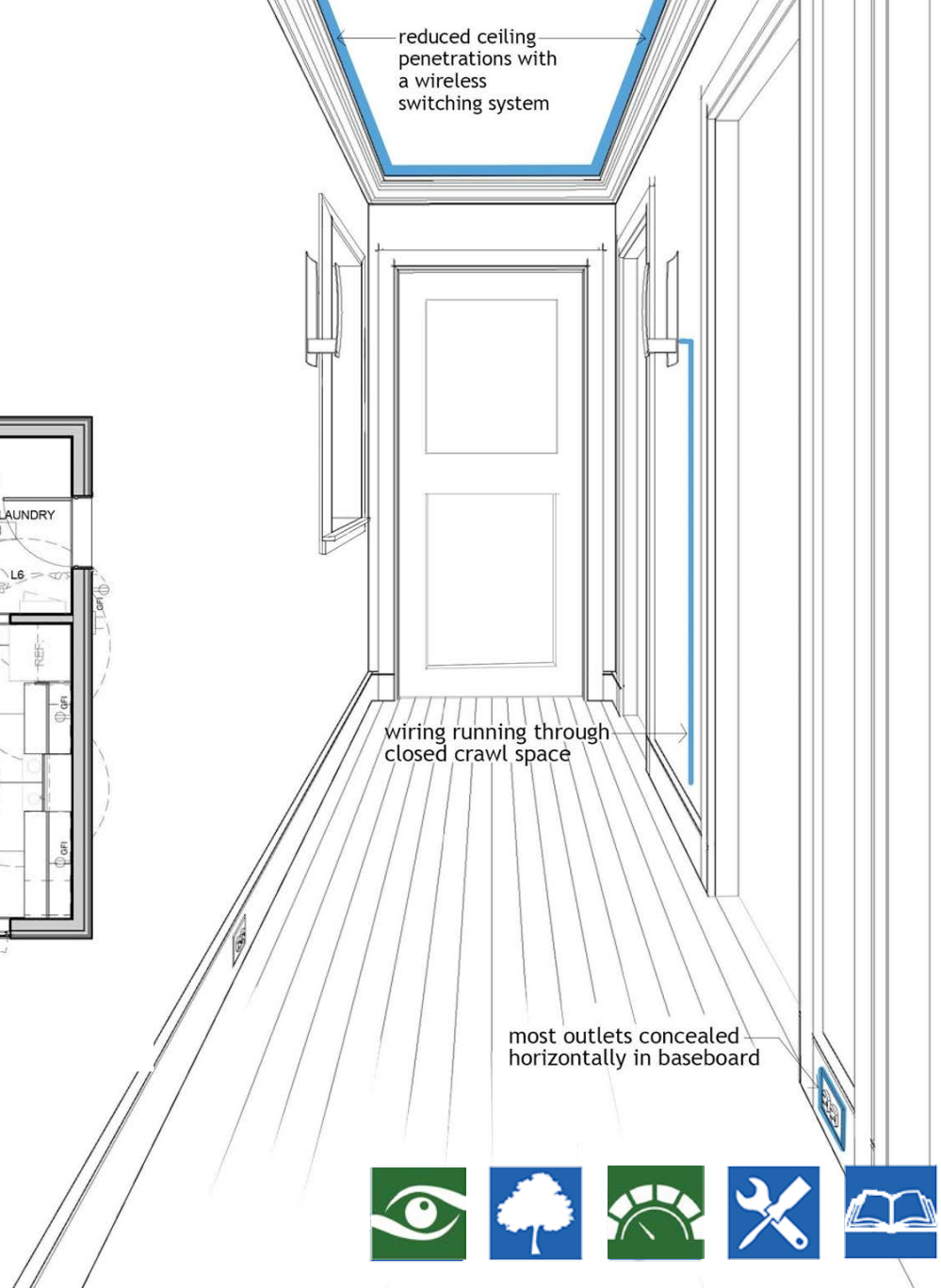
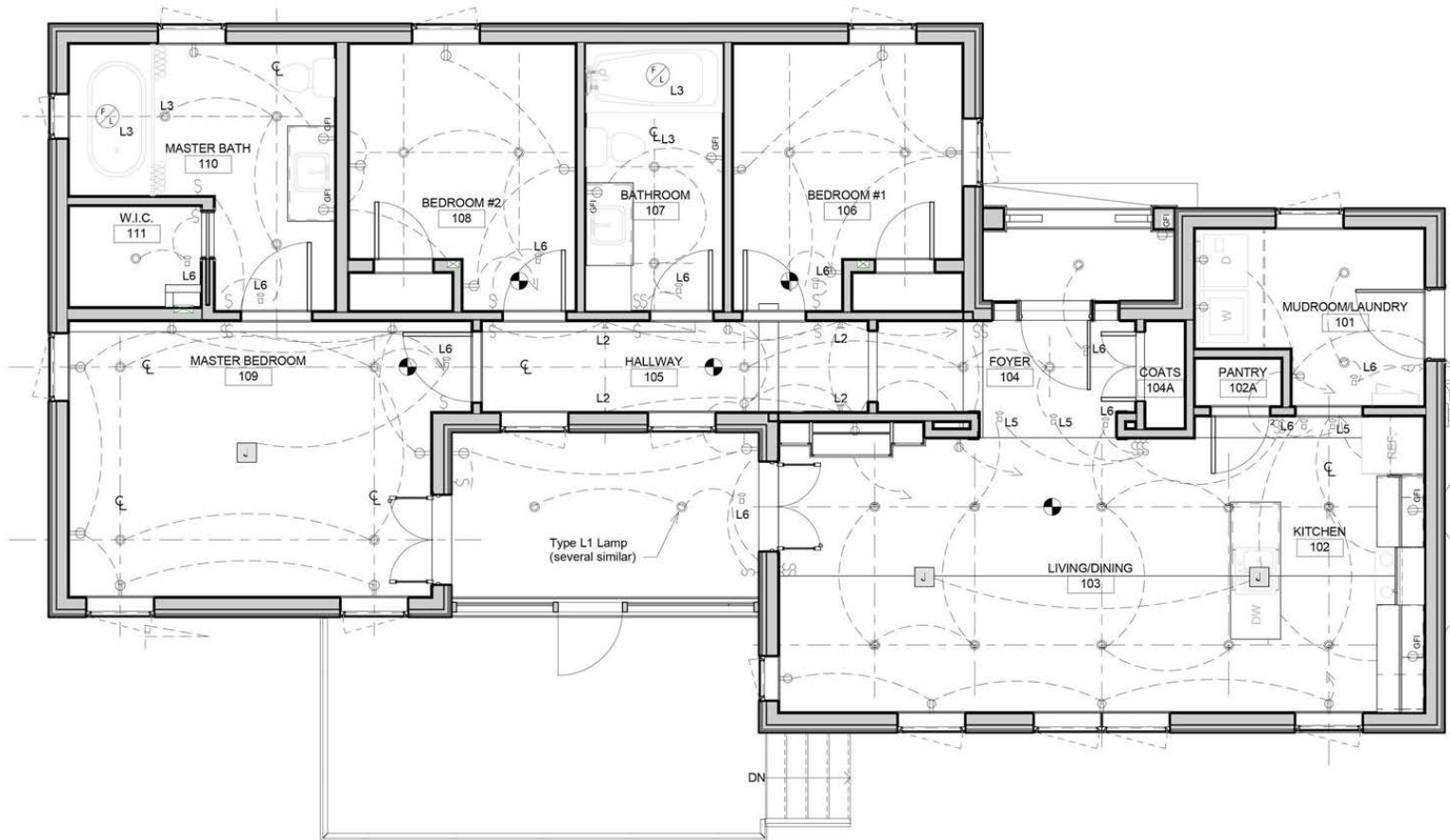
Minimized penetrations through air barrier





PV Schematic Diagram





Lighting Electrical Plan



Plumbing



Meet WaterSense Requirements

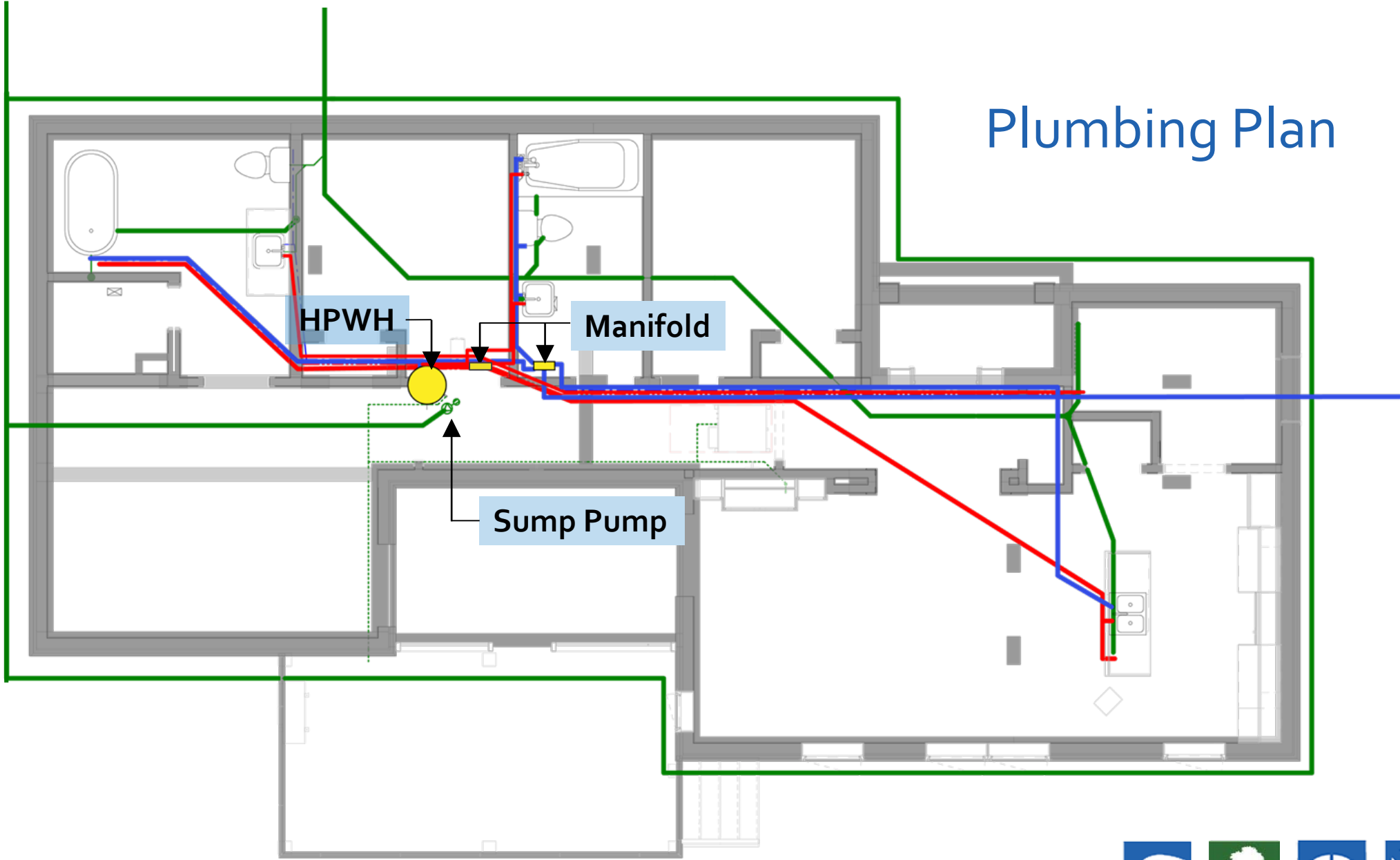


HPWH/ERV Transfer Hood



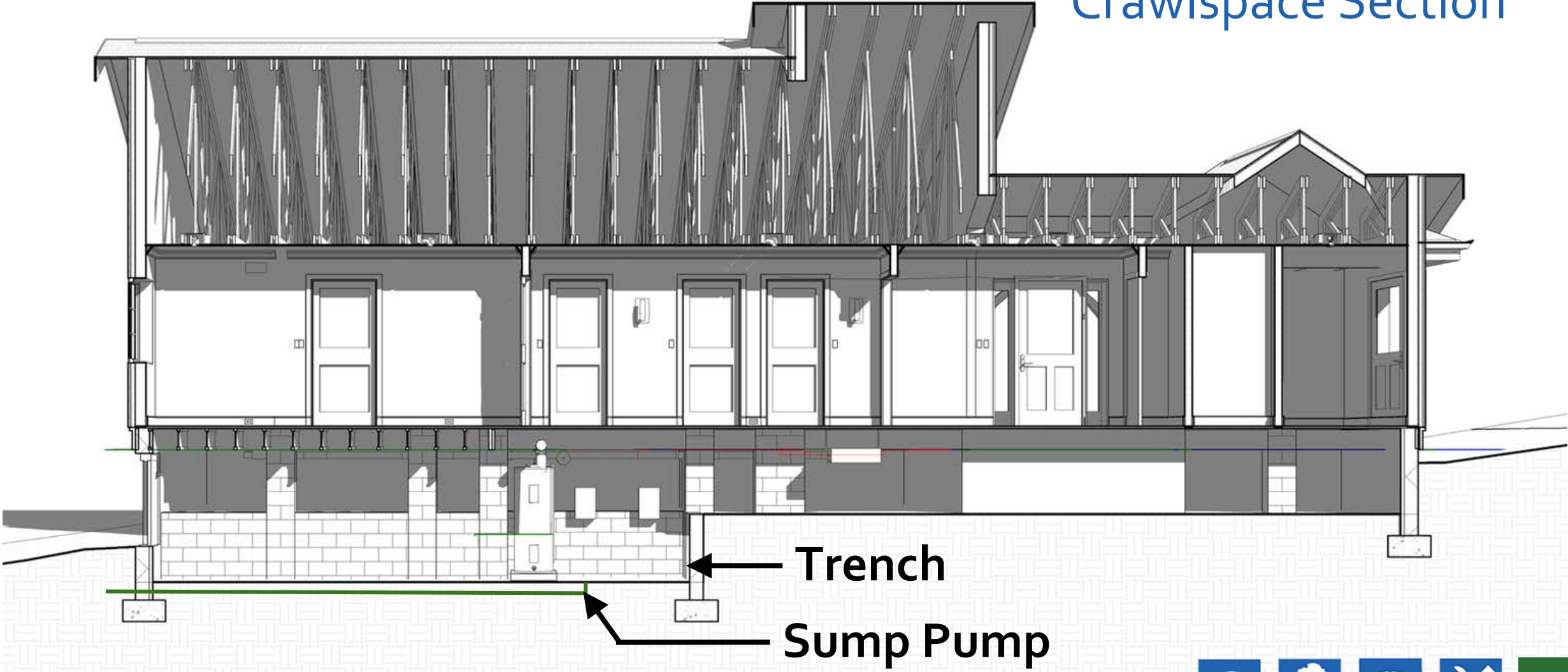


Plumbing Plan





Crawlspace Section





ERV/HPWH Energy Transfer Hood

	HPWH Energy Factors	
	Initial	Adjusted
Outside Energy Factor	2.2	2
Crawl Space Exhaust Only Energy Factor	2.9	1.3
Inside Energy Factor	3	2.5
Supplied by ERV Exhaust Energy Factor	2.4	2.1

Method Summary

- Used Energy Factors
- Averaged over 1 year
- Adjusted for HVAC Loads, Outside Conditions, Make-up Air Conditioning





CONSTRUCTABILITY

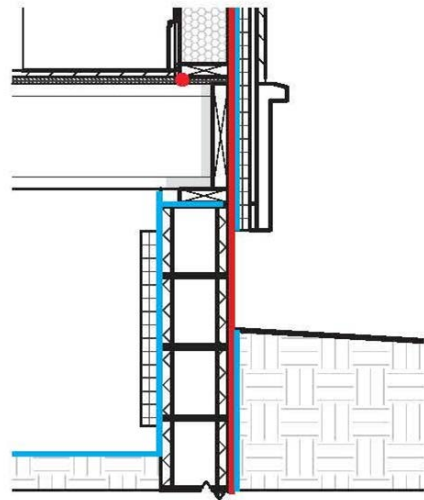
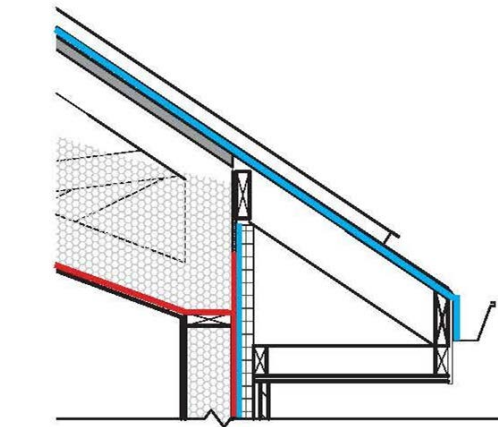
Abe Somers



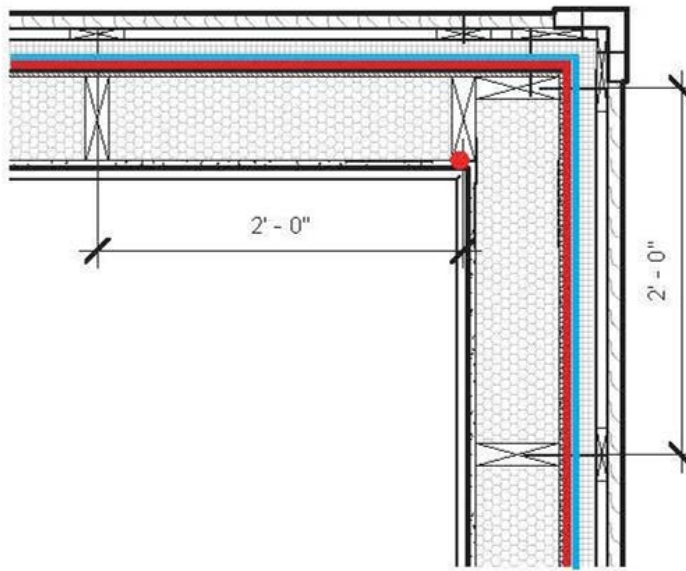


Envelope Layers

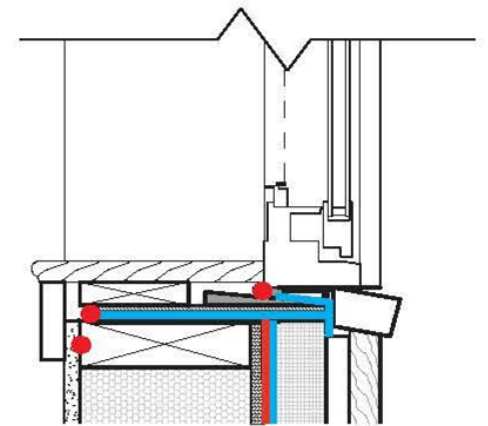
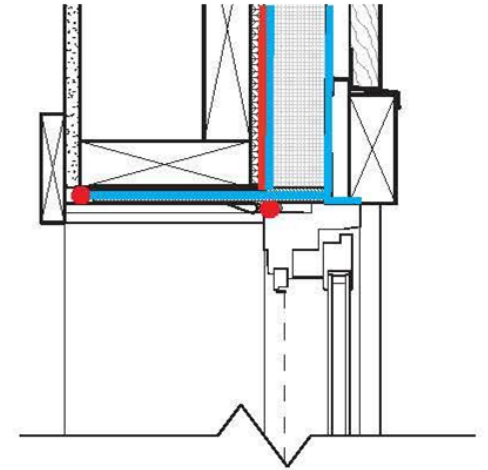
-  *Moisture Barrier*
-  *Air Barrier*
-  *Air Sealant Materials*



Section View

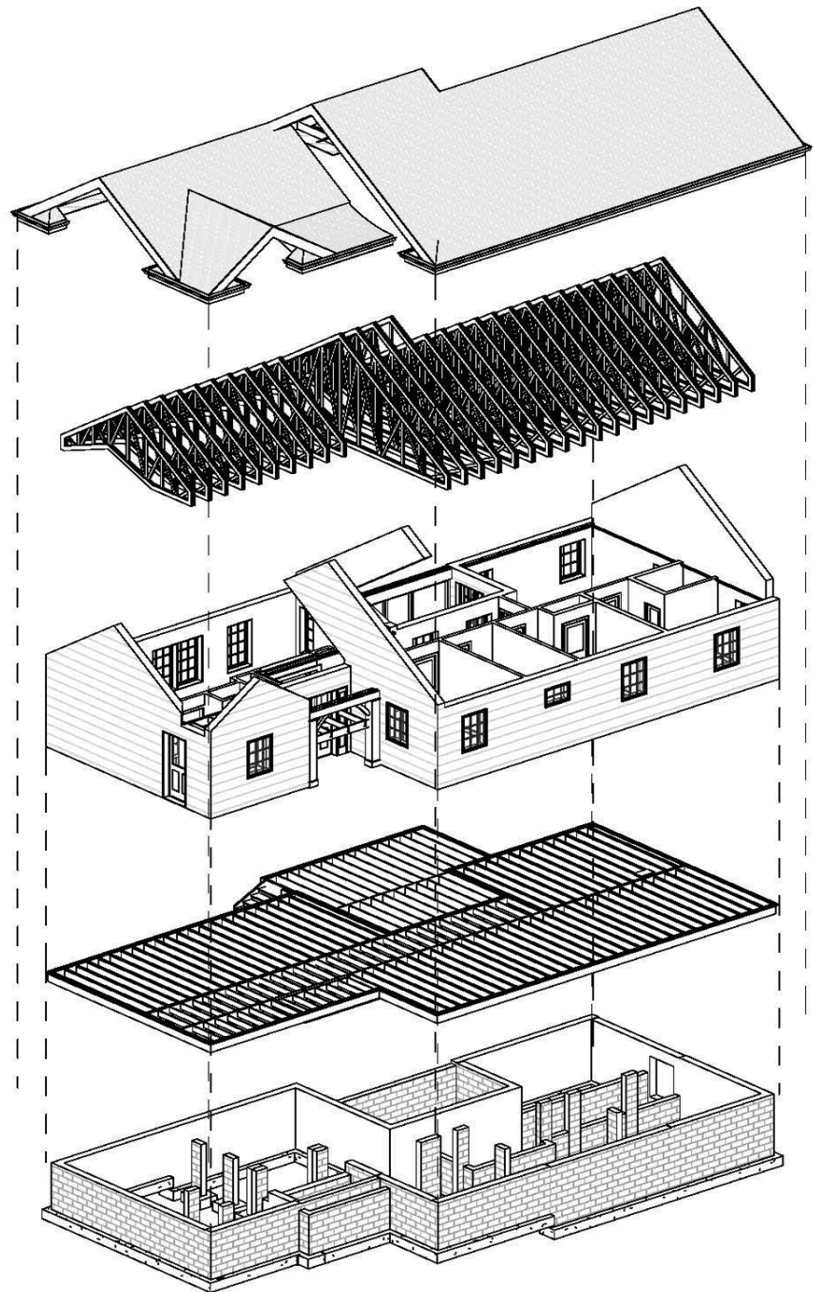


Wall Corner Detail



Window Section





Exploded isometric of construction systems.





Advanced Framing Details



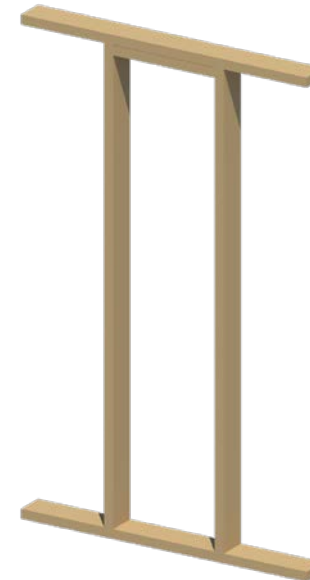
**NON-LOAD
BEARING WALL**



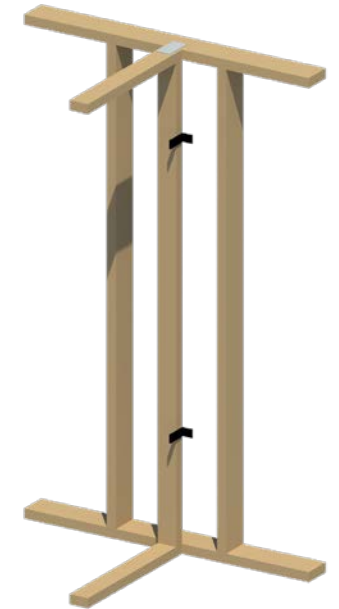
LOAD BEARING WALL



**NON LOAD BEARING
INTERIOR WALL**

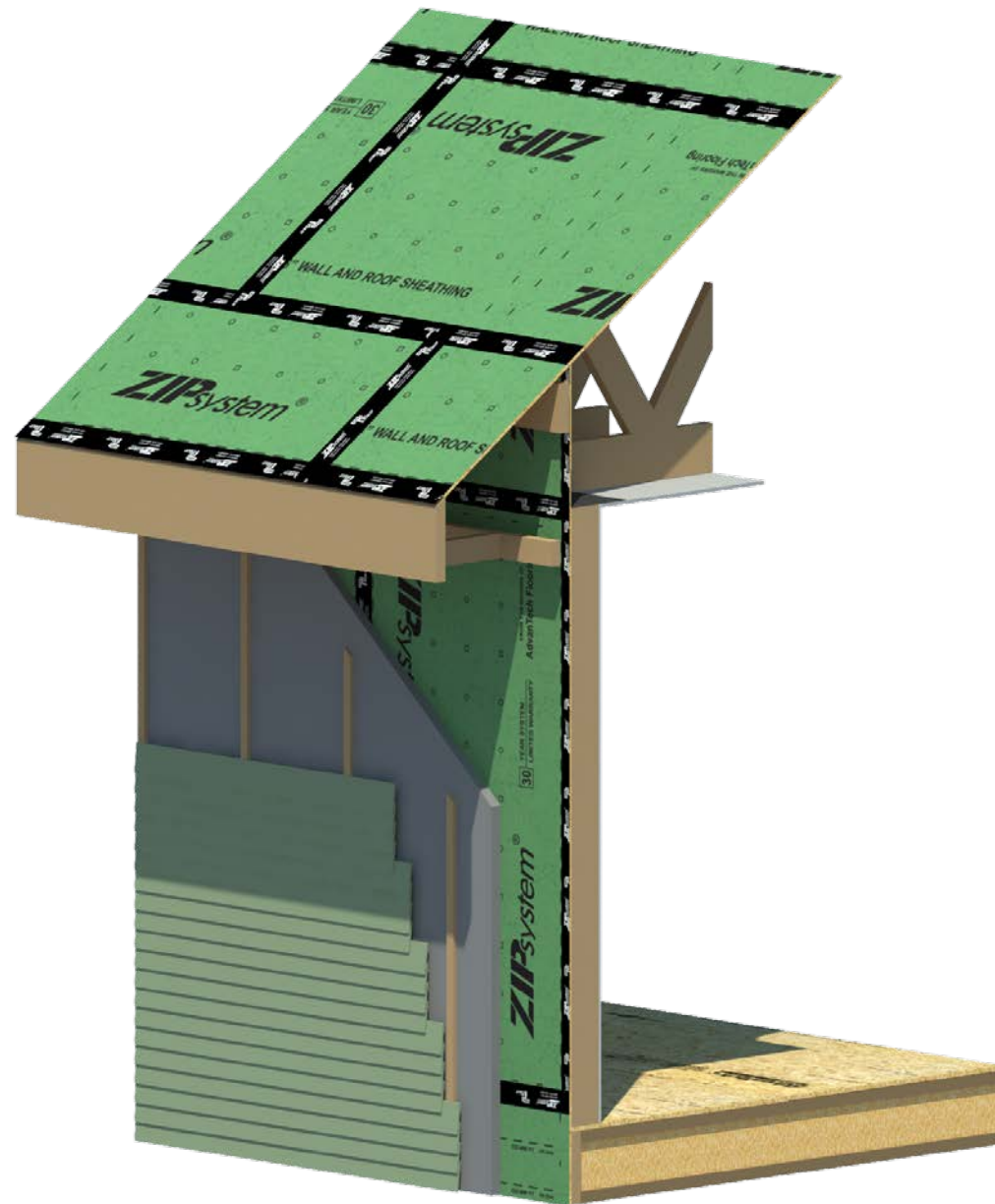


**SINGLE TOP PLATE
SPLICE**



**SINGLE TOP PLATE
AT PARTITION**





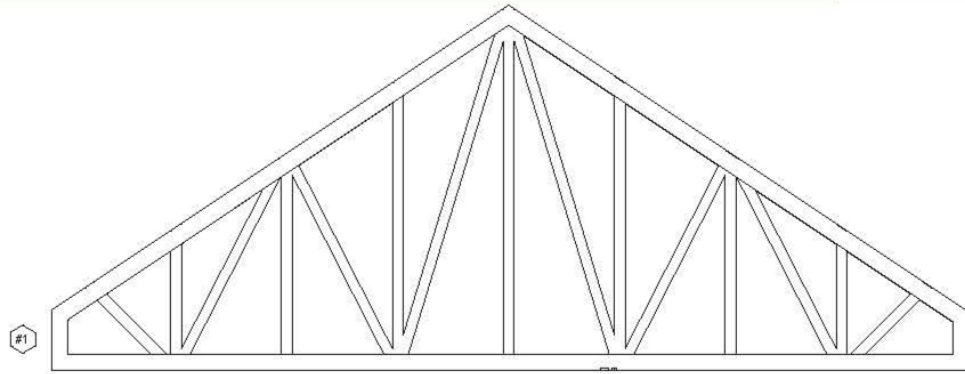
Control Layers

- Exterior 2" neopor insulation
- Raised heel truss with space to accept up to R-60 cellulose insulation
- Taped and sealed Huber ZIP sheathing system
- ZIP sheathing extend down to the block, acting as the air barrier for the rim joist

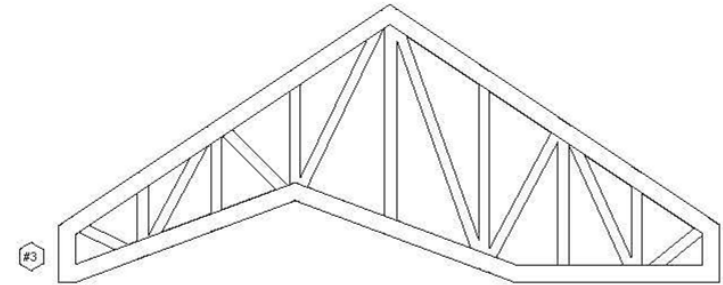




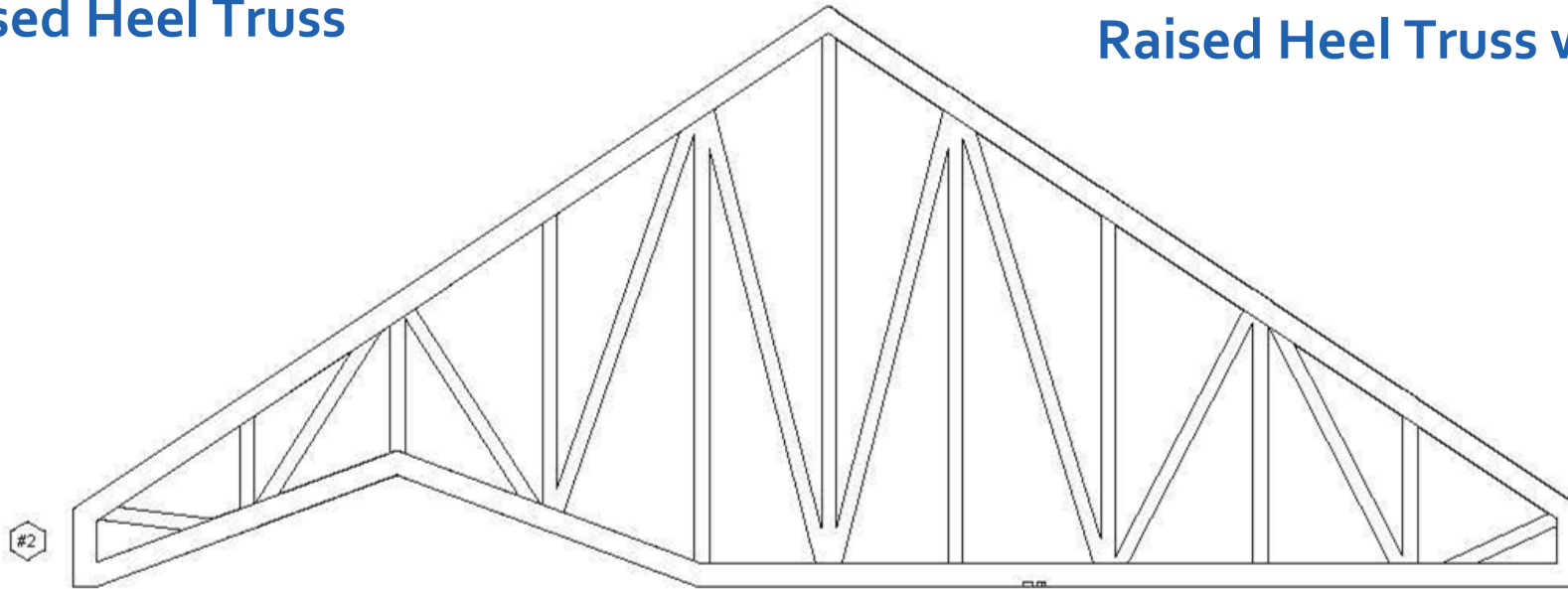
Truss Types



Simple Raised Heel Truss

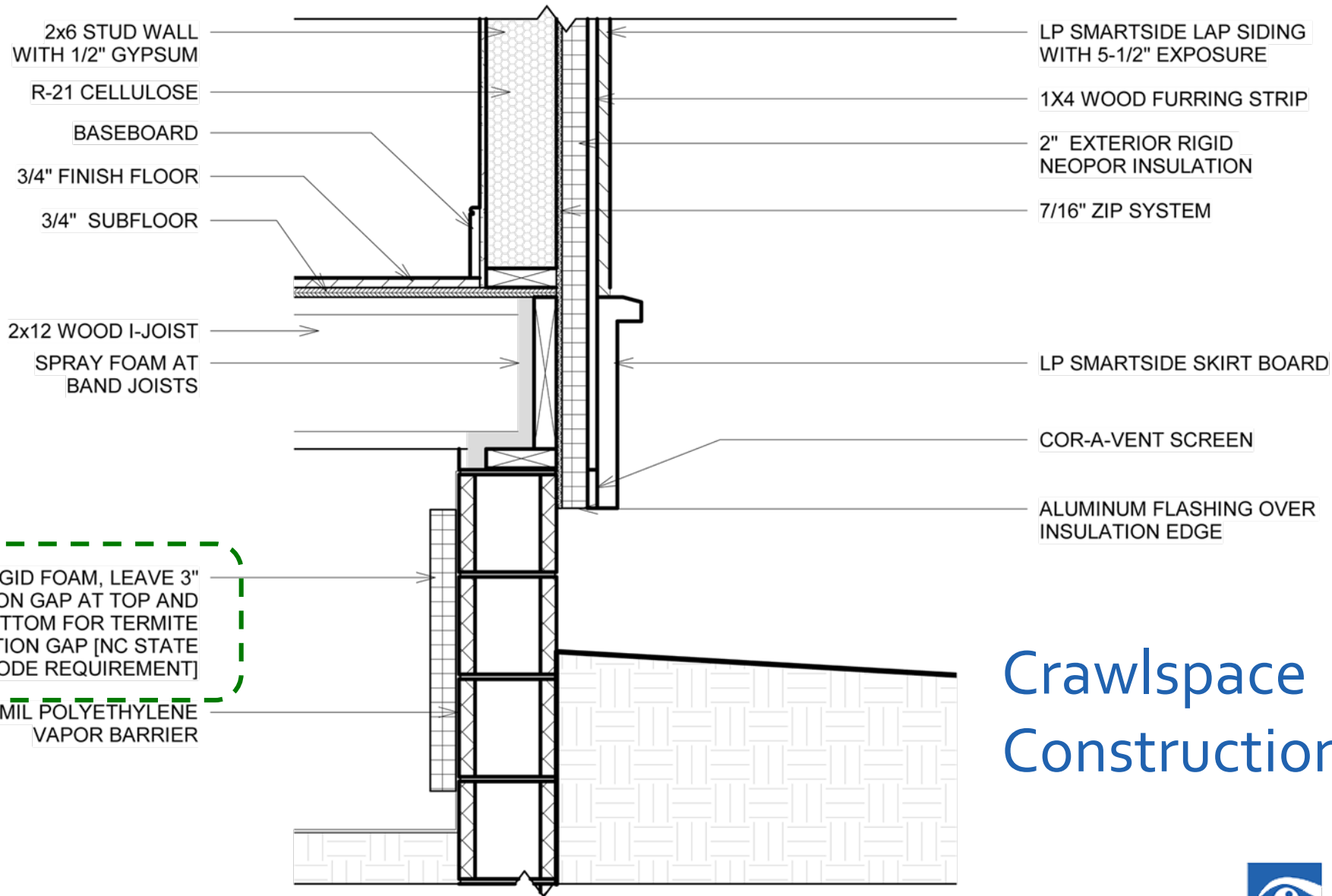


Raised Heel Truss w/ Scissors Vault



Large Raised Heel Truss w/ Scissors Vault

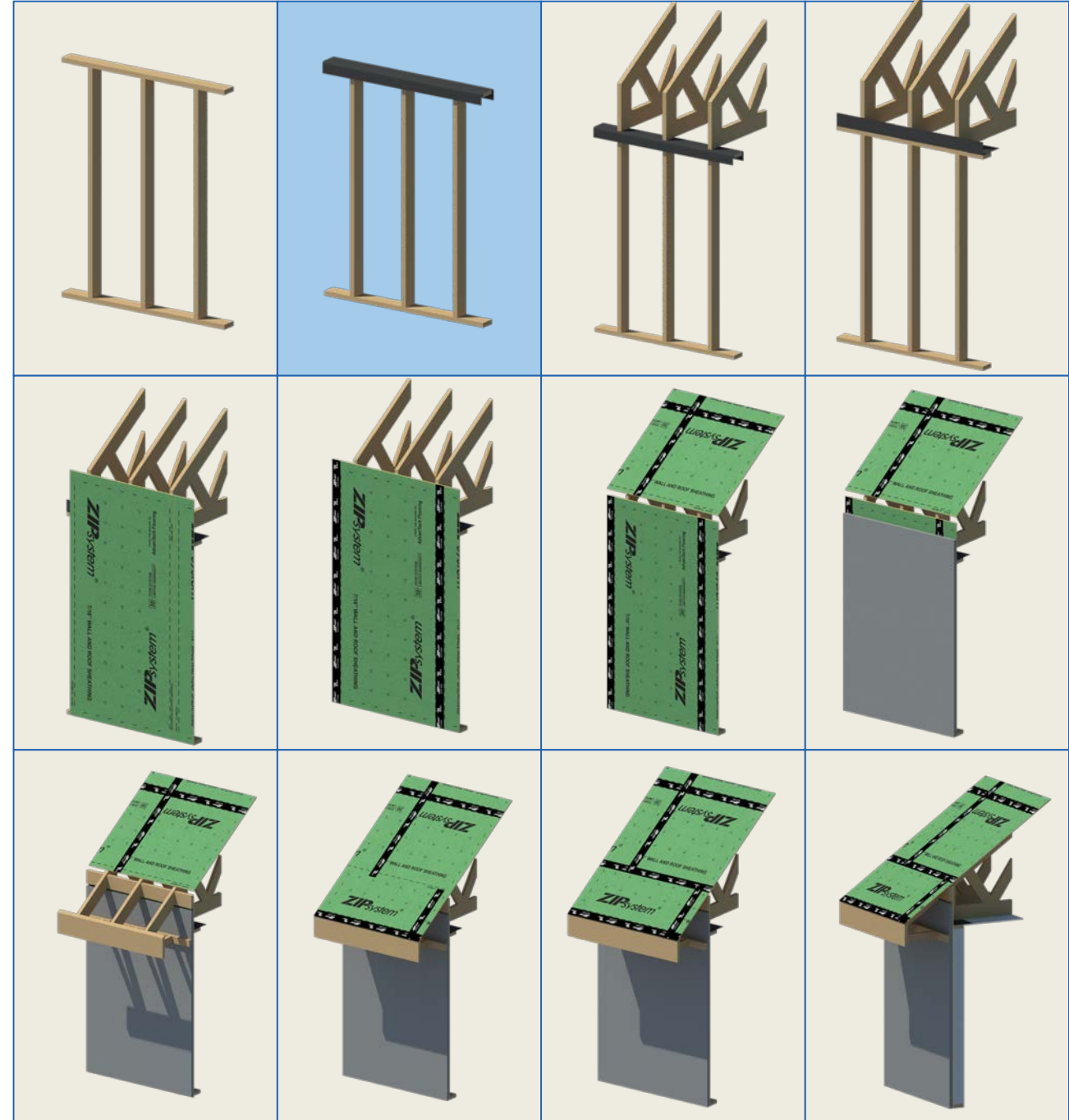
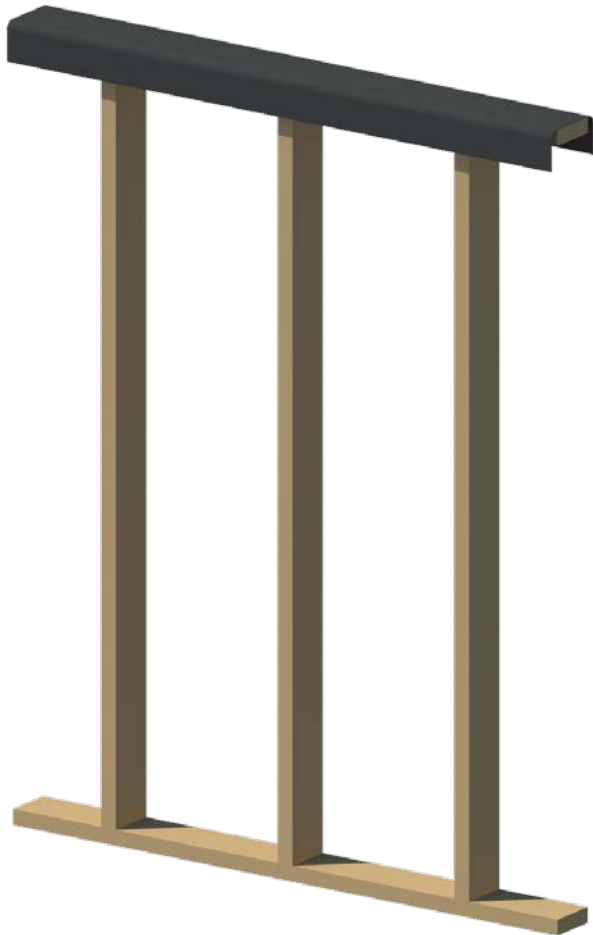




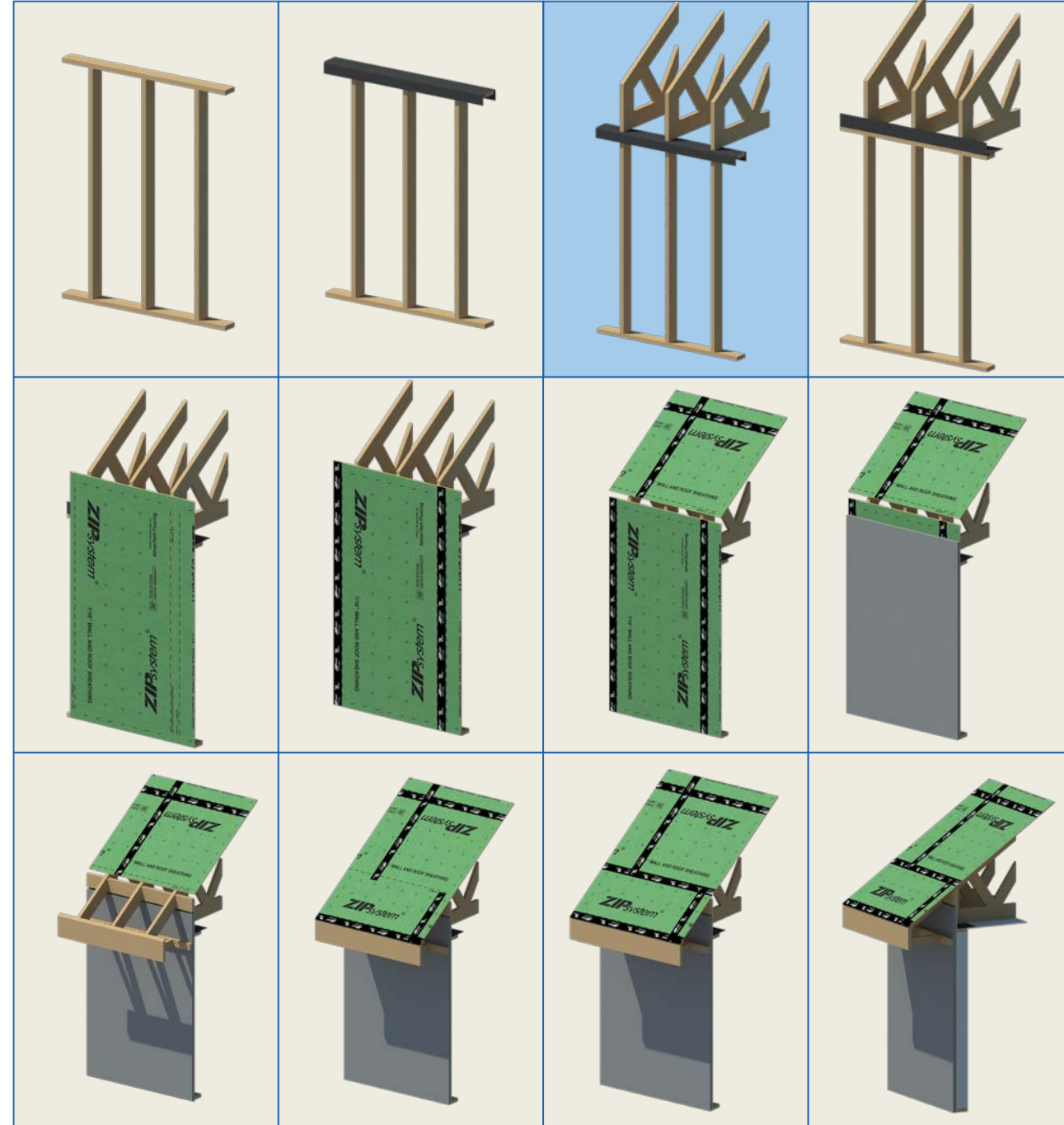
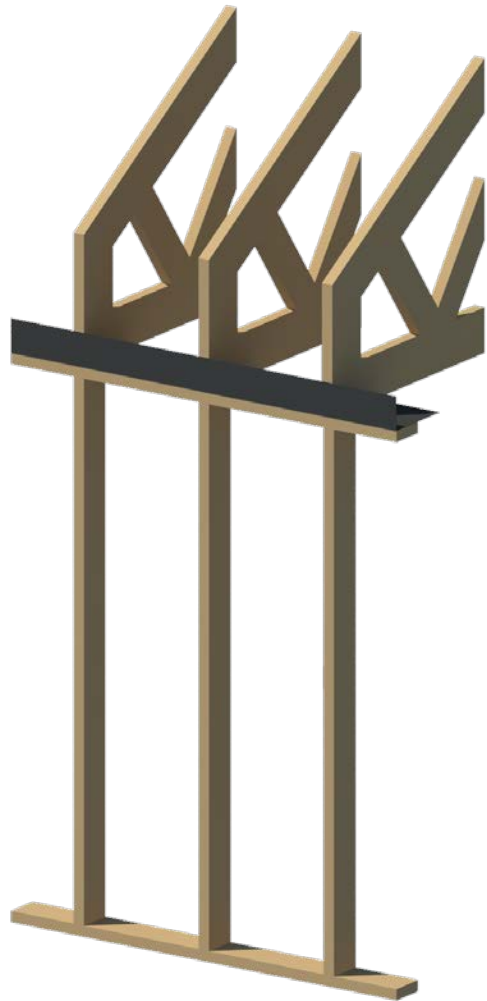
Crawlspace Construction



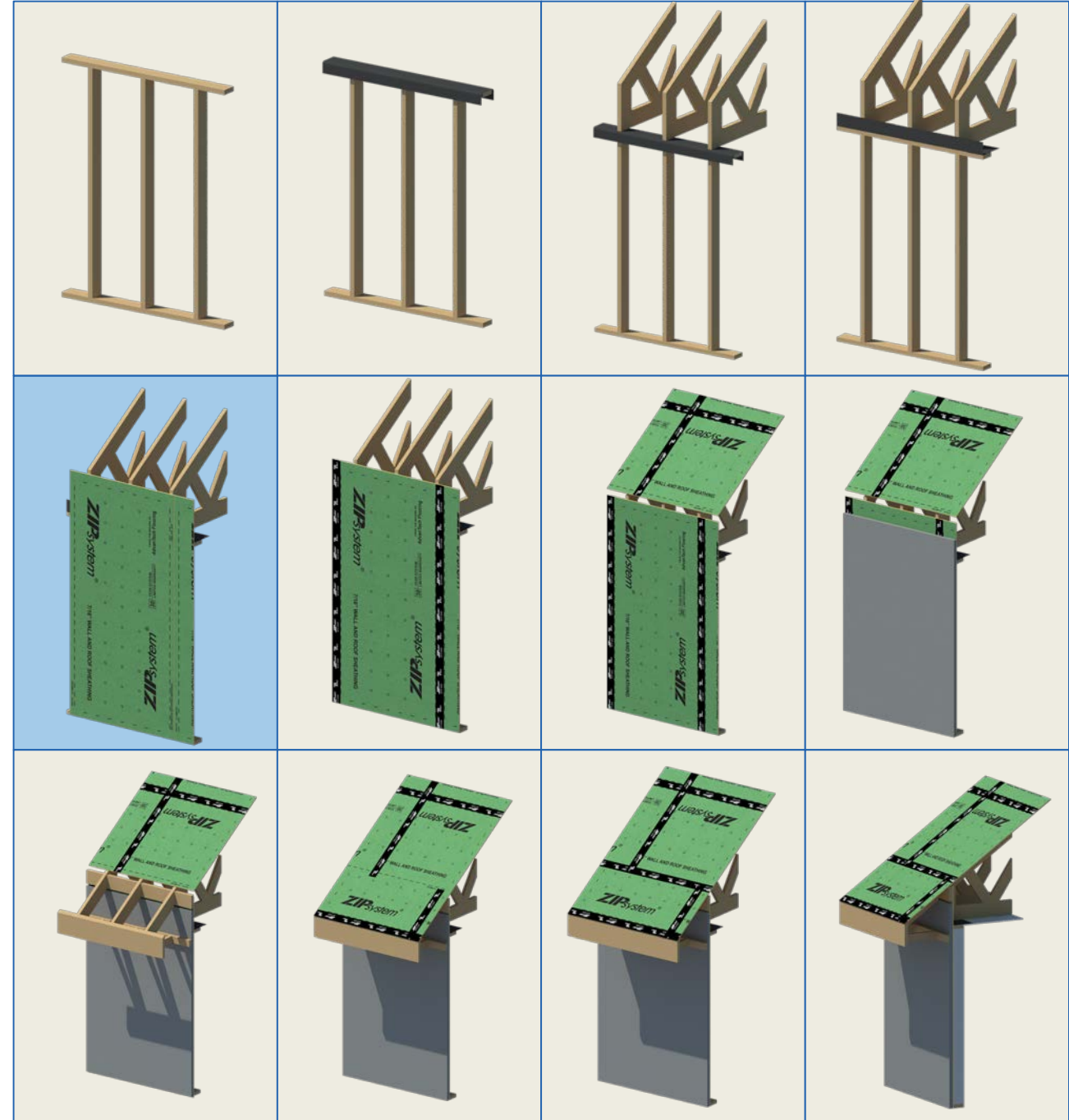
Peel-and-Stick Air Barrier Strip Sequence



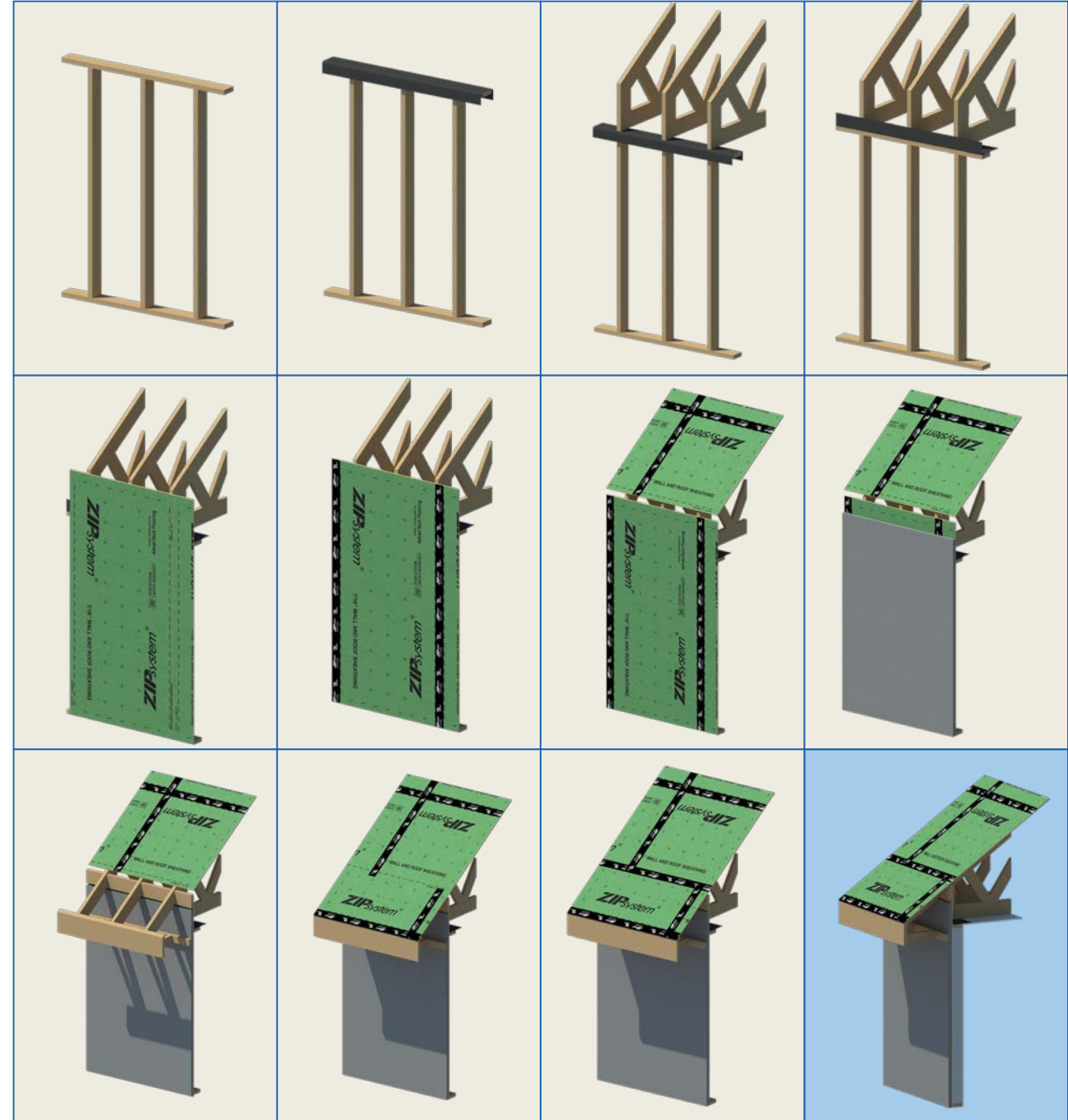
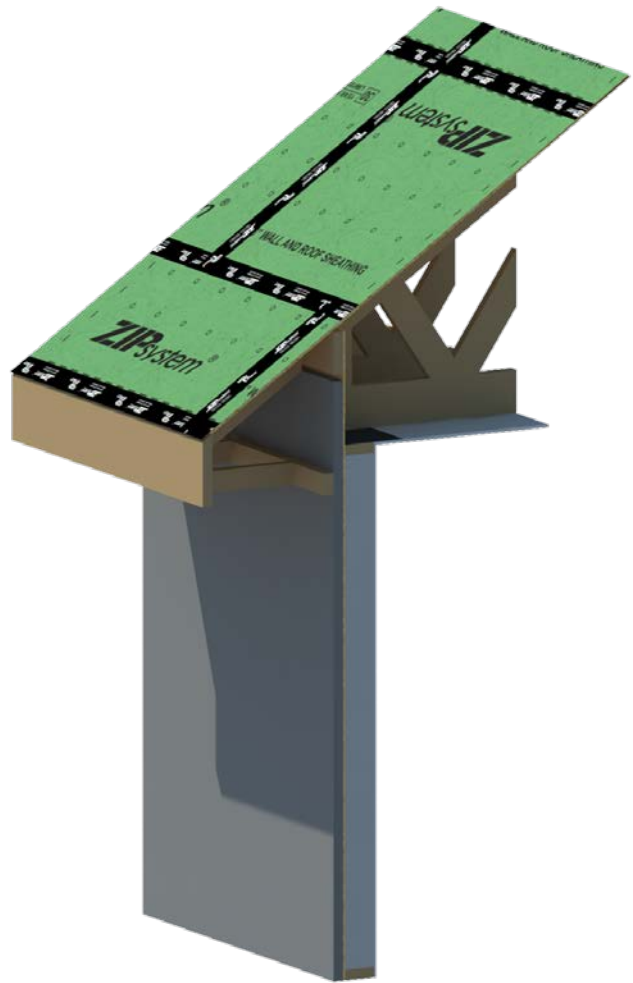
Peel-and-Stick Air Barrier Strip Sequence



Peel-and-Stick Air Barrier Strip Sequence



Peel-and-Stick Air Barrier Strip Sequence

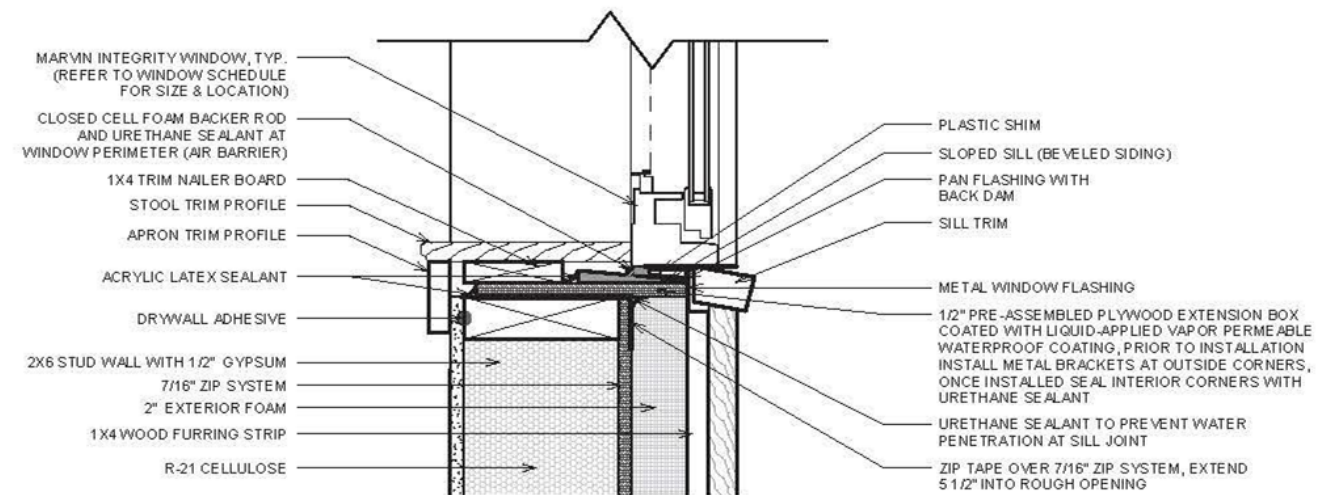
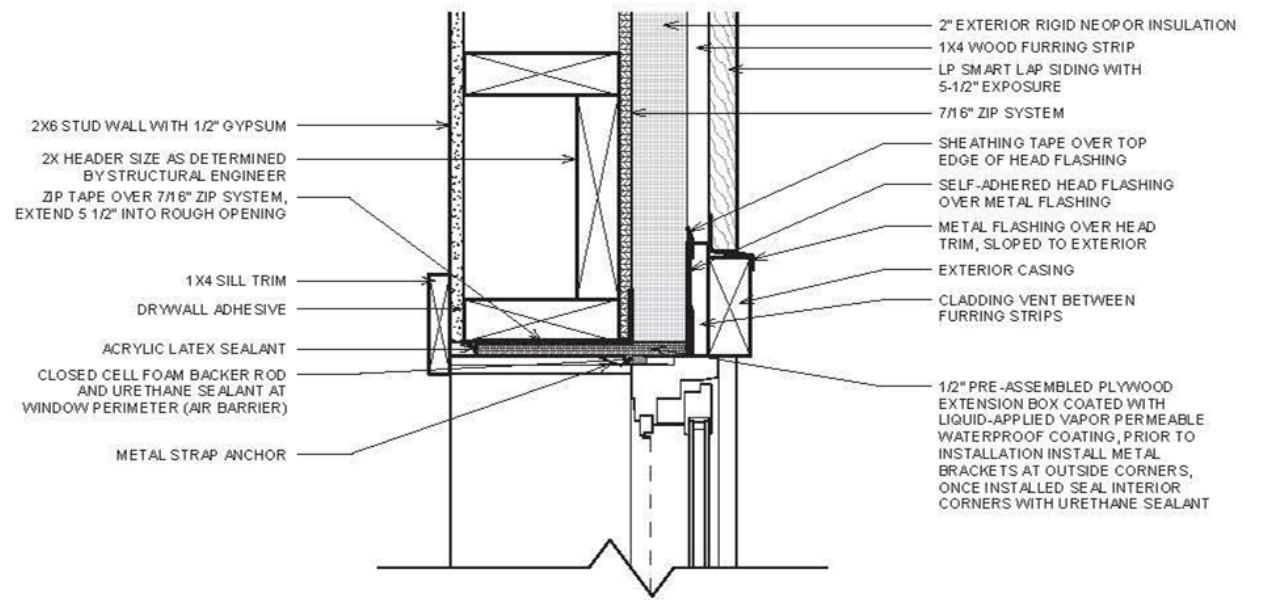
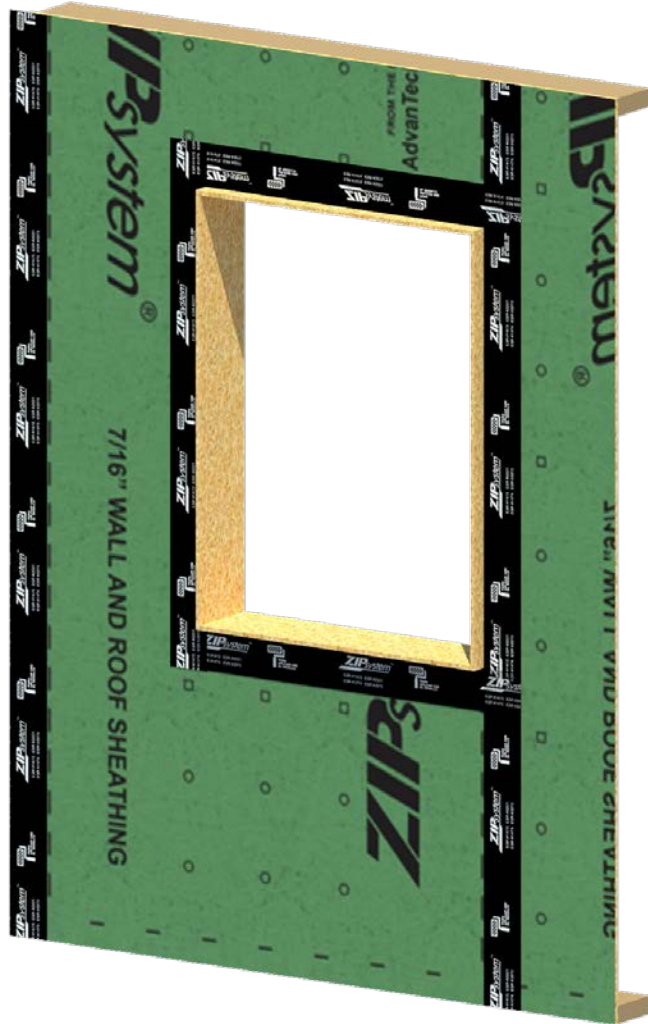




Window Detail



Plywood Window Buck



① WINDOW DETAIL
3" = 1'-0"



Testing Moisture Performance
in Stucco Assemblies



Cladding Evaluation



Construction Costs

Cost Estimate Comparison			
[In]visible House	Category	Percent of Total Cost	
		Baseline House	[In]visible house
\$16,051.84	Site Work	7%	9%
\$25,934.00	Foundations	9%	14%
\$21,059.00	Framing	19%	12%
\$30,255.00	Exterior Finishes	14%	17%
\$35,795.00	Major System Rough-ins	13%	20%
\$43,680.00	Interior Finishes	29%	24%
\$8,096.00	Final Steps	7%	4%
\$ -	Other	1%	0%

NAHB national average \$ per sq. ft.:
\$113/sq. ft.



Summary of Race to Zero Construction Costs and Financial Analysis

Category	Baseline House	[In]visible House	[In]visible House with PV
Sales Price	\$255,443	\$266,592	\$286,766
Monthly Costs:			
Mortgage	\$1,035	\$1,106	\$1,173
Monthly Household Debt (0.5%MFI)	\$ 261	\$ 275	\$ 275
Operations and Maintenance Costs	\$196	\$100	\$ 100
Monthly Utilities	\$160	\$77	\$27.00
Property Tax	\$332	\$127	\$132.37
Insurance	\$79	\$79	\$79
Total	\$2,063	\$1,764	\$1,786
Annual Median Family Income (MFI)	\$ 52,250	\$55,000	\$55,000
Debt to Income Ratio	47%	38%	39%

Summary of Race to Zero Construction Costs and Financial Analysis

Category	Baseline House	[In]visible House	[In]visible House with PV
Sales Price	\$255,443	\$266,592	\$280,601
Monthly Costs:			
Mortgage	\$1,035	\$1,106	\$1,173
Monthly Household Debt (0.5%MFI)	\$ 261	\$ 275	\$ 275
Operations and Maintenance Costs	\$196	\$100	\$ 100
Monthly Utilities	\$160	\$77	\$27.00
Property Tax	\$332	\$127	\$132.37
Insurance	\$79	\$79	\$79
Total	\$2,063	\$1,764	\$1,786
Annual Median Family Income (MFI)	\$ 52,250	\$55,000	\$55,000
Debt to Income Ratio	47%	38%	39%

Asheville, NC
median asking price
\$379K



Task Name	Duration	May '17	June '17	July '17	Aug'17	Sept '17	Oct '17	Nov '17
Receive NTP	0 days	● 5/15						
Site Prep	21 days		■					
Foundation	24 days		■					
Carpentry	35 days			■				
Exterior Finishes	9 days					■		
Finish Crawlspace	10 days					■		
MEP Rough-in	16 days					■		
Exterior Paint	9 days					■		
Interior Finishes	52 days					■		
Substantial Completion	0 days							● 11/13
Landscaping	1 day							■
Punchlist and Cleanup	3 days							■
Systems Commissioning	3 days							■

Construction Schedule Overview

Major milestone schedule:

- NTP: 5/15/17
- Foundation: 6/13/17
- Dried In: 8/31/17
- Substantial Completion: 11/13/17

NOTE: Complete 113 activity Critical Path Method schedule found in Volume II



[In]visible house

