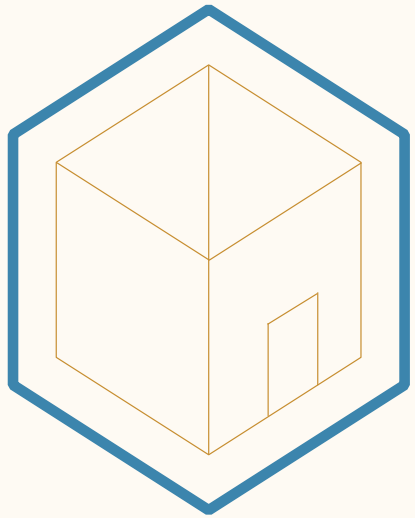
NZE Case Study: Stack Eight



Flywheel Development

February 20, 2020

Flywheel Development: Project Profiles

Perry Street Townhomes

Located in Mount Rainier, MD

4 market rate townhouses

Prince George's County's First Passive House net zero residences

Highest sales price for a home in Mount Rainier

Cycle House

Located at the intersection of North Capitol and Bates Street in the NOMA neighborhood

16 rental units serving people at 60% AMI and below over ground floor retail

19,000 square feet of gross building area

Stack Eight

Located in Ward 8 near the Congress Heights metro

18 new construction stacked flats and townhomes. 100% affordable homeownership

27,000 square feet of gross building area

DC's first Living Building Challenge Petal Certified project. DC's first net zero energy affordable housing project

Stack Eight Project: Deep Dive

Stack Eight Project

Location: Congress Heights neighborhood in Southeast DC. The site is two blocks from St. Elizabeth's and the Metro station

Competitive RFP issued by the DC Department of Housing and Community Development in 2016. Project awarded to Flywheel Development in 2017

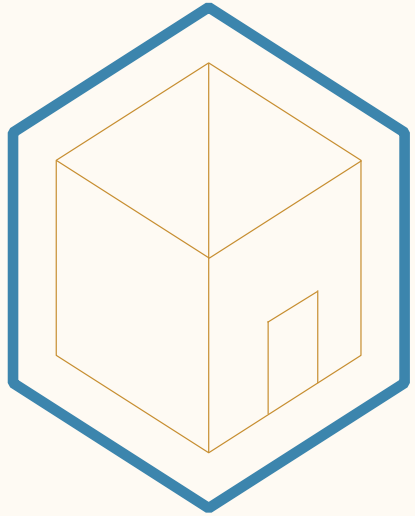
Program: 18 for-sale stacked flats and townhouses maximizes permittable density on site, 100% affordable to 50 and 80% AMI

Construction Start: Summer /Fall 2020

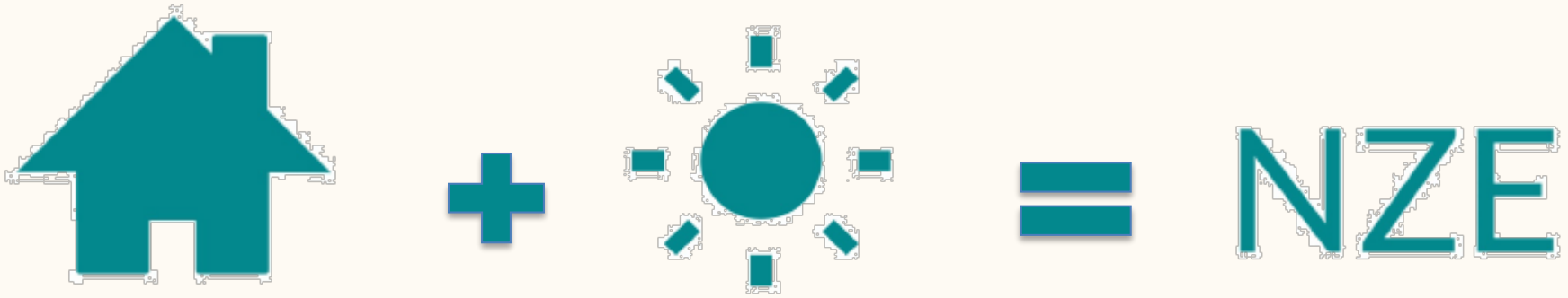
Innovations: passive house + net zero on-site, battery backup power for critical loads, district energy system for heating/cooling/hot water


Roosevelt Memorial
The Pentagon
SOUTHWEST WASHINGTON
The Yards Park
SOUTHEAST WASHINGTON
Pennsylvania Ave SE
DISTRICT OF COLUMBIA
VIRGINIA
395
PENTAGON CITY
AURORA HIGHLANDS
BARRY FARM
Ronald Reagan Washington National Airport
Potomac River
Suitland Pkwy
DISTRICT OF COLUMBIA
Interstate 395 HOV
295
POTOMAC YARD
Hillcrest Heights
DEL RAY
420
Marlow Heights
Janneys Ln
Potomac River
295
Temple Hills
Google
Forest Heights
www.dcbia.org
DCBIA

Designing for Net Zero Energy



The Basic Equation



Super-Efficient Building

Solar Panels

Net Zero Energy

Steps for Designing Net Zero Energy Buildings

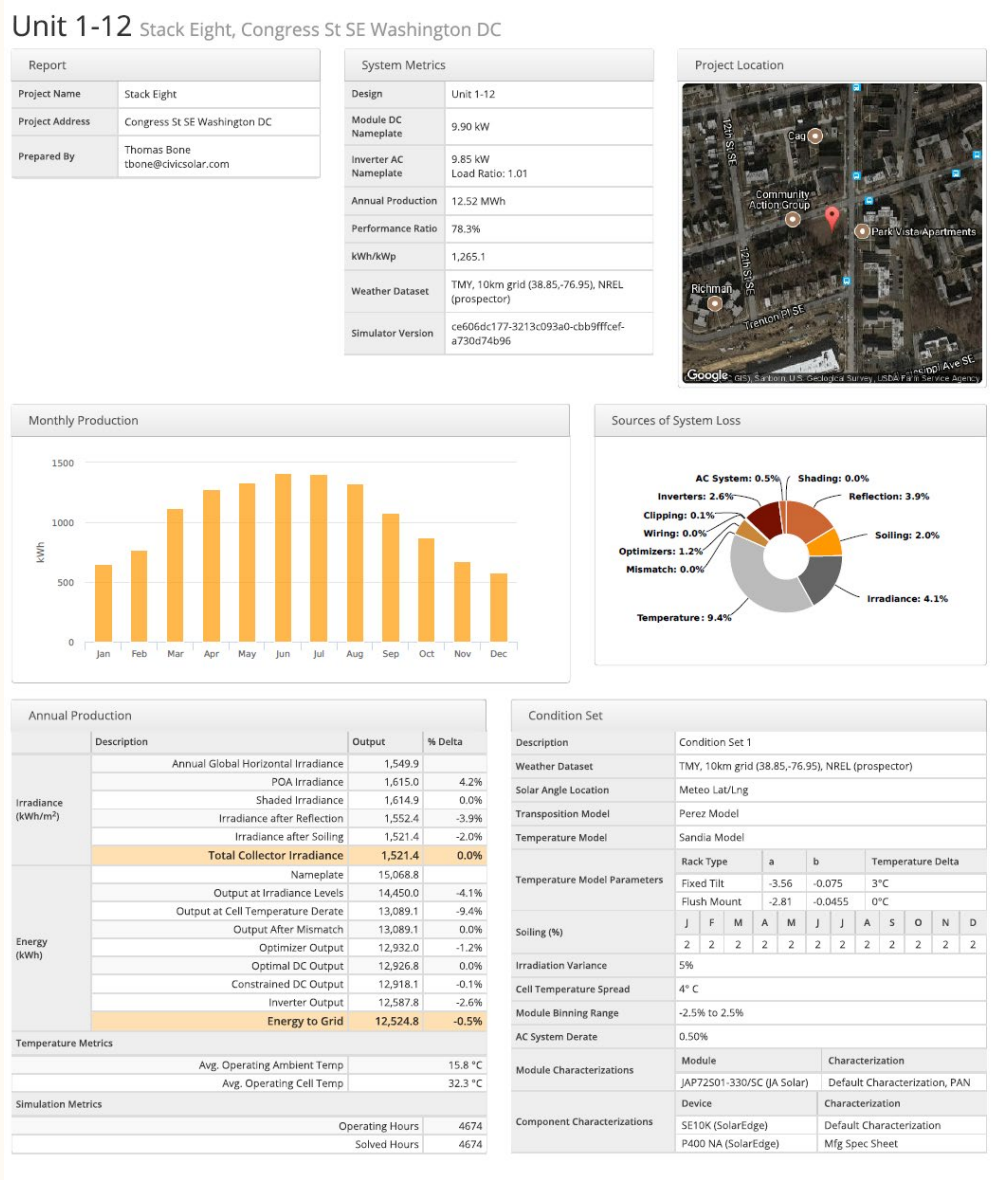
Set Your Goals: Different standards sometimes provide synergies, sometimes are duplicative

NZE-First Design: Design the building with net zero energy in mind from the beginning

Solar Potential Analysis: Conduct a solar potential analysis of rooftops -- how much solar can we generate on site?

Innovation is Key: Passive House standard sets a limit on energy use/square foot/per year: 4.29 kWh/ft2/year. Our internal target is 3.75

Build It: Find efficiencies with modern construction techniques of modular and panelized



Unit 1-12 Stack Eight, Congress St SE Washington DC

Report

Project Name	Stack Eight
Project Address	Congress St SE Washington DC
Prepared By	Thomas Bone tbone@civicsolar.com

System Metrics

Design	Unit 1-12
Module DC Nameplate	9.90 kW
Inverter AC Nameplate	9.85 kW Load Ratio: 1.01
Annual Production	12.52 MWh
Performance Ratio	78.3%
kWh/kWp	1,265.1
Weather Dataset	TMY, 10km grid (38.85,-76.95), NREL (prospector)
Simulator Version	ce606dc177-3213c093a0-cbb9fffcef-a730d74b96

Project Location

Monthly Production

Sources of System Loss

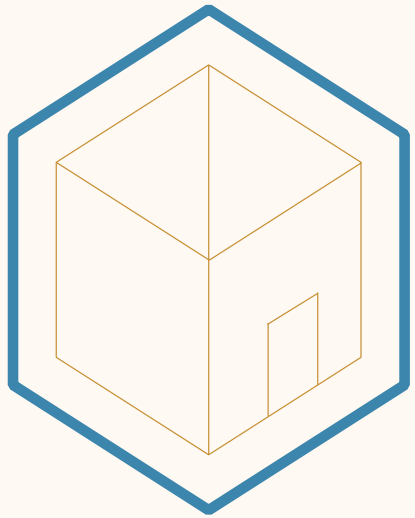
Annual Production

	Description	Output	% Delta
Irradiance (kWh/m²)	Annual Global Horizontal Irradiance	1,549.9	
	POA Irradiance	1,615.0	4.2%
	Shaded Irradiance	1,614.9	0.0%
	Irradiance after Reflection	1,552.4	-3.9%
	Irradiance after Soiling	1,521.4	-2.0%
	Total Collector Irradiance	1,521.4	0.0%
Energy (kWh)	Nameplate	15,068.8	
	Output at Irradiance Levels	14,450.0	-4.1%
	Output at Cell Temperature Derate	13,089.1	-9.4%
	Output After Mismatch	13,089.1	0.0%
	Optimizer Output	12,932.0	-1.2%
	Optimal DC Output	12,926.8	0.0%
	Constrained DC Output	12,918.1	-0.1%
	Inverter Output	12,587.8	-2.6%
	Energy to Grid	12,524.8	-0.5%
Temperature Metrics			
	Avg. Operating Ambient Temp		15.8 °C
	Avg. Operating Cell Temp		32.3 °C
Simulation Metrics			
	Operating Hours		4674
	Solved Hours		4674

Condition Set

Description	Condition Set 1											
Weather Dataset	TMY, 10km grid (38.85,-76.95), NREL (prospector)											
Solar Angle Location	Meteo Lat/Lng											
Transposition Model	Perez Model											
Temperature Model	Sandia Model											
Temperature Model Parameters	Rack Type	a	b	Temperature Delta								
	Fixed Tilt	-3.56	-0.075	3°C								
	Flush Mount	-2.81	-0.0455	0°C								
Soiling (%)	J	F	M	A	M	J	J	A	S	O	N	D
	2	2	2	2	2	2	2	2	2	2	2	2
Irradiation Variance	5%											
Cell Temperature Spread	4° C											
Module Binning Range	-2.5% to 2.5%											
AC System Derate	0.50%											
Module Characterizations	Module	Characterization										
	JAP72S01-330/SC (JA Solar)	Default Characterization, PAN										
Component Characterizations	Device	Characterization										
	SE10K (SolarEdge)	Default Characterization										
	P400 NA (SolarEdge)	Mfg Spec Sheet										

Designing for Net Zero Energy:



Setting Goals and Standards

Set Your Goal: Competing (& Complementary) Standards

Passive House: How we get to net zero; PHPP/quantitative analysis undergirding Living Building Challenge performance requirements

Living Building Challenge, NZE: Energy: goes 5% beyond net zero with 105% on-site performance and backup power requirements

Enterprise Green Communities: required for many affordable housing projects, net zero earns significant points towards certification

Baseline Code: (easy)

Stack Eight's LBC Petals

LIVING BUILDING CHALLENGE℠

PLACE

RESTORING A HEALTHY INTERRELATIONSHIP WITH NATURE

SCALE JUMPING PERMITTED FOR URBAN AGRICULTURE (IMPERATIVE 02) AND HABITAT EXCHANGE (IMPERATIVE 03)

BEAUTY

CELEBRATING DESIGN THAT UPLIFTS THE HUMAN SPIRIT

ENERGY

NET POSITIVE ENERGY

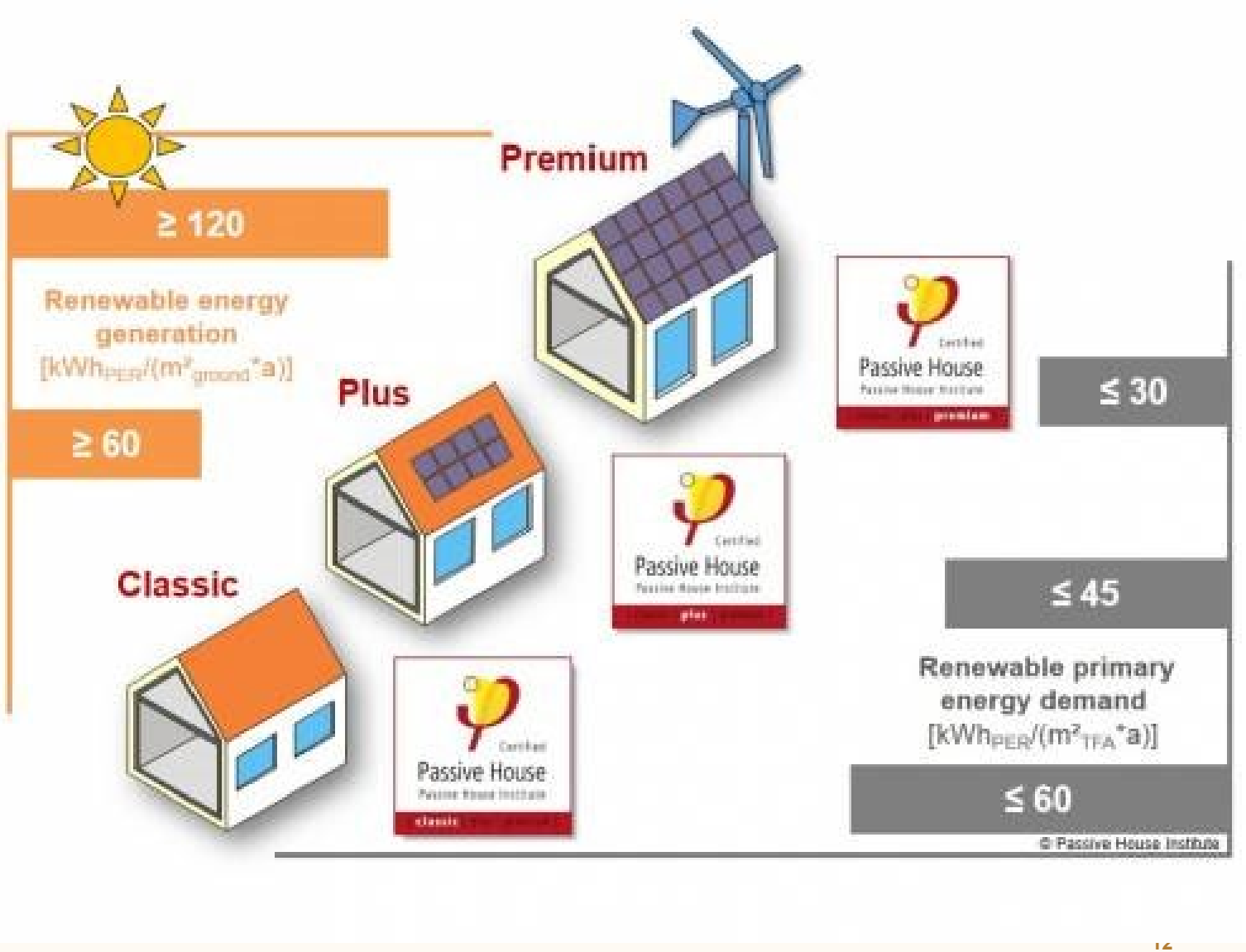
IMPERATIVE 06

One hundred and five percent of the project's energy needs must be supplied by on-site renewable energy on a net annual basis, without the use of on-site combustion.[15] Projects must provide on-site energy storage for resiliency.[16]

15 Refer to the v3.1 Energy Petal Handbook for a list of renewable energy systems, clarifications, and exceptions, including sub-metering requirements.

16 Single-family residences must demonstrate that sufficient back-up battery power is installed for emergency lighting (at least 10% of lighting load) and refrigeration use for up to one week for greater resiliency. All other project types must create a resiliency plan appropriate to the occupancy type that includes, at minimum, the capacity to store the energy equivalent to 10% of the lighting load for one week.

Stack Eight's Passive House Goal



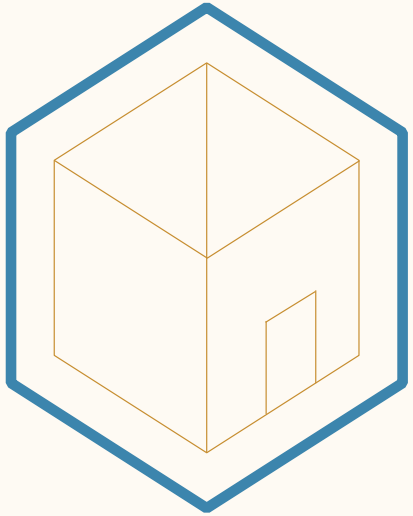
Stack Eight's Overarching Vision

Equity

Health

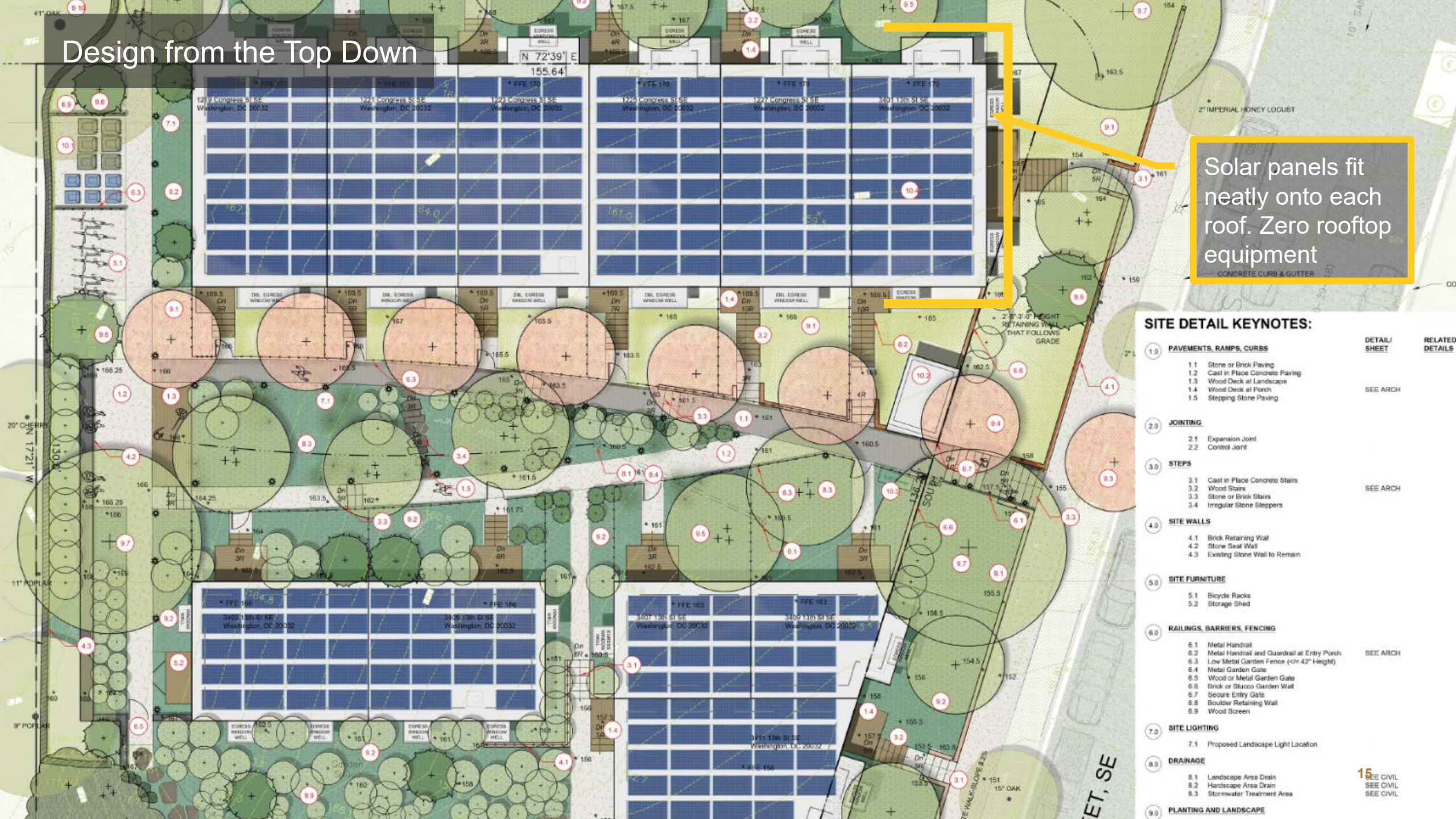
Environment

Designing for Net Zero Energy:

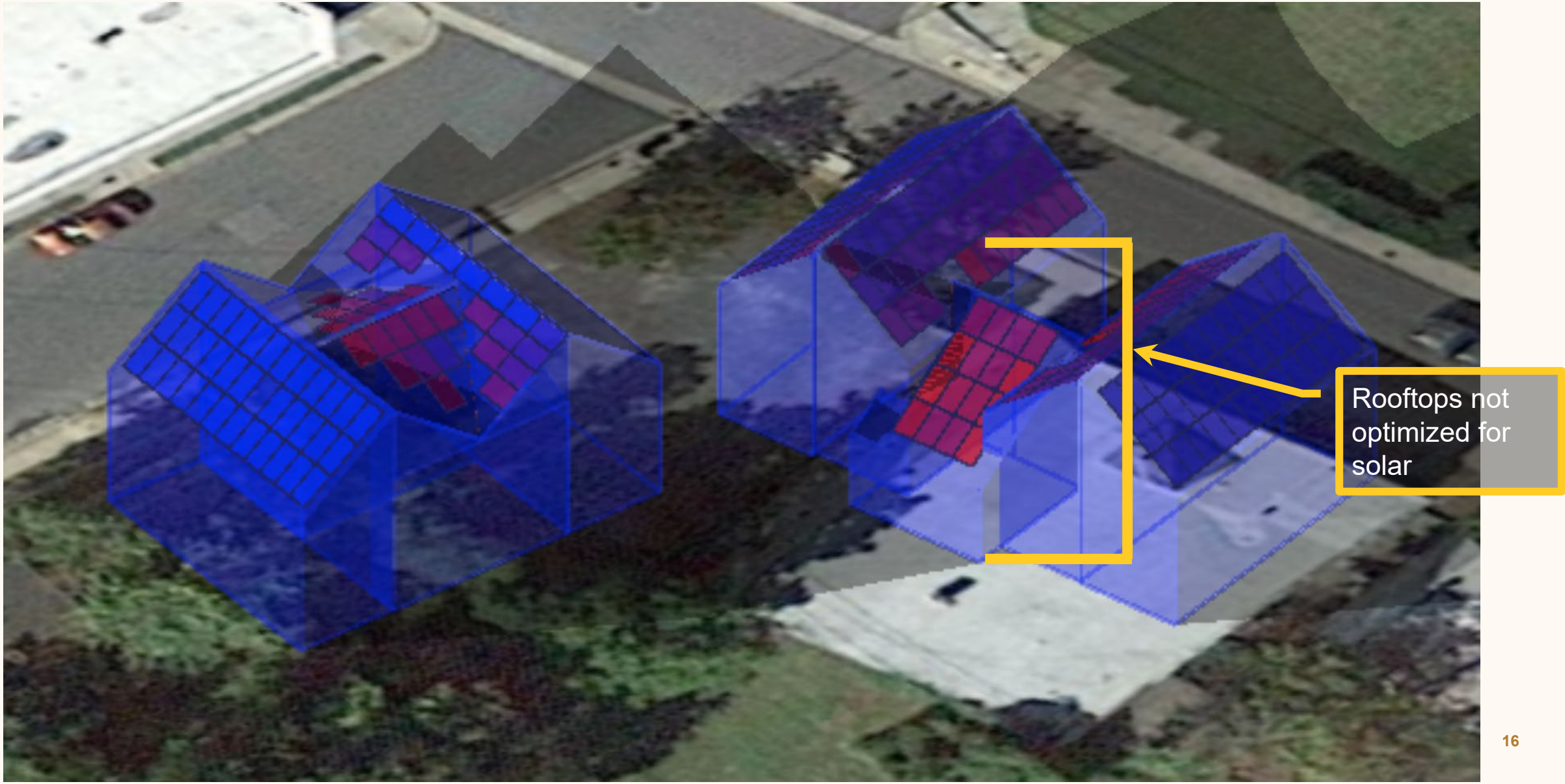


NZE-First Design

Design from the Top Down



Design from the Top Down



NZE-First Campus Design

Courtyard Width Option #1

2 pm

3 pm

Courtyard Width Option #2

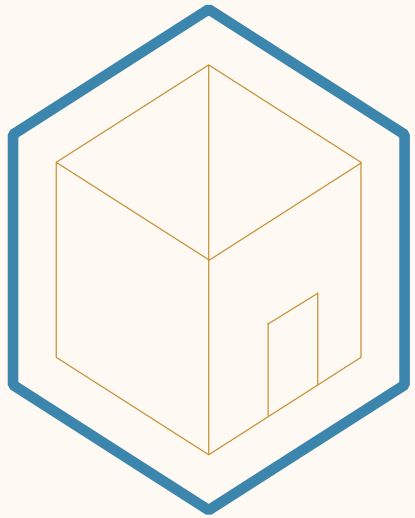
2 pm

3 pm

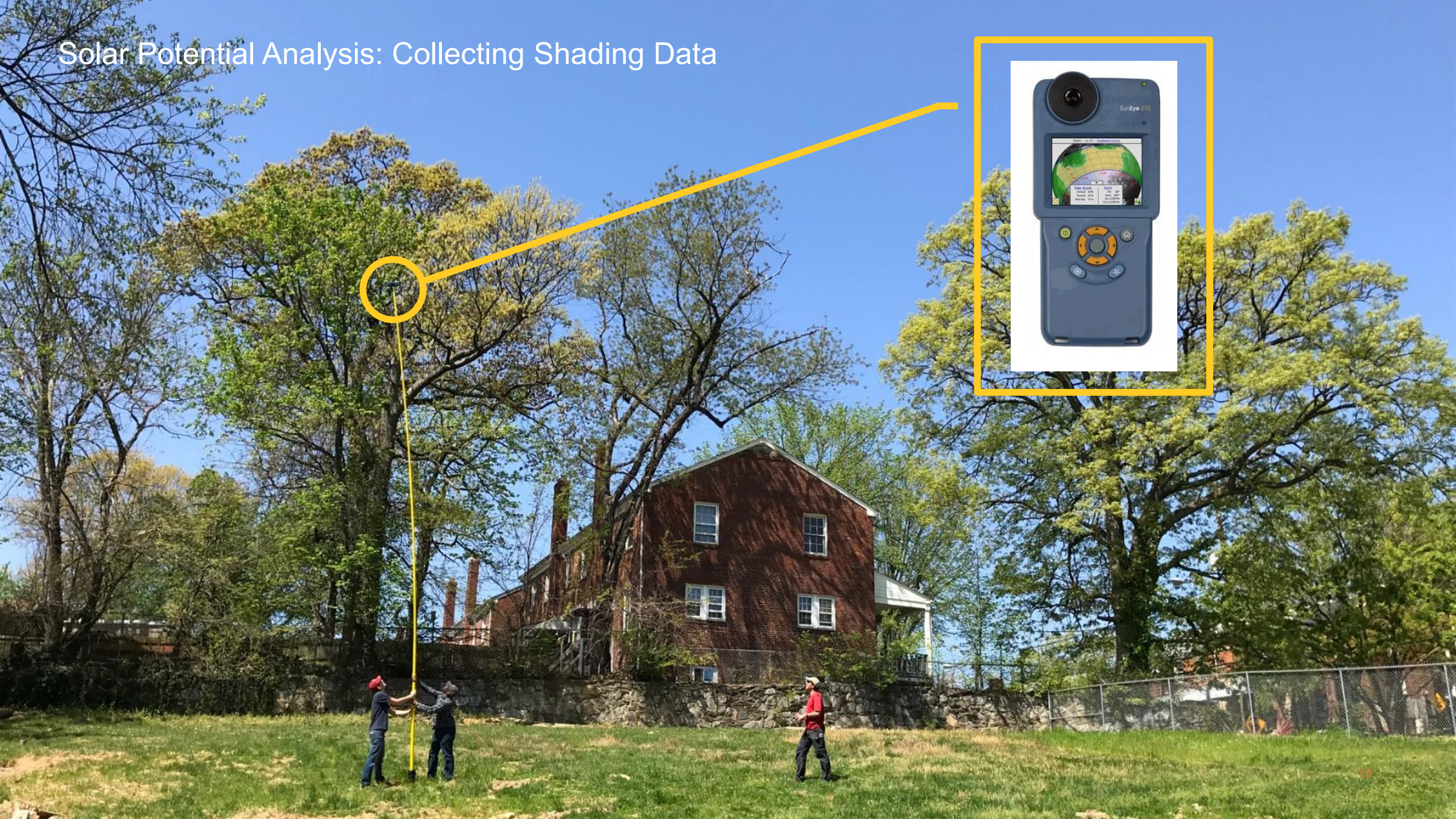
These windows receive less light in Option #2, which would have increased overall project EUI

Designing for Net Zero Energy:

Solar Analysis



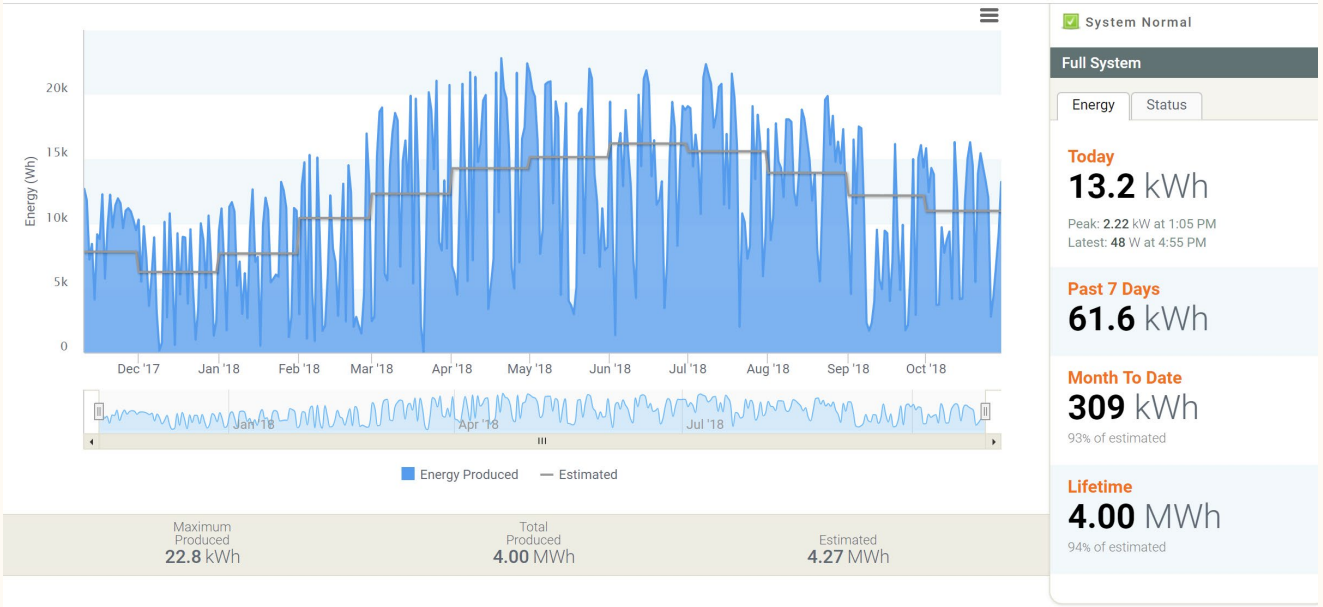
Solar Potential Analysis: Collecting Shading Data

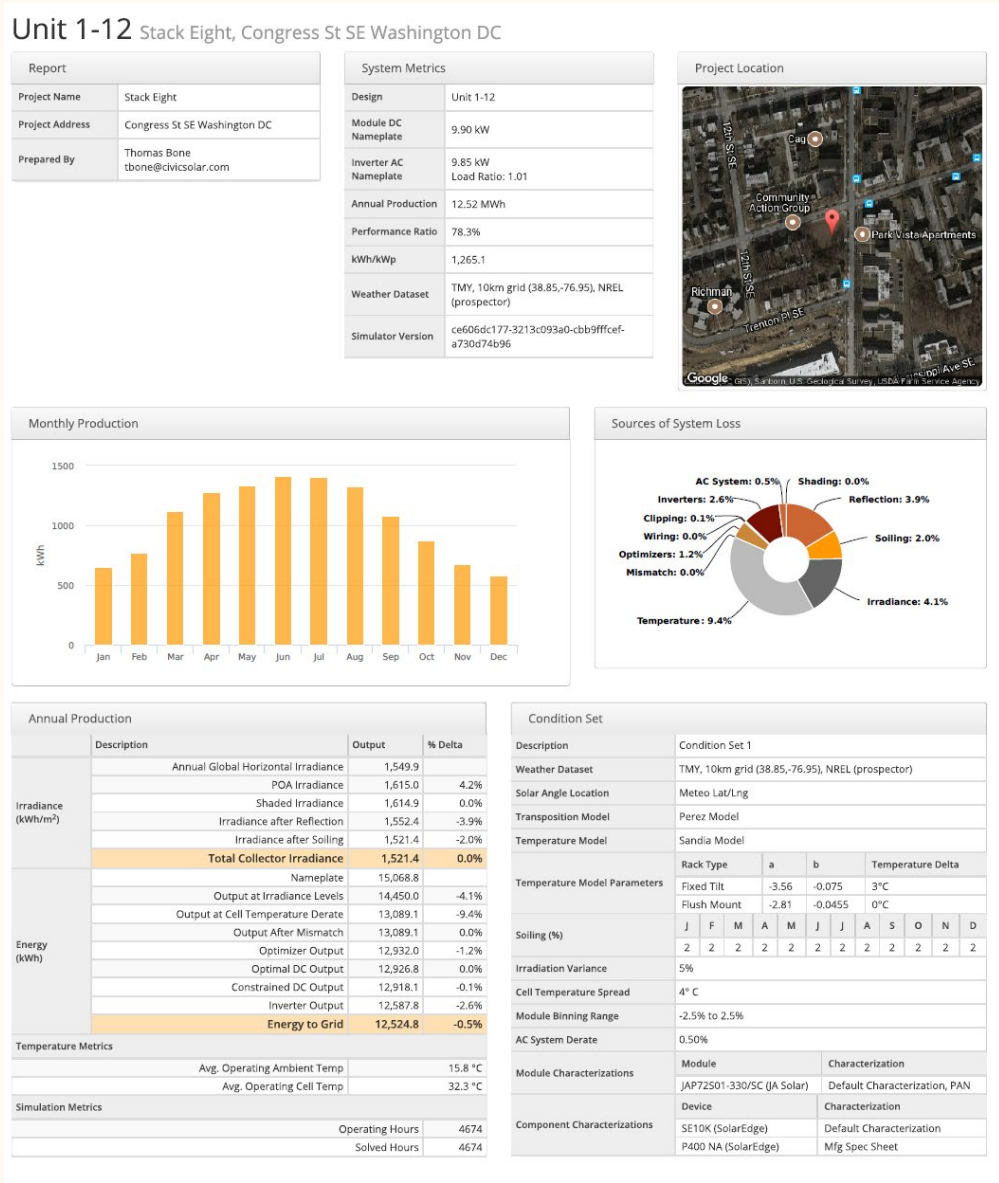


Solar Potential on an Annualized Basis

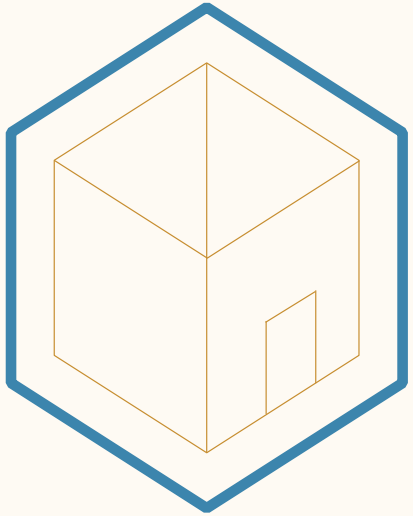
Quantify Solar Output: Turn site characteristics into annualized energy use expectations

If the solar provides enough power for our demand, we can achieve net zero, otherwise we need to beat the Passivhaus maximum allowable energy use



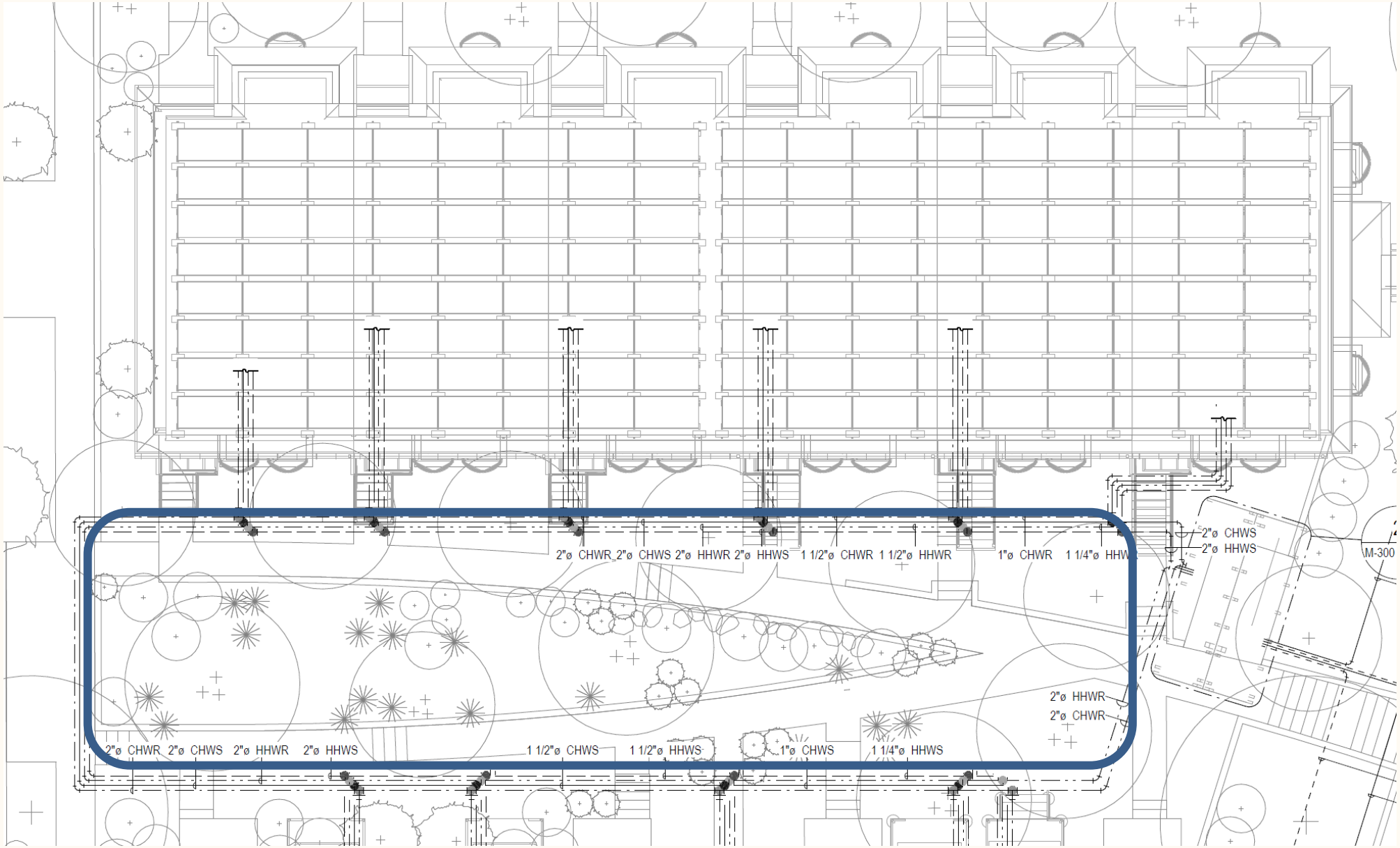


Designing for Net Zero Energy:



Innovation is Key

District Energy System



District Heating and Cooling

Passive House reduces loads by 80%

Location: Peak cooling loads for Stack Eight's units are ¾ ton for cooling – and regular loads much lower. Far too small for conventional equipment

District Energy system: creates a cost and energy savings opportunity: avoids oversized equipment, captures waste heat by creating hot and cold water simultaneously, allows units to "share" free energy

Load Aggregation: all 18 units are served by 10 tons of centralized heating and cooling equipment, using only six 500' deep geothermal wells – the same number you might see on one conventional house

Critical Loads Backup

Islandable Backup Power: Designed to keep critical systems online in the event of a power outage – and allow solar to continually recharge storage during an outage event

Critical Loads: Energy recovery ventilation, refrigerators, 10% of lighting, emergency plugs are backed up per Living Building Challenge (ILFI) requirements. Because of the building's high insulation levels, heating/cooling is not a critical load

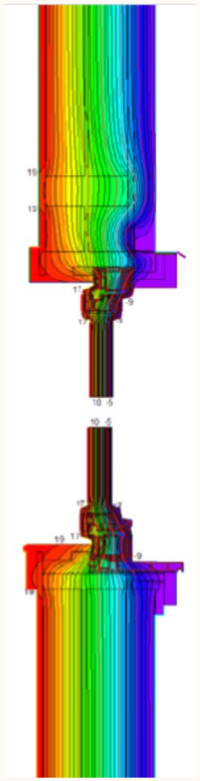
Passive House Reduces Battery Size: We only need 16 batteries for all 18 units

Construction Assemblies & Energy Performance

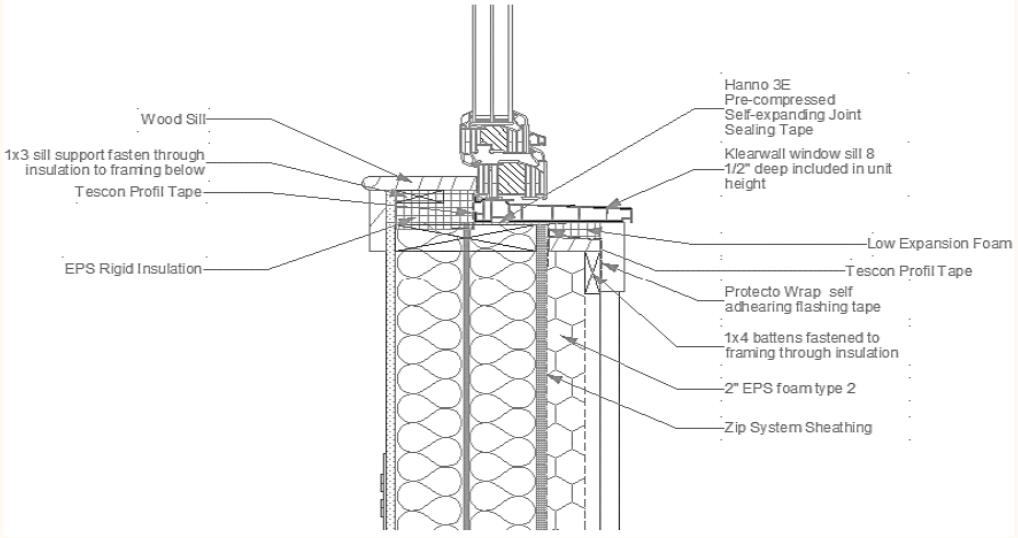
Energy Performance First

- Materials are selected for energy performance (e.g. windows and doors)
- Construction assemblies are modeled for their energy performance

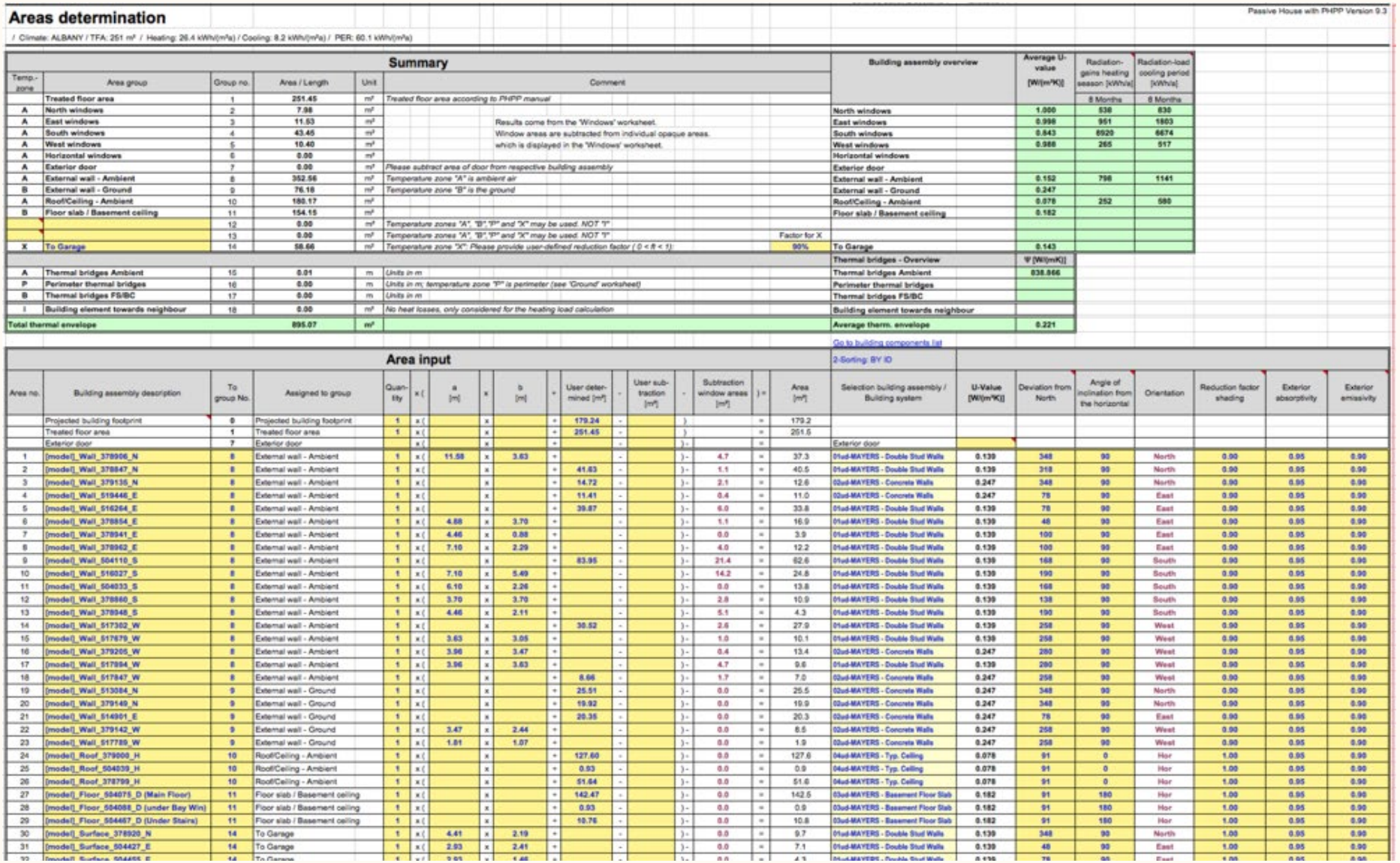
Thermal Bridge Analysis



Envelope Details



Energy Modeling



Areas determination

Passive House with PHPP Version 9.3

/ Climate: ALBANY / TFA: 251 m² / Heating: 26.4 kWh/(m²a) / Cooling: 8.2 kWh/(m²a) / PER: 60.1 kWh/(m²a)

Summary

Temp.-zone	Area group	Group no.	Area / Length	Unit	Comment		Building assembly overview	Average U-value [W/(m²K)]	Radiation-gains heating season [kWh/a]	Radiation-load cooling period [kWh/a]
	Treated floor area	1	251.45	m²	Treated floor area according to PHPP manual				8 Months	8 Months
A	North windows	2	7.98	m²			North windows	1.000	536	830
A	East windows	3	11.53	m²	Results come from the 'Windows' worksheet.		East windows	0.998	951	1803
A	South windows	4	43.45	m²	Window areas are subtracted from individual opaque areas.		South windows	0.843	6920	6674
A	West windows	5	10.40	m²	which is displayed in the 'Windows' worksheet.		West windows	0.988	265	517
A	Horizontal windows	6	0.00	m²			Horizontal windows			
A	Exterior door	7	0.00	m²	Please subtract area of door from respective building assembly		Exterior door			
A	External wall - Ambient	8	352.56	m²	Temperature zone "A" is ambient air		External wall - Ambient	0.152	798	1141
B	External wall - Ground	9	76.18	m²	Temperature zone "B" is the ground		External wall - Ground	0.247		
A	Roof/Ceiling - Ambient	10	180.17	m²			Roof/Ceiling - Ambient	0.078	252	580
B	Floor slab / Basement ceiling	11	154.15	m²			Floor slab / Basement ceiling	0.182		
		12	0.00	m²	Temperature zones "A", "B", "P" and "X" may be used. NOT "I"					
		13	0.00	m²	Temperature zones "A", "B", "P" and "X" may be used. NOT "I"	Factor for X				
X	To Garage	14	58.66	m²	Temperature zone "X": Please provide user-defined reduction factor (0 < ft < 1):	99%	To Garage	0.143		
							Thermal bridges - Overview	Ψ [W/(mK)]		
A	Thermal bridges Ambient	15	0.01	m	Units in m		Thermal bridges Ambient	038.866		
P	Perimeter thermal bridges	16	0.00	m	Units in m; temperature zone "P" is perimeter (see 'Ground' worksheet)		Perimeter thermal bridges			
B	Thermal bridges FS/BC	17	0.00	m	Units in m		Thermal bridges FS/BC			
I	Building element towards neighbour	18	0.00	m²	No heat losses, only considered for the heating load calculation		Building element towards neighbour			
Total thermal envelope			895.07	m²			Average therm. envelope	0.221		

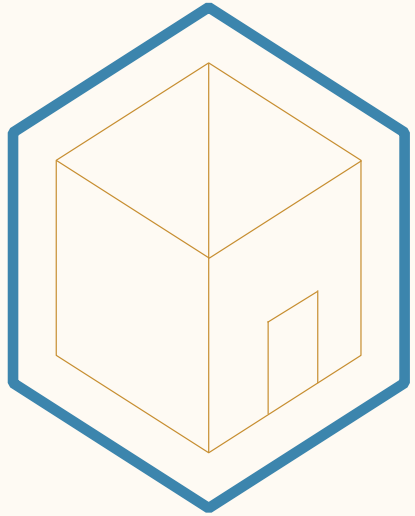
Go to building components list

Area input

2-Sorting: BY ID

Area no.	Building assembly description	To group No.	Assigned to group	Quan-tity	x (	a [m]	x	b [m]	+	User deter-mined [m²]	-	User sub-traction [m²]	-	Subtraction window areas [m²]	) =	Area [m²]	Selection building assembly / Building system	U-Value [W/(m²K)]	Deviation from North	Angle of inclination from the horizontal	Orientation	Reduction factor shading	Exterior absorptivity	Exterior emissivity
	Projected building footprint	0	Projected building footprint	1	x (		x		+	179.24	-		) -		=	179.2								
	Treated floor area	1	Treated floor area	1	x (		x		+	251.45	-		) -		=	251.5								
	Exterior door	7	Exterior door		x (		x		+		-		) -		=		Exterior door							
1	[model]_Wall_378906_N	8	External wall - Ambient	1	x (	11.58	x	3.63	+		-		) -	4.7	=	37.3	01ud-MAYERS - Double Stud Walls	0.139	348	90	North	0.90	0.95	0.90
2	[model]_Wall_378847_N	8	External wall - Ambient	1	x (		x		+	41.63	-		) -	1.1	=	40.5	01ud-MAYERS - Double Stud Walls	0.139	318	90	North	0.90	0.95	0.90
3	[model]_Wall_379135_N	8	External wall - Ambient	1	x (		x		+	14.72	-		) -	2.1	=	12.6	02ud-MAYERS - Concrete Walls	0.247	348	90	North	0.90	0.95	0.90
4	[model]_Wall_519446_E	8	External wall - Ambient	1	x (		x		+	11.41	-		) -	0.4	=	11.0	02ud-MAYERS - Concrete Walls	0.247	78	90	East	0.90	0.95	0.90
5	[model]_Wall_516264_E	8	External wall - Ambient	1	x (		x		+	39.87	-		) -	6.0	=	33.8	01ud-MAYERS - Double Stud Walls	0.139	78	90	East	0.90	0.95	0.90
6	[model]_Wall_378854_E	8	External wall - Ambient	1	x (	4.88	x	3.70	+		-		) -	1.1	=	16.9	01ud-MAYERS - Double Stud Walls	0.139	48	90	East	0.90	0.95	0.90
7	[model]_Wall_378941_E	8	External wall - Ambient	1	x (	4.46	x	0.88	+		-		) -	0.0	=	3.9	01ud-MAYERS - Double Stud Walls	0.139	100	90	East	0.90	0.95	0.90
8	[model]_Wall_378962_E	8	External wall - Ambient	1	x (	7.10	x	2.29	+		-		) -	4.0	=	12.2	01ud-MAYERS - Double Stud Walls	0.139	100	90	East	0.90	0.95	0.90
9	[model]_Wall_504110_S	8	External wall - Ambient	1	x (		x		+	83.95	-		) -	21.4	=	62.6	01ud-MAYERS - Double Stud Walls	0.139	168	90	South	0.90	0.95	0.90
10	[model]_Wall_516027_S	8	External wall - Ambient	1	x (	7.10	x	5.49	+		-		) -	14.2	=	24.8	01ud-MAYERS - Double Stud Walls	0.139	190	90	South	0.90	0.95	0.90
11	[model]_Wall_504033_S	8	External wall - Ambient	1	x (	6.10	x	2.26	+		-		) -	0.0	=	13.8	01ud-MAYERS - Double Stud Walls	0.139	168	90	South	0.90	0.95	0.90
12	[model]_Wall_378860_S	8	External wall - Ambient	1	x (	3.70	x	3.70	+		-		) -	2.8	=	10.9	01ud-MAYERS - Double Stud Walls	0.139	138	90	South	0.90	0.95	0.90
13	[model]_Wall_378848_S	8	External wall - Ambient	1	x (	4.46	x	2.11	+		-		) -	5.1	=	4.3	01ud-MAYERS - Double Stud Walls	0.139	190	90	South	0.90	0.95	0.90
14	[model]_Wall_517302_W	8	External wall - Ambient	1	x (		x		+	30.52	-		) -	2.6	=	27.9	01ud-MAYERS - Double Stud Walls	0.139	258	90	West	0.90	0.95	0.90
15	[model]_Wall_517679_W	8	External wall - Ambient	1	x (	3.63	x	3.05	+		-		) -	1.0	=	10.1	01ud-MAYERS - Double Stud Walls	0.139	258	90	West	0.90	0.95	0.90
16	[model]_Wall_379205_W	8	External wall - Ambient	1	x (	3.96	x	3.47	+		-		) -	0.4	=	13.4	02ud-MAYERS - Concrete Walls	0.247	280	90	West	0.90	0.95	0.90
17	[model]_Wall_517894_W	8	External wall - Ambient	1	x (	3.96	x	3.63	+		-		) -	4.7	=	9.6	01ud-MAYERS - Double Stud Walls	0.139	280	90	West	0.90	0.95	0.90
18	[model]_Wall_517847_W	8	External wall - Ambient	1	x (		x		+	8.66	-		) -	1.7	=	7.0	02ud-MAYERS - Concrete Walls	0.247	258	90	West	0.90	0.95	0.90
19	[model]_Wall_513084_N	9	External wall - Ground	1	x (		x		+	25.51	-		) -	0.0	=	25.5	02ud-MAYERS - Concrete Walls	0.247	348	90	North	0.90	0.95	0.90
20	[model]_Wall_379149_N	9	External wall - Ground	1	x (		x		+	19.92	-		) -	0.0	=	19.9	02ud-MAYERS - Concrete Walls	0.247	348	90	North	0.90	0.95	0.90
21	[model]_Wall_514901_E	9	External wall - Ground	1	x (		x		+	20.35	-		) -	0.0	=	20.3	02ud-MAYERS - Concrete Walls	0.247	78	90	East	0.90	0.95	0.90
22	[model]_Wall_379142_W	9	External wall - Ground	1	x (	3.47	x	2.44	+		-		) -	0.0	=	8.5	02ud-MAYERS - Concrete Walls	0.247	258	90	West	0.90	0.95	0.90
23	[model]_Wall_517789_W	9	External wall - Ground	1	x (	1.81	x	1.07	+		-		) -	0.0	=	1.9	02ud-MAYERS - Concrete Walls	0.247	258	90	West	0.90	0.95	0.90
24	[model]_Roof_379000_H	10	Roof/Ceiling - Ambient	1	x (		x		+	127.60	-		) -	0.0	=	127.6	04ud-MAYERS - Typ. Ceiling	0.078	91	0	Hor	1.00	0.95	0.90
25	[model]_Roof_504039_H	10	Roof/Ceiling - Ambient	1	x (		x		+	0.93	-		) -	0.0	=	0.9	04ud-MAYERS - Typ. Ceiling	0.078	91	0	Hor	1.00	0.95	0.90
26	[model]_Roof_378799_H	10	Roof/Ceiling - Ambient	1	x (		x		+	51.64	-		) -	0.0	=	51.6	04ud-MAYERS - Typ. Ceiling	0.078	91	0	Hor	1.00	0.95	0.90
27	[model]_Floor_504075_D (Main Floor)	11	Floor slab / Basement ceiling	1	x (		x		+	142.47	-		) -	0.0	=	142.5	03ud-MAYERS - Basement Floor Slab	0.182	91	180	Hor	1.00	0.95	0.90
28	[model]_Floor_504088_D (under Bay Win)	11	Floor slab / Basement ceiling	1	x (		x		+	0.93	-		) -	0.0	=	0.9	03ud-MAYERS - Basement Floor Slab	0.182	91	180	Hor	1.00	0.95	0.90
29	[model]_Floor_504467_D (Under Stairs)	11	Floor slab / Basement ceiling	1	x (		x		+	10.76	-		) -	0.0	=	10.8	03ud-MAYERS - Basement Floor Slab	0.182	91	180	Hor	1.00	0.95	0.90
30	[model]_Surface_378920_N	14	To Garage	1	x (	4.41	x	2.19	+		-		) -	0.0	=	9.7	01ud-MAYERS - Double Stud Walls	0.139	348	90	North	1.00	0.95	0.90
31	[model]_Surface_504427_E	14	To Garage	1	x (	2.93	x	2.41	+		-		) -	0.0	=	7.1	01ud-MAYERS - Double Stud Walls	0.139	48	90	East	1.00	0.95	0.90

Designing for Net Zero Energy:



Build It!

Modular Construction

Quality Control

Repeatable, reliable quality every time

Precision Manufacturing

Fully coordinated construction team and building trades

Superior Components

Quality modular homes are superior to “site-built” homes

Building a modular **high performance building** is like building a Swiss watch or Apple iPhone – the team spends many months in **integrative design**, ensuring that all the components are exactly right. Construction doesn't start until every detail is worked out.

Lessons Learned

- **There is no shortcut to innovation.** Encourage (actual) integrative design: Inspire, but force the team to collaborate if you have to. Challenge normal assumptions. Have very long conference calls. Be the worst (or best?) client ever
- **Developer-led design build:** there's a reason so many Passive House developers also wear another hat (or 3)
- **Cost-effective, durable, reproducible solutions:** Spend lots of time on R&D, then build on that. Sometimes the best products are not for sale in the USA and you have to go and find them. More – and more specialized consultants – is not the answer
- **Pre-fab:** Find ways to simplify construction, achieve efficiency. Don't build small multifamily or single family in the field if you can help it. We'd pay to bury the power lines if we had to
- **Re-envision the team:** Real estate is a form of serial entrepreneurship – every deal is different – which discourages learning and collaboration. The team matters. Stack Eight's site plan was heavily influenced by the landscape architect – their discipline is usually an afterthought
- **Nothing beats field experience:** Its essential to suffer through the details on an actual construction project to understand how to design a buildable project

"Innovation in the construction industry continues to be constrained by deep-seated barriers, including a lack of emphasis on R&D, a high degree of fragmentation, and widespread risk aversion."

-Reinventing Construction: A Route to Higher Productivity, McKinsey, 2017

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