

Developing a Residential Carbon Dashboard Funded by an AIA Upjohn Grant

Northwest Energy Efficiency Alliance Product Council
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Research Professor and Co-Director, University of Washington, Integrated Design Lab

Agenda

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Opportunity – the Gap in the Industry



US Building Stock

- Residential buildings comprise 61% of current US building stock.
- There is a lack of tools focused on this sector.



AIA Firm Sizes

Almost 75% of AIA member firms are 10 people or less and don't have adequate resources to conduct full lifecycle analysis.

This tool fills both these needs simultaneously.



AIA
College of Fellows

American institute of Architects (AIA) Upjohn Research Initiative (2024)

Funds annual research grants of \$15,000–\$30,000 for applied research projects that enhance the value of design and professional practice knowledge.

Algae Foam: Prototype for Buildings

Principal Investigators: Martin Bechthold, DDes and Daniel Tish, DDes

Integrated Carbon Dashboard for Residential Architecture

Principal Investigators: Vikram Sami, AIA, LEED AP, BEMP, Teresa Moroseos AIA, Christopher Savage, PhD, LEED AP BD+C, Christopher Meek, FAIA, Heather Burpee, AIA, Pawel Sapiecha

Masonry Material Recovery: Building Disassembly and Remanufacture for the Circular Economy

Principal Investigator: Dillon Pranger, AIA (Illinois Institute of Technology) Collaborators: Steve Filyo (BlueEarth Deconstruction), Matt Gombeda (Illinois Institute of Technology), Scott Conwell, FAIA, FCSI, CDT, LEED AP (International Masonry Institute)

<https://www.aia.org/advocacy/research/grants-fellowships/upjohn-research-initiative>

The Team



Vikram Sami
Director of Building
Performance



Chris Savage
Senior BP Analyst



Pawel Sapiecha
BP Analyst



Rohit Raman
Intern

Olson Kundig

- Embodied Carbon Simulations
- Building the interface
- Tweaking the algorithm



Teresa Moroseos
Research Engineer



Chris Meek
Director



Heather Burpee
Director of Education and
Outreach

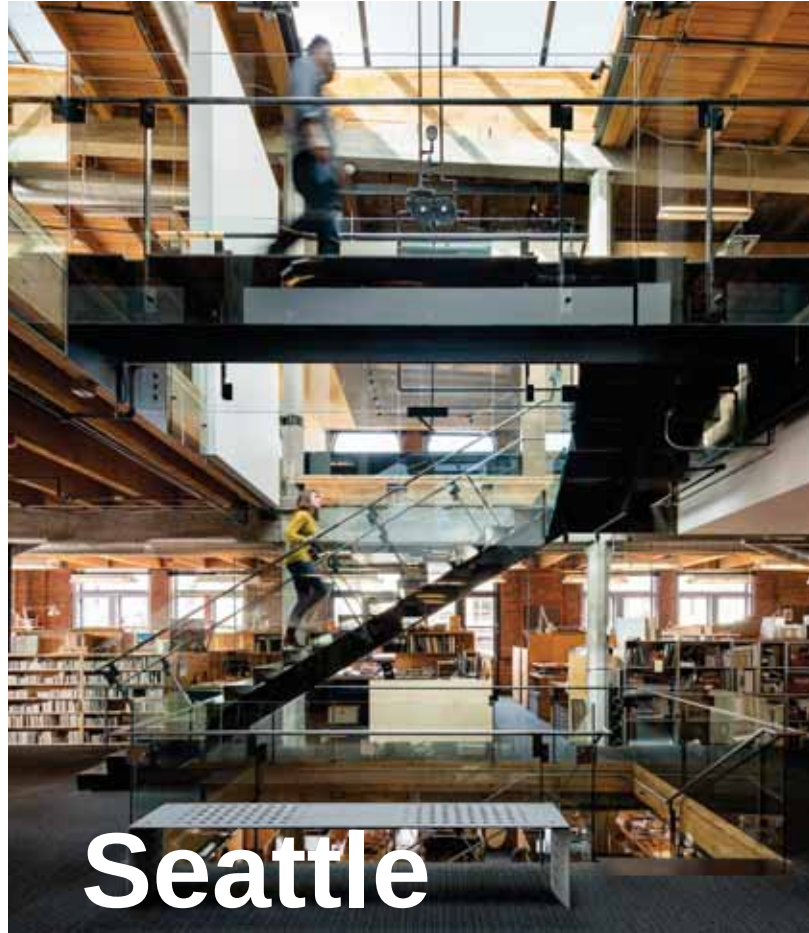


Bearach Miwatani-Minter
M. Arch Candidate



- Energy Simulations
- Building the algorithm

About Olson Kundig



Project Typologies



UW INTEGRATED DESIGN LAB

AREAS OF ACTIVITY:

BUILDING PERFORMANCE, ENERGY EFFICIENCY, EXISTING BUILDING RETROFITS, WHOLE BUILDING LIFECYCLE ANALYSIS, HEALTH AND THE BUILT ENVIRONMENT, HVAC SYSTEMS, FACADES, LIGHTING AND DAYLIGHTING, TOOLS AND METHODS

- **Research**
- **Technical Assistance**
- **Education and Outreach**



INTEGRATED DESIGN LAB
Annual Report
2022-2023

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INTEGRATED DESIGN LAB
Annual Report
2023-2024

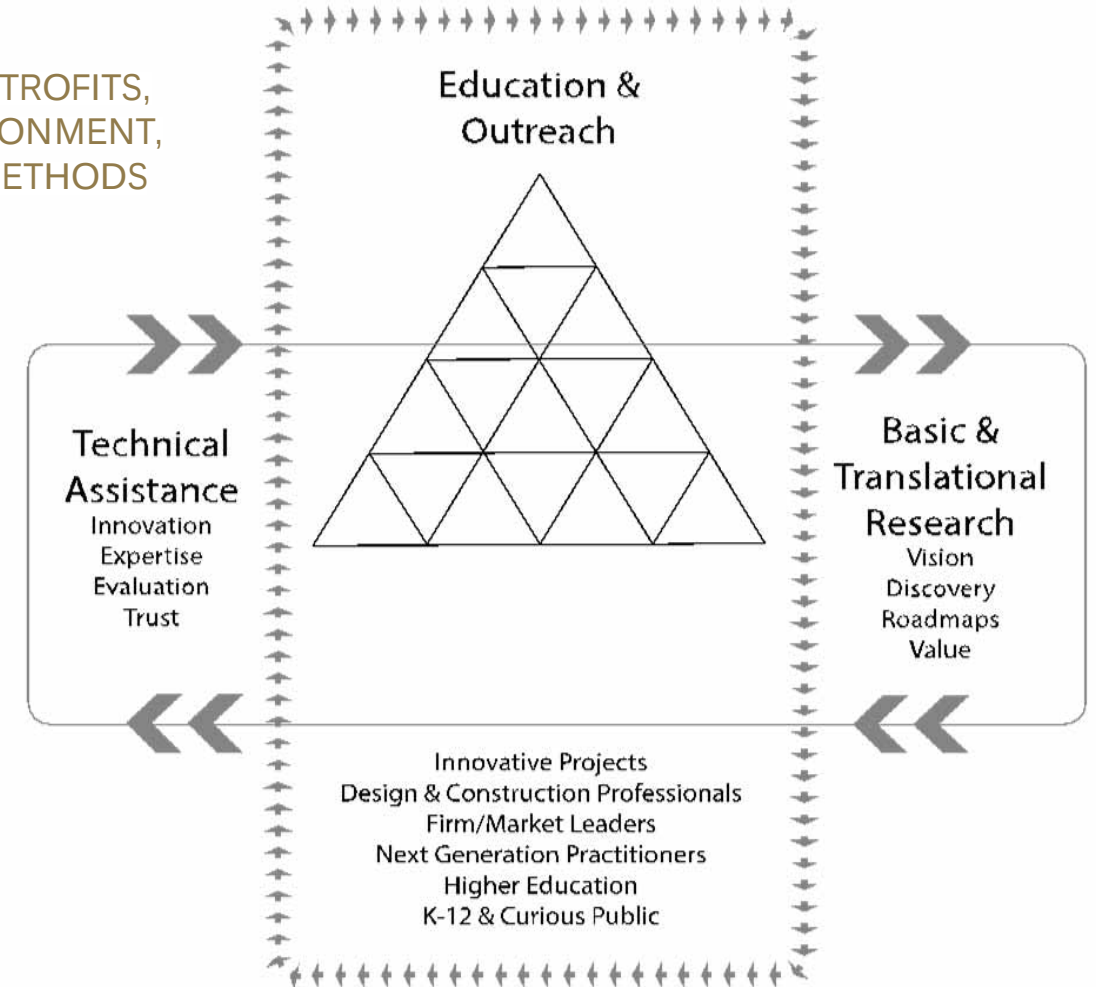
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The Economic Case for High Performance Design



BUSINESS INTELLIGENCE

ROI: Increasing asset values

NOVEMBER 28, 2023

Owners and developers are interested in the financial upsides of high-performance design, particularly increasing asset or market value. Green labeling and operational cost reductions help boost a



BUSINESS INTELLIGENCE

ROI: Reducing operational costs

NOVEMBER 28, 2023

Out-of-pocket operational expenses add up fast and can account for up to 15% of a company's total business expenses, creating a huge incentive for owners, tenants, and society to drive down costs with



BUSINESS INTELLIGENCE

ROI: Reducing up-front costs

NOVEMBER 28, 2023

Sustainable, high-performance design can cause concerns about high up-front costs, but an integrated design process, smart tradeoffs, and various grants and incentives are proven to reduce initial



BEST PRACTICES

ROI: Codes, standards, & reporting on resilient design

NOVEMBER 28, 2023

Designing beyond building codes and standards provides significant resilience benefits to both building owners and occupants.



CLIMATE ACTION

ROI: The economic case for resilient design

NOVEMBER 30, 2023

The climate crisis has long-term economic consequences. Incorporating resilient design helps establish economic resilience to better withstand and recover from the unexpected.



FIRM MANAGEMENT

ROI: Attracting & retaining talent

JUNE 22, 2023



BEST PRACTICES

ROI: Healthier, more productive occupants

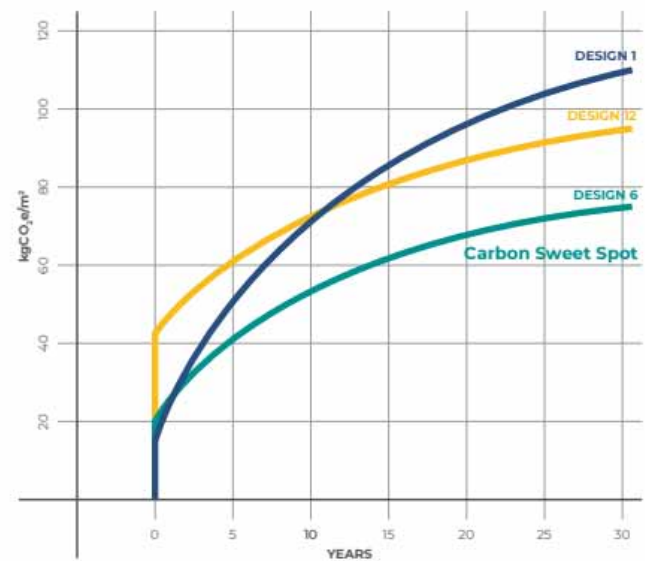


CLIMATE ACTION

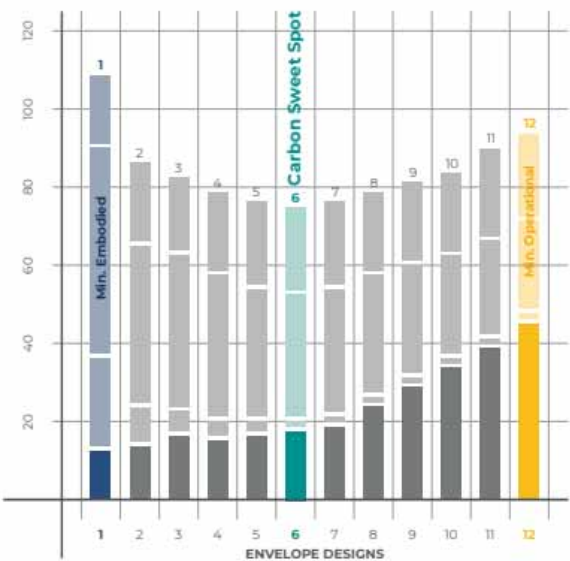
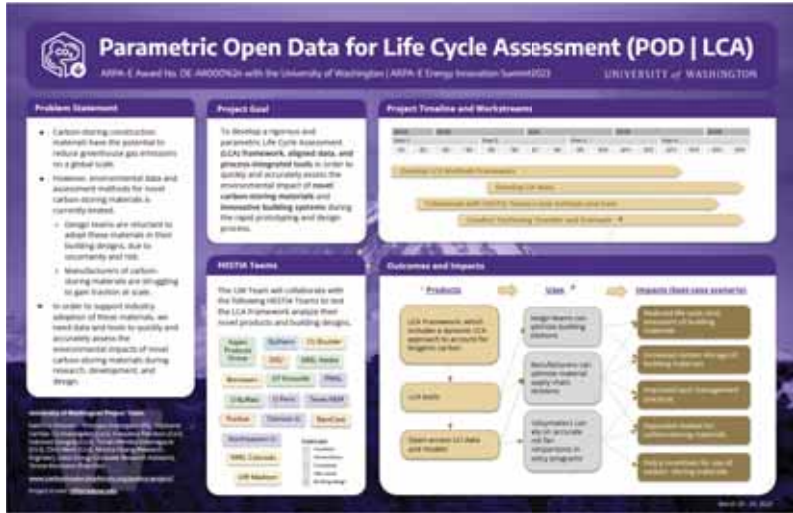
ROI: Designing for reduced embodied carbon

<https://www.aia.org/resources/6409378-roi-of-high-performance-design>

<https://www.aia.org/pages/6514515-roi-the-economic-case-for-resilient-design>



<https://knowledge.uli.org/en/reports/research-reports/2024/the-carbon-sweet-spot>



<https://www.lifecyclelab.org/project/pod-lca/>



On the tradeoffs between embodied and operational carbon in building envelope design: The impact of local climates and energy grids

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Operational carbon
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Building performance simulation
Parametric modeling

ABSTRACT

The building envelope has a substantial influence on a building's life cycle operational and embodied carbon emissions. Window-to-wall ratios, wall assemblies, shading and glazing types, have been shown to have a significant impact on total emissions. This paper provides building designers, owners, and policy makers with actionable guidance and a prioritization framework for establishing co-optimized lifecycle carbon performance of facade assembly components in a broad spectrum of climate contexts and energy carbon intensities. A large parametric study of building envelopes is conducted using building performance simulation and cradle-to-gate embodied carbon calculations in 6 US cities. The authors derive the total carbon emissions optimization for commercial office and residential space types using standard code-reference models and open-source lifecycle data. Comparisons between optimal total carbon solutions and (i) optimal operational carbon and (ii) minimum required assemblies, show the impact of under and over investing in envelope-related efficiency measures for each climate. Results show how the relationship between embodied and operational carbon is highly localized, that optimal design variables can vary significantly. In low carbon intensity energy grids, over investment in envelope embodied carbon can exceed as 10 kgCO₂e/m², while under investment in high carbon intensity grids can be higher than 150 kgCO₂e/m².

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1. Introduction

The construction sector has dedicated significant investments in research and legislation toward energy efficiency and reduced operational carbon emissions, while embodied emissions have historically received far less attention. More recently, increased attention has been given to embodied carbon due to the realization that they are increasingly representing a large percentage of the total lifecycle GHG emissions, in some cases representing more than 50% of the lifecycle emissions [1]. As buildings become more energy efficient, and energy sources, especially grid electricity become less carbon intensive, embodied emissions will represent an even higher percentage of lifecycle emissions [2].

In most buildings, the envelope is responsible for a high percentage of the embodied emissions [3]. It is made up of high carbon intensity materials such as aluminum, glass, gypsum and insulation. Operationally, managing unwanted heat gain and loss through the building enclosure including windows represents over 30% of the primary energy consumed in residential and commercial buildings in the United States [4] translating to approximately 483.6 MMT CO₂ [5]. This makes the envelope a critical building component in terms of embodied, operational and total carbon emissions.

As such, the design of the building envelope is a multi-criteria problem that has to factor a large number of contrasting environmental metrics that all share the same design parameters, i.e. wall assemblies, window-to-wall ratios (WWRs), shading devices, glazing types, etc. Designers have to consider the tradeoff between embodied and operational emissions over the lifespan of the building. Operational emissions are also largely determined by the local climate and the carbon intensity of the local energy grid. The embodied emissions of the envelope are determined by the quantity and choice of materials (glass, insulation, cladding, internal finishes) and their carbon intensity. While it is considered ideal to have materials come from local sources to minimize transportation costs and emissions, material supply chains are often very complex and globalized. This scenario implies that the study of the tradeoffs between operational and embodied emissions is very localized, high variations in total emissions as well as optimal solutions can be expected between cities.

Several studies have started to look into the embodied and operational tradeoffs in several ways. Röck et al. looked into

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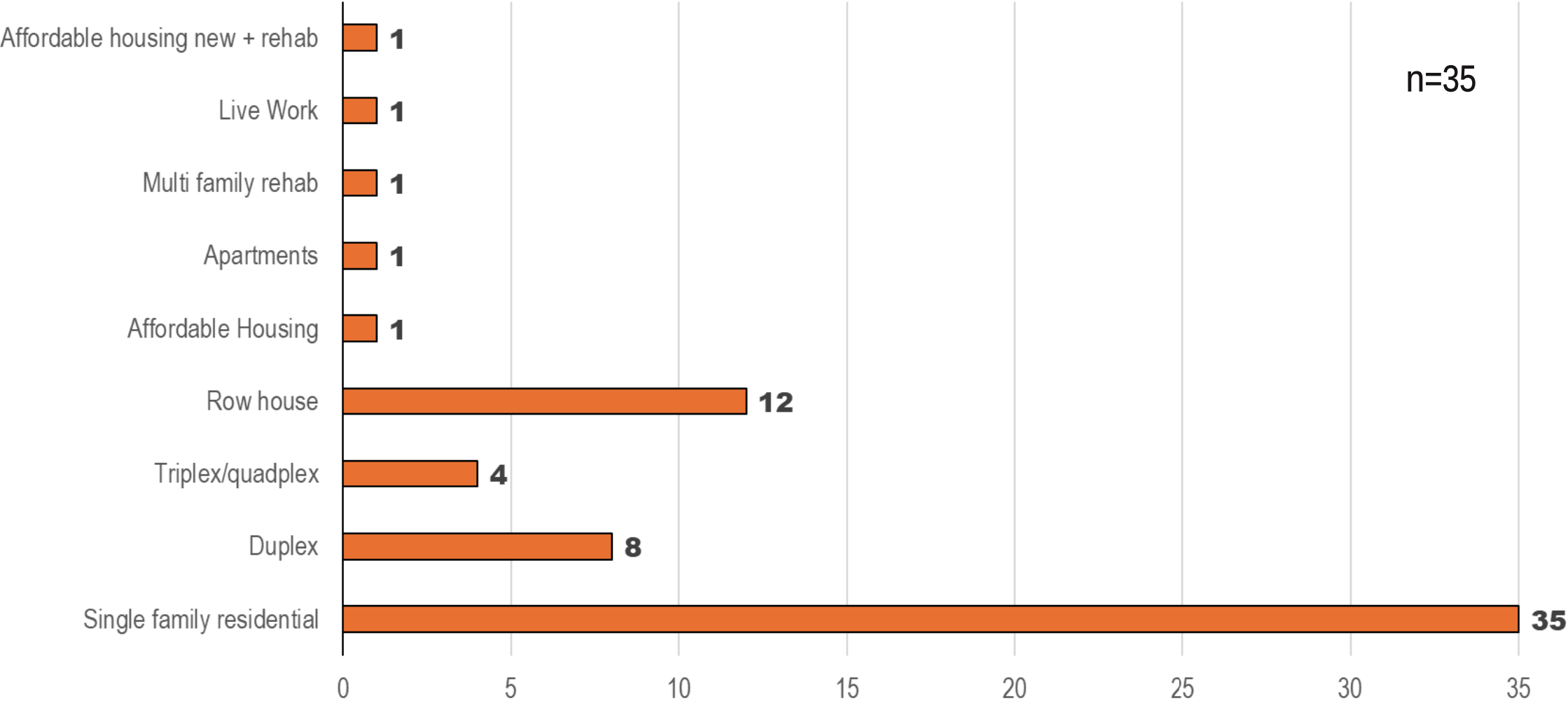
<https://www.sciencedirect.com>

AIA Small Firm Roundtable: Survey on Small Residential Carbon Analysis

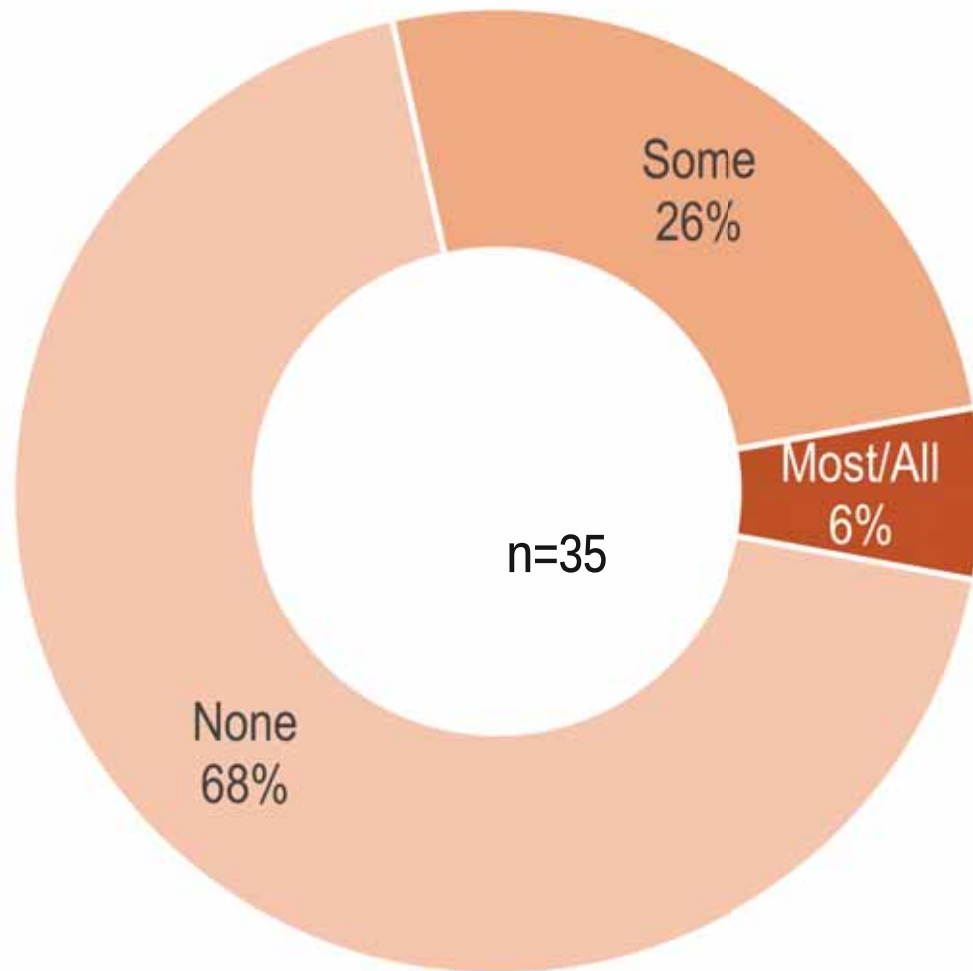


- Understand the unique needs of small firms
- Primary typologies
- Current baseline of operational/embodied carbon analysis
- Tools used
- Identify markets gaps in tools and methods
- Identify analysis measures to prioritize
- Gain perspective and insights from potential users

What Type of Small Residential Projects do you Work On?

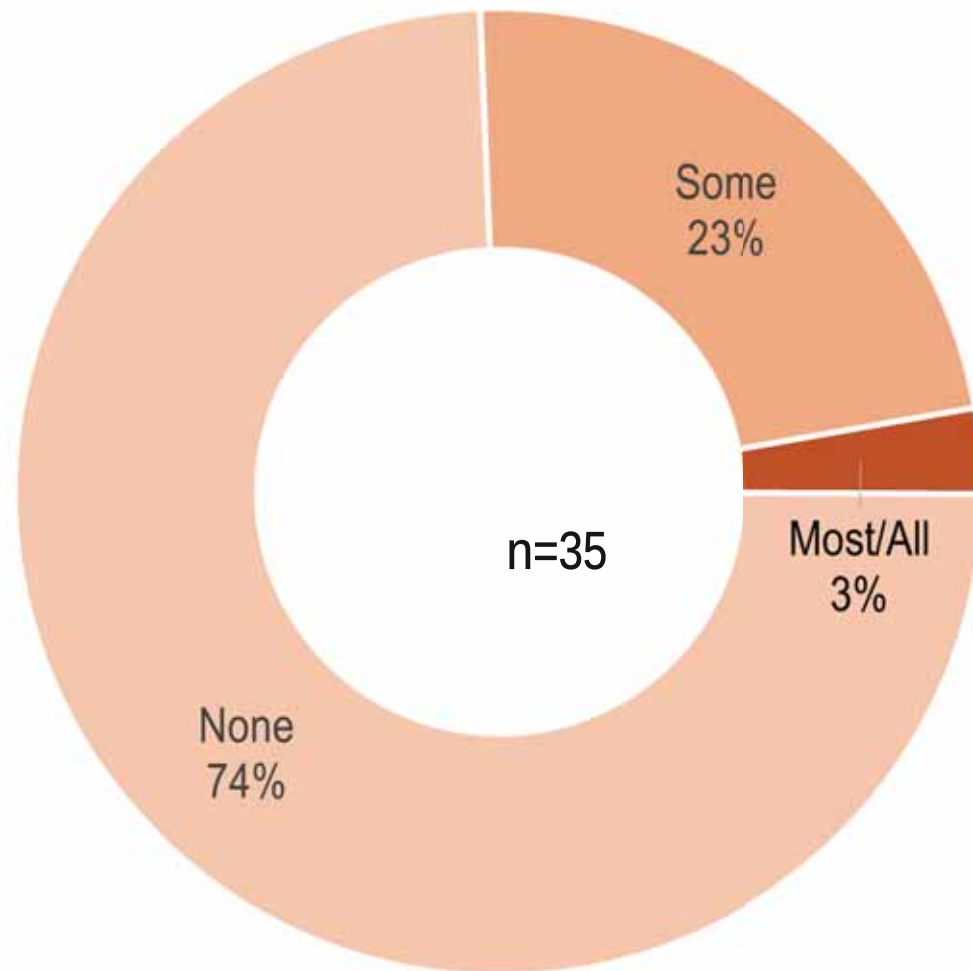


Benchmarking Operational Carbon Emissions or Energy?



Do you or your consultants currently benchmark or estimate **operational energy** and/or **operational carbon** emissions on your small-scale residential projects?

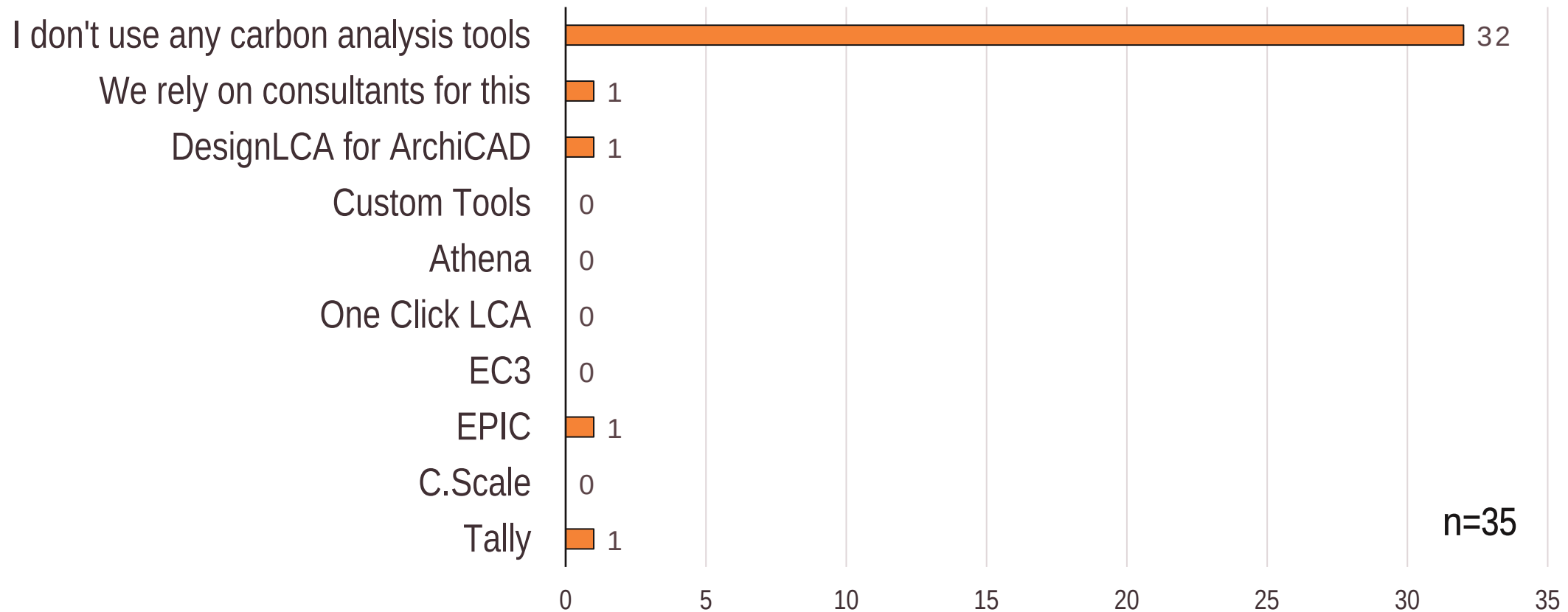
Benchmarking Embodied Carbon?



Do you or your consultants currently benchmark or estimate **embodied carbon** emissions on your small-scale residential projects?

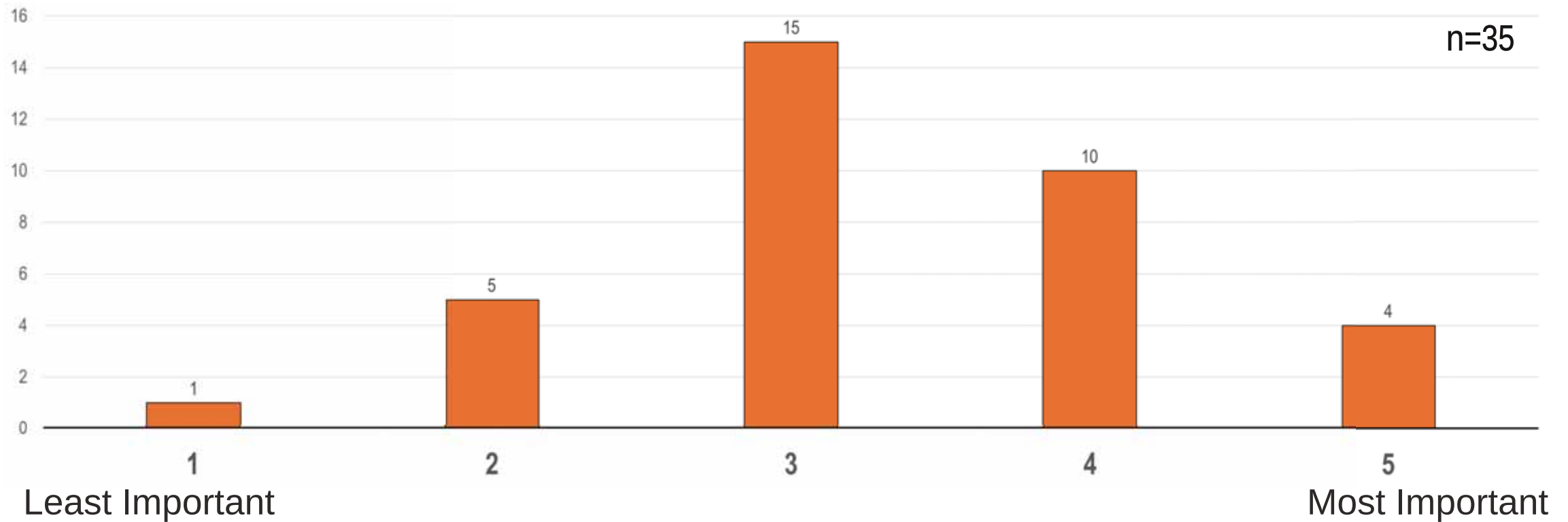
What Embodied Carbon/LCA Tools are Currently Being Used?

If you are analyzing/benchmarking embodied carbon in your practice, what tools are you using on your small-scale residential projects? Select all that apply:



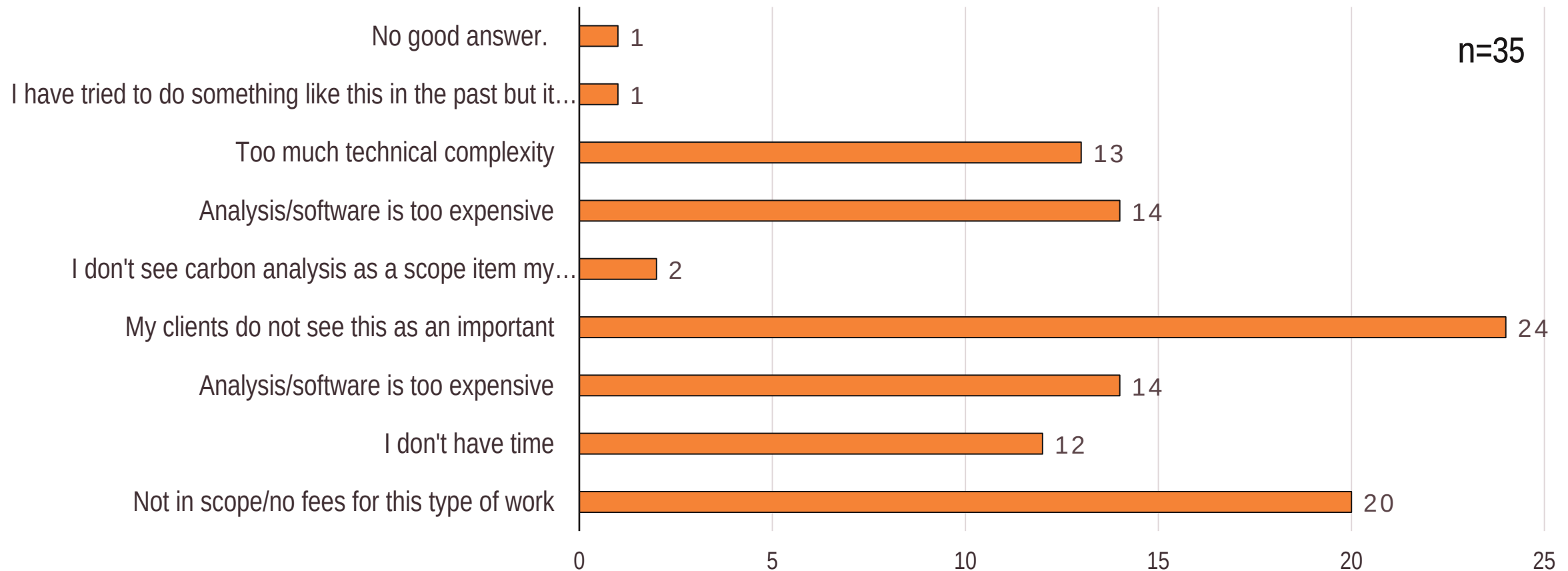
Tool Value To Users?

Do you perceive being able to assess operational and embodied carbon as important to your practice and/or adding value to your design process? (Scale of 1 – 5)



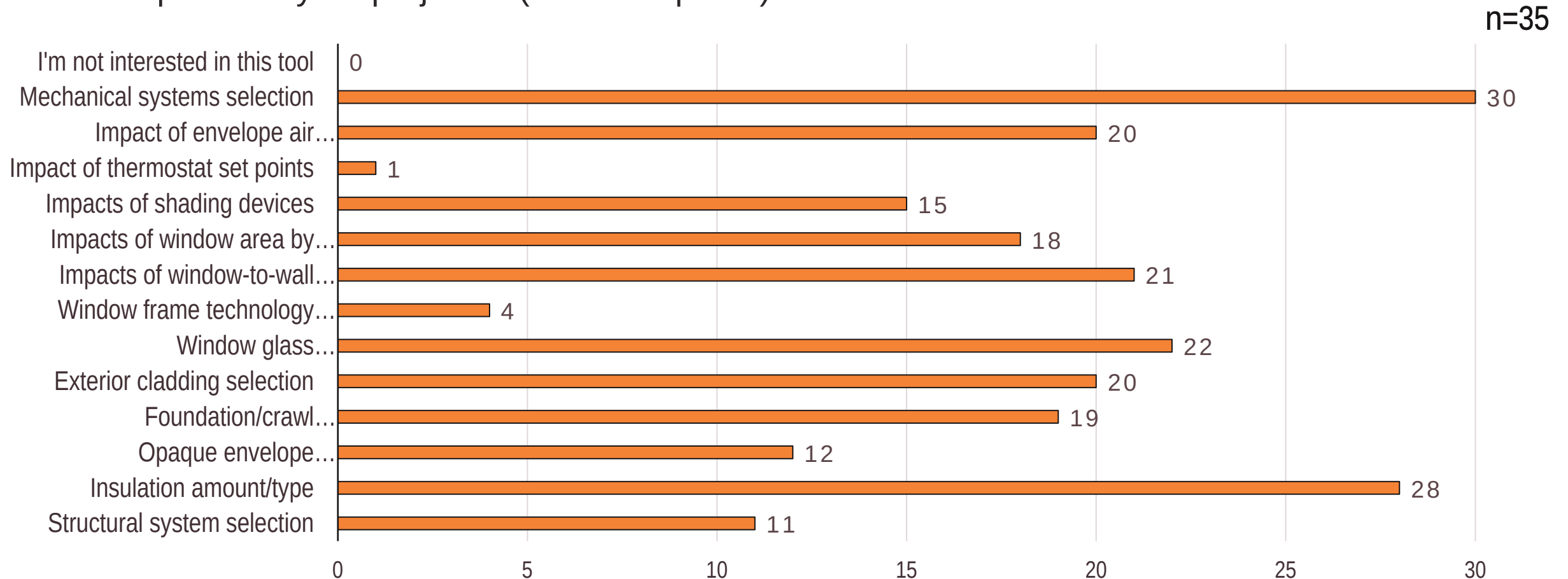
What Barriers Prevent You From Doing Carbon Analysis?

If you would like to be able to assess the impact of design decisions for embodied and operational carbon but currently do not, what barriers do you perceive to prevent you doing that? Choose all that apply:



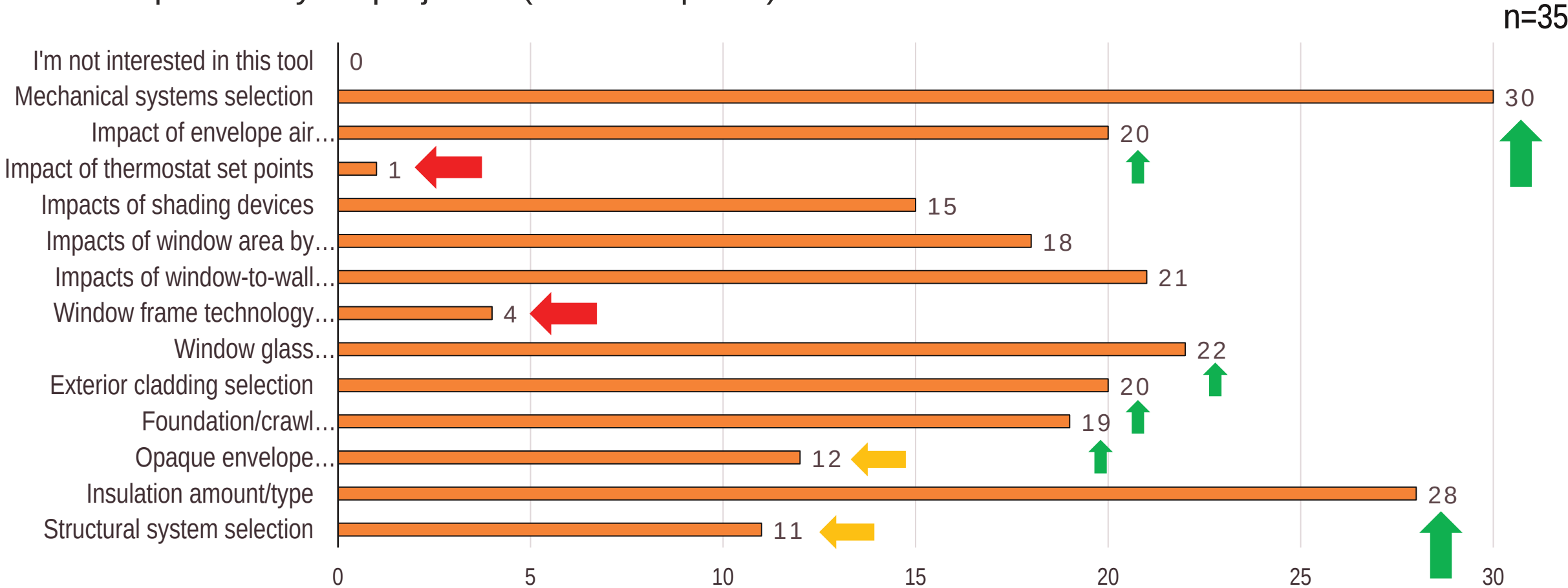
What Design Decisions/Measures Would You Prioritize?

What design decisions would be most helpful to assess operational/embodied carbon impacts for your projects? (Choose up to 7):

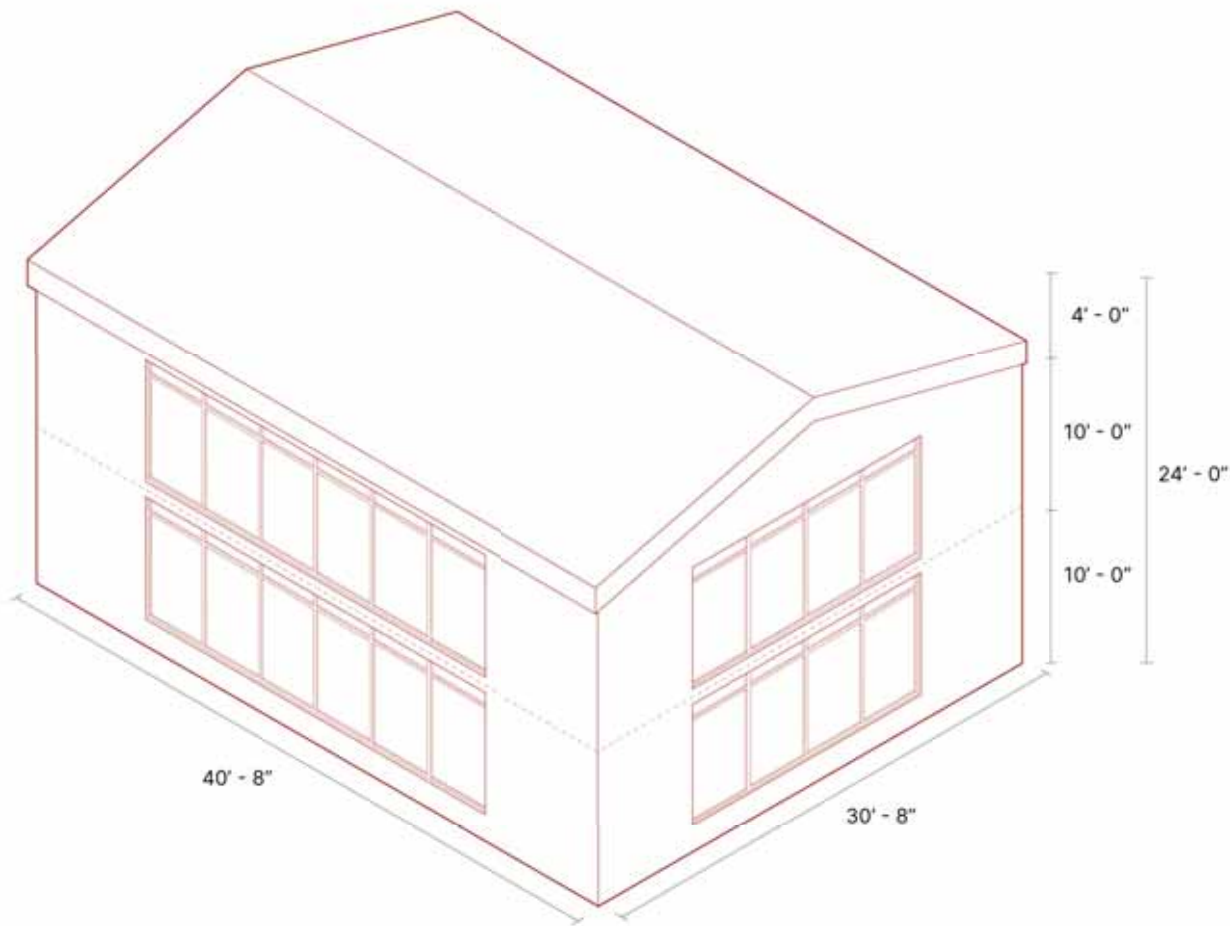


What Design Decisions/Measures Would You Prioritize?

What design decisions would be most helpful to assess operational/embodied carbon impacts for your projects? (Choose up to 7):



The Building



Based on the DOE
prototype building for single
family residential

Dataset Development

Operational & embodied data generated for millions of design options in 19 climates

Variables

19	Climate Zones	8	Window Frames
4	Foundation types	5	WWR per Orientation
4	Vertical Structures	5	Roofs
4	Horizontal Structures	4	Cavity insulations
5	Interior Wall Finishes	3	Infiltration Rates
10	Wall Cores	3	Fuel Choices
5	Exterior Wall Finishes	S	Rooftop Solar
4	Insulation Boards	S	Urban Trees
		S	Equipment COPS

Operational Carbon Calculations



+



Ladybug Tools



Annual Energy Use
Intensity (EUI) per End
Use (kBtu/sf)

X

Carbon Intensity of
Electricity or Natural
Gas Consumption
(kgCO₂eq/kBtu)

=

Operational Carbon
Emissions (kgCO₂eq/sf)

Total Operational Carbon Design Options

Variables	Preferred User Options
Wall Insulation	4
Glazing U-Factor	4
SHGC N, E, S, W	4
WWR N	5
WWR E	5
WWR S	5
WWR W	5
Roof Insulation	4
Infiltration	4
Foundation	3
Location	19
Ventilation Type	2
Total Combinations	72,960,000
Simulation Days*	456 !!!

*Simulation days on an institutional computer cluster

Total Operational Carbon Design Options

Variables	Preferred User Options	Interpolated Dataset
Wall Insulation	4	2
Glazing U-Factor	4	3
SHGC N, E, S, W	4	2
WWR N	5	2
WWR E	5	3
WWR S	5	3
WWR W	5	2
Roof Insulation	4	2
Infiltration	4	2
Foundation	3	3
Location	19	19
Ventilation Type	2	2
Total Combinations	72,960,000	196,992
Simulation Days*	456 !!!	1.2 ✓

*Simulation days on an institutional computer cluster

Multi-Linear Interpolation

Interpolation to estimate Heating & Cooling
EUI occurs across all (9 total) continuous
variables

- For each variable, interpolation is one-dimensional linear interpolation based on the nearest control points
- Calculates product of the linear weight for each variable at every surrounding “corner” combination of modeled points

Validation Analysis

- Used to evaluate linearity of heating & cooling EUIs across variable ranges and determine number & placement of “control points” for final dataset
- **Validation goal:** maintain absolute error below 5% or 1 EUI point between interpolated and simulated results for both heating & cooling EUI in validation datasets
- Two validation datasets: **Glazing & Envelope**

Glazing Validation

Glazing U-Factor (2 Control Points):

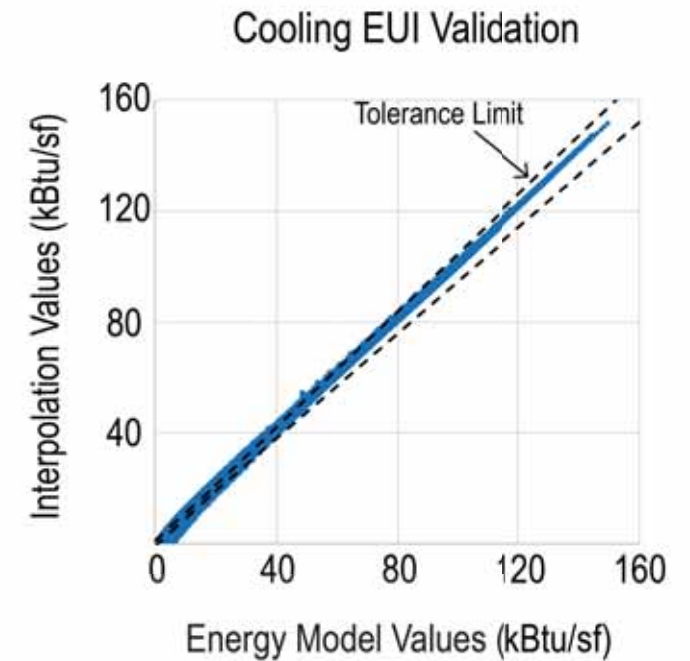
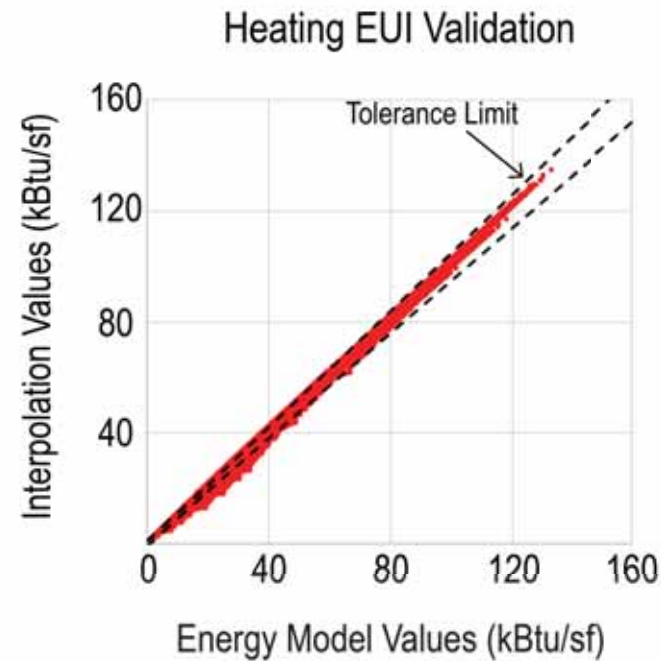
- 1) 0.5 BTU/(hr·ft²·°F)
- 2) 0.1 BTU/(hr·ft²·°F)

SHGC (2 Control Points):

- 1) 0.25
- 2) 0.6

WWR (2 Control Points):

- 1) 0%
- 2) 80%



76% Points Passing

Glazing Validation

Glazing U-Factor (3 Control Points):

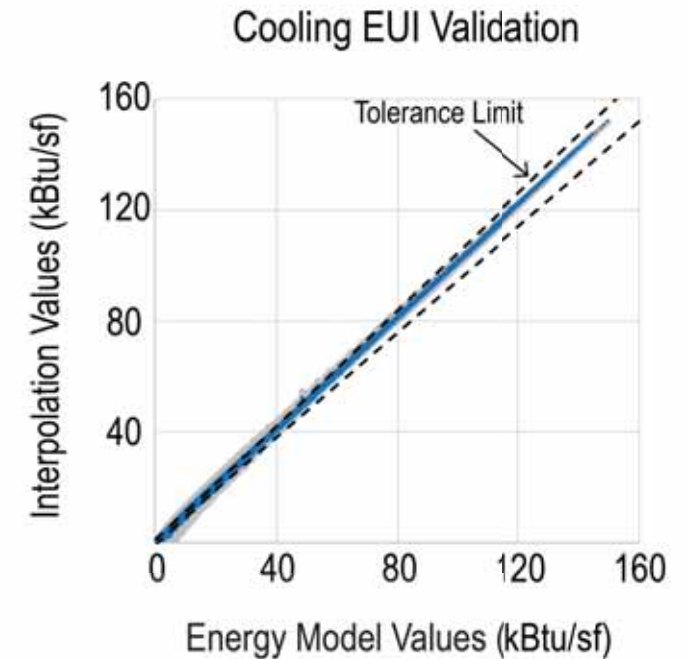
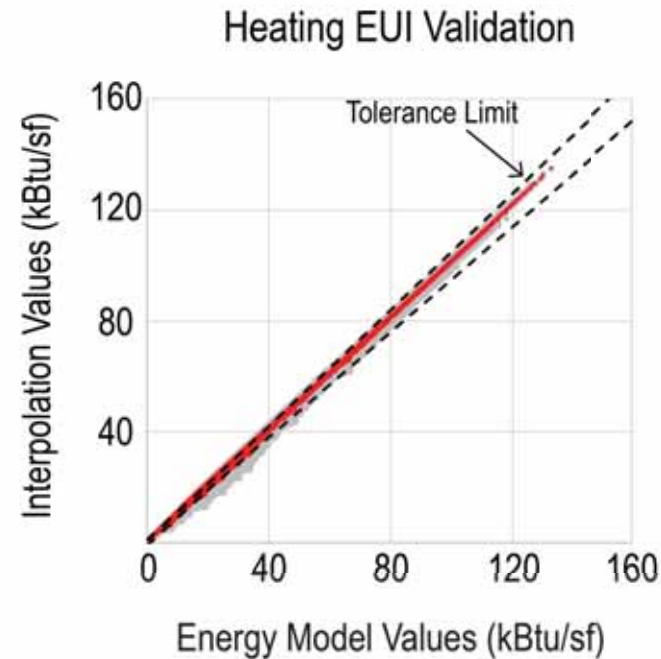
- 1) 0.5 BTU/(hr·ft²·°F)
- 2) 0.4 BTU/(hr·ft²·°F)
- 3) 0.1 BTU/(hr·ft²·°F)

SHGC (3 Control Points):

- 1) 0.25
- 2) 0.4
- 3) 0.6

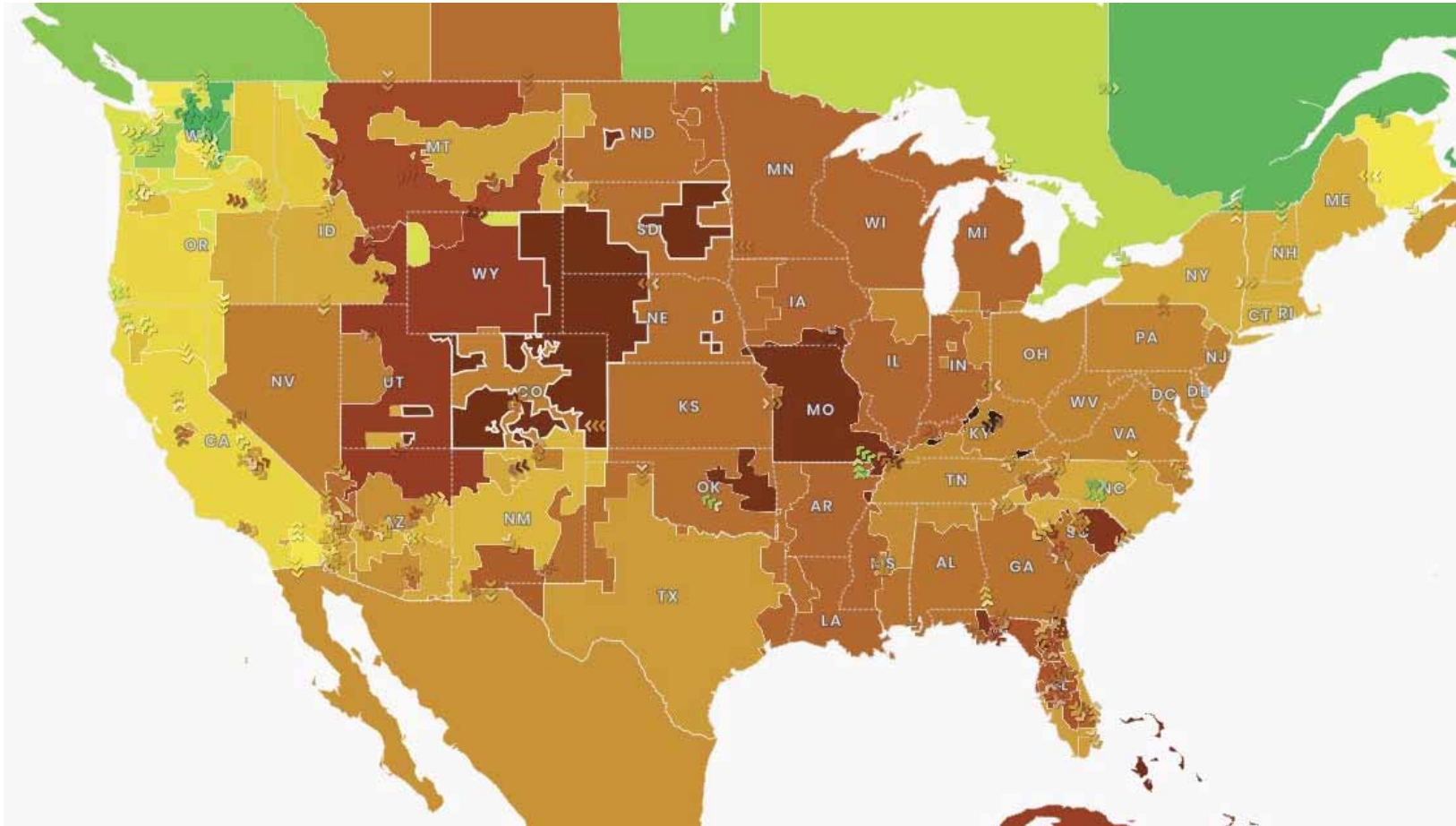
WWR (3 Control Points – WWR S):

- 1) 0%
- 2) 40% (WWR S)
- 3) 80%



95% Points Passing

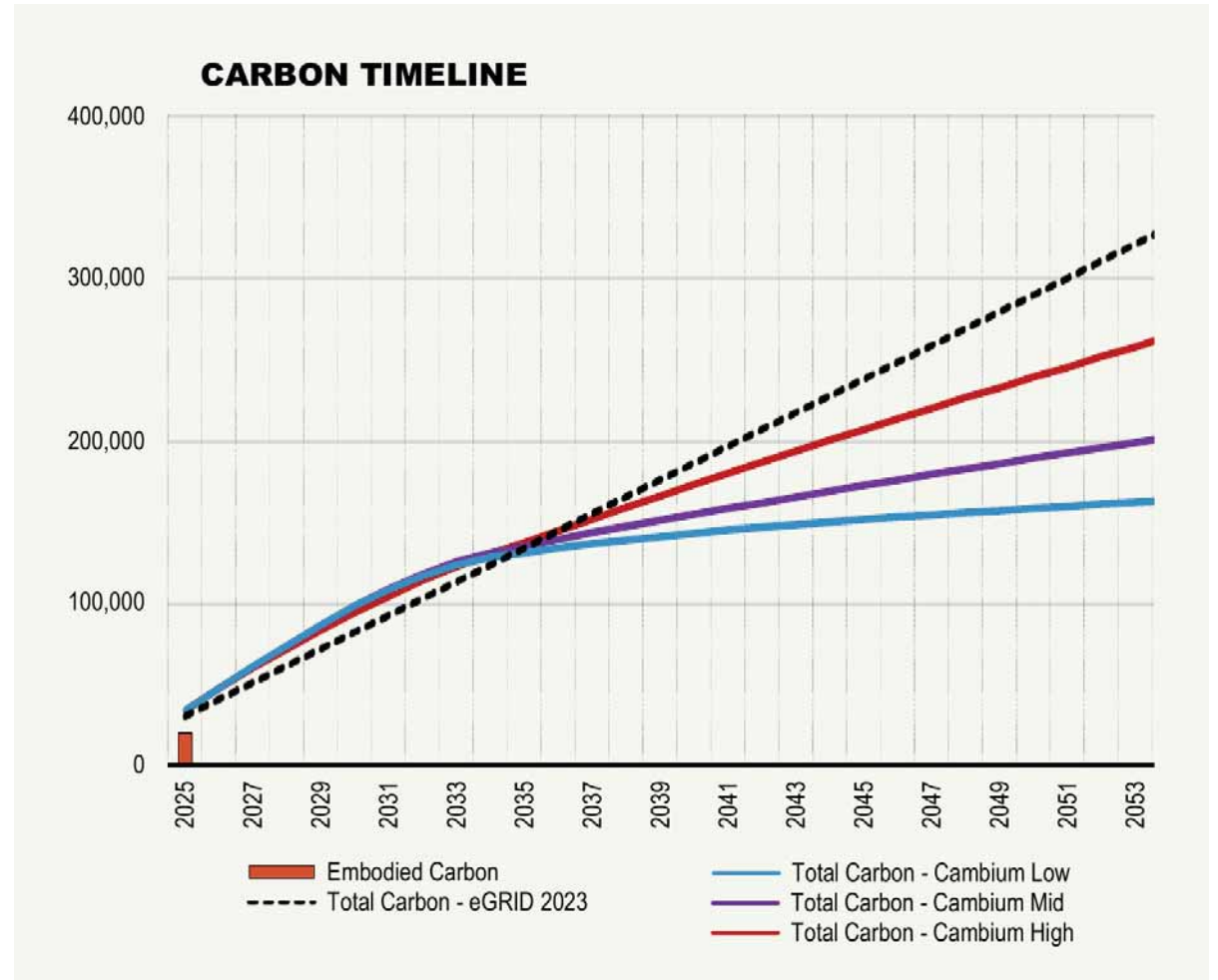
Operational Carbon



<https://app.electricitymaps.com/map/all/yearly> (2025)

Operational Carbon

- Interpolated energy consumption
- Electric grid emissions use NREL Cambium 2024 and/or eGrid 2023 data
- Cambium projects how local grid emissions will evolve through 2050 under different scenarios (includes upstream emissions)
- Scenarios considered:
 - Mid-case (“mid”)
 - Lower renewables / higher natural gas costs (“low”)
 - Higher renewables / lower natural gas costs (“high”)



Lifecycle Stages

PRODUCT			CONSTRUCTION		BUILDING USE							END OF LIFE				BENEFITS BEYOND NORMAL BOUNDARY
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw Materials	Transport	Manufacture	Transport	Construction	Use	Maintenance	Repair	Replacement	Refurbishment	Operational Energy	Operational Water	Deconstruction & Demolition	Transport	Waste Processing	Disposal	Re-use Recovery and Recycling

The Interface

PROJECT INFO

STRUCTURE

FINISHES

FACADES

PV & TREES

County: King County

State: WA

Climate zone: 4C

Conditioned Area: 3000

Ignore eGRID? ☒

Include Biogenic Carbon? ☒

Foundation Type: Slab on Grade

Vertical Structure: Bearing Walls

Horizontal Structure: Plywood over joist

Wall Interior Finish: 5/8 Gypsum board

Ceilings: Gypsum Ceiling

Acoustic batts (Ceiling & wall)? ☒

Floors: Carpet

Wall - Core: 2x6 Wood Studs

Wall - Exterior: Cement Board

Wall Continuous Insulation Board: Mineral Wool

Window U Value: 0.350 R13.9

Fenestration: Aluminum Frame Double Pane

Assembly U value: 0.3 BTU/(hr·ft²)

Assembly SHGC: 0.25

SOUTH Window/Wall Ratio: 30%

NORTH Window/Wall Ratio: 30%

EAST Window/Wall Ratio: 30%

WEST Window/Wall Ratio: 30%

PV System: 0 kW (0kW)

Tree Offset: 0 Trees Planted

Factor in Survival rates of trees? ☒

Tree Growth Rate: Fast

Roofing: Asphalt Shingles

Roof Continuous Insulation Board: XPS

Roof Cavity Insulation: Unfaced Fiberglass Batts

Underfloor Insulation: Unfaced Fiberglass Batts

Infiltration Rate: 0.22 cfm/ft²

Ventilation: Exhaust Fan

Cooling COP: 3.49

Heating COP: 0.83

Heating Fuel Source: Natural Gas

Water Heater Fuel Source: Natural Gas

Roof & Floor Insulation

HVAC & HOT WATER

NRMCA Region: Pacific Northwest

State: Washington

CARBON TIMELINE

Total Lifetime kgCO2e: 1,010,607

Carbon Reduction: 0%

Carbon Sequestered by Trees: 0

CUMULATIVE CARBON (kgCO2e)

CRADLE - GATE

CRADLE - CRADLE

EMBODIED CARBON (kgCO2e/m²)

CRADLE - GATE

CRADLE - CRADLE

ENERGY USE (kBtu/ft²-yr)

CRADLE - GATE

CRADLE - CRADLE

DARA

Decarbonization Analysis for Residential Architecture

Ground Source Heat Pump

Air Source Heat Pump

Elec. Furnace + AC

Gas Furnace + AC

Heat Pump Water Heater

Electric Tank Water Heater

Gas Tank Water Heater

Reset Embodied

Code Minimum

W

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UNIVERSITY of WASHINGTON

Olson Kundig

INTEGRATED DESIGN LAB
 UNIVERSITY of WASHINGTON
 Department of Architecture

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Location & Area

PROJECT INFORMATION

First Year of Occupancy	2026
Building Lifecycle	60
Zip Code	30306
County	Fulton County
State	GA
Climate zone	3A
Conditioned Area	3000
Ignore eGRID?	☒
Include Biogenic Carbon?	☒

STRUCTURE

Foundation Type	Slab on Grade
Vertical Structure	Bearing Walls
Horizontal Structure	Plywood over joist
Wall Interior Finish	5/8 Gypsum board
Ceilings	Gypsum Ceiling
Acoustic batts (Ceiling & wall)?	☒
Floors	Carpet
Wall - Core	2x6 Wood Studs
Wall - Exterior	Cement Board
Wall Continuous Insulation Board	Mineral Wool
Wall U Value = 0.060	R13.8
Fenestration	Aluminum Frame Double Pane
Assembly U-value = 0.3 BTU/(hr·ft²·°F)	
Assembly SHGC = 0.25	
SOUTH Window Wall Ratio = 30%	
NORTH Window Wall Ratio = 30%	
EAST Window Wall Ratio = 30%	
WEST Window Wall Ratio = 30%	
PV System = 0 kW (0ft2)	
Tree Offset: 0 Trees Planted	
Factor in Survival rates of trees?	☒
Tree Growth Rate	Fast

FINISHES

ROOF & FLOOR INSULATION

HVAC & HOT WATER

PV & TREES

PROJECT INFORMATION

First Year of Occupancy	2025
Building Lifecycle	60
Zip Code	98104
County	King County
State	WA
Climate zone	4C
Conditioned Area	2500
Ignore eGRID?	☒

AREA

Energy and carbon are prorated for area.

LOCATION

Zip code triggers:

- Climate Zone (19 possible Climate Zones)
- Grid Carbon Projections (4 Scenarios)
- Regional Concrete Mix (NRMCA Regions)
- Minimum Code Values (2023 IECC)

Structure

PROJECT INFORMATION

First Year of Occupancy

2026

Building Lifecycle

60

Zip Code

30306

County

Fulton County

State

GA

Climate zone

3A

Conditioned Area

3000

STRUCTURE

Ignore eGRID?

☒

Include Biogenic Carbon?

☒

Foundation Type ▼

Slab on Grade

Vertical Structure ▼

Bearing Walls

Horizontal Structure ▼

Plywood over joist

FINISHES

Wall Interior Finish ▼

5/8 Gypsum board

Ceilings ▼

Gypsum Ceiling

Acoustic batts (Ceiling & wall)?

☒

Floors ▼

Carpet

Wall - Core ▼

2x6 Wood Studs

Wall - Exterior ▼

Cement Board

Wall Continuous Insulation Board ▼

Mineral Wool

Wall U Value = 0.060

R13.8

Fenestration ▼

Aluminum Frame Double Pane

Assembly U-value = 0.3 BTU/(hr·ft²·°F)

Assembly SHGC = 0.25

SOUTH Window Wall Ratio = 30%

NORTH Window Wall Ratio = 30%

EAST Window Wall Ratio = 30%

WEST Window Wall Ratio = 30%

PV System = 0 kW (0ft2)

Tree Offset: 0 Trees Planted

Factor in Survival rates of trees?

☒

Tree Growth Rate ▼

East

ROOF

Undermoor Insulation ▼

Unfaced Fiberglass batts

Infiltration Rate = 0.13 cfm/ft2

R30

Ventilation ▼

Tight envelope (better)

Energy Recovery Ventilator

Cooling COP = 5.4

Heating COP = 2.5

Heating Fuel Source ▼

Electricity

Water Heater COP = 3.5

Water Heater Fuel Source ▼

Electricity

HVAC & HOT WATER

Climate zone

4C

Conditioned Area

2500

Ignore eGRID?

☒

Include biogenic Carbon?

☒

Foundation Type ▼

Slab on Grade

Vertical Structure ▼

Bearing Walls

Horizontal Structure ▼

Plywood over joist

FINISHES

Wall Interior Finish ▼

5/8 Gypsum board

Ceilings ▼

Gypsum Ceiling

Acoustic Ceiling batts?

☒

Floors ▼

Carpet

Wall - Core ▼

2x6 Wood Studs

Bar graph shows Cradle-Cradle breakdown

Embodied Carbon

Operational Carbon

Year 1 Embodied Carbon

23,164

Year 1 Operational Carbon

11,044

Year 0-60 Embodied Carbon

57,383

Year 0-60 Operational Carbon

Envelope

83.08

Structure

205.81

Reduction: 46%

Reduction: 13%

STRUCTURE

Options for foundation, vertical structure and horizontal structure.

These choices affect embodied carbon, but not energy use.

RECS 2001 Base: 49.0

Gross EUI

29.43

Net EUI

29.43

Reduction: 55%

Reduction: 40%

Lighting

12%

Cooling

24%

Fans

12%

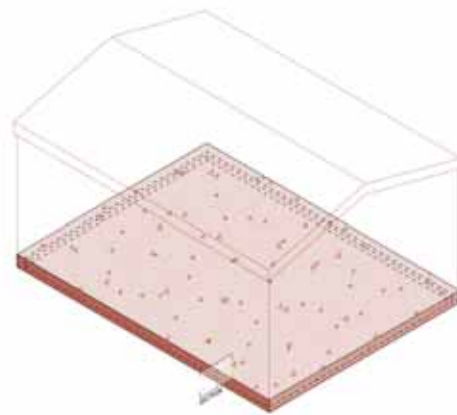
Equipment

37%

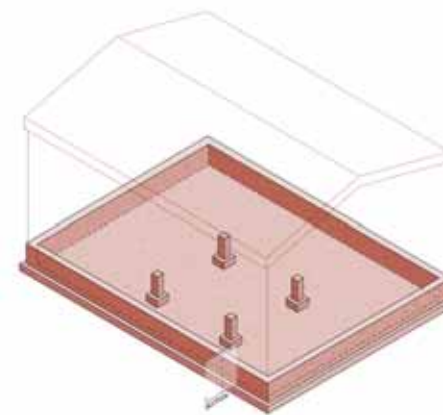
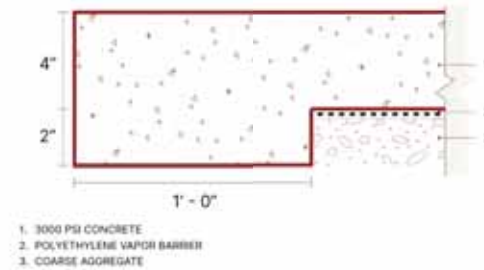
Water Heater

5%

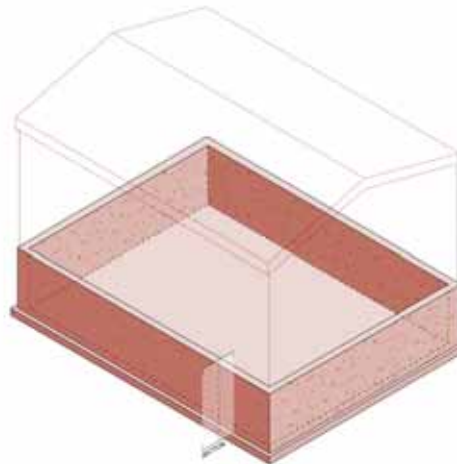
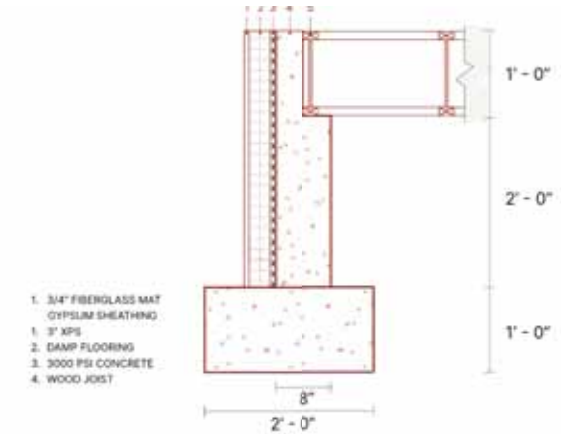
Foundations: 4 Options (Affect Operational & Embodied Carbon)



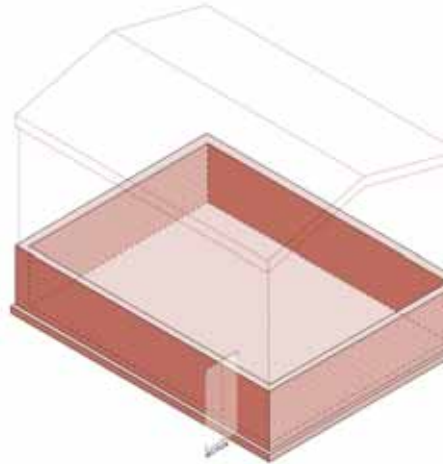
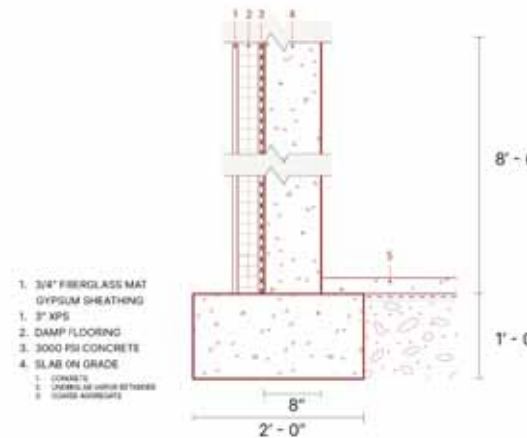
Slab on Metal Deck



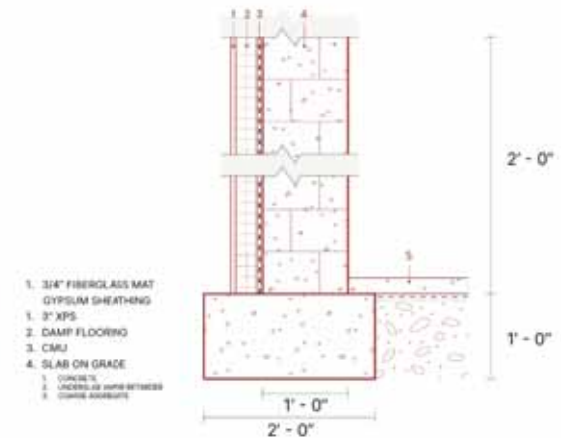
Concrete Stem Walls



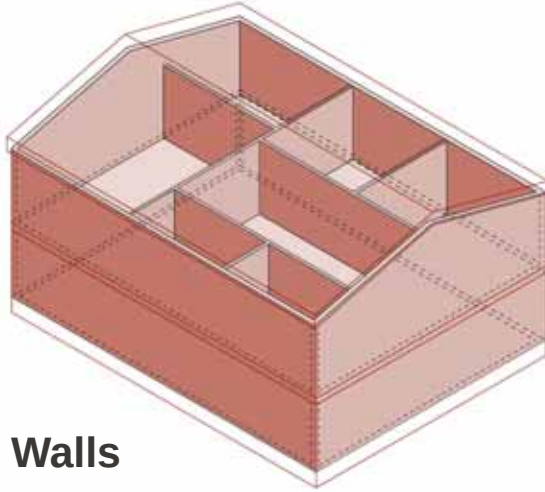
Concrete Basement



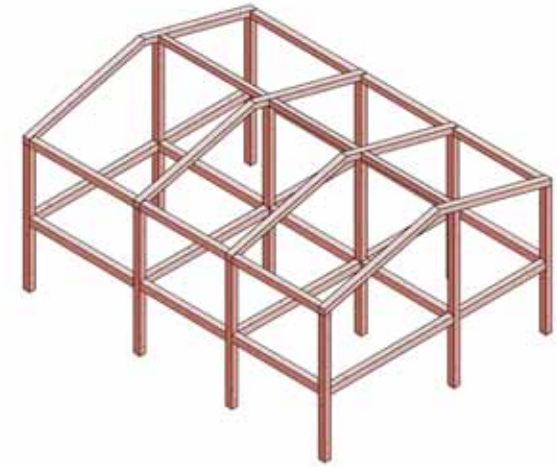
CMU Basement



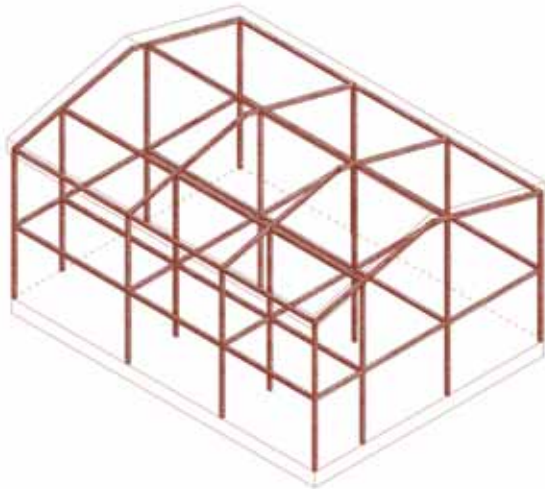
Vertical Structure: 4 Options (Affect only Embodied Carbon)



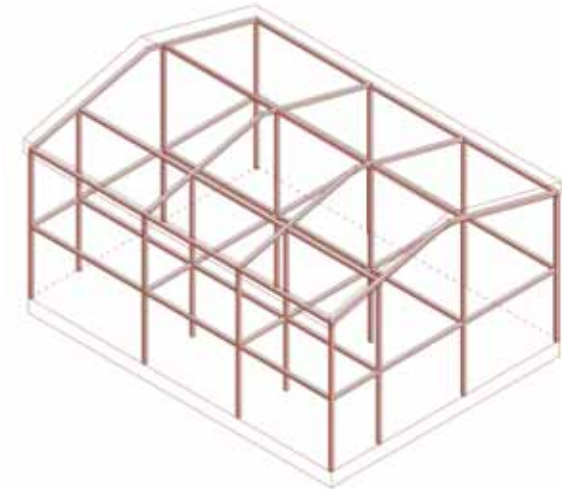
Load Bearing Walls



Concrete Columns

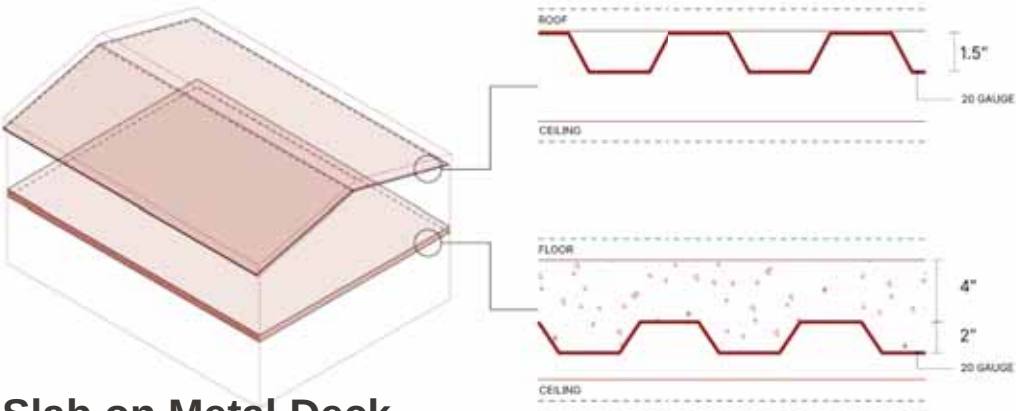


Wood Posts

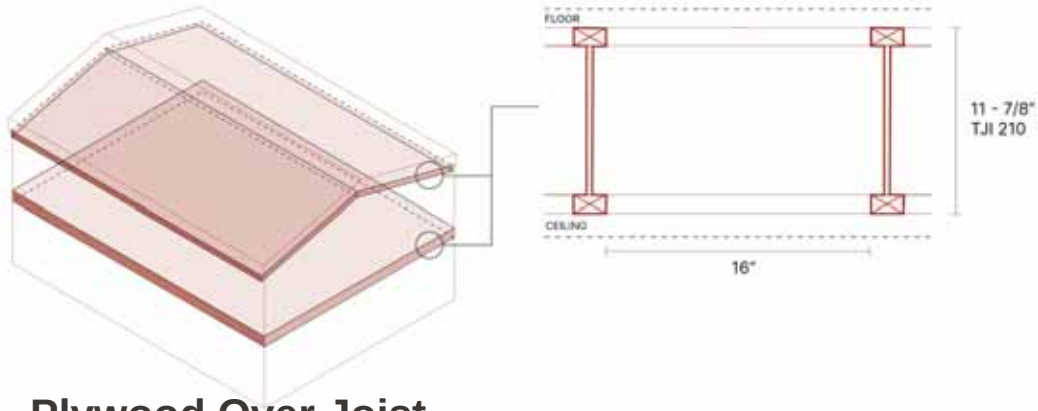


Steel Columns

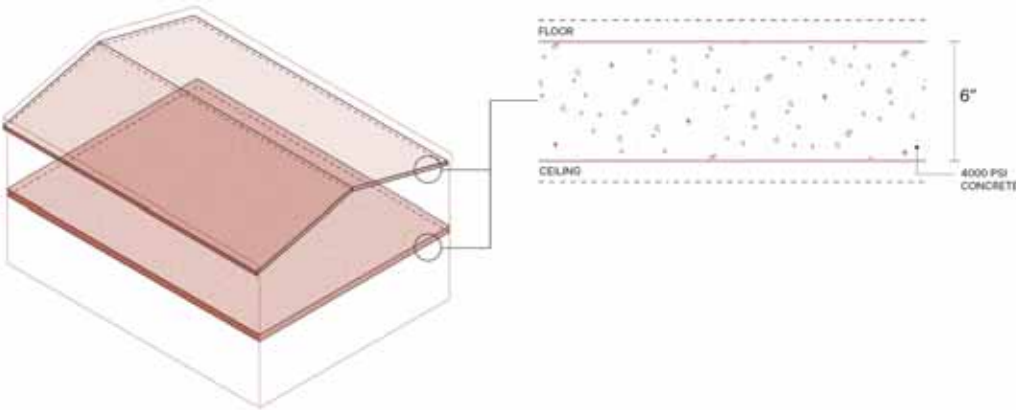
Horizontal Structure: 4 Options (Affect only Embodied Carbon)



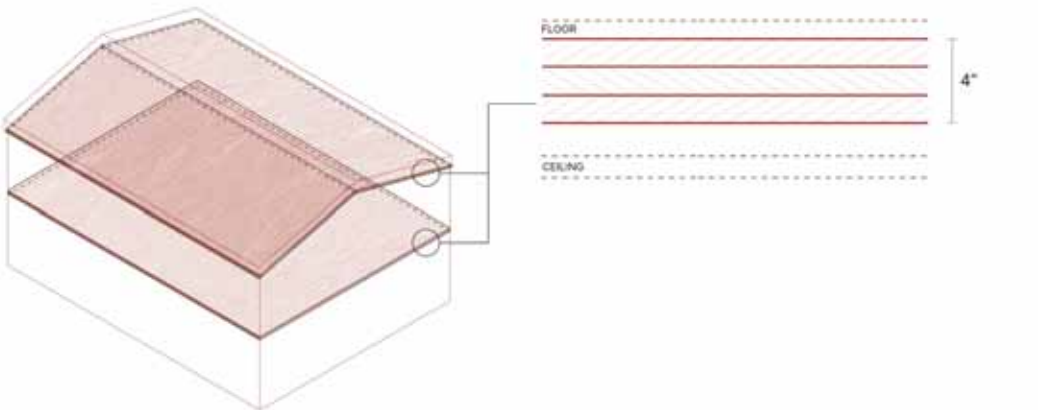
Slab on Metal Deck



Plywood Over Joist



Concrete Flat Slab



Mass Timber (CLT)

Facades and Finishes

FINISHES

- Options for floors, ceilings and walls.
- These choices affect embodied carbon, but not energy use.

FINISHES	
Wall Interior Finish ▼	5/8 Gypsum board
Ceilings ▼	Gypsum Ceiling
Acoustic Ceiling batts? ☒	
Floors ▼	Carpet
Wall - Core ▼	2x6 Wood Studs
Wall - Exterior ▼	Cement Board
Wall Continuous Insulation Board ▼	Mineral Wool
R19.3 < >	
Fenestration ▼	Aluminum Frame Double Pane
Assembly U-value = 0.28 BTU/(hr·ft²·°F) < >	
Assembly SHGC = 0.6 < >	
SOUTH Window Wall Ratio = 30% < >	
NORTH Window Wall Ratio = 30% < >	
EAST Window Wall Ratio = 30% < >	
WEST Window Wall Ratio = 30% < >	

ROOFS

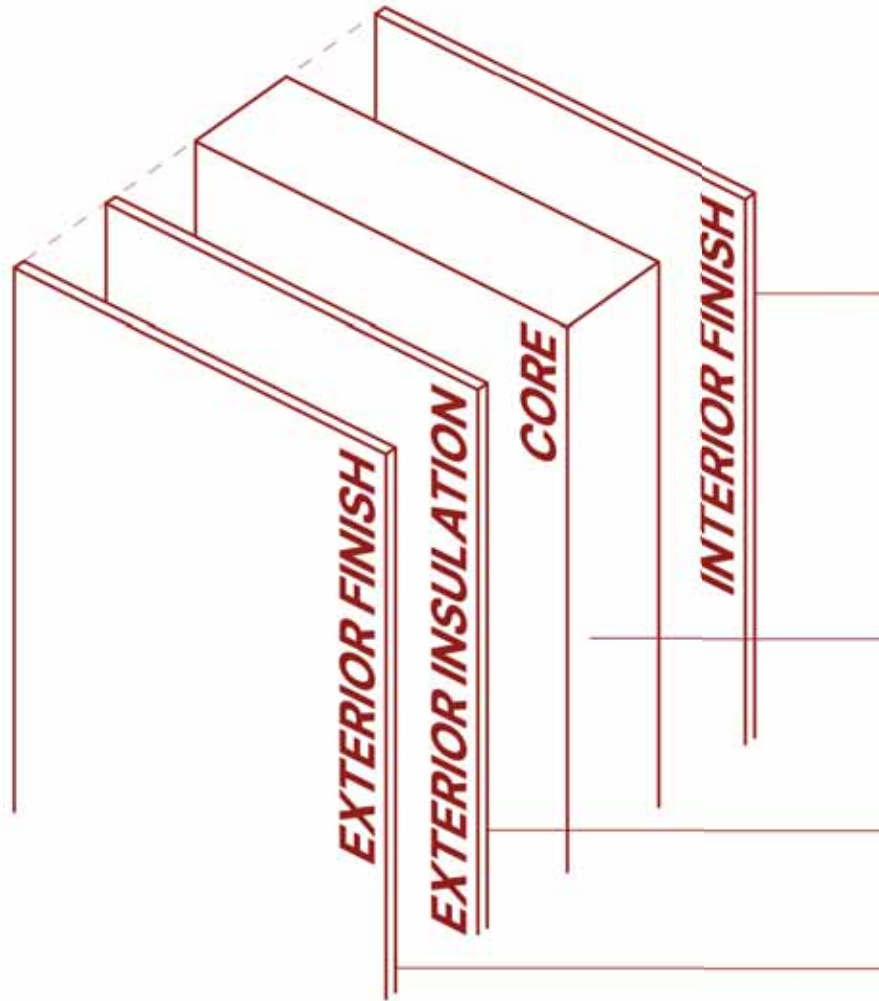
- Options for roof makeup and insulation.
- These choices affect embodied carbon AND energy use.

ROOFS	
Roofing ▼	Asphalt Shingles
Roof Continuous Insulation Board ▼	None
R0 < >	
Roof Cavity Insulation ▼	Unfaced Fiberglass Batts
R38.5 < >	
Underfloor Insulation ▼	Unfaced Fiberglass Batts
R30 < >	

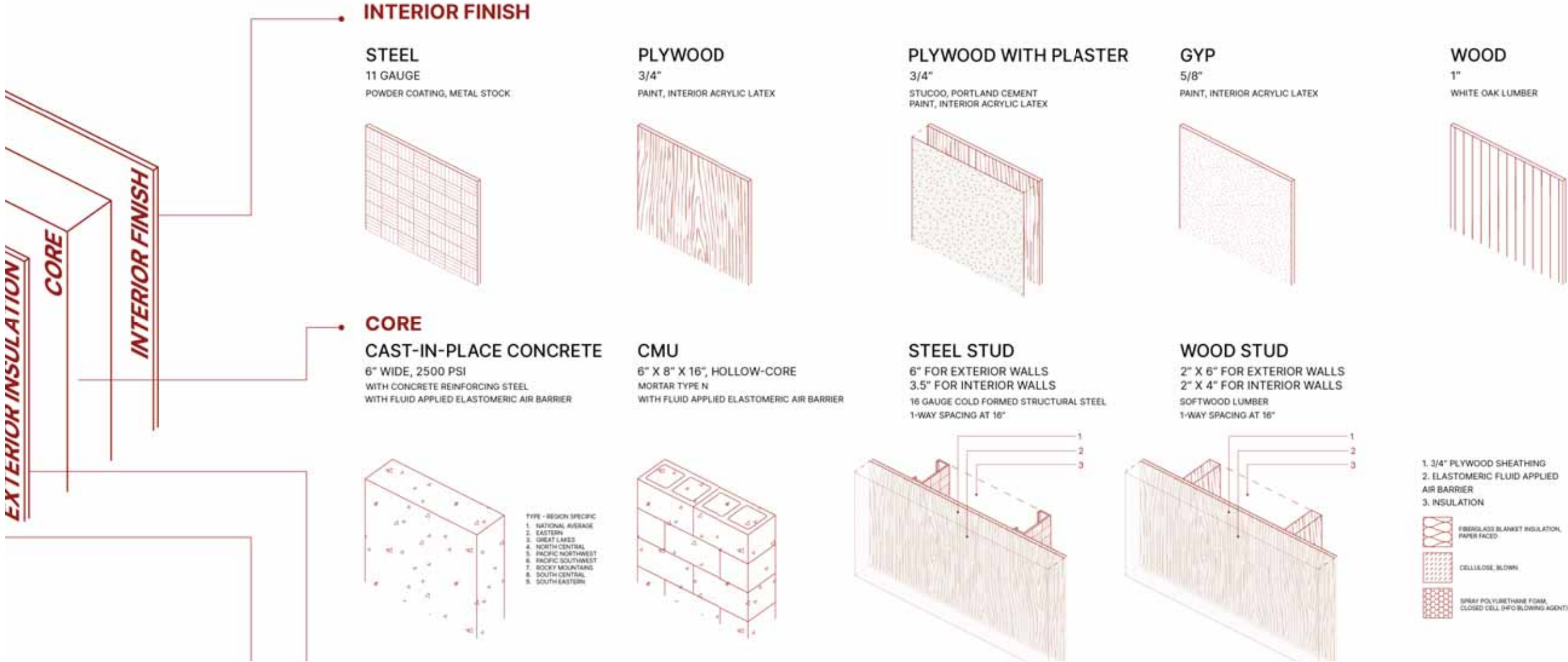
FACADES

- Options for walls and fenestration.
- These choices affect embodied carbon AND energy use.

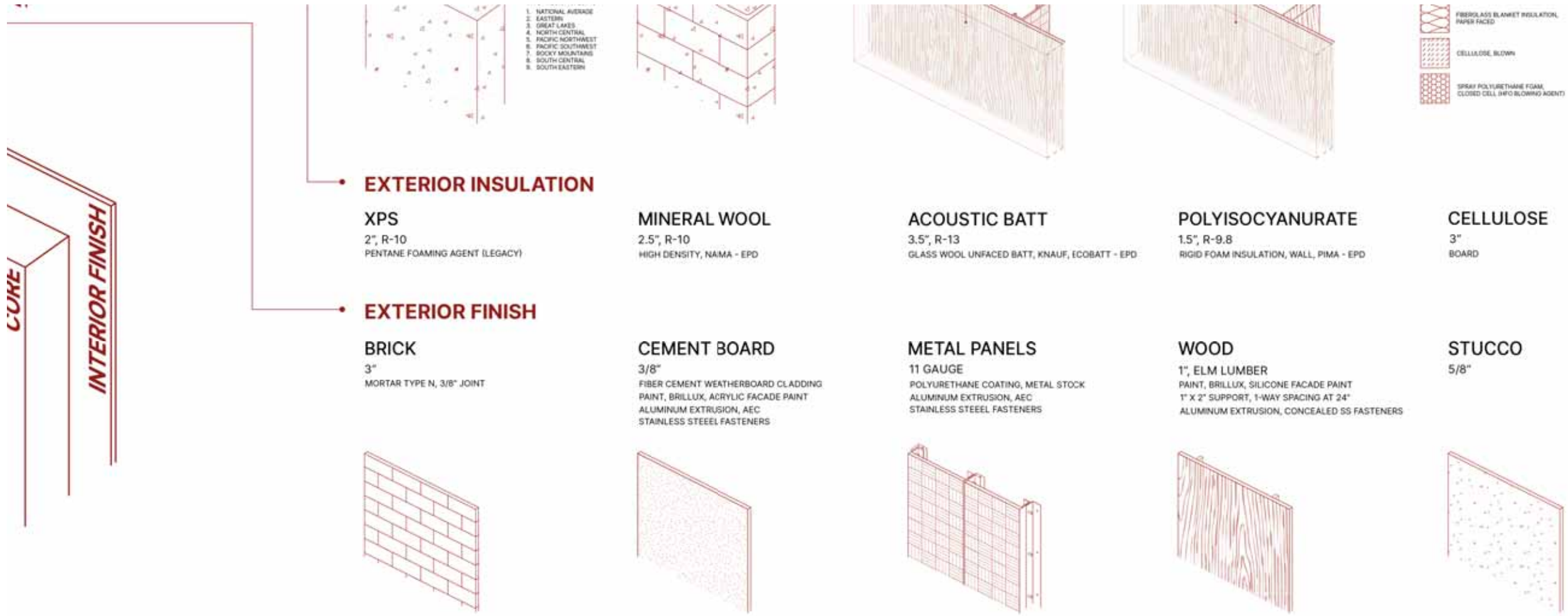
Wall Assemblies: 1,250 possible combinations (Affect Both)



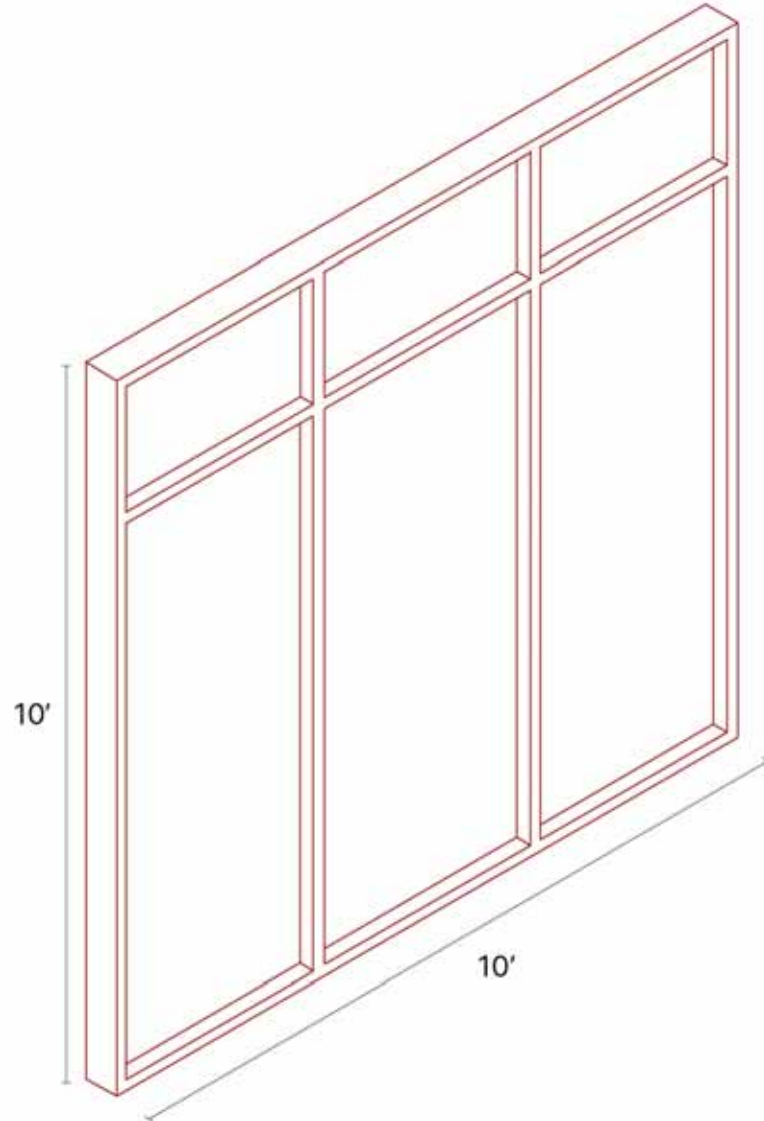
Wall Assemblies: 1,250 possible combinations (Affect Both)



Wall Assemblies: 1,250 possible combinations (Affect Both)



Fenestration: 8 options (Affect Both)

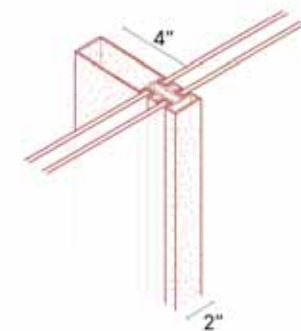


Fenestration: 8 options (Affect Both)

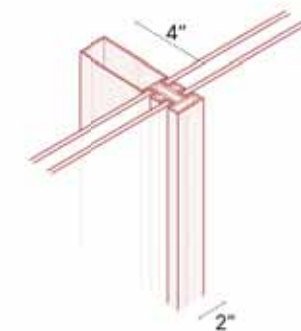
DOUBLE-PANE

ALUMINUM DOUBLE-PANE

ALUMINUM EXTRUSION, THERMALLY-IMPROVED MILL-FINISHED
POWDER COATING, METAL STOCK

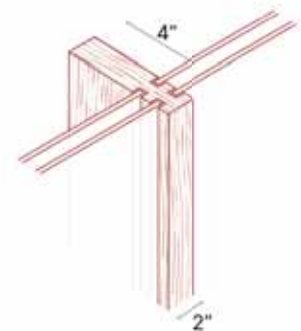


FIBERGLASS DOUBLE-PANE



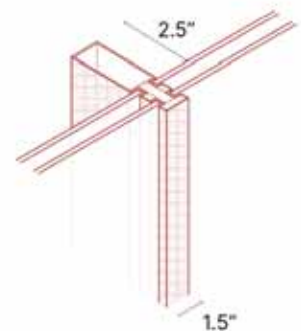
WOOD DOUBLE-PANE

WHITE OAK LUMBER



STEEL DOUBLE-PANE

STAINLESS STEEL, EXTRUDED, CHROMIUM 18/8



GLAZING LAYERS

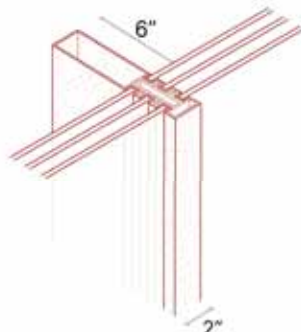
- GLAZING, MONOLITHIC SHEET, TEMPERED
- LOW-E COATING (FOR GLAZING)
- IGU SPACER
- ARGON GAS FOR IGU
- GLAZING, MONOLITHIC SHEET, TEMPERED



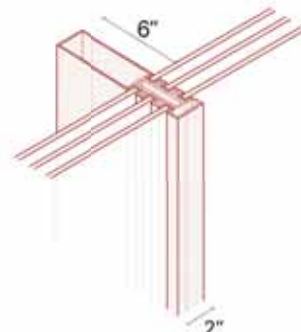
TRIPLE-PANE

ALUMINUM TRIPLE-PANE

ALUMINUM EXTRUSION, THERMALLY-IMPROVED MILL-FINISHED
POWDER COATING, METAL STOCK

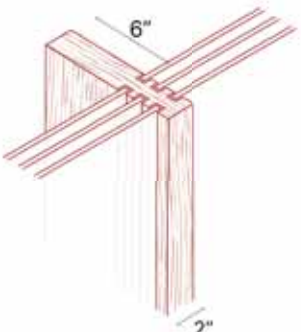


FIBERGLASS TRIPLE-PANE



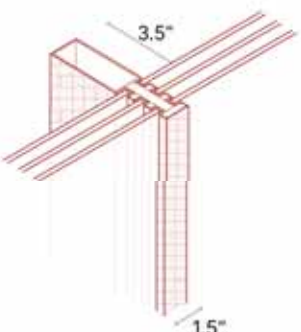
WOOD TRIPLE-PANE

WHITE OAK LUMBER



STEEL TRIPLE-PANE

STAINLESS STEEL, EXTRUDED, CHROMIUM 18/8



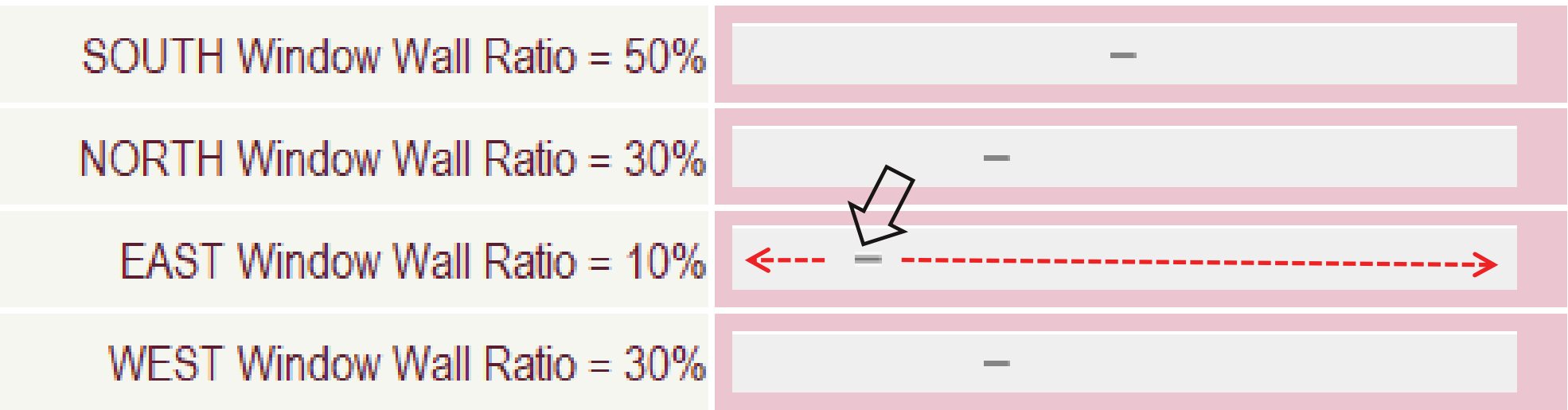
GLAZING LAYERS

- GLAZING, MONOLITHIC SHEET, TEMPERED
- LOW-E COATING (FOR GLAZING)
- IGU SPACER
- ARGON GAS FOR IGU
- GLAZING, MONOLITHIC SHEET, TEMPERED
- IGU SPACER
- ARGON GAS FOR IGU
- GLAZING, MONOLITHIC SHEET, TEMPERED

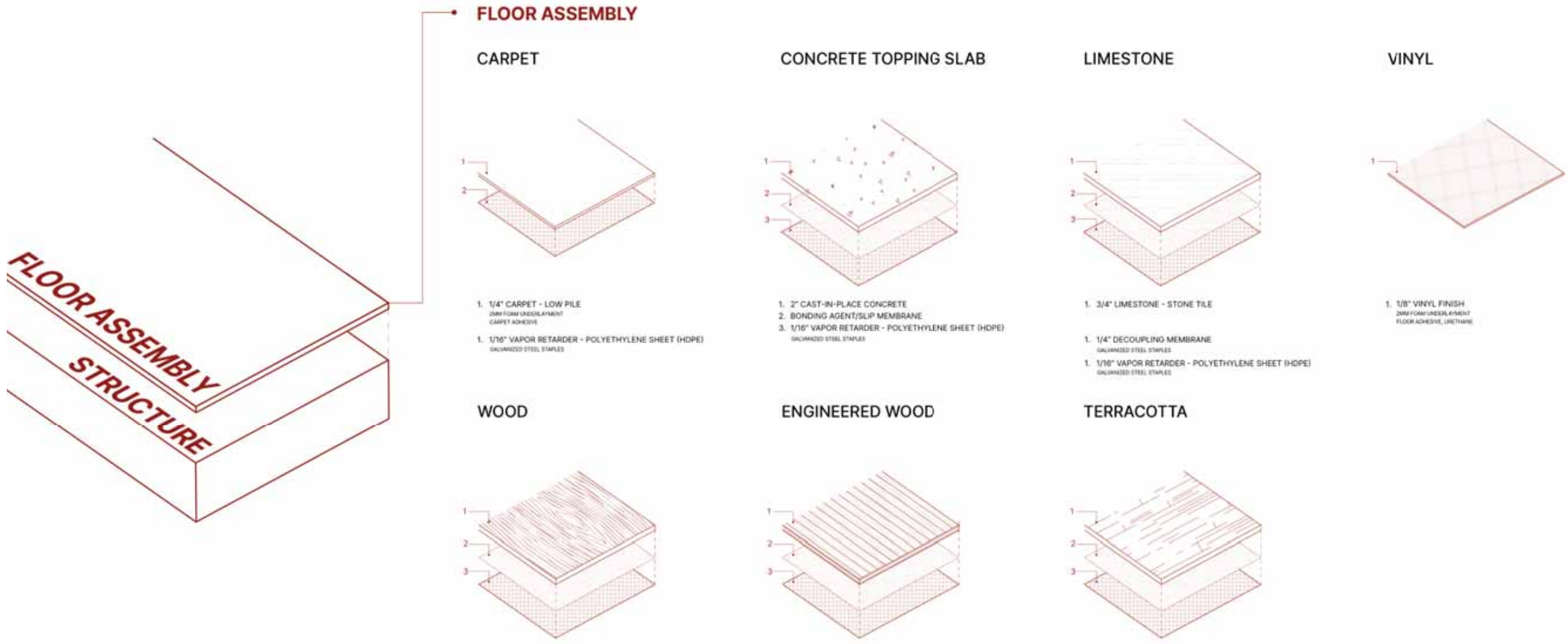


DARA Interface: Fenestration

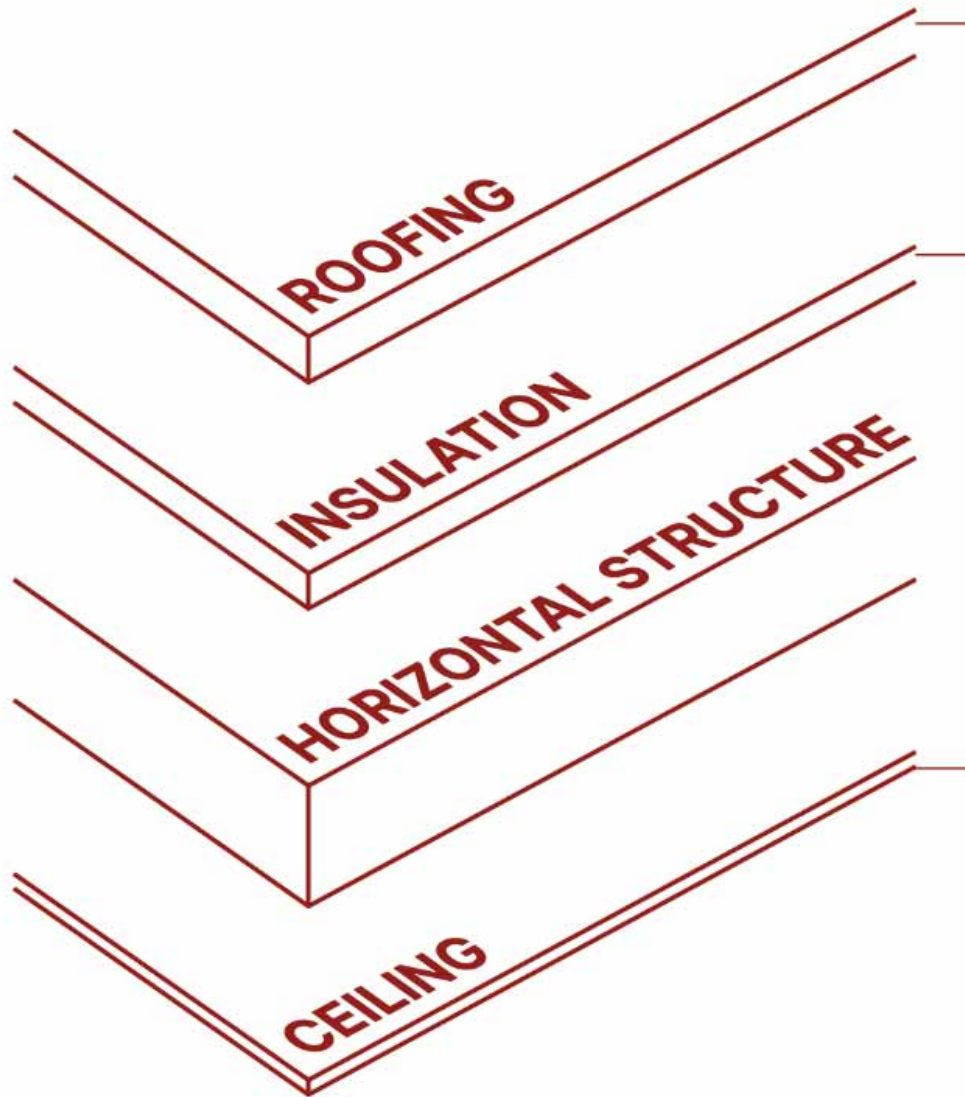
Window-to-Wall Ratio Slider Bar:



Floors: 7 Options (Affect only Embodied Carbon)



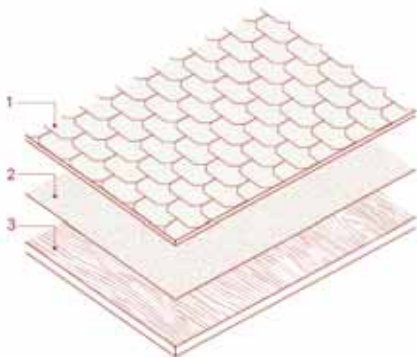
Roofs: 80 Possible Combinations (Affect Both)



Roofs: 80 Possible Combinations (Affect Both)

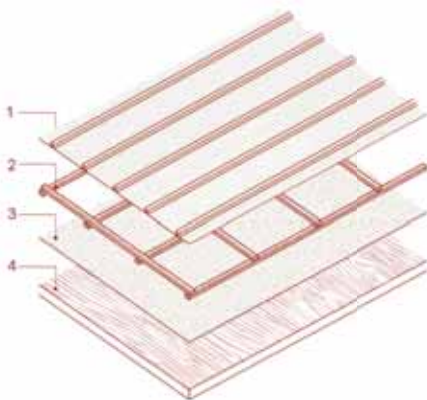
• ROOFING

ASPHALT SHINGLES



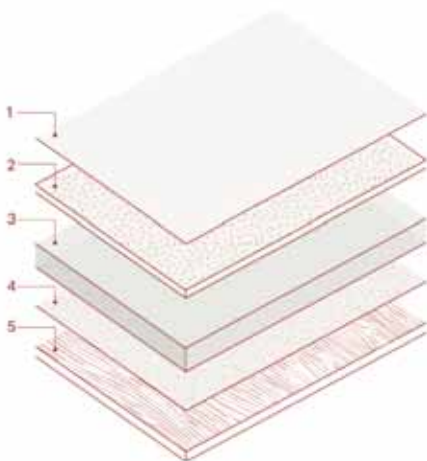
1. 1/4" ASPHALT ROOFING SHINGLES
STAINLESS STEEL FASTENERS
1. ASPHALT FELT SHEET (TAR PAPER)
GALVANIZED STEEL FASTENERS
1. 3/4" PLYWOOD SHEATHING

STANDING SEAM



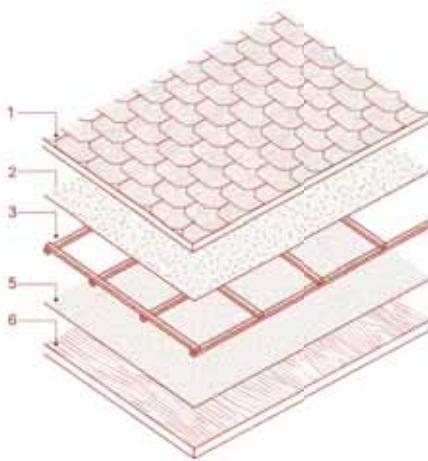
1. 1 3/4" METAL PANELS
FLUOROPOLYMER COATING, METAL STOCK
GALVANIZED STEEL SUPPORT
1. 1" X 2" TWO-WAY 16" SPACING WOOD PURLINS
2. SELF ADHERING MEMBRANE
3. 3/4" PLYWOOD SHEATHING

TPO THERMOPLASTIC POLYOLEFIN



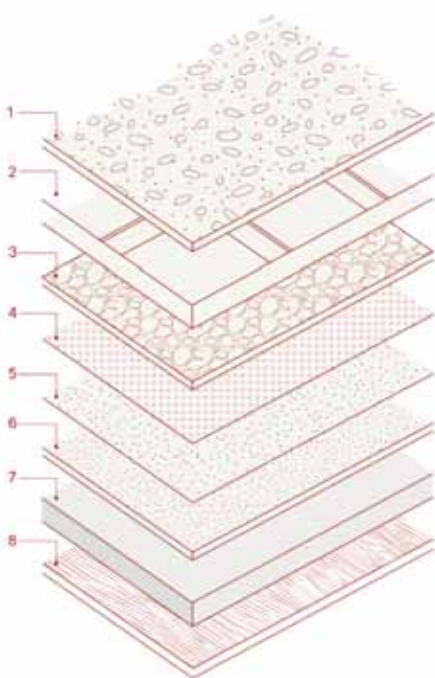
1. TPO ROOFING MEMBRANE
ADHESIVE, ACRYLIC
1. 1/2" GYPSUM (MOISTURE- AND MOLD-RESISTANT)
2. 2" POLYISOCYANURATE (PIR) BOARD
RIGID FOAM INSULATION, R=8.8
1. SELF ADHERING MEMBRANE
2. 3/4" PLYWOOD SHEATHING

WOOD SHINGLES

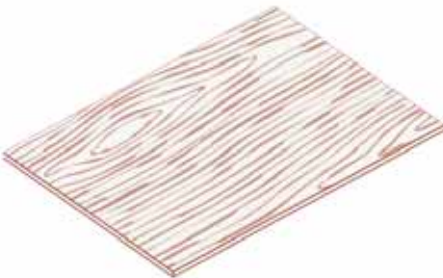


1. CEDAR WOOD SHINGLES
STAINLESS STEEL FASTENERS
1. ASPHALT FELT SHEET
GALVANIZED STEEL FASTENERS
1. 1" X 2" AT 16" SPACING WOOD PURLINS
2. SELF ADHERING MEMBRANE
3. 3/4" PLYWOOD SHEATHING

GREEN ROOF



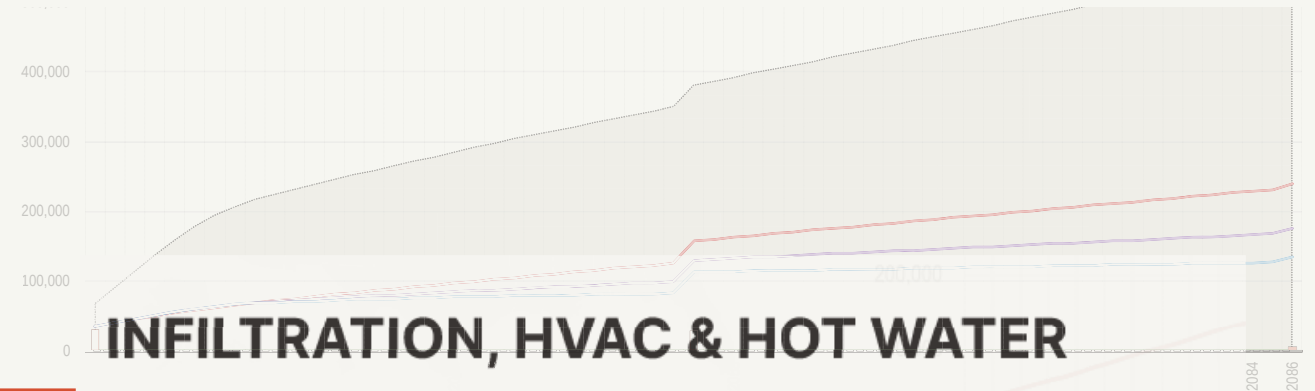
Roofs: 80 Possible Combinations (Affect Both)

INSULATION			
CLOSED CELL SPRAY FOAM R-10 SPRAY POLYURETHANE FOAM, CLOSED CELL ROOFING (HFO BLOWING AGENT)	MINERAL WOOL R-10 HIGH DENSITY, NAIMA - EPD	BLOWN CELLULOSE R-10	UNFACED FIBERGLASS BATTS R-11 GLASS WOOL UNFACED BATT, KNAUF, ECOBATT - EPD
CEILING			
PLYWOOD 3/4" PAINT, INTERIOR ACRYLIC LATEX	GYPSUM (GWB) 5/8" PAINT, INTERIOR ACRYLIC LATEX	STEEL PLATE 11 GAUGE POWDER COATING, METAL STOCK	WOOD PANEL 1" WHITE OAK LUMBER
			

HVAC, Hot Water, Infiltration, Solar and Trees

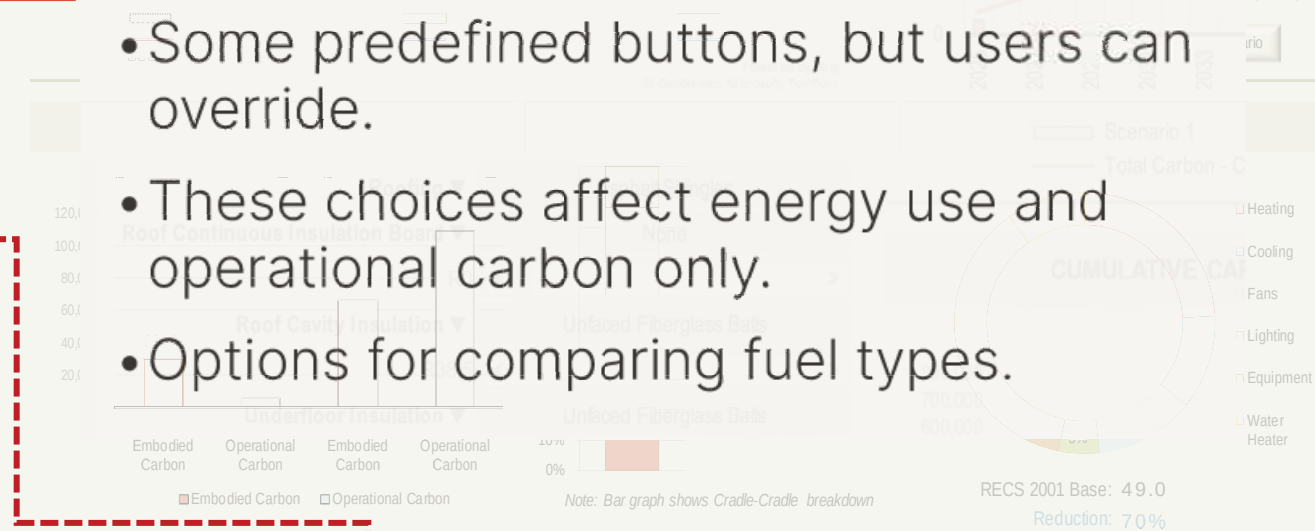
PV & TREES

- Options for offsetting and getting to carbon neutral.
- PV affects energy use AND embodied carbon

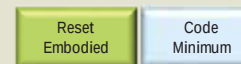
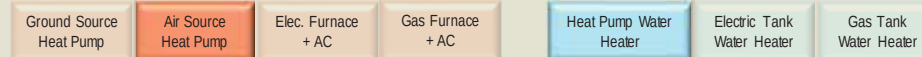


INFILTRATION, HVAC & HOT WATER

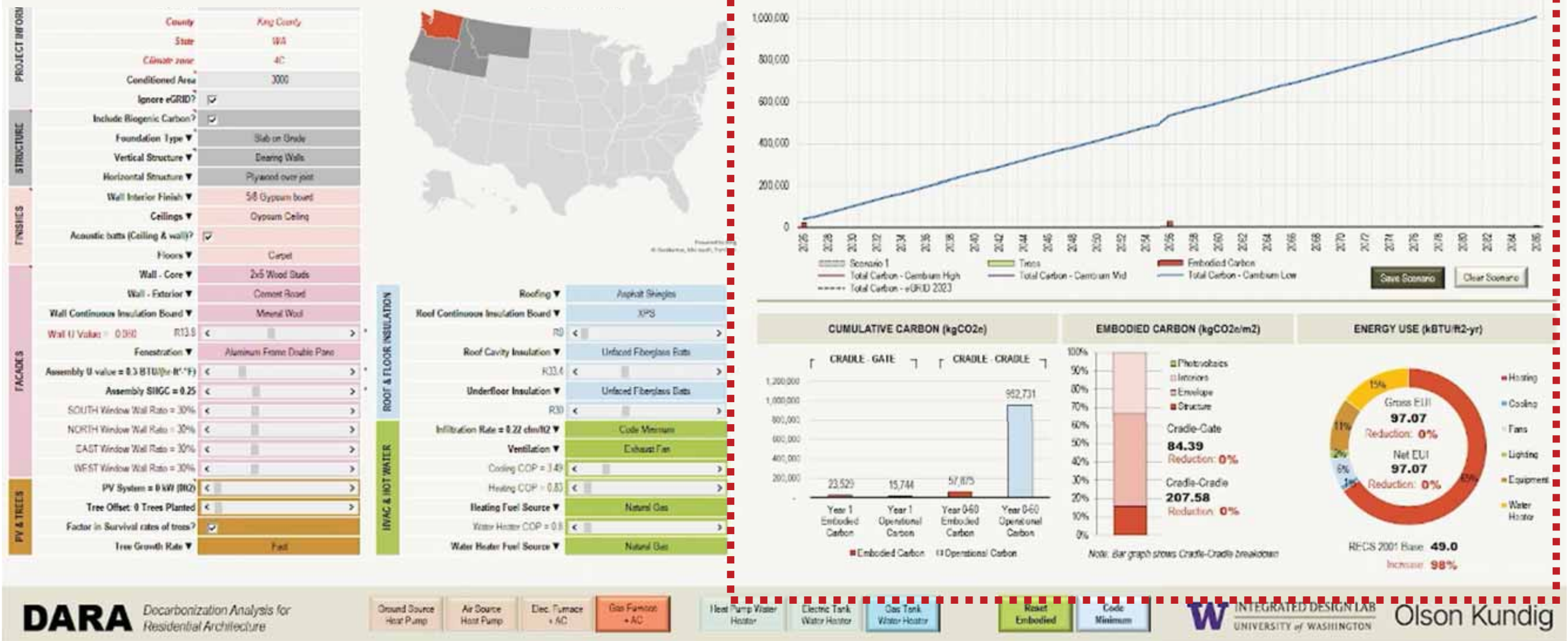
- Some predefined buttons, but users can override.
- These choices affect energy use and operational carbon only.
- Options for comparing fuel types.



DARA *Decarbonization Analysis
for Residential Architecture*

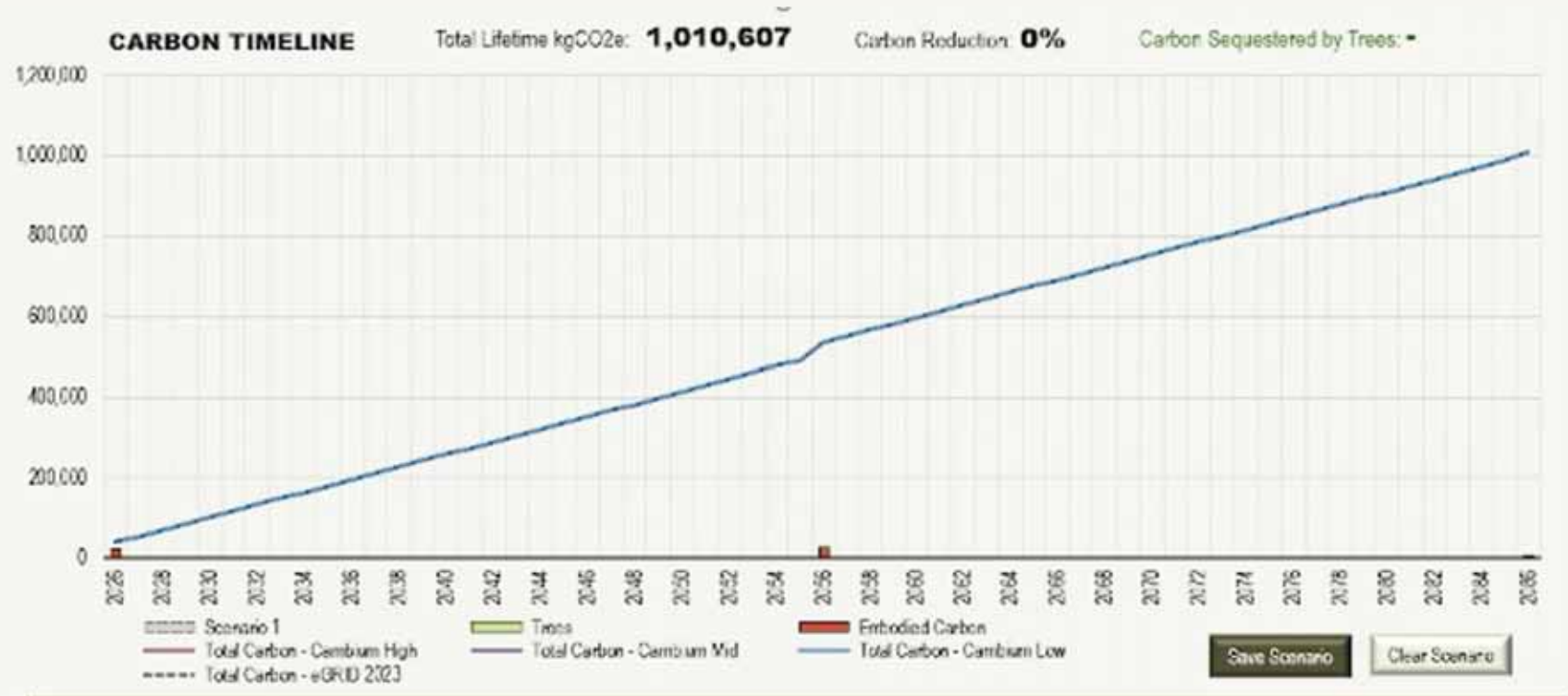


Feedback Data

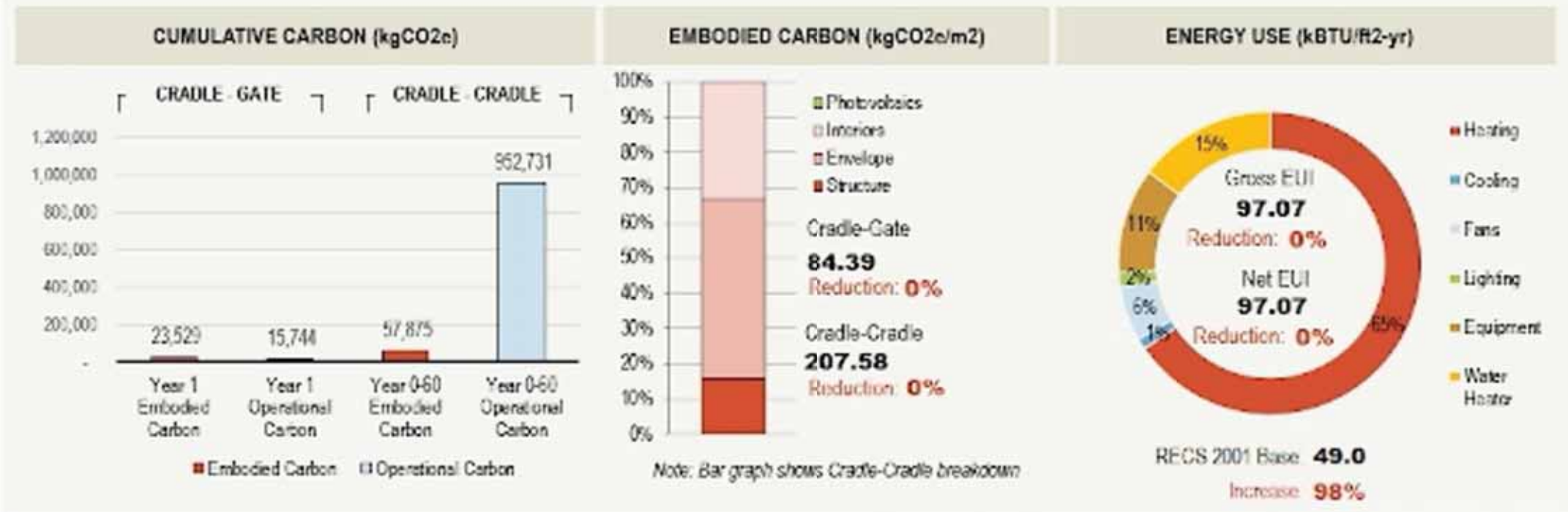


Carbon Timeline

- Shows carbon outlook scenarios over time.
- Allows you to save a scenario and compare changes over that scenario.
- Gives you total lifetime carbon and reduction over saved option.



Embodied vs Operational Carbon



Compares year one and end of life operational versus embodied carbon.

Compares cradle-cradle and cradle-gate embodied carbon. Includes Photovoltaics.

Compares net and gross EUI and shows energy use distribution. Shows status compared to RECS 2001

DARA 2026

PROJECT INFORMATION

Zip Code: 98104

County: King County

State: WA

Climate zone: 4C

Conditioned Area: 3000

Ignore eGRID? ☒

Include Biogenic Carbon? ☒

Foundation Type: Slab on Grade

Vertical Structure: Dearing Walls

Horizontal Structure: Plywood over joist

Wall Interior Finish: 5/8 Gypsum board

Ceilings: Gypsum Ceiling

Acoustic batts (Ceiling & wall)? ☒

Floors: Carpet

Wall - Core: 2x6 Wood Studs

Wall - Exterior: Cement Board

Wall Continuous Insulation Board: Mineral Wool

Wall U Value: 0.090 R13.6

Fenestration: Aluminum Frame Double Pane

Assembly U value: 0.3 BTU/(hr·ft²·°F)

Assembly SHGC: 0.25

SOUTH Window Wall Ratio: 30%

NORTH Window Wall Ratio: 30%

EAST Window Wall Ratio: 30%

WEST Window Wall Ratio: 30%

PV System: 0 kW (B12)

Tree Offset: 0 Trees Planted

Factor in Survival rates of trees? ☒

Tree Growth Rate: Fast

STRUCTURE

State: Washington

Roofing: Asphalt Shingles

Roof Continuous Insulation Board: XPS

Roof Cavity Insulation: Unfaced Fiberglass Batts

Underfloor Insulation: Unfaced Fiberglass Batts

Infiltration Rate: 0.22 cfm/ft²

Ventilation: Exhaust Fan

Cooling COP: 3.49

Heating COP: 0.83

Heating Fuel Source: Natural Gas

Water Heater COP: 0.8

Water Heater Fuel Source: Natural Gas

FINISHES

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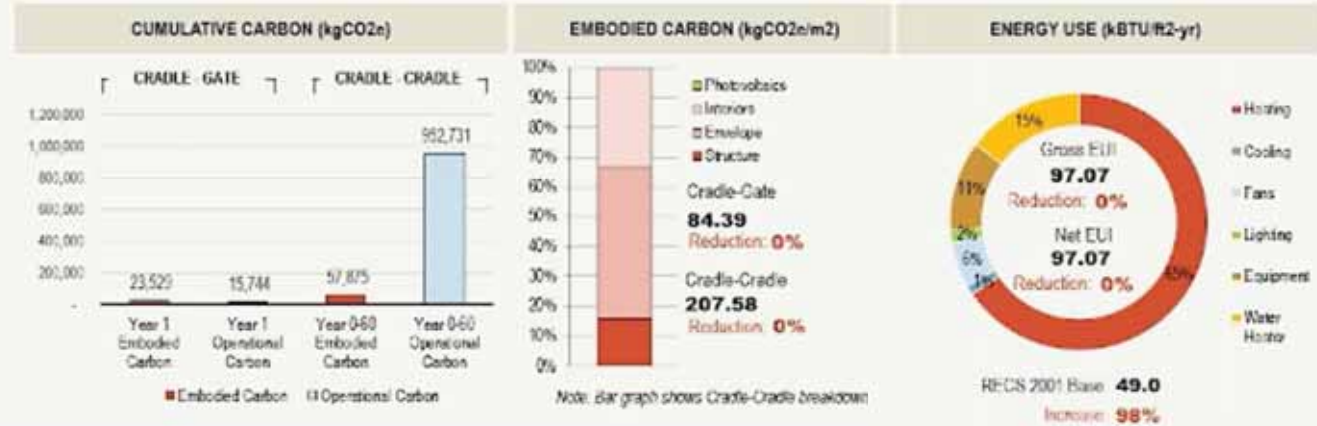
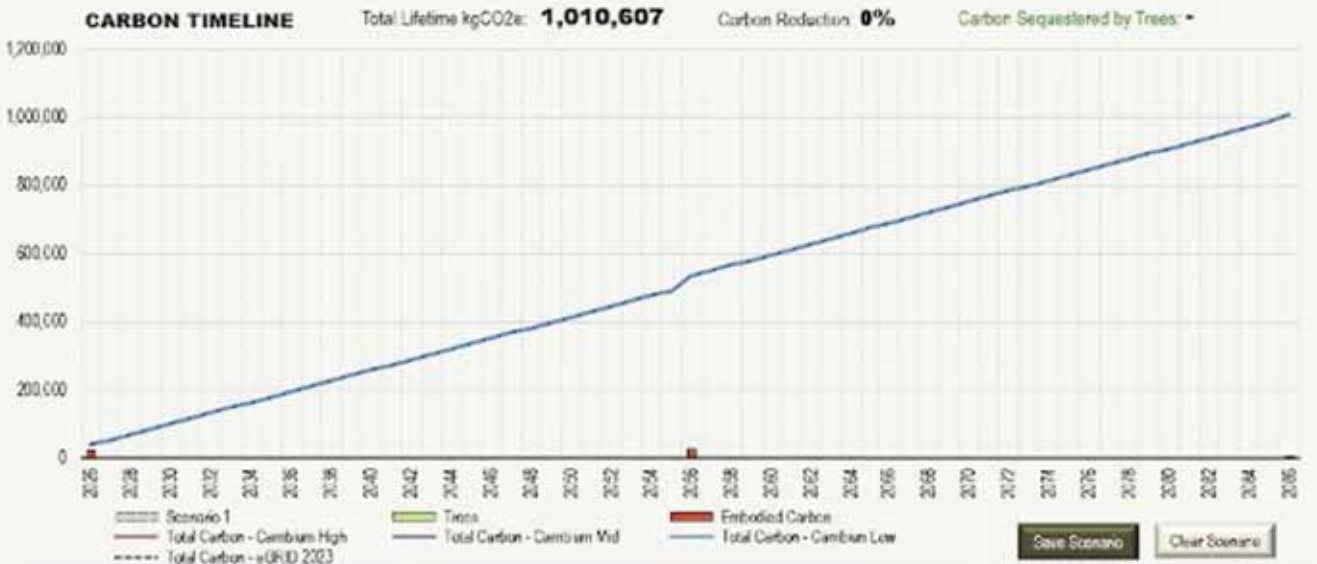
Cooling COP: 3.49

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Heating Fuel Source: Natural Gas

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Water Heater Fuel Source: Natural Gas



What it is

- Early design modeling tool to help create a viable path to zero carbon.
- Material choices use generic industry EPDs
- Use it to help inform your process.

What it is not

- A bespoke energy or embodied carbon modeling tool.
- You cannot compare impacts of specific products.
- Do not use it as a compliance tool or for sizing systems.

Acknowledgement

This project would not have been possible without the financial help and encouragement from the AIA.



It was partially funded through the AIA Upjohn Research Initiative, and we are deeply grateful to the AIA & the AIA College of Fellows for their support.

We would also like to thank Shana Kelly & Amie Sullivan from KPFF Engineers for providing advice on our structural systems.

To download the DARA Tool
www.olsonkundig.com/DARA

Questions?
Thank you!

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