

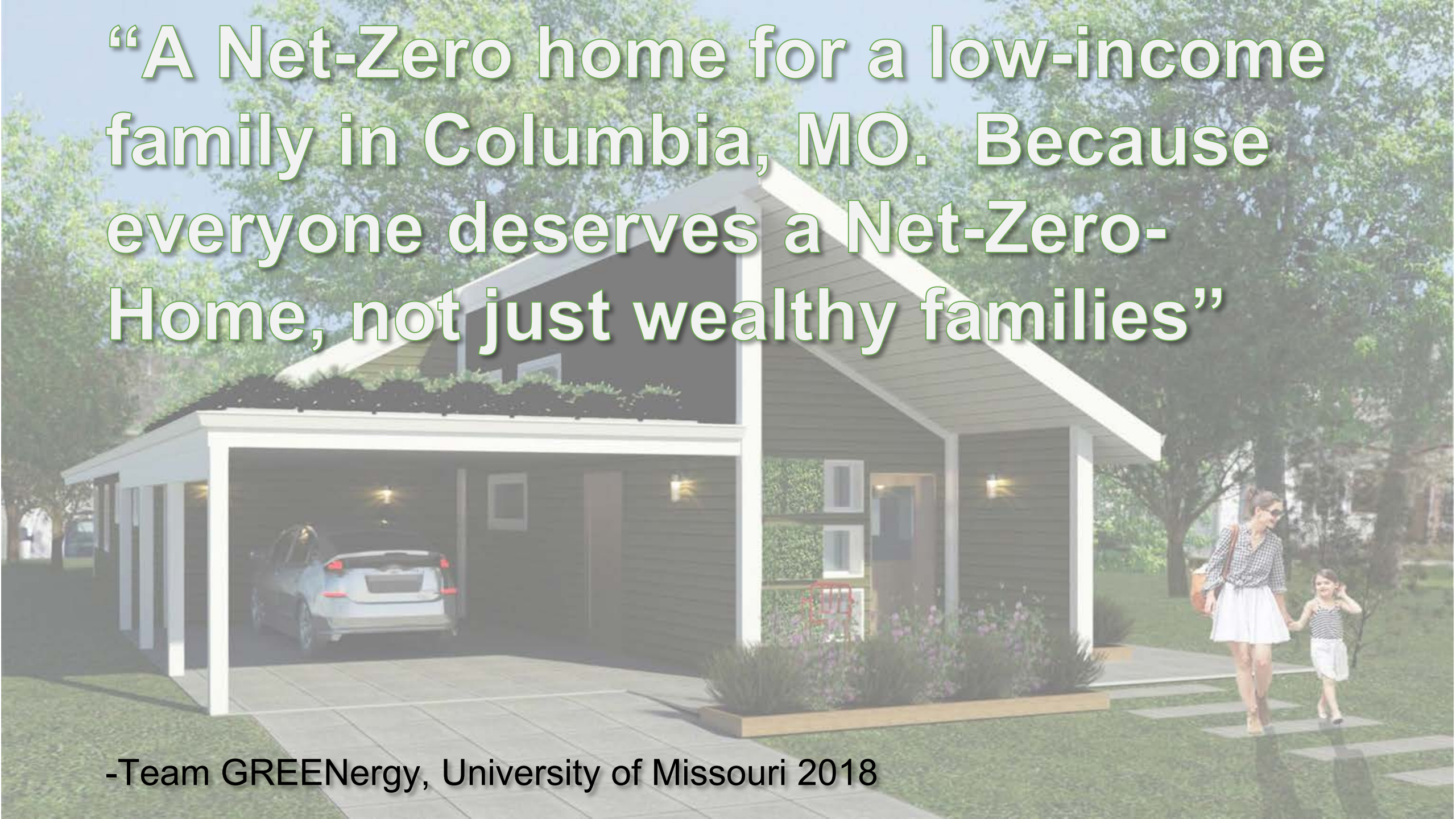
Zanos II House

Team GREENergy

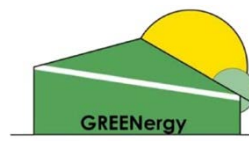


“A Net-Zero home for a low-income family in Columbia, MO. Because everyone deserves a Net-Zero-Home, not just wealthy families”

-Team GREENergy, University of Missouri 2018



Design Constraints



Team GREENergy
University of Missouri



Climate Summary

Climate Zone: 4A

Mixed-humid

Cool to cold winters

-4800 heating degree days

Long, hot, and humid summers

-1550 cooling degree days

Site Location and Summary

Located on King Avenue Columbia, Missouri

Ridgeway neighborhood

-lowest income neighborhood neighborhood

-near ample parks and green space

Lot 50' wide and 115' long

-East-West Axis

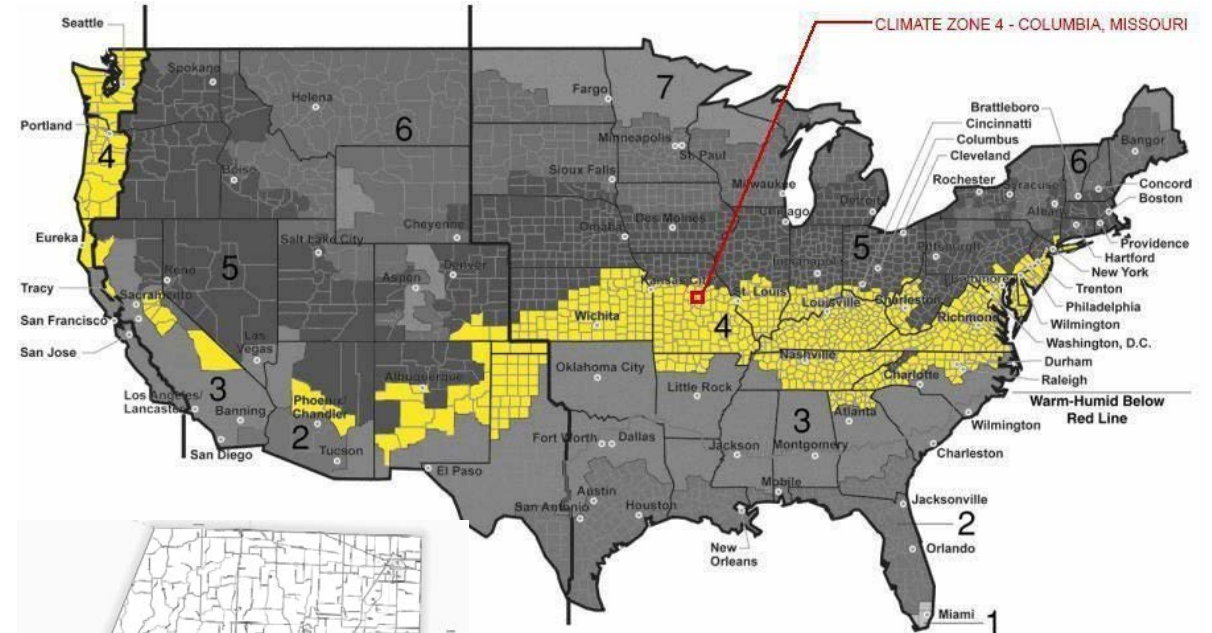
Project Summary

Location: 804 King Avenue Ridgeway Neighborhood Columbia, Missouri

Neighborhood: Suburban, Low-Income

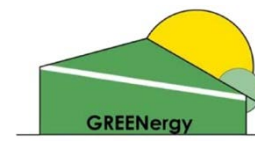
Lot Size: 5750 SF (50' wide by 115' long)

House Size: 1390 SF; 1 Story, 2 Bedrooms, 1-1/2 Bath



Boone County Missouri

Design Goal



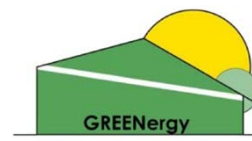
Team GREENergy
University of Missouri



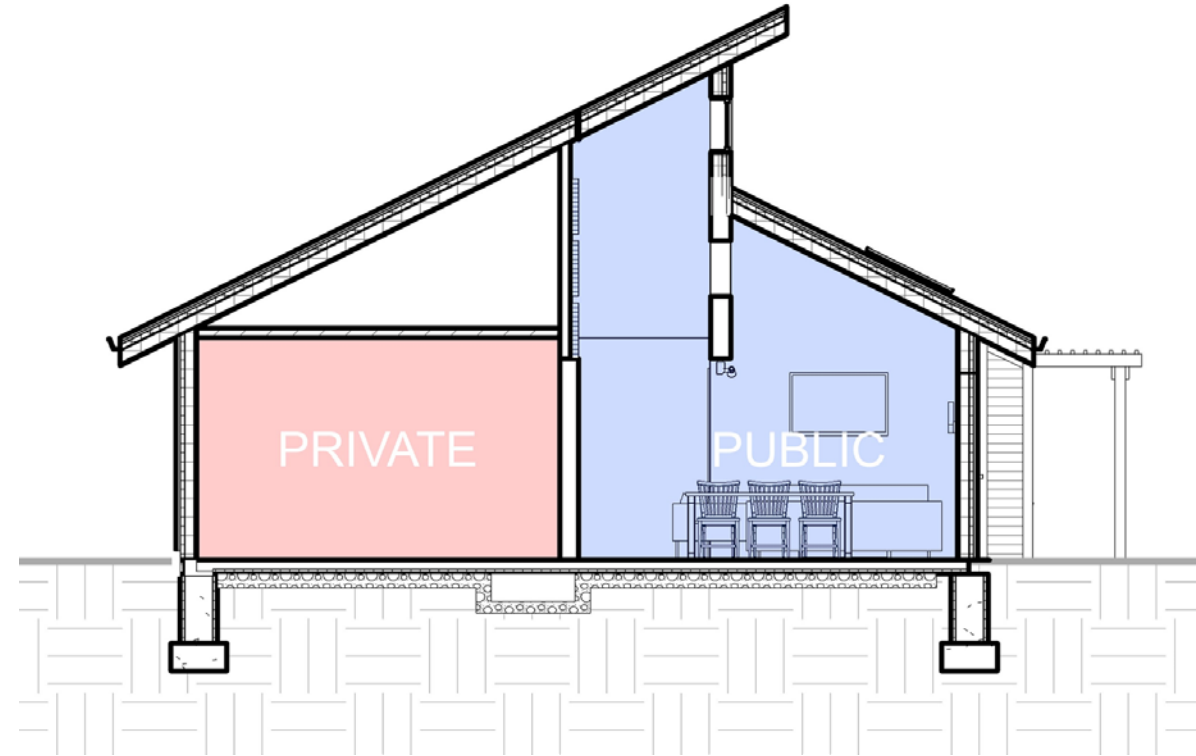
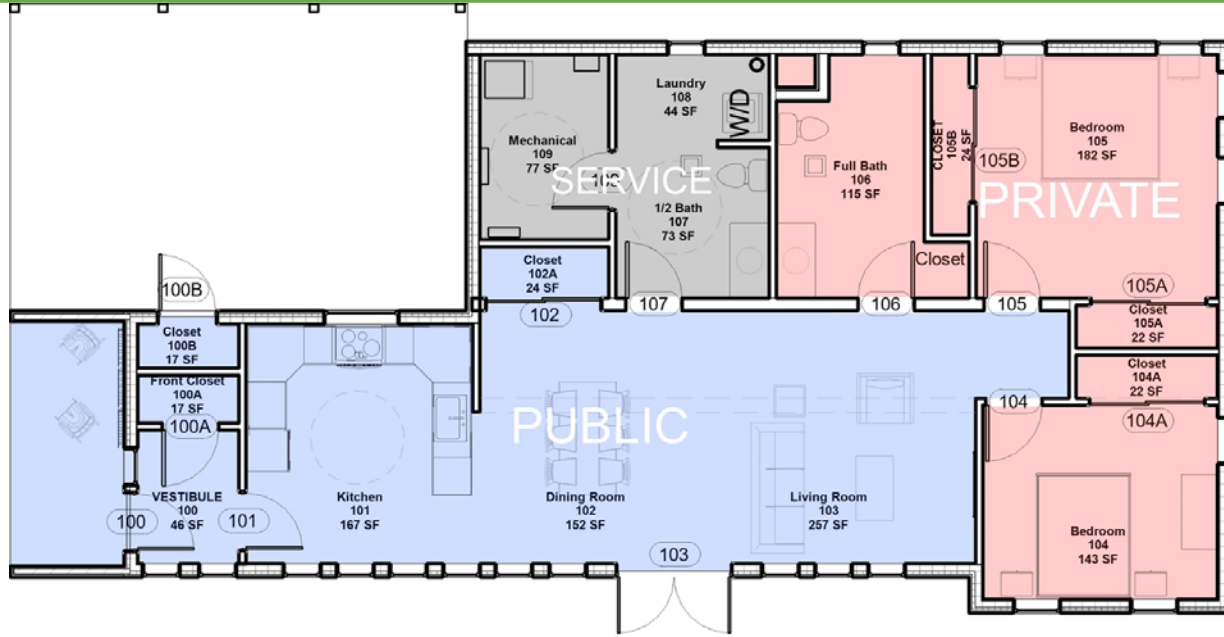
To create an affordable, energy-efficient, resilient, and environmentally friendly home for a family of three.



Architectural Design



Team GREENergy
University of Missouri



Long central axis maximizes solar (**passive** and **active**) exposure



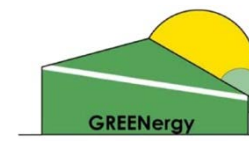
Separation of **Public/Private/Services** spaces

Slope and **shape** of roof inspired by surrounding street and neighborhood

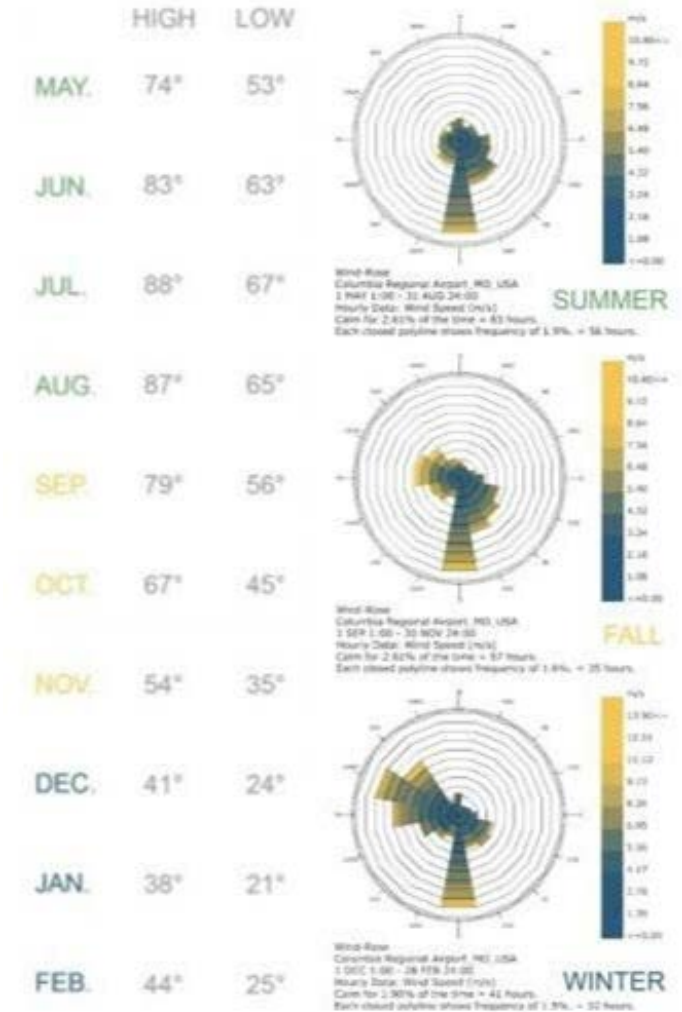
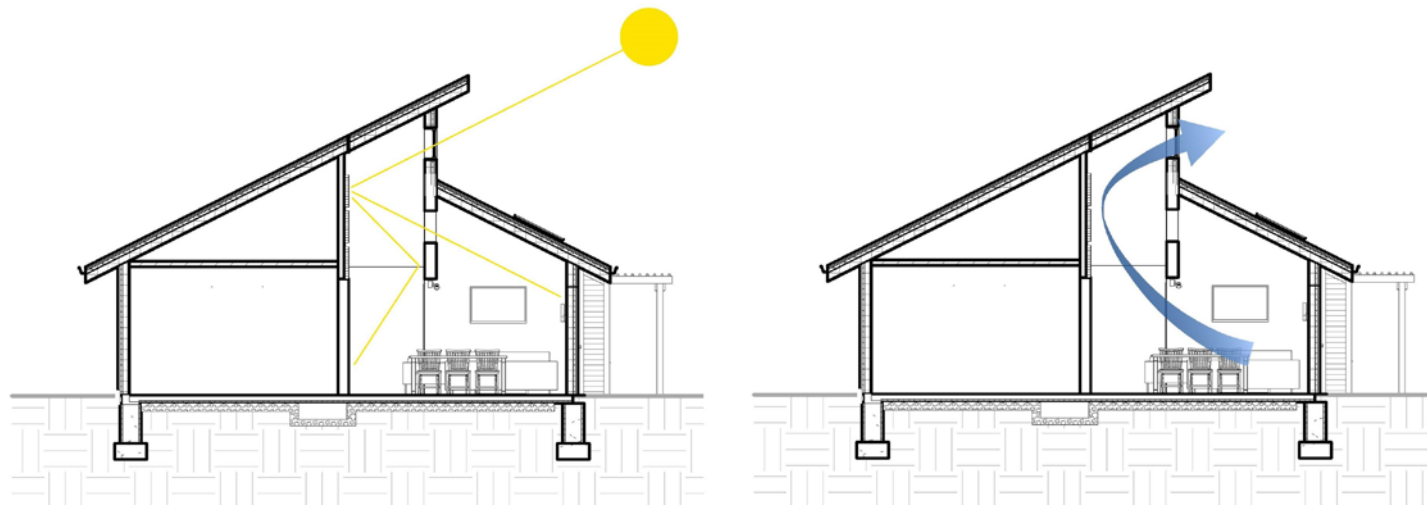
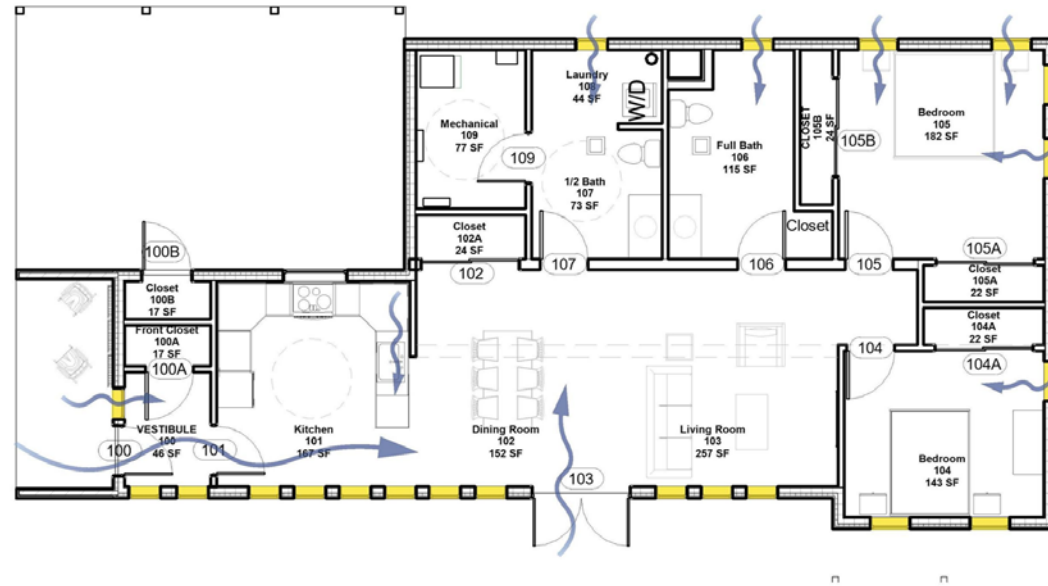
Most houses do not have garage or **carport**

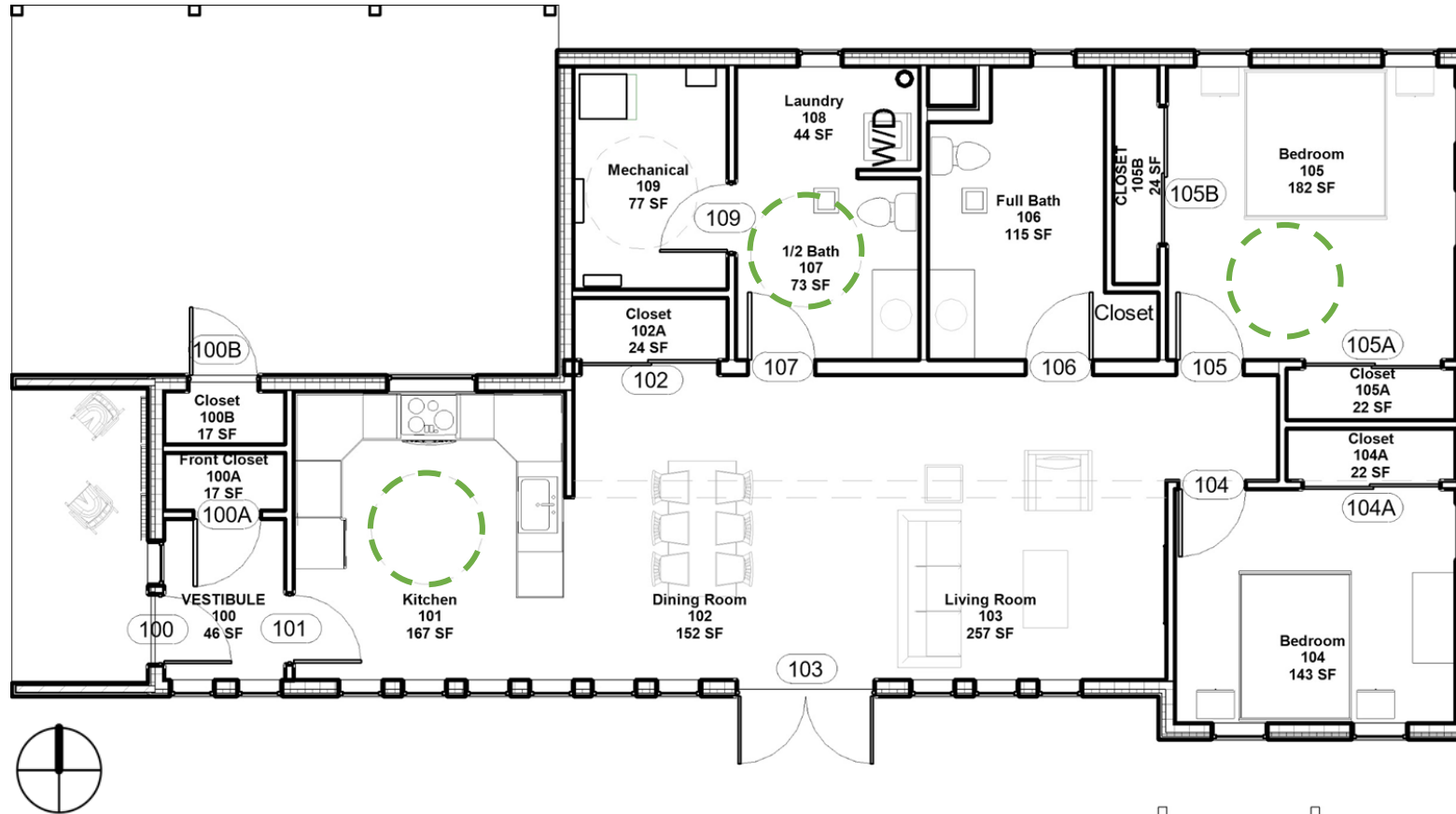


Architectural Design



- **Clerestory** for heating, daylighting, and ventilation
- Roof overhangs and trellis shade in summer, let in sunlight in winter





Sun space (dining, living, kitchen)
with thermal mass for solar heating

Universal design principles:

- 3 foot doors
- 5 foot turning diameter
- Clearances for approach
- One level
- Clear lines of sight
- Motor operated clerestory windows

Heat spaces (kitchen, laundry, mechanical) located on north and northwest

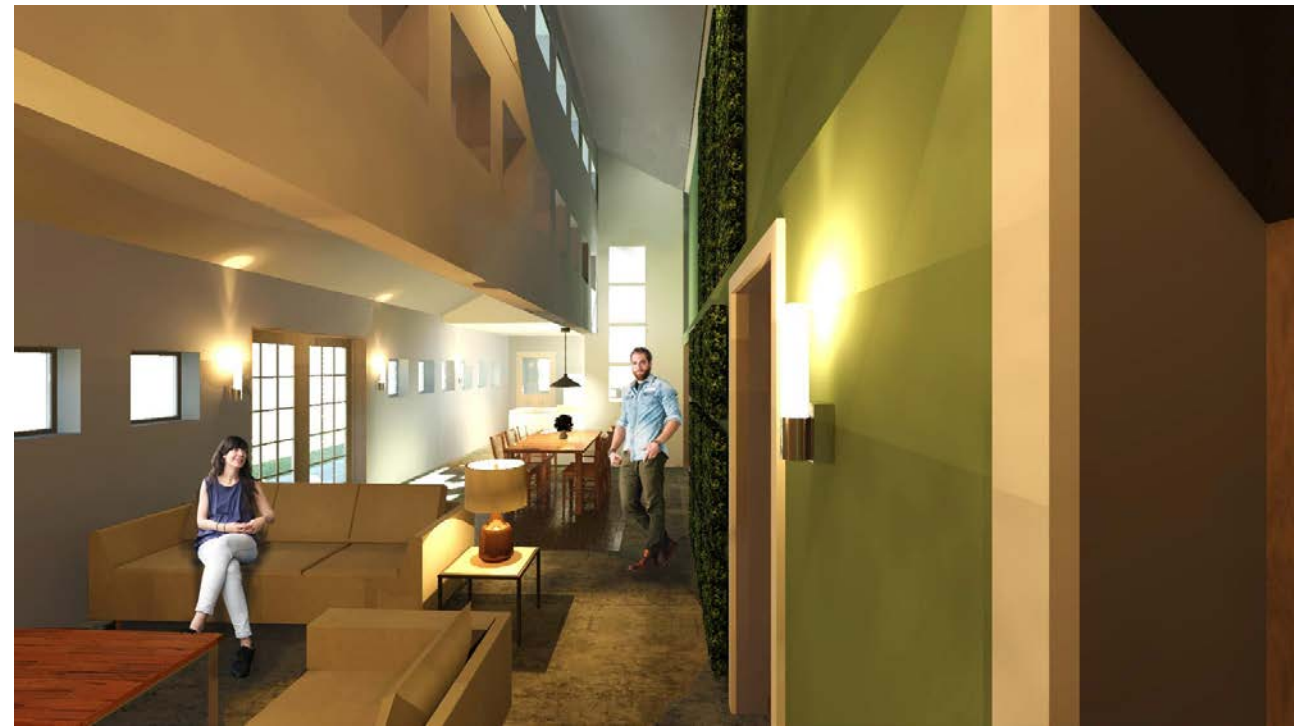
Open floor plan (flexibility)



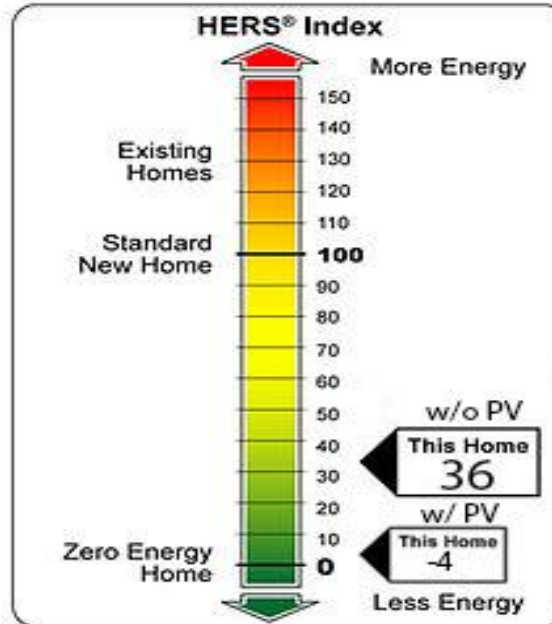
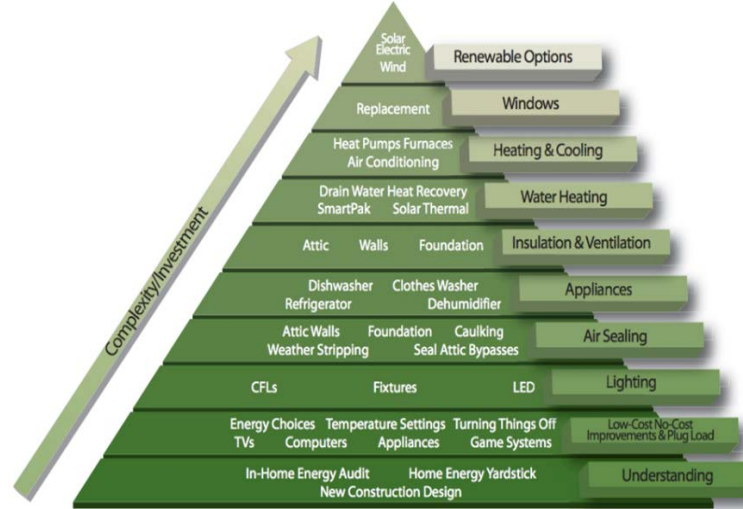
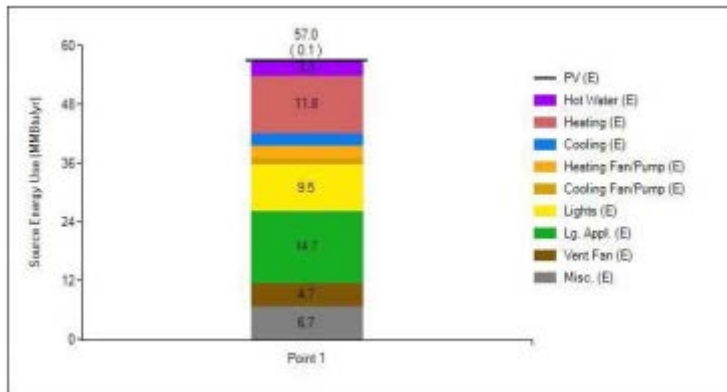
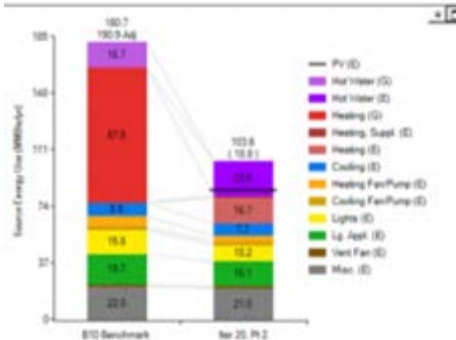
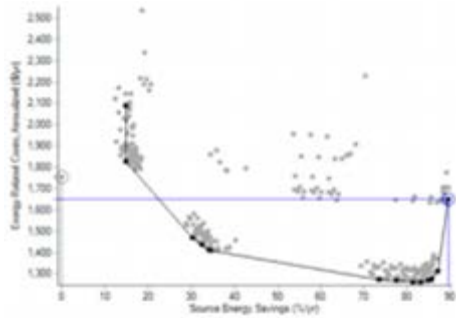
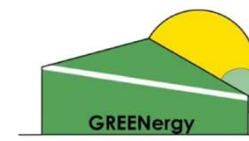
Green wall as focal point in living/dining
Clerestory for daylighting and natural
ventilation.

Ecologically sensitive interior materials:

- Rapidly renewable, recycled content, or local materials
 - Includes furniture selection (not included in financial)
- No VOCs or Formaldehyde
- Cork flooring in bedrooms
- Concrete floor in public areas for thermal mass
- Recycled tile in bathrooms, entry
- Recycled wood from demolition of existing house on site



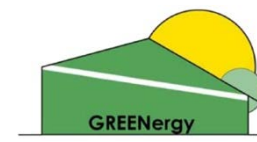
Energy Analysis



- Followed Energy Pyramid
- **BeOpt** to optimize energy efficient strategies
- **REMRate** analysis to determine:
 - **HERS Rating:**
 - **36** without PV
 - **-4** with PV
 - Fine tuning of energy use
 - Compliance with IECC, ASHRAE 90.1, EnergyStar Homes
 - DOE Net-Zero Ready Home requirements

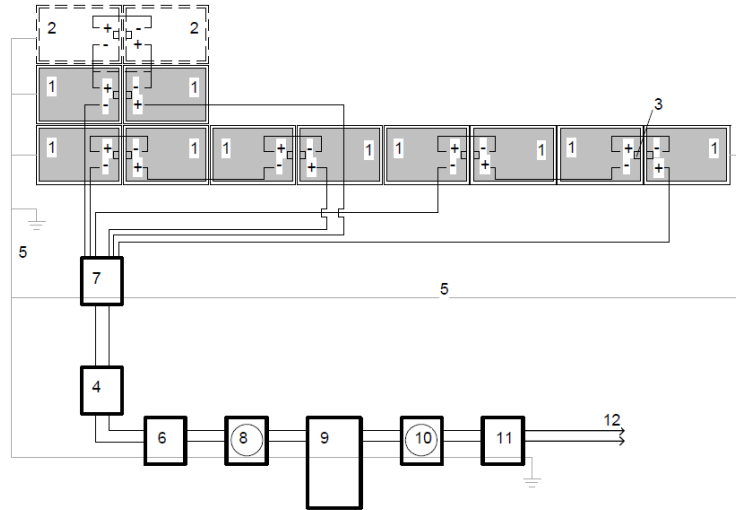
Energy-efficiency optimization but also affordability- eliminated some options.

Photovoltaic Array



PV ARRAY NOTES:

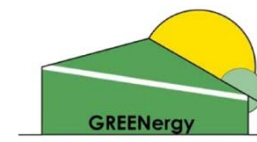
1. 345W PV MODULE
2. PV EXPANSION
3. MICROINVERTER - TYP. WITH ANTI-ISLANDING PROTECTION
4. 30A AC DISCONNECT - ON WALL
5. GROUND WIRE AT EACH PANEL
6. RAPID SHUTDOWN CONTROL - ON WALL
7. AC COMBINER WITH 3 30A CIRCUITS
8. AC METER - PV ARRAY PRODUCTION
9. AC SERVICE PANEL WITH 30A DEDICATED BREAKERS FOR PV ARRAY
10. UTILITY METER
11. AC DISCONNECT
12. CONNECTION TO UTILITY GRID



Photovoltaic array:

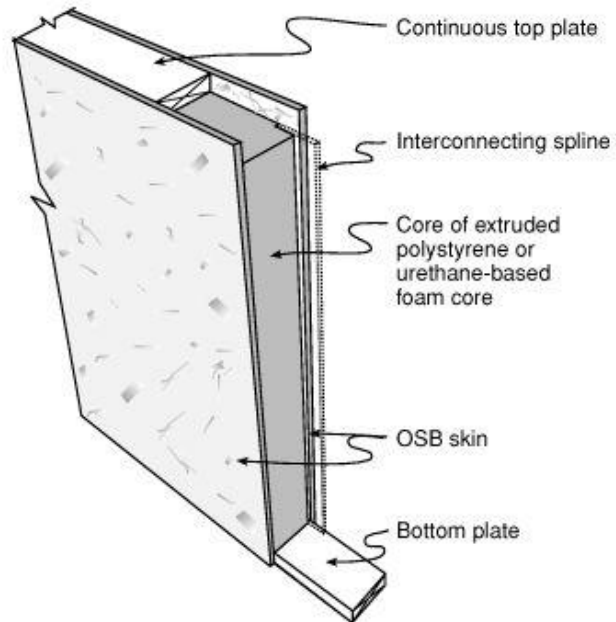
- 10 panel, 3.75kW array
 - Room to expand to 4kW (12 panels)
- SunPower X21-345
 - Micro-inverters versus String or DC Optimizers
 - 345 W per panel
 - 17.5 SF per panel
- Per PVWatt:
 - 5416KWh per year
 - 26.6 degrees tilt (roof slope)
- **Micro-Inverters** used for NEC/ISEP Compliance:
 - Rapid Shutdown
 - Anti-Islanding
 - Better performance under shading
 - Missouri PV Installers prefer micro-inverter systems
- Columbia requires two meters for grid-tied systems
- Pathways/ clearances per 2015 ISEP
- PV Array wired in Series and Parallel (172VAC 18A)
 - Costs:
 - \$4.43 per Watt, total system without rebates/ credits
 - Minus Federal 30% Tax Credit
 - Minus City of Columbia rebate (\$500/watt)
 - Per PV Watt: Savings of \$557/ year
 - Achieves Net-Zero or better

Constructability



SIPs walls and roofs

- R-40 walls (6-1/2 inches)
- R-50 roof (8-1/4 inches)
- Thermocore of Missouri (30 minutes from site)
- CMCA builds their houses with SIPs or ICF
- Minimizes thermal gaps
- Job Point (Youth Build) experience with SIPs
 - Teachable system to high school and college vocational program
 - Easier to teach flashings and connections



Top View



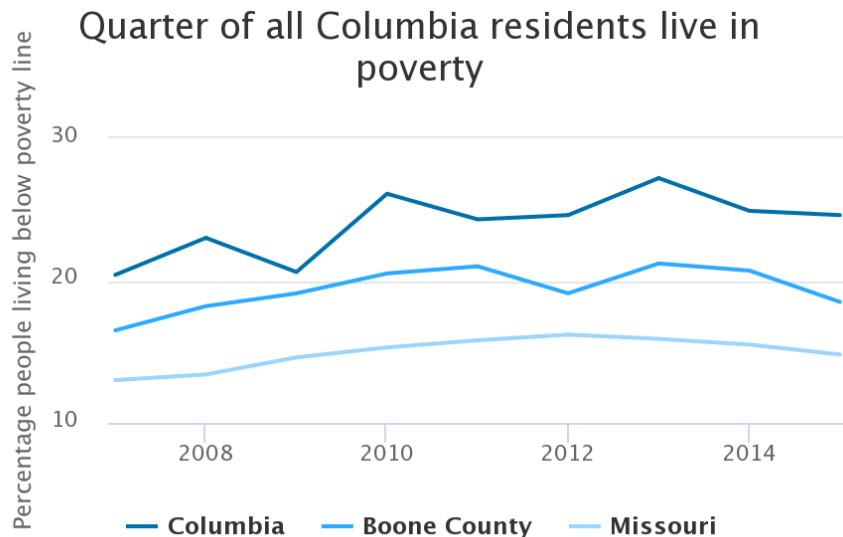
Side View



Columbia, MO

Client:

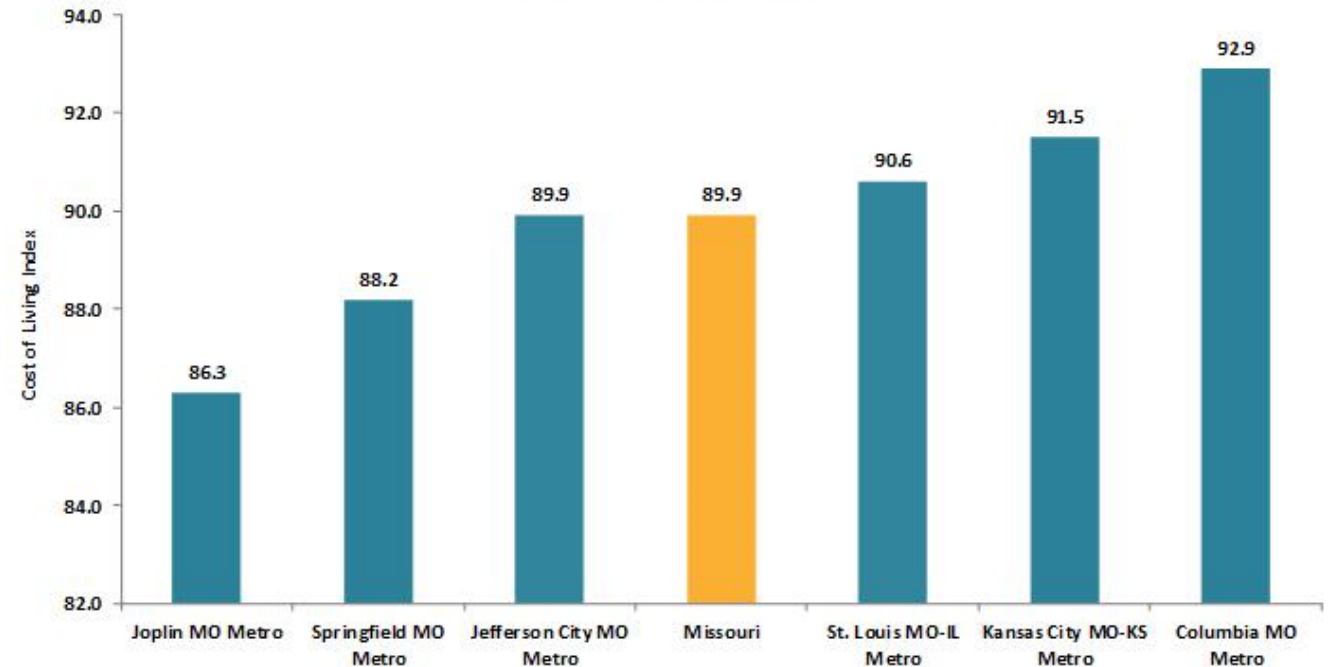
Central Missouri Community Action
(CMCA) (Project Client and General
Contractor)



Highcharts

<https://www.columbiamisourian.com>

Cost of Living for Selected Missouri Cities 2017 Annual Average



https://www.missourieconomy.org/indicators/cost_of_living/

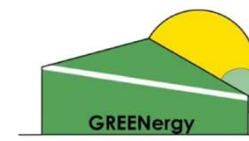
Target Homeowner: 3-4 family members, low-income

Target Family Income: \$45,221

Cost of Living (Columbia, MO): 92.9%

Site and Target Homeowner qualifies for CDBG investments

Financial Analysis



Construction Costs per RSMeans and local subcontractors

Team Name: GREENergy
Contest Category: Suburban Single Family (SSF)

Construction Cost Summary

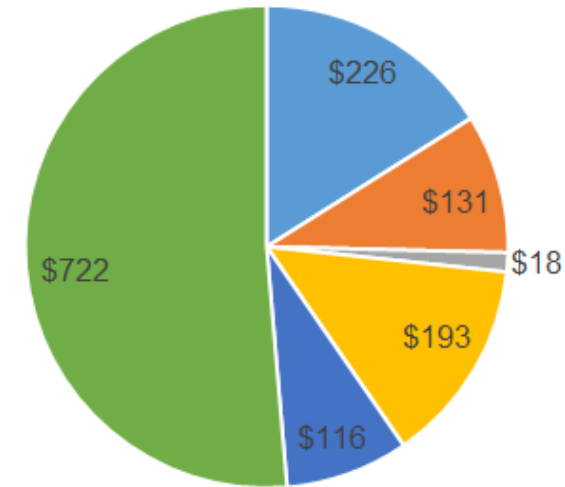
	Baseline Design	Team Design
Site Work	\$ 7,979	\$ 5,796
Foundations	\$ 16,597	\$ 16,555
Framing	\$ 25,812	\$ 41,807
Exterior Finishes	\$ 21,559	\$ 31,025
Major Systems Rough-ins	\$ 18,779	\$ 17,557
Interior Finishes	\$ 42,478	\$ 35,363
Final Steps	\$ 9,702	\$ 8,555
Other	\$ 667	\$ 11,505
Total Construction Costs	\$ 143,573	\$ 168,162

Sales Price Summary and Cost of Living

	Baseline Design	Team Design
Total Sales Price	\$ 232,750	\$ 180,726
Monthly Household Debt (0.5% MFI)	\$ 295	\$ 226
Operations and Maintenance Costs	\$ 196	\$ 131
Monthly Utility Costs	\$ 160	\$ 18 (Net Metering State)
Property Tax	\$ 332	\$ 193
Insurance	\$ 79	\$ 116
Mortgage	\$ 1,405	\$ 722
Total	\$ 2,467	\$ 1,406
Estimated Target Family Income	\$ 59,039	\$ 45,221
Debt to Income Ratio	50%	37%

VI: Cost Estimate (pg. 206)

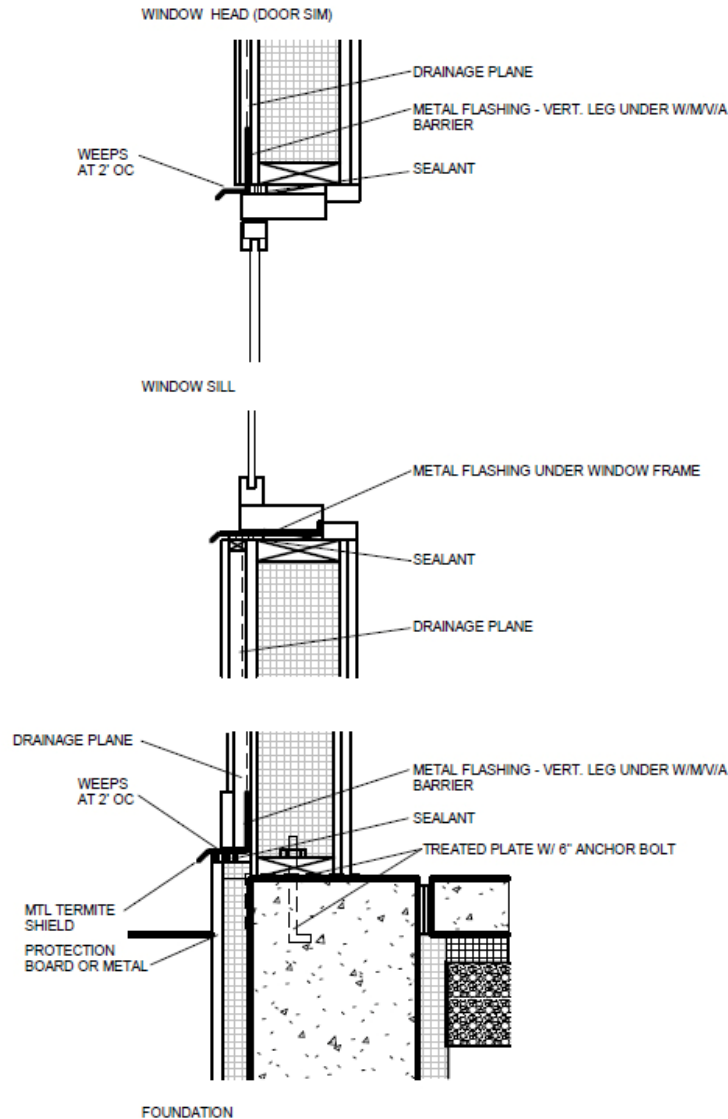
Sales Price Summary and Cost of Living



- Monthly Household Debt
- Monthly Utility Costs
- Insurance
- Operation and Maintenance Costs
- Property Tax
- Mortgage

37% Debt to Income Ratio

Total Home Costs with PV: **\$180,726**
 Total Home Cost Without PV: **\$169,183**
 Total Home Cost After \$30k Down Payment Assistance: **\$150,726**
 (combination of city and bank assistance for this location)



Window and Foundation Details

Drainage Planes (Ventilation space):

- 2x2 treated wood battens, sealant at screw holes
- Walls: Between siding and air/moisture/vapor layer
- Roofs: between metal roofing and air/moisture/vapor layer
- A/M/V barrier - Wall: self-adhered Grace Vycor enV-s
 - Air permeance: <0.0004 cfm/ft² 1.57 pcf
 - Water vapor permeance: 15 perms
- A/M/V barrier - Roof: self-adhered Grace Ice and Water Shield

Metal flashing with weeps at bottom of exterior walls and heads of windows and doors to direct water away from drainage planes

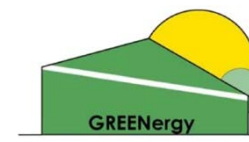
Underslab layer: 10 mil polyethylene sheet, overlapped and taped

Continuous thermal barrier

- All insulation joints taped
- SIPs joints taped with Grace Vycor self-adhered membrane flashing



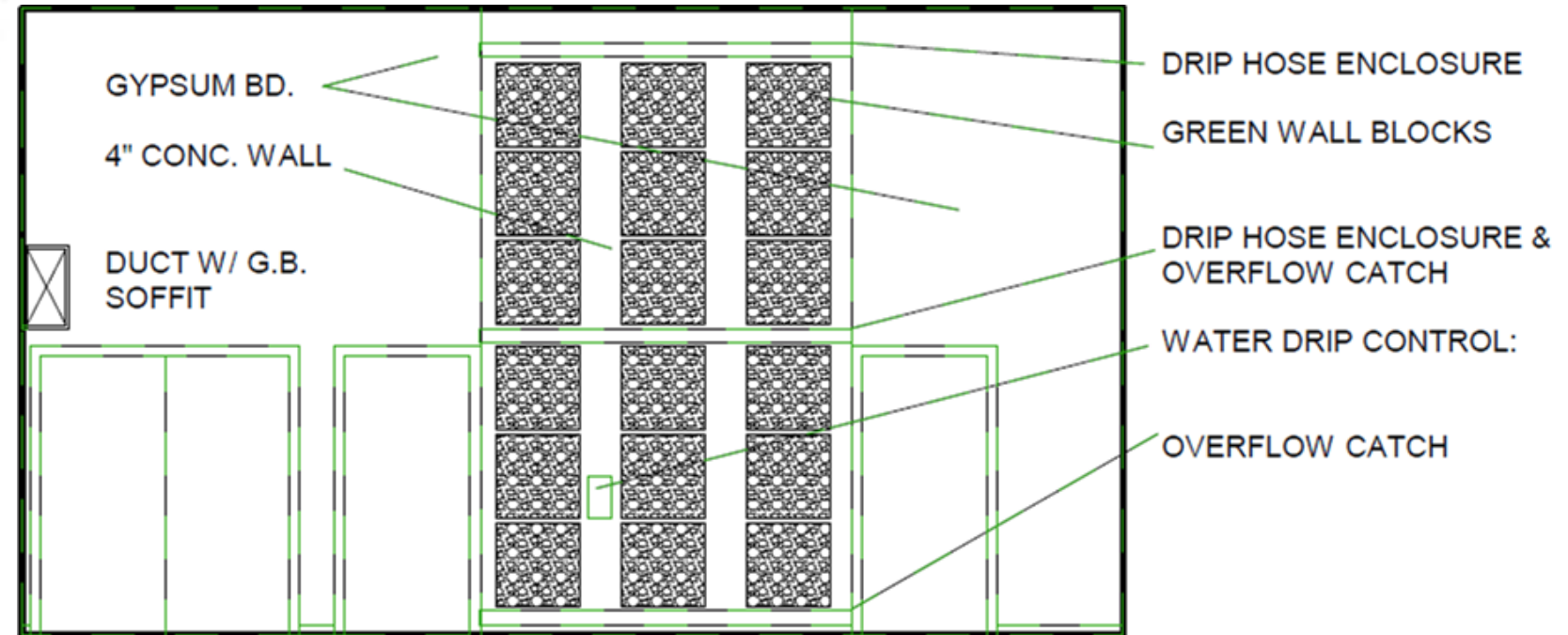
IAQ and Ventilation



8 Principles of a Healthy Home: Dry, Ventilated, Clean, Contaminant Free, Comfortable, Maintained, Pest Free and Safe

A) Pollutant Avoidance B) Point Source Removal C) Fresh Air Distribution

- All wood products (trim, cabinetry, oriented strand board, etc.) contain no formaldehyde content and all paints, adhesives, and coatings in the Zanos II House contain no VOCs.
- **Green Wall:** Indoor Vertical Garden
 - plants that can filter air
 - Philodendron, English Ivy, Aloe Vera, Spider Plants, Golden Pothos, Boston Fern, and Areca Palm
- The fabric of the planter allows water to seep through each plant from top to bottom and a catchment system recovers excess drips





Honeywell VNT5070 E 1000
Energy Recovery Ventilator

- **Radon Reduction:** Passive system in Laundry Alcove
- **Whole House Ventilation:** Honeywell VNT5070 E 1000 Energy Recovery Ventilator (ERV)
60 to 65 CFM
ASHRAE 62.2 compliance
- **Filtration:** MERV 10 (Winter and Summer), MERV 13 (Spring and Autumn)
- **Source Exhaust** (ducted to outside):
Bathrooms: 80 CFM
Kitchen: 100 CFM

HVAC

Geothermal Heat Pump 2-ton

CDi SM-024 Split System with attached
Bosch DX025-1VTX compact air handler and fan coil



Vertical Loop (4)
100 - 200 feet deep

19.1 kBTUs Heating (32° F)
25.3 kBTUs Cooling (77° F)
(EER 16.2)

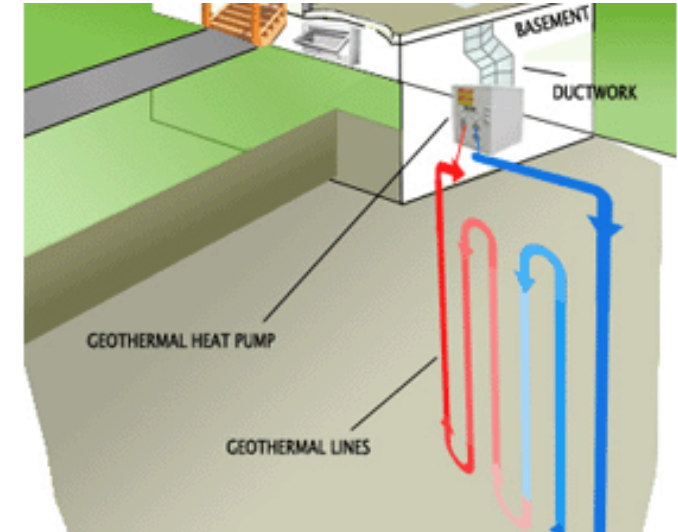
Heating & Cooling COP: 3.5

MERV 11 (W/S)
MERV 13 filter (S/F)
Max noise level 40db

Replace VI Figure 31: Bosch Geothermal Heat Pump
with Water Heating (pg. 38)

Constant Ground Temp 55°

Geothermal – vertical loop



<http://www.system-selector.ingramswaterandair.com>

Thermostat

Honeywell Lyric T5



VI Figure 30: Honeywell WiFi Smart Thermostat (pg. 37)

Green Modularity

The house's main unique feature is a green ribbon that starts with exterior two-foot square roof and wall blocks that relate to the 2 foot square windows on the south wall and clerestory, which relate to the interior green wall modules and 2 foot square cut holes in walls around the clerestory. The green ribbon also provides interior humidity control and assists with good indoor air quality.

Affordability

The Zanos II House is able to incorporate advanced, high-performance energy strategies in a design that is affordable to the surrounding neighborhood and marketable to low-income residents of Columbia, Missouri. The house design is an example that a net-zero home is within the income reach of a majority of Columbia residents.

Accessibility

The Zanos II House incorporates accessibility and universal design strategies without compromising affordability or energy-efficiency.

Beauty

The Zanos II House design combines energy-efficient and sustainable design strategies with beauty as a stand-alone home, but also blends in with the existing neighborhood context.