phius con
NEW YORK 2021

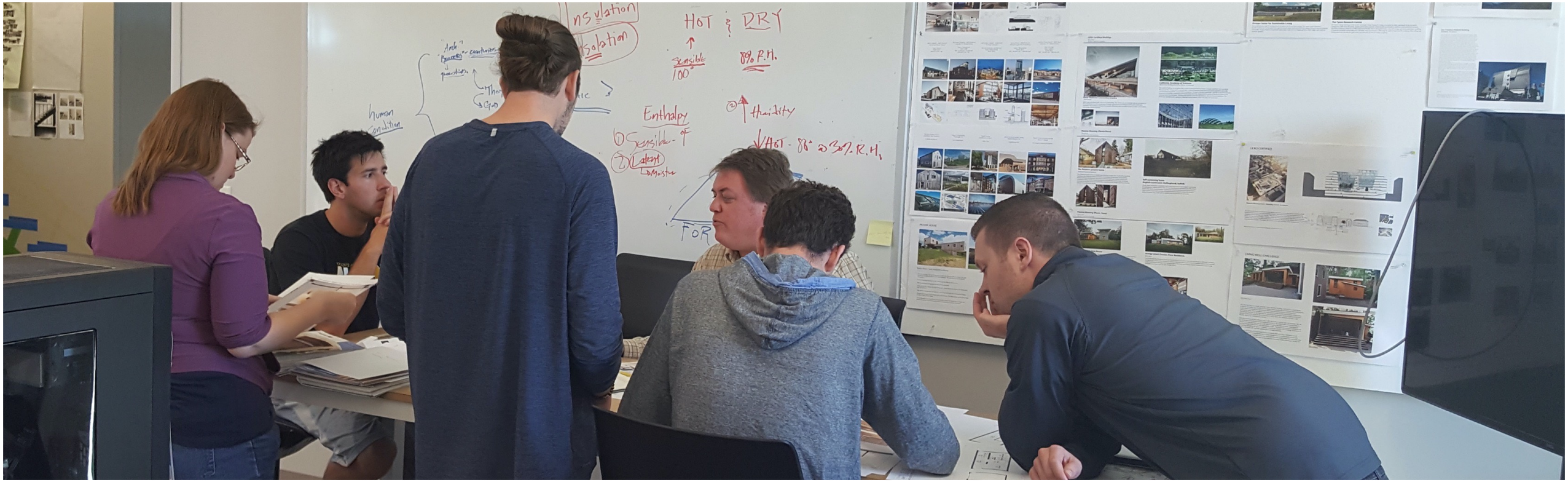
Assisting Passive House Owner Behavior by Leveraging Energy Monitoring and Post-Occupancy Reports

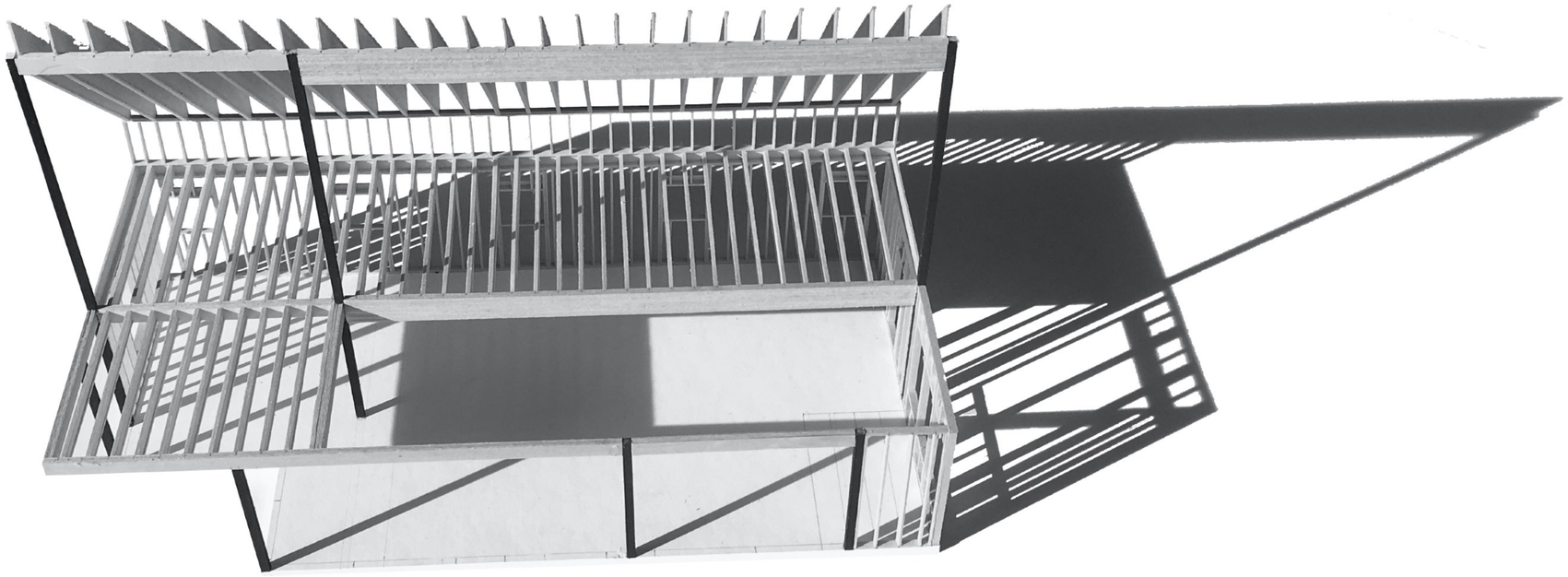
Charles MacBride, AIA, CPHC
University of Texas at Arlington

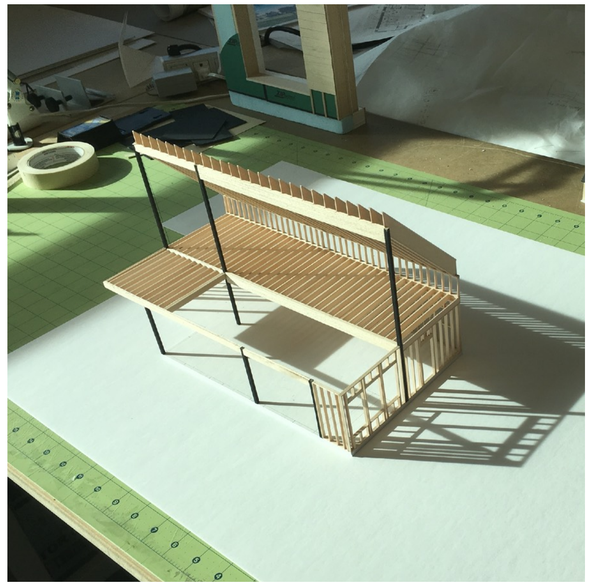
Robert Arlt, AIA, CPHC
South Dakota State University

Background

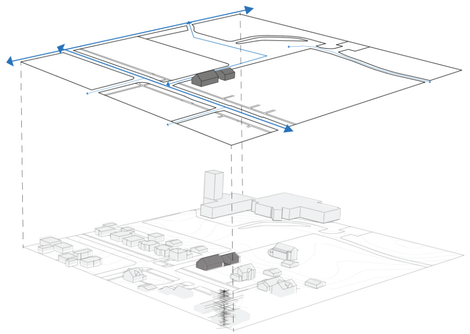
PH01:BRK and the South Dakota Passive Housing Initiative


HOT & DRY
88% R.H.
Enthalpy
humidity
HOT - 88° @ 30% R.H.





Circulation Diagram



Climate Zone

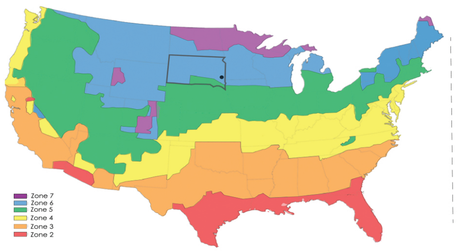
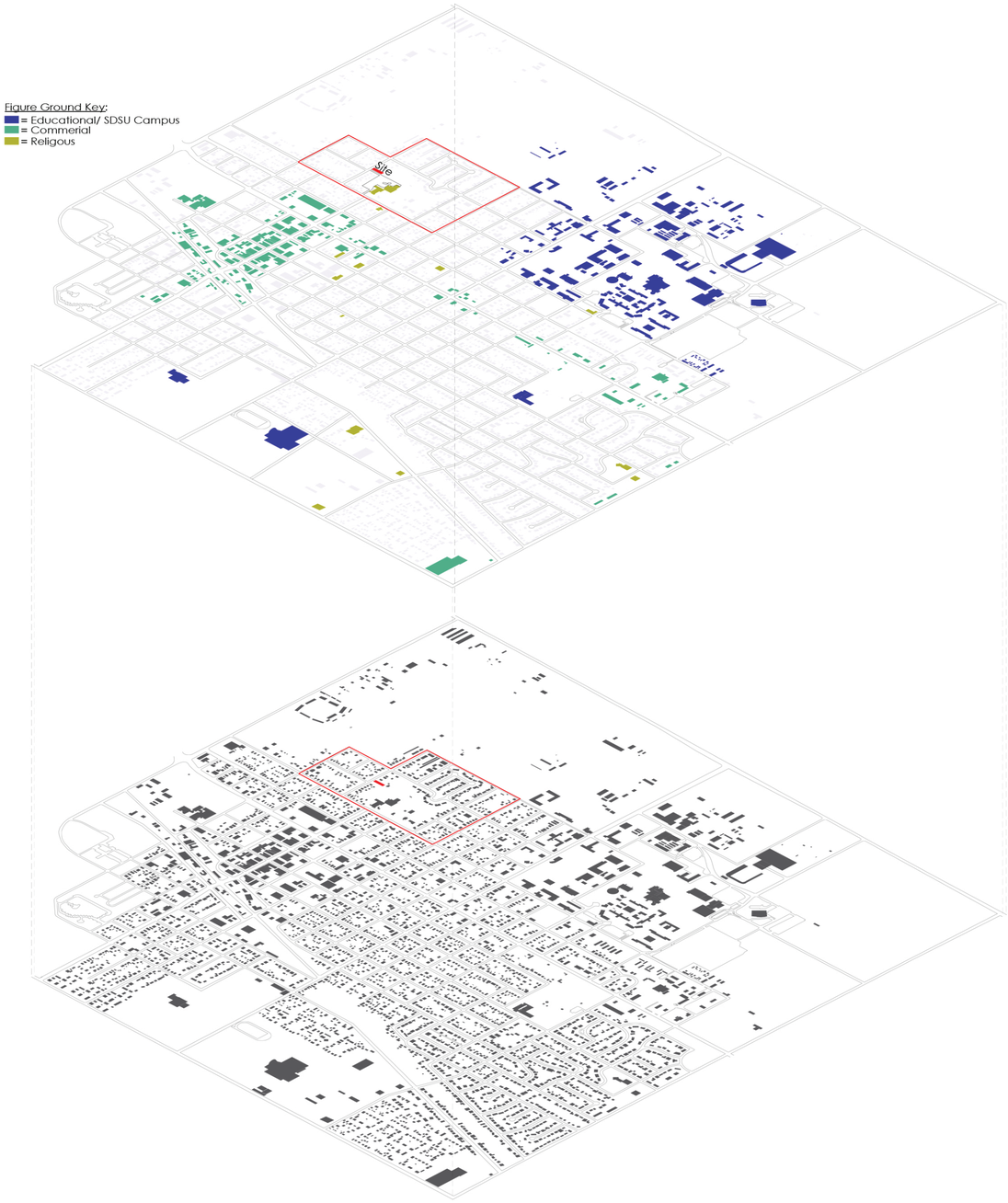


Figure Ground Key:
= Educational/ SDSU Campus
= Commerial
= Religous



CODE SUMMARY:
-Zoning: R-2

-CURRENT BUILDING CODES:
-2015 International Building Code (IBC)
-2015 International Residential Code(IRC)
-2015 International Energy Conservation Code (IECC)
-2015 International Plumbing Code (IPC)
-2015 National Electrical Code (NEC)

BUILDING CODES:
-All work performed, including materials furnished, workmanship and means & methods of construction, shall conform with all applicable requirements and building codes. This includes handicap/ADA regulations, fire department & utility company regulations, safety codes, ordinances and other site specific regulations.

-The contractor shall employ laborers and subcontractors who are trained, experienced and completely familiar with the specified work herein. Where, required, work shall be preformed by licensed tradesmen who shall arrange for and obtain all required permits, inspections and sign-offs. The contractor is fully responsible for all subcontractors and their work.

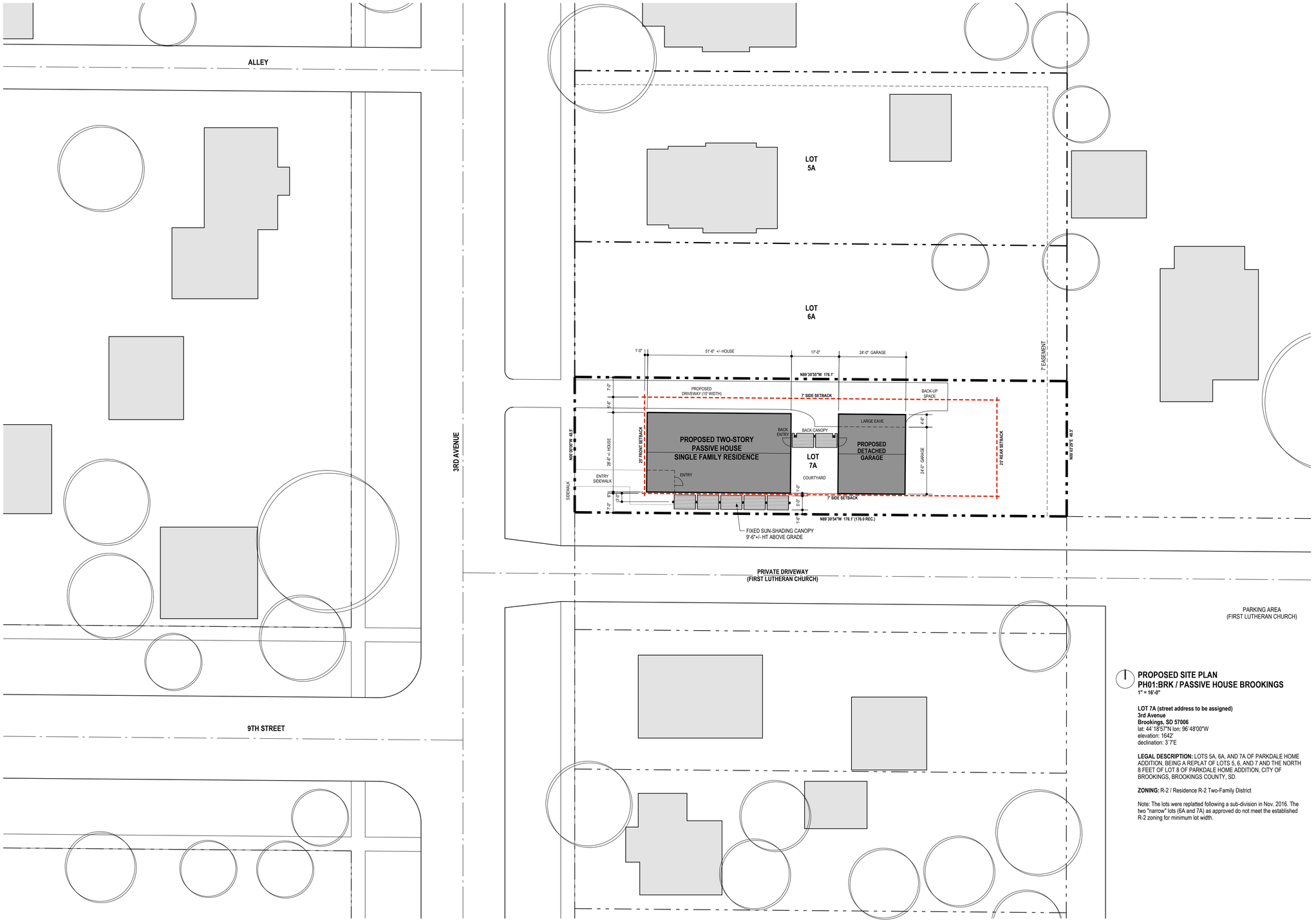
LEGAL DESCRIPTION:
-Lot 7 & the North 8' lot 8, Block1, Parkdale Home addition to the city of Brookings, Brookings County, South Dakota.

CLIMATE AND GEOGRAPHIC DESIGN CRITERIA
2012 International Residential Code

Ground Snow Load:	**50 lb/ft 2**
Wind Speed:	**90 mph**
Wind Topographic Effects:	**NO**
Seismic Design Category:	**A**
Subject to Damage from	
Weathering:	**severe**
Frost Line:	**48"**
Depth Termite:	**slight to moderate**
Winter Design Temp:	**-20˚F**
Ice Barrier Required:	**YES**
Flood Hazards:	**NO**
Air Freezing Index:	**3034 ˚F-Days**
Mean Annual Temp:	**42.5˚F**

PASSIVE HOUSE DESIGN CRITERIA

Heating Degree Days:	**7090**
Cooling Degree Days:	**899**
Climate Zone:	**6**
Mean Days Clear:	
Mean Days Rain:	
Mean Days Snow:	
Pct Possible Sunshine:	**55%**
Avg Annual Precipitation:	**26.74"**
Avg Annual Snowfall:	**31.9"**
Conditioned Area:	**2012.87 sq.ft.**
Conditioned Volume:	**21,334.35 cu.ft.**



PROPOSED SITE PLAN
PH01:BRK / PASSIVE HOUSE BROOKINGS
1" = 16'-0"

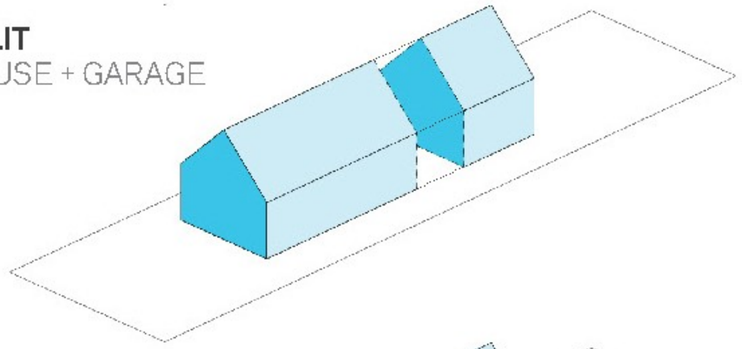
LOT 7A (street address to be assigned)
3rd Avenue
Brookings, SD 57006
lat: 44°18'57"N lon: 96°48'00"W
elevation: 1642'
declination: 3°7'E

LEGAL DESCRIPTION: LOTS 5A, 6A, AND 7A OF PARKDALE HOME ADDITION, BEING A REPLAT OF LOTS 5, 6, AND 7 AND THE NORTH 8 FEET OF LOT 8 OF PARKDALE HOME ADDITION, CITY OF BROOKINGS, BROOKINGS COUNTY, SD.

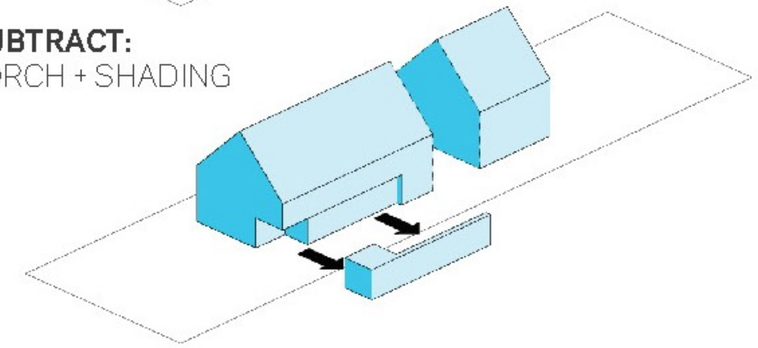
ZONING: R-2 / Residence R-2 Two-Family District

Note: The lots were replatted following a sub-division in Nov. 2016. The two "narrow" lots (6A and 7A) as approved do not meet the established R-2 zoning for minimum lot width.

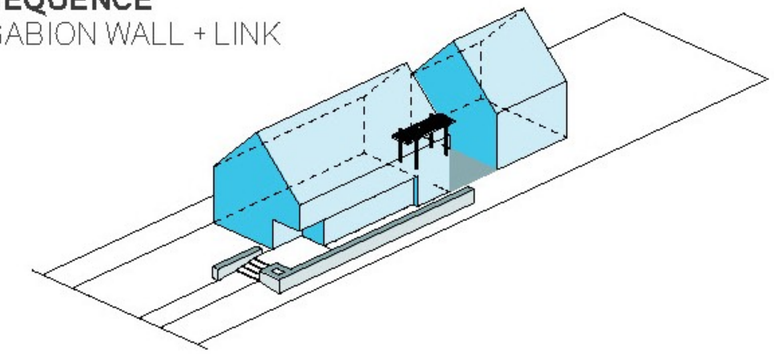
SPLIT
HOUSE + GARAGE

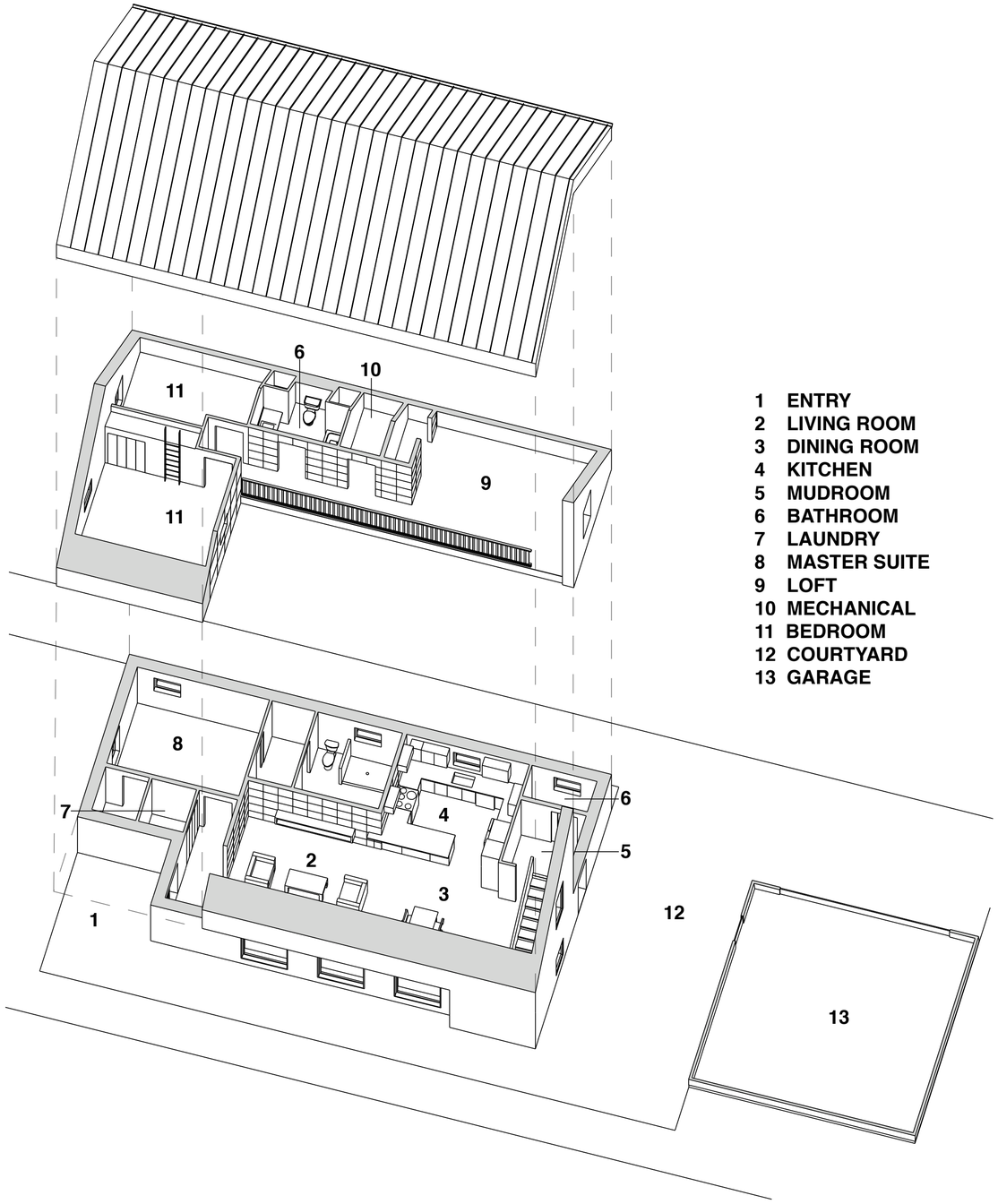


SUBTRACT:
PORCH + SHADING



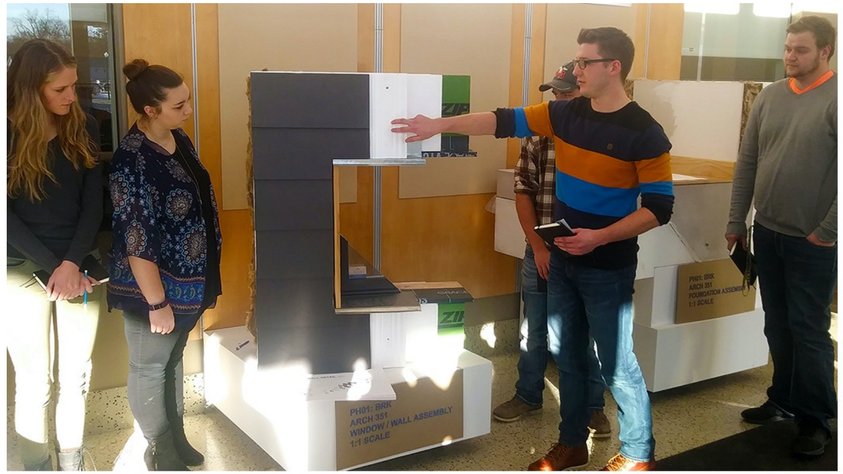
SEQUENCE
GABION WALL + LINK





1 ENTRY
2 LIVING ROOM
3 DINING ROOM
4 KITCHEN
5 MUDROOM
6 BATHROOM
7 LAUNDRY
8 MASTER SUITE
9 LOFT
10 MECHANICAL
11 BEDROOM
12 COURTYARD
13 GARAGE


FIRE SPRINKLER WATER


PHYS. BRK
ARCH 351
WINDOW / WALL ASSEMBLY
1:1 SCALE


ZIP System


CertainTeed
OPTIMA


ZIP System


902

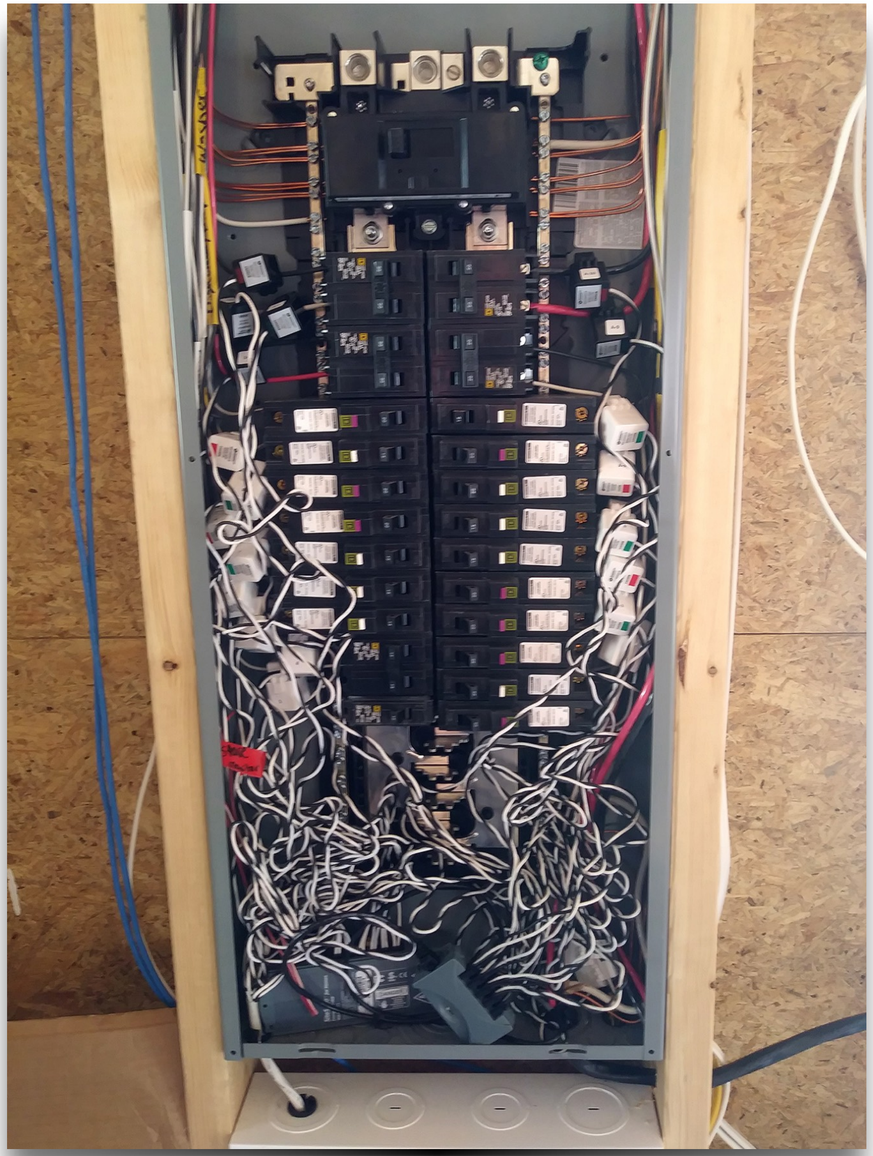
Ribbon Cutting

phius con
NEW YORK 2021

Data

Post Occupancy & Monitoring

Site Sage Energy & IAQ Monitoring
Enphase PV System Monitoring
Behavioral and Social Research with Human Subjects (HSR)
Incidental Homeowner Activities



SiteSage For Homes: Channel Setup Worksheet

Page 1 of 2

Installation Address: 902 3rd STREET, BROOKINGS, SD 57006

Monitored Panel: MAIN PANEL (Descriptive name, e.g.: Main Panel)

Energy Monitor Serial # (ePod): EM2A1 20138

Gateway Serial #: EG1A1 9742 3897

Monitor Powered by Breaker #:

Computed Mains?

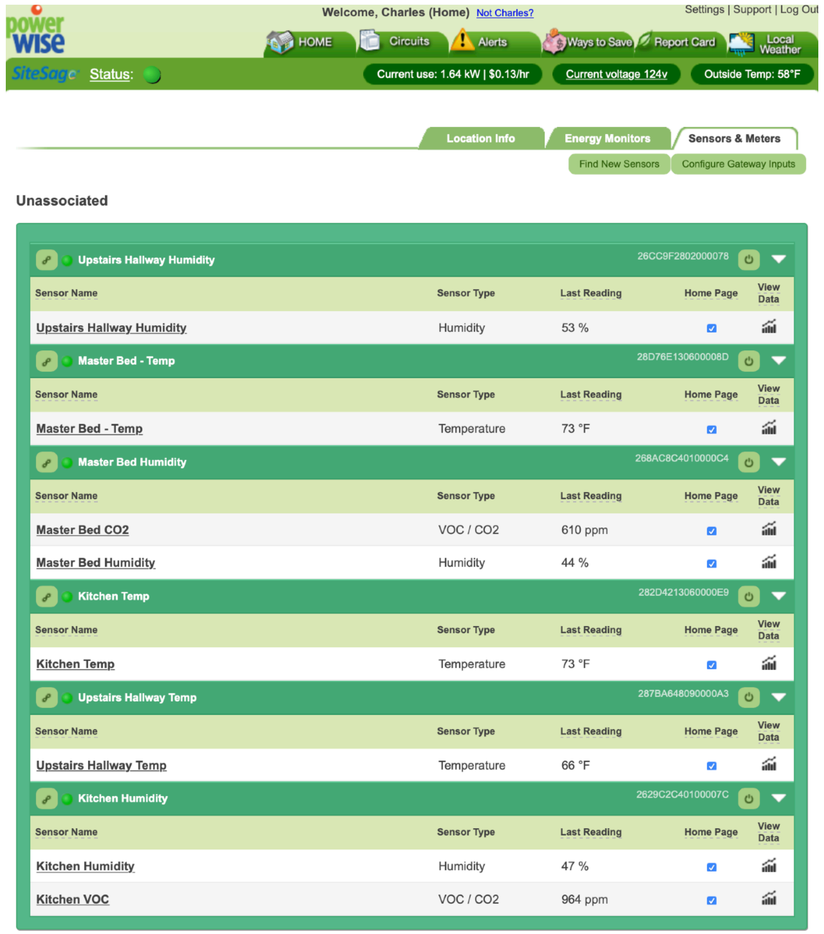
If you can't connect CTs to the Mains, SiteSage will estimate Mains by summing branch circuits

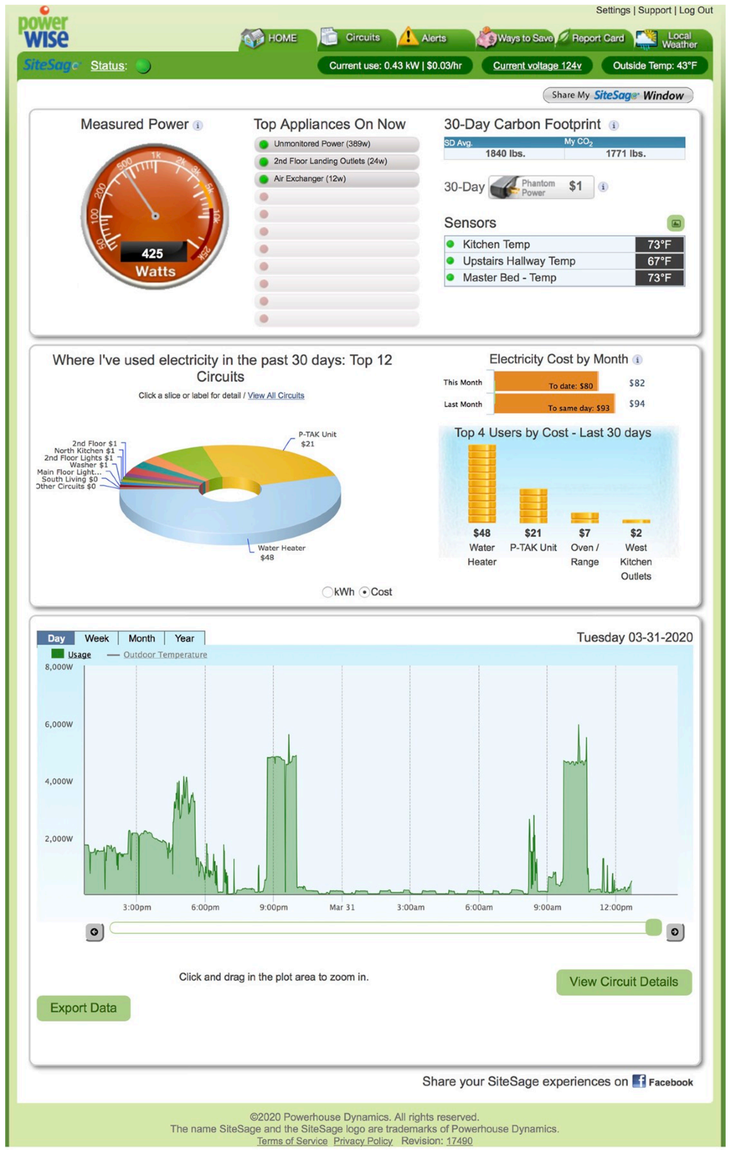
Breaker Number(s)	Size (A)	Double Breaker?	Circuit Label	SiteSage Sensors and Channels: CT/Sensor Size (Check box or specify Other) White 20A	Black 50A	Large 150A	2 CTs?	Monitor Channel #	
			MAIN			✓		1	Best used for Mains
			MAIN			✓		2	Best used for Mains
25	15	✓	AIR MAKE-UP	✓				3	
23	15	✓	AIR MAKE-UP	✓				4	
21	15		MASTER BEDRM OUTLETS	✓				5	
19	15		MAIN FLOOR LIGHTS	✓				6	
17	15		2D FLOOR LIVING OUTLETS	✓				7	
15	20		1/2 BATH, 2D FL BATH	✓				8	
13	20		WASHER	✓				9	
11	15		UPSTAIRS BEDROOMS	✓				10	
10	15		2D FLOOR LIGHTS	✓				11	
22	?		MASTER BATH OUTLETS	✓				12	
5	?	✓	DRYER		✓			13	
7	?	✓	DRYER		✓			14	
3	?	✓	WATER HEATER		✓			A-1	For M-24h/M-44h
1	?	✓	WATER HEATER		✓			A-2	
20	20		NW KITCHEN	✓				A-3	
18	15		S. LIVING RM OUTLETS	✓				A-4	
16	15		N. LIVING RM OUTLETS	✓				A-5	
12	20		N KITCHEN OUTLET	✓				A-6	
8	20	✓	P-TAK UNIT	✓				A-7	
6	20	✓	P-TAK UNIT	✓				A-8	
4	?	✓	RANGE		✓			A-9	
2	?	✓	RANGE		✓			A-10	

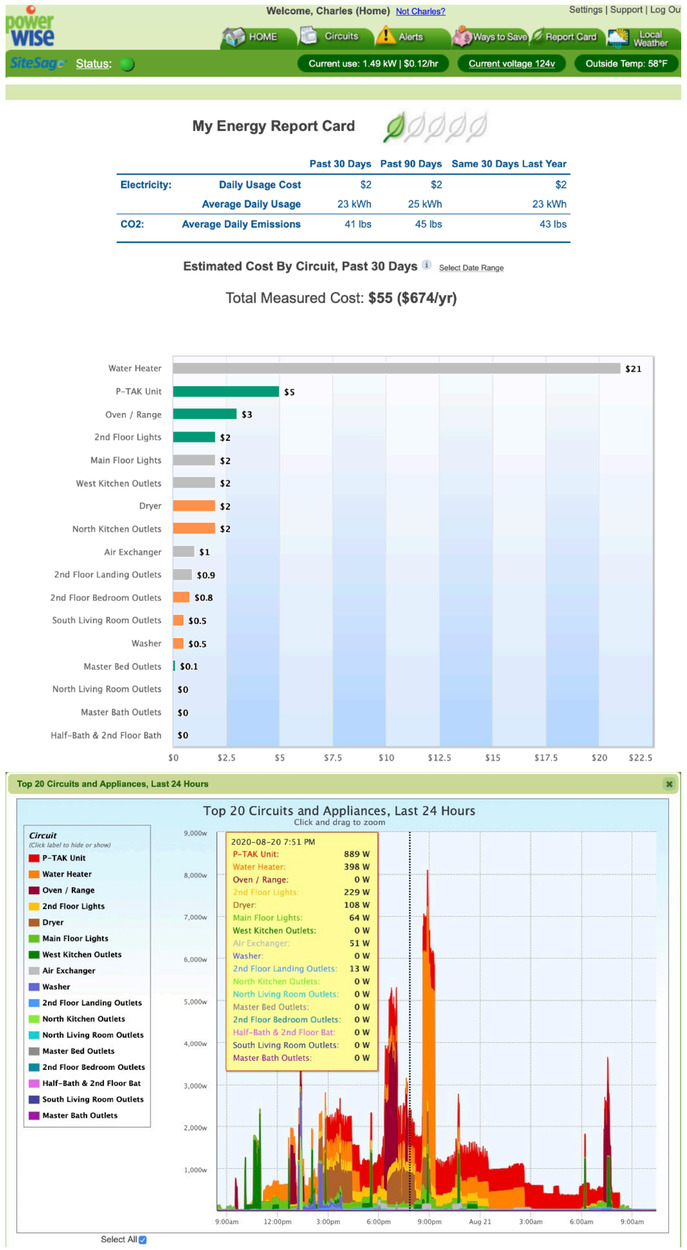
Note: Green label CTs on odd channels; Red on even

For SiteSage M-44h continue to Side 2 ⟶

Electrical usage monitoring:
Site-Sage 24 connections at individual breakers



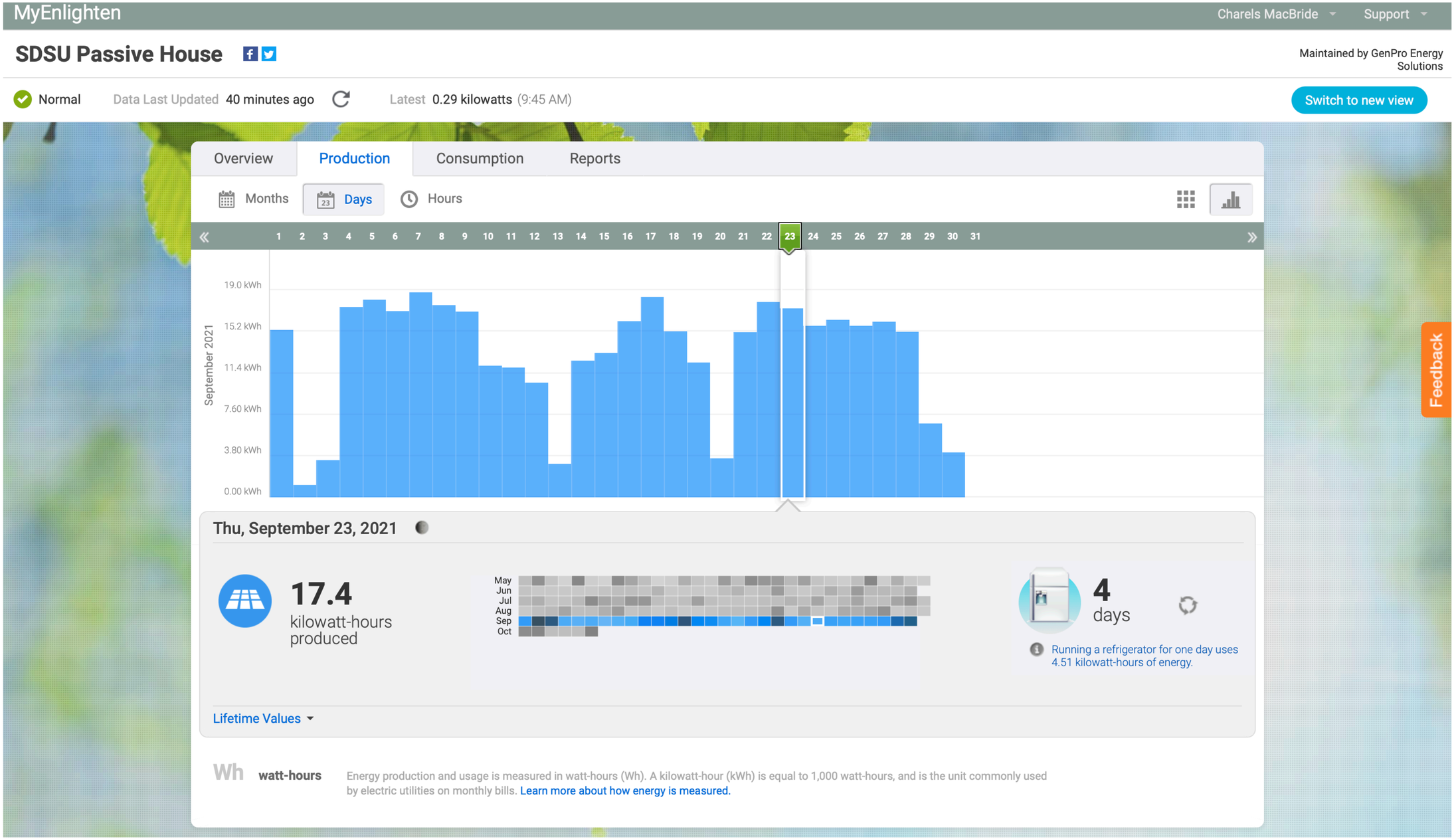




IAQ monitored by Site-Sage 24

PowerWise Home page (above) and real-time circuit usage (right).

Photovoltaic installation



The online PV portal indicates generated electricity from the PV system has thus far averaged slightly less than the electrical demand, roughly 15-19 kWh on sunny days.

BUILDING INFORMATION

Category:	**Residential**
Status:	**In planning**
Building type:	**New construction**
Year of construction:	**2017**
Units:	**1**
Number of occupants:	**4 (Design)**

Boundary conditions

Climate:	**User defined**	
Internal heat gains:	**0.8**	Btu/hr ft²
Interior temperature:	**68**	°F
Overheat temperature:	**77**	°F

Building geometry

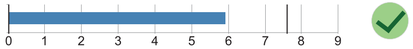
Enclosed volume:	**32657.6**	ft³
Total area envelope:	**6571.8**	ft²
AV ratio:	**0.2**	1/ft
Floor area:	**1948.3**	ft²

PASSIVEHOUSE REQUIREMENTS

Certificate criteria: PHIUS+ 2015 Standard

Heating demand

specific:	**5.93**	kBtu/ft²yr
target:	**7.6**	kBtu/ft²yr
total:	11557.61	kBtu/yr

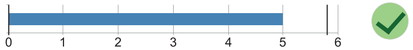


Cooling demand

specific:	**1.02**	kBtu/ft²yr
target:	**2.1**	kBtu/ft²yr
total:	1985.05	kBtu/yr
latent:	0.02	kBtu/ft²yr

Heating load

specific:	**4.99**	Btu/hr ft²
target:	**5.8**	Btu/hr ft²
total:	9729.94	Btu/hr

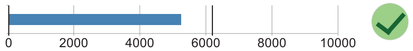


Cooling load

specific:	**2.83**	Btu/hr ft²
target:	**4**	Btu/hr ft²
total:	5506.87	Btu/hr

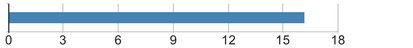
Primary energy

specific:	**5237**	kWh/Person yr
target:	**6200**	kWh/Person yr
total:	71465.37	kBtu/yr



Site energy

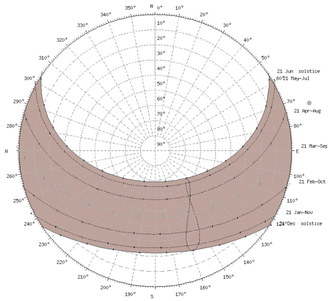
total:	16.19	kBtu/ft²yr
building systems:	36.58	kBtu/yr
photovoltaic savings:	0	kBtu/ft²yr



Air tightness

ACH50:	**0.6**	1/hr
target:	**0.95**	1/hr
CFM50 per envelope area:	**0.03**	cfm/ft²
target:	**0.05**	cfm/ft²

PHO1:BRK BUILDING SYSTEMS



Heating/ Cooling Degree Days

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Heating Degree Days	1587	1268	1008	543	240	50	10	22	165	508	960	1448	7809
Cooling Degree Days	0	0	0	0	35	149	298	220	42	0	0	0	744

Prevailing Winds

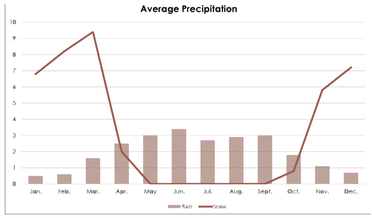
Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Direction	NW.	NW.	WNW	WNW	NNW	NNW	N	N	S	S	S	S	S
Speed	11	11	12	13	12	11	10	10	10	11	12	11	**11**
Max	67	58	56	64	53	71	66	47	53	61	58	53	**71**

Weather Indicators

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Average Winds Speed	10.9	11.1	12.4	12.9	11.8	10.7	9.8	9.8	10.3	10.7	11.5	10.7	**11.1**
Clear Days	8	7	6	7	7	9	12	12	12	11	7	8	**105**
Partly Cloudy Days	8	7	8	8	10	11	12	11	8	8	7	7	**103**
Cloudy Days	15	15	17	15	14	11	8	9	10	12	16	16	**157**
Avg Relative Humidity	56.5	75	75.5	73	68.5	68.5	70.5	71	72	70	70	74	**77**

Average Temperature

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Average Temperature	13.8	19.7	32.5	46.9	58.4	68.3	74.3	71.4	60.9	48.6	33	18.3	**45.5**
Average Max Temperature	24.3	29.6	42.3	59	70.7	80.5	86.3	83.3	73.1	61.2	43.4	28	**56.8**
Average Min. Temperature	3.3	9.7	22.6	34.8	45.9	56.1	62.3	59.4	48.7	36	22.6	8.6	**34.2**



ENERGY RECOVERY VENTILATION - Recovers both sensible and latent head from outgoing (exhaust) air stream by transferring it to the incoming (supply) air stream.
Ultimate Air 200DX up to 200 CFM
Apparent Sensible Effectiveness (ASE) of 93%.
SRE of 81% in heating season
TRE of 40% in the cooling season
Pre heater needed for operating temps below 10 degrees F

DHW: TANK-LESS WATER HEATER - ECO Smart ECO 36 36 KW with 99.8% efficiency.
3.9 GPM unit capacity with 42 degree inlet Temp.

MINI SPLIT HEAT PUMP - LG-LS090HSV4
Ductless Indoor and outdoor condenser
SEER: 21.5
HSPF: 10.8
Operating Range:
Cooling: 14°F DB to 118°F DB
Heating: -4°F WB to 65°F WB

ROOF ASSEMBLY - R-84 - Standing seam, sheathing, 4" EPS foam insulation, sheathing, 24" TJI joist 2'-00" o.c. filled w/ dense pack cellulose, taped and sealed sheathing (Vapor Barrier),interior finish.

DOUBLE HEIGHT VOLUME - Allows for better air flow throughout the house

Floor Assembly - R-50 - 12 inch EPS foam insulation, engineer backfill, 6" concrete, finish floor

WALL ASSEMBLY - R-45 - Rain Screen, 2.5" InSoFast Insulation, 2" EPS Foam, 0.75" OSB sheathing taped and sealed, 2x6 framed cavity wall infill with Knauff mineral wool insulation. Interior finish.

WINDOWS PASSIVE HEATING & COOLING - Provides breeze to enter house in summer for natural ventilation and cooling

Deflects heat from escaping the house.

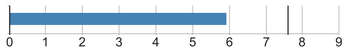
Large south facing windows allow sunlight to warm the house in Winter Months

PASSIVE COOLING - LOUVERS - Provides sun shading in summer months to minimize solar heat gain.

Certificate criteria: **PHIUS+ 2015 Standard**

Heating demand

specific:	**5.93**	kBtu/ft²yr
target:	**7.6**	kBtu/ft²yr
total:	11557.61	kBtu/yr

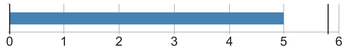


Cooling demand

specific:	**1.02**	kBtu/ft²yr
target:	**2.1**	kBtu/ft²yr
total:	1985.05	kBtu/yr
latent:	0.02	kBtu/ft²yr

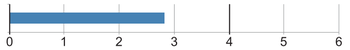
Heating load

specific:	**4.99**	Btu/hr ft²
target:	**5.8**	Btu/hr ft²
total:	9729.94	Btu/hr



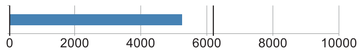
Cooling load

specific:	**2.83**	Btu/hr ft²
target:	**4**	Btu/hr ft²
total:	5506.87	Btu/hr



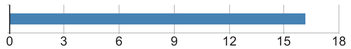
Primary energy

specific:	**5237**	kWh/Person yr
target:	**6200**	kWh/Person yr
total:	71465.37	kBtu/yr



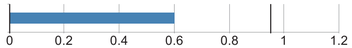
Site energy

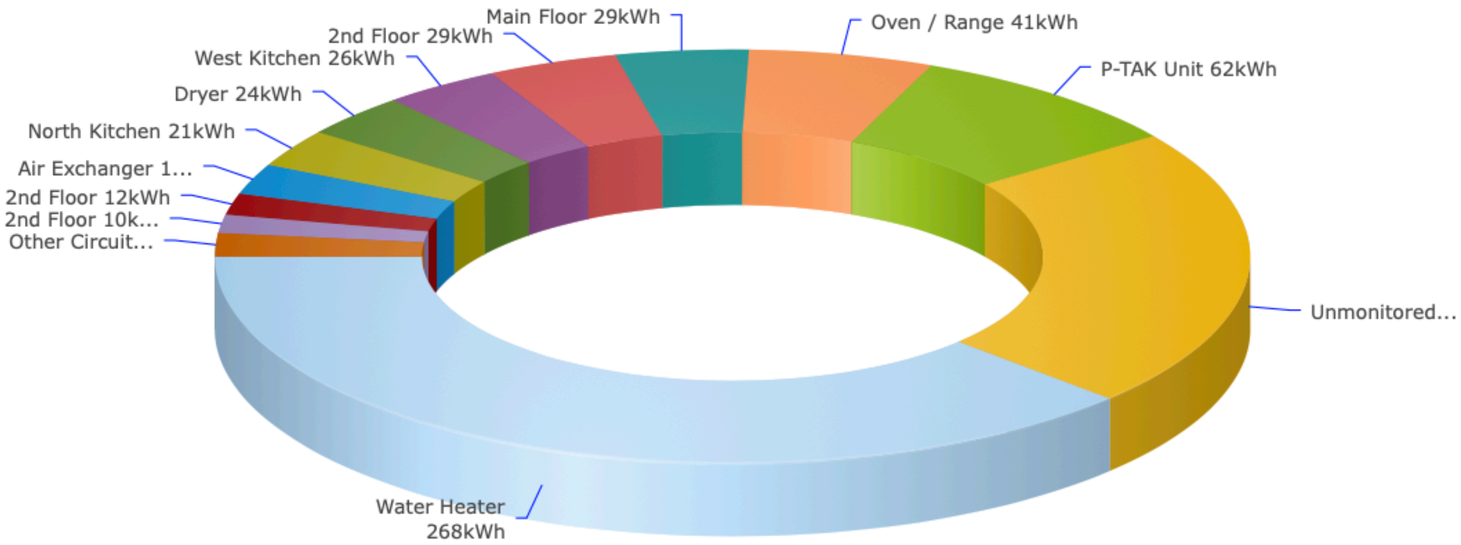
total:	16.19	kBtu/ft²yr
building systems:	36.58	kBtu/yr
photovoltaic savings:	0	kBtu/ft²yr



Air tightness

ACH50:	**0.6**	1/hr
target:	**0.95**	1/hr
CFM50 per envelope area:	**0.03**	cfm/ft²
target:	**0.05**	cfm/ft²





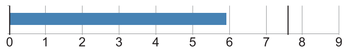
SEPTEMBER 2021 REPORT

Water Heater	268 kWh
Unmonitored	155 kWh
Minisplit	62 kWh
Oven/Range	41 kWh
Main floor	29 kWh
Second floor	26 kWh
Dryer	24 kWh
North Kitchen	21 kWh
ERV	17 kWh
Second floor	12 kWh
Second floor	10 kWh
Other circuits	13 kWh
TOTAL	678 kWh = 2313.34 kBTU

Certificate criteria: PHIUS+ 2015 Standard

Heating demand

specific:	**5.93**	kBtu/ft²yr
target:	**7.6**	kBtu/ft²yr
total:	11557.61	kBtu/yr

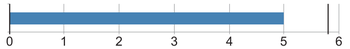


Cooling demand

specific:	**1.02**	kBtu/ft²yr
target:	**2.1**	kBtu/ft²yr
total:	1985.05	kBtu/yr
latent:	0.02	kBtu/ft²yr

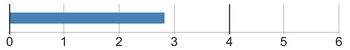
Heating load

specific:	**4.99**	Btu/hr ft²
target:	**5.8**	Btu/hr ft²
total:	9729.94	Btu/hr



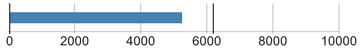
Cooling load

specific:	**2.83**	Btu/hr ft²
target:	**4**	Btu/hr ft²
total:	5506.87	Btu/hr



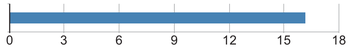
Primary energy

specific:	**5237**	kWh/Person yr
target:	**6200**	kWh/Person yr
total:	71465.37	kBtu/yr



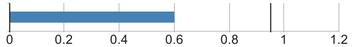
Site energy

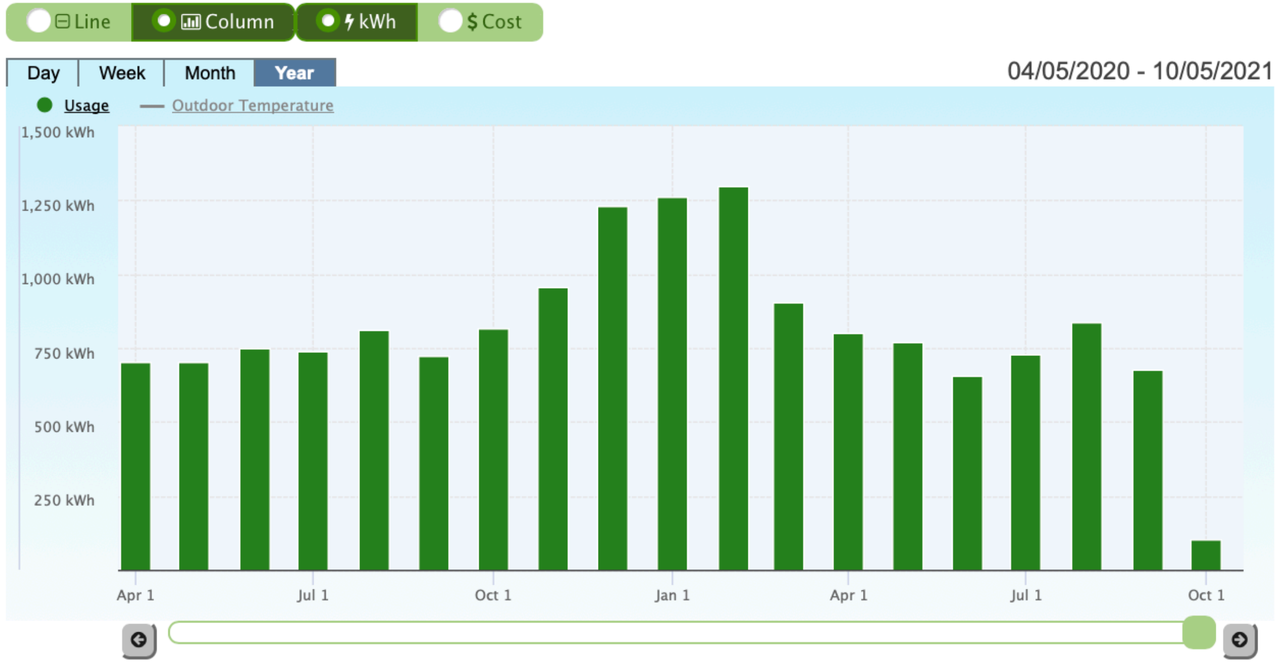
total:	16.19	kBtu/ft²yr
building systems:	36.58	kBtu/yr
photovoltaic savings:	0	kBtu/ft²yr



Air tightness

ACH50:	**0.6**	1/hr
target:	**0.95**	1/hr
CFM50 per envelope area:	**0.03**	cfm/ft²
target:	**0.05**	cfm/ft²





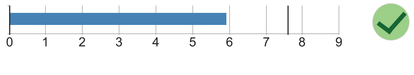
OCTOBER 2020 - SEPTEMBER 2021 REPORT

OCT 2020	815 kWh
NOV 2020	959 kWh
DEC 2020	1,233 kWh
JAN 2021	1,262 kWh
FEB 2021	1,298 kWh
MAR 2021	905 kWh
APR 2021	803 kWh
MAY 2021	722 kWh
JUN 2021	655 kWh
JUL 2021	731 kWh
AUG 2021	840 kWh
SEP 2021	680 kWh
TOTAL	10,903 kWh = 37,201.04 kBTU

Certificate criteria: PHIUS+ 2015 Standard

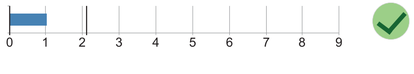
Heating demand

specific:	**5.93**	kBtu/ft²yr
target:	**7.6**	kBtu/ft²yr
total:	11557.61	kBtu/yr



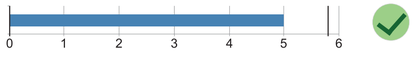
Cooling demand

specific:	**1.02**	kBtu/ft²yr
target:	**2.1**	kBtu/ft²yr
total:	1985.05	kBtu/yr
latent:	0.02	kBtu/ft²yr



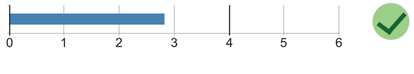
Heating load

specific:	**4.99**	Btu/hr ft²
target:	**5.8**	Btu/hr ft²
total:	9729.94	Btu/hr



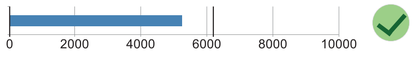
Cooling load

specific:	**2.83**	Btu/hr ft²
target:	**4**	Btu/hr ft²
total:	5506.87	Btu/hr



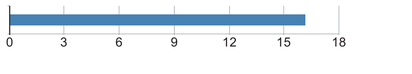
Primary energy

specific:	**5237**	kWh/Person yr
target:	**6200**	kWh/Person yr
total:	71465.27	kBtu/yr



Site energy

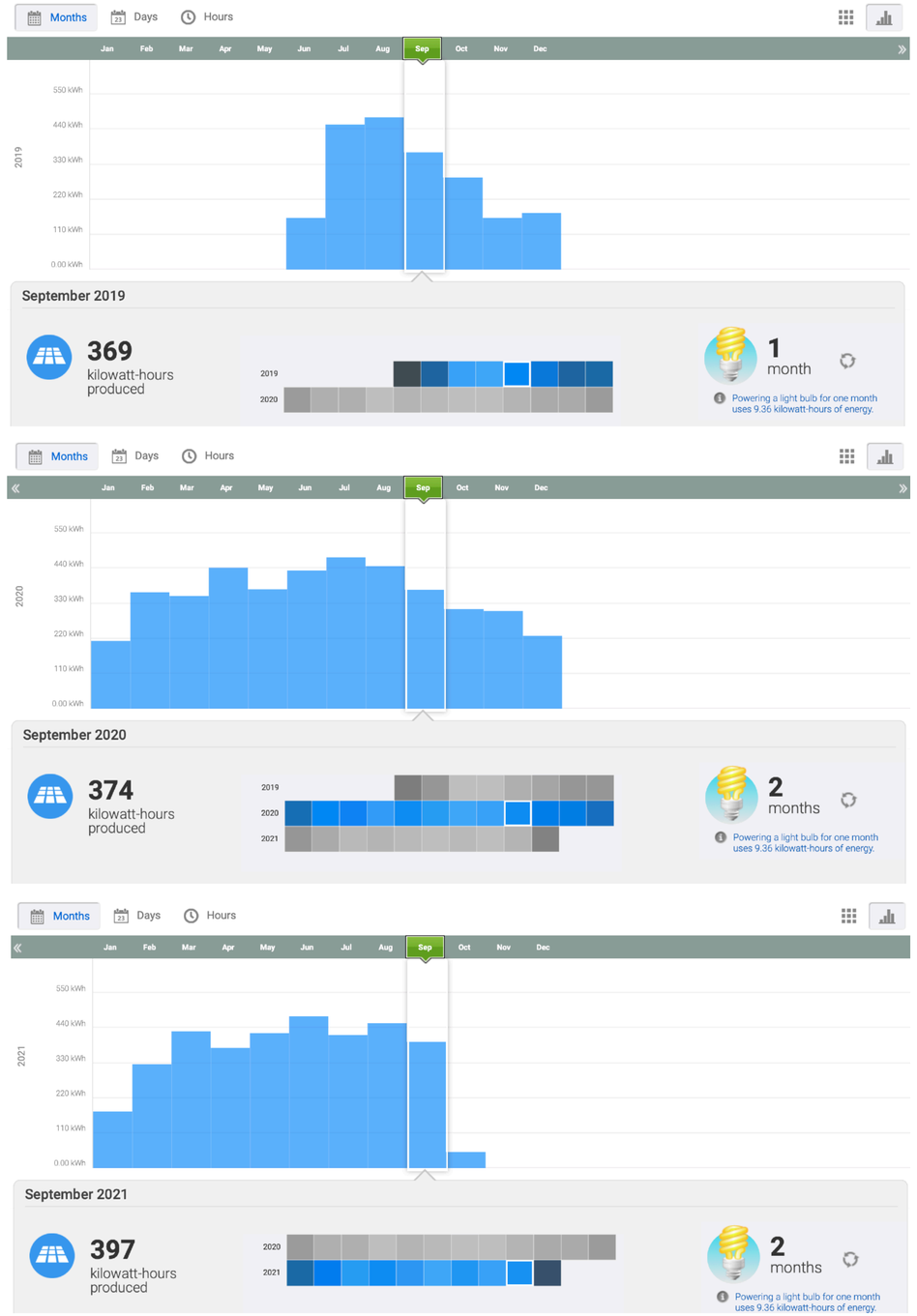
total:	16.19	kBtu/ft²yr
building systems:	36.58	kBtu/yr
photovoltaic savings:	0	kBtu/ft²yr



Air tightness

ACH50:	**0.6**	1/hr
target:	**0.95**	1/hr
CFM50 per envelope area:	**0.03**	cfm/ft²
target:	**0.05**	cfm/ft²

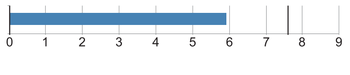
The pre-certification did not include the PV array.
Funding and design for PV came later in the construction phase.
PV generation began in June 2019.



Certificate criteria: PHIUS+ 2015 Standard

Heating demand

specific:	**5.93**	kBtu/ft²yr
target:	**7.6**	kBtu/ft²yr
total:	11557.61	kBtu/yr

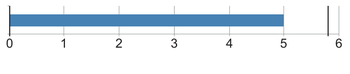


Cooling demand

specific:	**1.02**	kBtu/ft²yr
target:	**2.1**	kBtu/ft²yr
total:	1985.05	kBtu/yr
latent:	0.02	kBtu/ft²yr

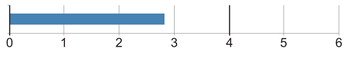
Heating load

specific:	**4.99**	Btu/hr ft²
target:	**5.8**	Btu/hr ft²
total:	9729.94	Btu/hr



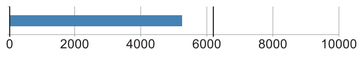
Cooling load

specific:	**2.83**	Btu/hr ft²
target:	**4**	Btu/hr ft²
total:	5506.87	Btu/hr



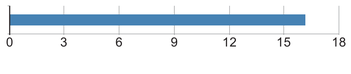
Primary energy

specific:	**5237**	kWh/Person yr
target:	**6200**	kWh/Person yr
total:	71465.27	kBtu/yr



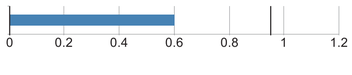
Site energy

total:	16.19	kBtu/ft²yr
building systems:	36.58	kBtu/yr
photovoltaic savings:	0	kBtu/ft²yr



Air tightness

ACH50:	**0.6**	1/hr
target:	**0.95**	1/hr
CFM50 per envelope area:	**0.03**	cfm/ft²
target:	**0.05**	cfm/ft²



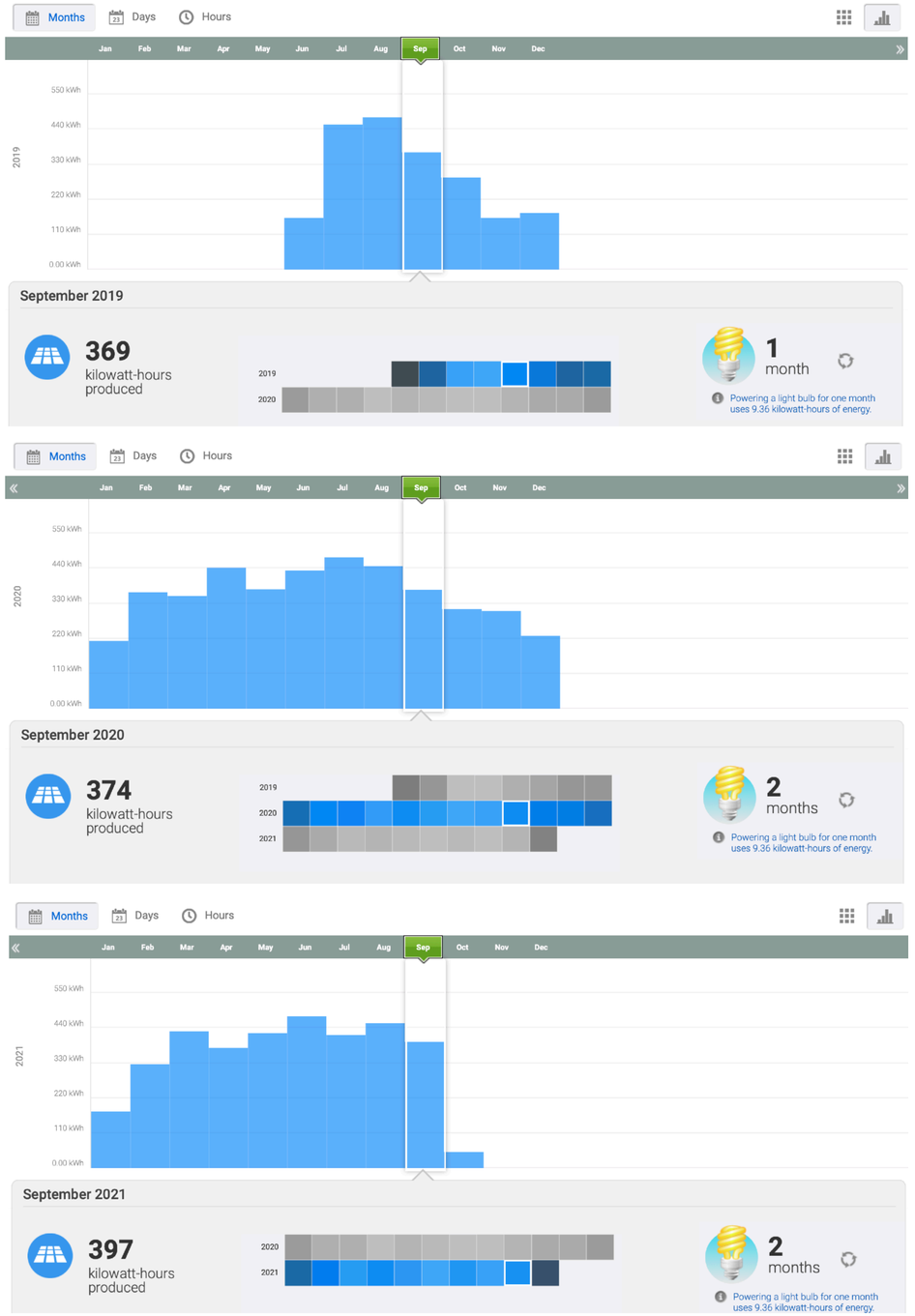
OCTOBER 2020 - SEPTEMBER 2021

PV PRODUCTION REPORT

OCT 2020	313 kWh
NOV 2020	307 kWh
DEC 2020	228 kWh
JAN 2021	178 kWh
FEB 2021	328 kWh
MAR 2021	430 kWh
APR 2021	379 kWh
MAY 2021	426 kWh
JUN 2021	478 kWh
JUL 2021	419 kWh
AUG 2021	455 kWh
SEP 2021	397 kWh
TOTAL	4,338 kWh

= 14,801.26 kBTU

= 7.35 kBTU/ft2-yr



Behavioral and Social Research with Human Subjects (HSR)
Incidental Homeowner Activities

Do you refer to the online PowerWise and/or Enphase dashboards? What are you looking at when youre there?

At what temperature do you keep your thermostat set?

Have you noticed any uncomfortable indoor conditions with temperature or humidity?

Have the kitchen or laundry appliances been a problem or altered your habits?

Have you learned how to use and program the wall-mounted minisplit heating/ cooling units?

Have you learned how to check and maintain the Water Heater and/or the Zehnder air exchanger?

Has the PV system posed any challenges?

Have the utility bills been better that what you would normally expect?

Do you open and close the windows (or keep windows open)?

You had mentioned that the CO2 readings were spiking when using the stationary bike – can you elaborate?

You had mentioned that your daughter enjoys the house acoustics when playing piano – can you elaborate?

Behavioral and Social Research with Human Subjects (HSR)
Incidental Homeowner Activities

Do you refer to the online PowerWise and/or Enphase dashboards? What are you looking at when youre there?
yes

At what temperature do you keep your thermostat set?
68°F

Have you noticed any uncomfortable indoor conditions with temperature or humidity?
humidity in bathrooms & kitchen range

Have the kitchen or laundry appliances been a problem or altered your habits?
only slightly

Have you learned how to use and program the wall-mounted minisplit heating/ cooling units?
yes

Have you learned how to check and maintain the Water Heater and/or the Zehnder air exchanger?
yes

Has the PV system posed any challenges?
only with the vendor, not the system

Have the utility bills been better that what you would normally expect?
only slightly – PV sellback rate is very low

Do you open and close the windows (or keep windows open)?
yes

You had mentioned that the CO2 readings were spiking when using the stationary bike – can you elaborate?
yes – opening interior doors helps

You had mentioned that your daughter enjoys the house acoustics when playing piano – can you elaborate?
great combination of a "live" space with an airtight building

phius con
NEW YORK 2021

Teaching

Monitoring as an Emerging Professional Role


TEST
TL
EATON
TEST
TL
EATON
TEST
TL
EATON
10KA
120/240V~
EATON
TypeCH
Powerhouse Dynamics
890-000002-B
20A/0.333V
Hi-Pot OK
191226

WUFI® Passive Free V.3.0.3.0 F:\fa16\ARCH651\PH0.BRK Therm+WUFI\WUFI\WUFI PROJECT FILES\PH01.BRK_11.22.2016.mwp

File Input Options Database Help

Scope **Passive house verification** | English/IP/Outer dimensions | Assign data | **Project/Case 1: PH01:BRK/Building/PH case: Passive house: Residential/Zone 1: Inside/Visualized components/Component 3**

- Visualized components
  - Component 1
  - Component 2
  - Component 3
  - Component 4
  - Component 5
  - Component 6
  - Component 7
  - Component 8
  - Component 9
  - Component 10
  - Component 11
  - Component 12
  - Component 13
  - Component 14
  - Component 15
  - Component 16
  - Component 17
  - Component 18
  - Component 19
  - Component 20
  - Component 21
  - Component 22
  - Component 23
  - Component 24
  - Component 25
  - Component 26
- Not visualized components
- Internal Loads
- Ventilation/Rooms
- Thermal bridges
- Attached zones
  - Attached zone 1: Unheated cellar
    - Visualized components
    - Not visualized components

General | Assembly | Surface

Assigned assembly

Name	R [hr ft² °F/Btu]
PH01:BRK Wall	63.992

Select from database | Edit

Available assemblies

Inclined Roof #2	101.152
New	7.211
PH01:BRK-InSoFast Wall	51.398
Lightweight timber framed wall #3	38.015
New	25.759

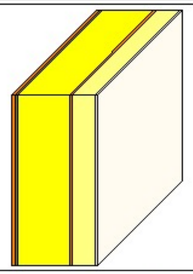
New | Delete | Copy | Insert | New/Insert: after | Assign

Homogenous layers

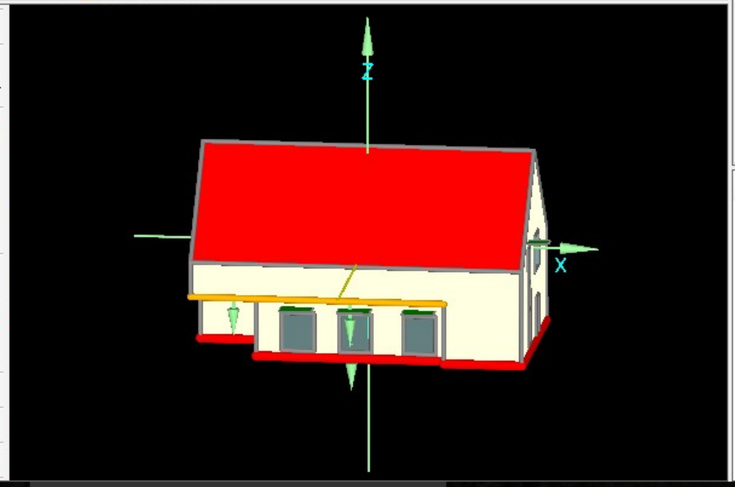
Thermal resistance: 63.992 hr ft² °F/Btu (without Rsi, Rse)

Heat transfer coefficient(U-value): 0.02 Btu/hr ft² °F

Thickness: 19.745 in

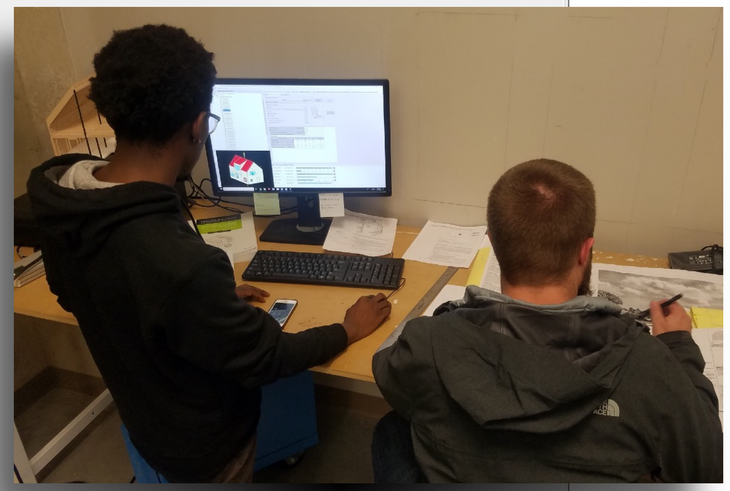


Nr.	Material/Layer (from outside to inside)	ρ [lb/ft³]	c [Btu/lb°F]	λ [Btu/hr ft °F]	Thickness [in]	Color
1	Oak, longitudinal	42.76	0.36	0.1733	0.75	
2	Oriented Strand Board (density 595 kg/m³)	37.14	0.36	0.0751	0.591	
3	Cellulose Fiber (heat cond.: 0,04 W/mK)	4.37	0.6	0.0231	11.875	
4	Oriented Strand Board (density: 630 kg/m³)	39.33	0.36	0.0751	0.787	



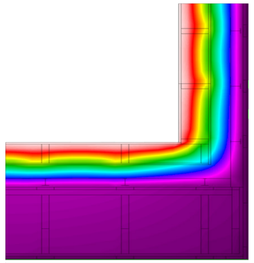
Data state/results | Show warnings

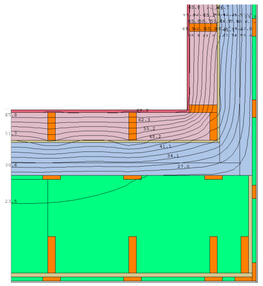
Heating demand:	5.99	kBtu/ft²yr
Cooling demand:	0.99	kBtu/ft²yr
Heating load:	5.13	Btu/hr ft²
Cooling load:	2.88	Btu/hr ft²
Primary energy:	5282	kWh/Person yr
Site energy:	16.48	kBtu/ft²yr

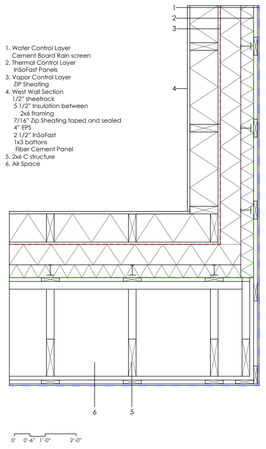


Search the web and Windows

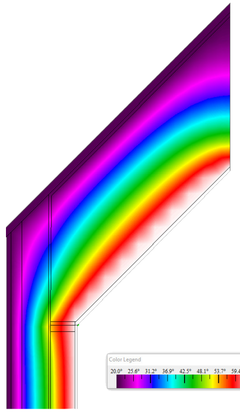
3:14 PM
11/28/2016

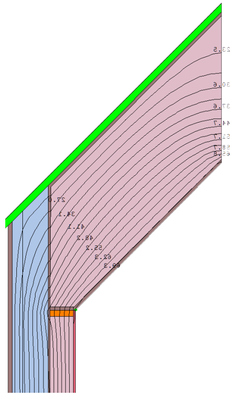




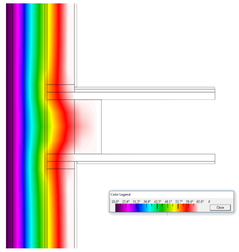


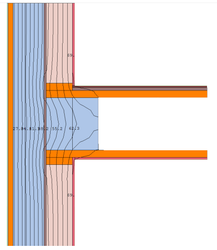
Analysis of wall with 4" of EPS



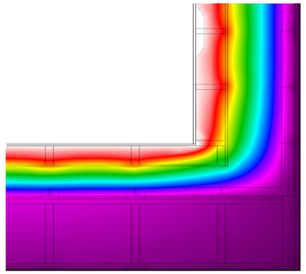


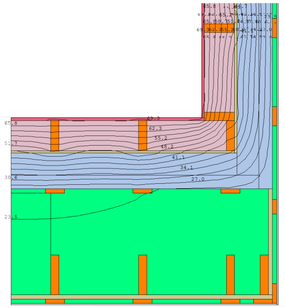
Analysis of wall to Ceiling

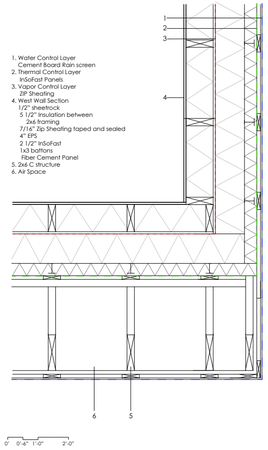




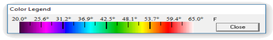
Analysis of wall to 2nd floor

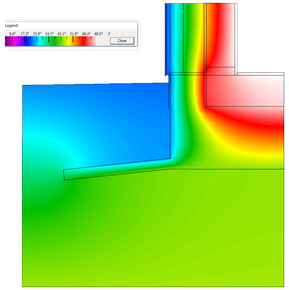




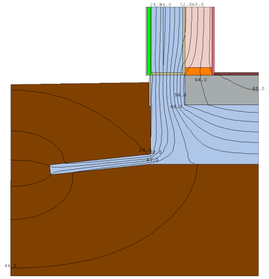


Analysis of wall with 6" EPS





Analysis of wall to ground



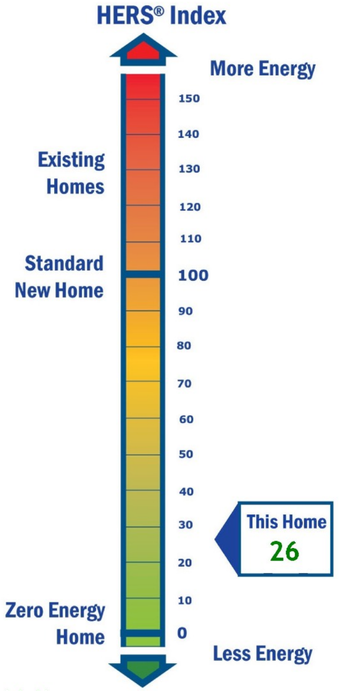

Dual-Channel Digital Micromanometer and Control
Baseline
Time Zero
Pressure
Mode
Set
Range
Config
-48.9 Pa
197 cfm
C2
Speed
Device
DM-2 mark II
Mode
1
Range
Config
2
Setup
3

ZERO
ENERGY READY HOME

YOUR HOME WAS DESIGNED, ENGINEERED, AND CONSTRUCTED IN CONFORMANCE TO U.S. DEPARTMENT OF ENERGY (DOE) GUIDELINES FOR EXTRAORDINARY LEVELS OF EXCELLENCE AND QUALITY.

This home built at	910 3rd Avenue
By	Brookings Built Green
Verified by	David Holtzclaw

an independent professional organization, to meet or exceed strict home performance guidelines set by The U.S. Department of Energy on 4/30/2019



THIS HOME MEETS OR EXCEEDS THE MINIMUM CRITERIA FOR THE FOLLOWING:

EPA WaterSense for New Homes Program
DOE Zero Energy Ready Home Quality Management Guidelines

REM/Rate - Residential Energy Analysis and Rating Software v15.7.3

SAM RASHKIN, CHIEF ARCHITECT
BUILDING TECHNOLOGIES
U.S. DEPARTMENT OF ENERGY

ENERGY STAR® CERTIFIED NEW HOME

Builder Name: Brookings Built Green
Permit Date/Number:
Home Address: 910 3rd Avenue
Brookings, SD 57006

Rating Company: Transduction Technologies
Rater Identification Number: 0595540
Rating Date: 2018-12-07
Version: 3.0

Standard Features of an ENERGY STAR Certified New Home

Your ENERGY STAR certified new home has been designed, constructed, and independently verified to meet rigorous requirements for energy efficiency set by the U.S. Environmental Protection Agency (EPA), including:

Thermal Enclosure System

A complete thermal enclosure system that includes comprehensive air sealing, quality-installed insulation and high-performing windows to deliver improved comfort and lower utility bills.

Air Infiltration Test: **Htg: 0.32 Clg: 0.32 ACH50**

Primary Insulation Levels:
Ceiling: R-72.0
AGWall: R-54.0 **Floor: R-60.2** **Slab: R-33.4, R-50.0**

Primary Window Efficiency:
U-Value: 0.110, SHGC: 0.250

Water Management System

A comprehensive water management system to protect roofs, walls, and foundations.

Flashing, a drainage plane, and site grading to move water from the roof to the ground and then away from the home.

Water-resistant materials on below-grade walls and underneath slabs to reduce the potential for water entering into the home.

Management of moisture levels in building materials during construction.

Heating, Cooling, and Ventilation System

A high-efficiency heating, cooling system, and ventilation system that is designed and installed for optimal performance.

Total Duct Leakage:
NA

Duct Leakage to Outdoors:
NA

Primary Heating (System Type • Fuel Type • Efficiency):
Electric, Htg: 10.3 HSPF. Clg: 21.5 SEER.

Primary Cooling (System Type • Fuel Type • Efficiency):
Electric, Htg: 10.3 HSPF. Clg: 21.5 SEER.

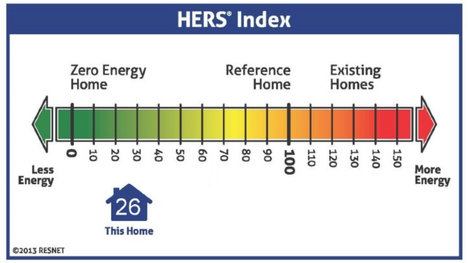
Energy Efficient Lighting and Appliances

Energy efficient products to help reduce utility bills, while providing high-quality performance.

ENERGY STAR Qualified Lighting: **100%**

ENERGY STAR Qualified Appliances and Fans:
Refrigerators: 1 **Dishwashers: 1**
Ceiling Fans: 5 **Exhaust Fans: 0**

Primary Water Heater (System Type • Fuel Type • Efficiency):
Heat pump, Electric, 3.39 EF, 50.0 Gal.



The certificate provides a summary of the major energy efficiency and other construction features that contribute to this home earning the ENERGY STAR, including its Home Energy Rating System(HERS) score, as determined through independent inspection and verification performed by a trained professional. The home Energy Rating System is a nationally-recognized uniform measurement of the energy efficiency of homes.

Note that when a home contains multiple performance levels for a particular feature (e.g., window efficiency or insulation levels), the predominant value is shown. Also, homes may be certified to earn the ENERGY STAR using a sampling protocol, whereby one home is randomly selected from a set of homes for representative inspections and testing. In such cases, the features found in each home within the set are intended to meet or exceed the values presented on this certificate. The actual values for your home may differ, but offer equivalent or better performance.

This certificate was printed using REM/Rate - v15.7.3.

Learn more at www.energystar.gov/homefeatures

phius con
NEW YORK 2021

Assisting Passive House Owner Behavior by Leveraging Energy Monitoring and Post-Occupancy Reports

Charles MacBride, AIA, CPHC
University of Texas at Arlington

Robert Arlt, AIA, CPHC
South Dakota State University