



The Phototropic Project

a low impact, carbon neutral, net zero solution

“light” as in “**photo**graph” “turned toward” as in “**geotropic**”



Shown with roof removed

Engineering

- High performance thermal envelope
- State of the art energy systems
- Rainwater catchment
- Survivability in severe storms

Materials

- Polycarbonate
- Stainless steel
- Acetylated wood
- Fiberglass doors & windows
- Local concrete
- Bamboo plywood

Power

- 1200 w vertical wind turbine
- 4 x 1220 w photovoltaic "leaves"
- Satellite dish > internet, phone & video
- Air/ground source heating/cooling



Hale Hibiscus

Residence

Live off the grid in a 717 square foot home configured with bedroom, living/dining, kitchen, bath/shower, and multiple decks.

No hookups are required to the electrical grid, water or sewer systems.

Ideal for locations with an annual rainfall of 24 inches or more.



Paradigm Shift

Eco Lodge

Rent this cozy retreat for a week or two and live using only the power and water that nature has provided.

A built-in monitoring system tracks your consumption on the internet.

These measurements become a record of your stay and may even encourage you to alter your habits.

Also available for renewable energy education and presentations.

Solarchow

Cafe

This modern day diner is outfitted with food and drink equipment powered by the sun, wind and rain and offers a unique ecological message for hungry visitors.

Informational flat screens provide animated descriptions of the construction, systems and equipment.



Exterior

Double roof - - - - ->

High performance vinyl fabric

Cool roofing system - - - - ->

Single ply/ treated wood framing/
R80 VIP system

Polycarbonate - - - - ->

Petal surfaces and clerestory windows

Stainless steel tubing - - - - ->

Framing of petals, corner supports,
decking and window/door walls

Acetylated/thermally modified wood - - - - ->

Deck surfaces

Energy shades - - - - ->

Seasonal insulation/ R60 VIP system

Door/window walls - - - - ->

High performance units w/thermally
broken frames w/ triple/quad low E glazing

Stainless steel - - - - ->

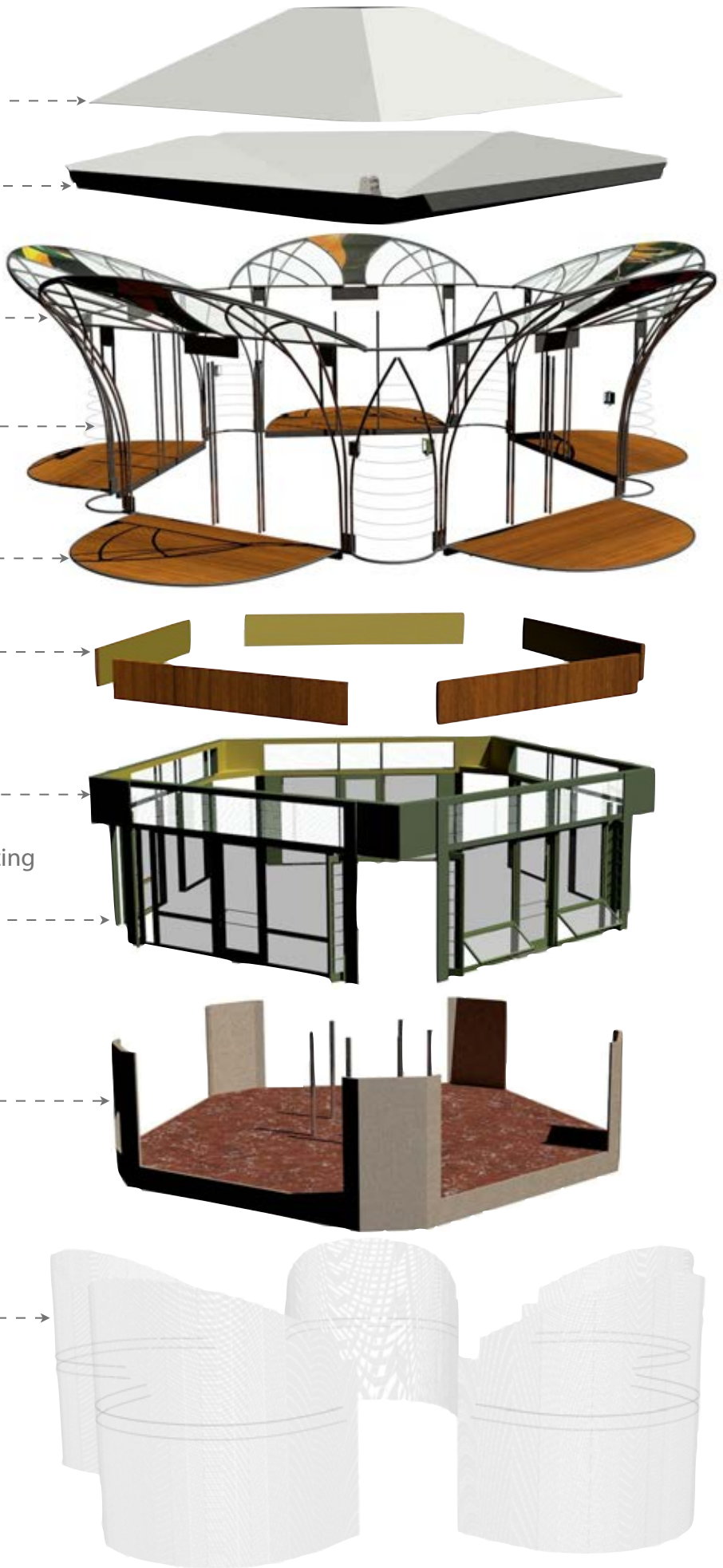
Hardware, fasteners & thresholds

Local concrete - - - - ->

Floating floor slab with five shear walls
Shear walls/ R60 VIP system

Stainless steel screening - - - - ->

Optional enclosed outdoor deck(s)



Interior



Cabinetry

Non-load bearing units from polycarbonate, bamboo plywood & stainless steel



Seating

From bamboo, leather & stainless steel

Lighting
Custom LED fixtures throughout with tunable colors.



Renewables

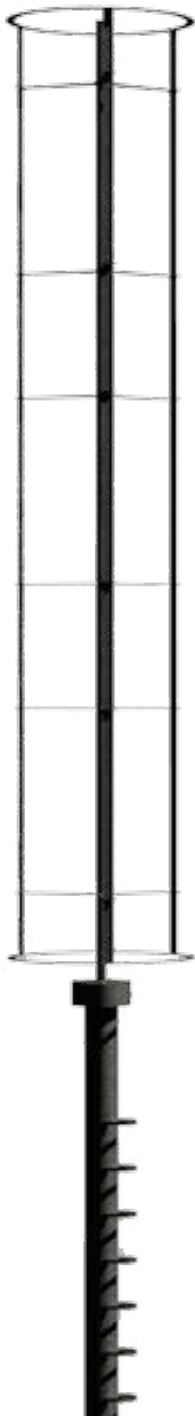
Sun

Four photovoltaic "leaves", each composed of 4 x 305w panels, track the sun's movement by pumping water between saddle tanks.



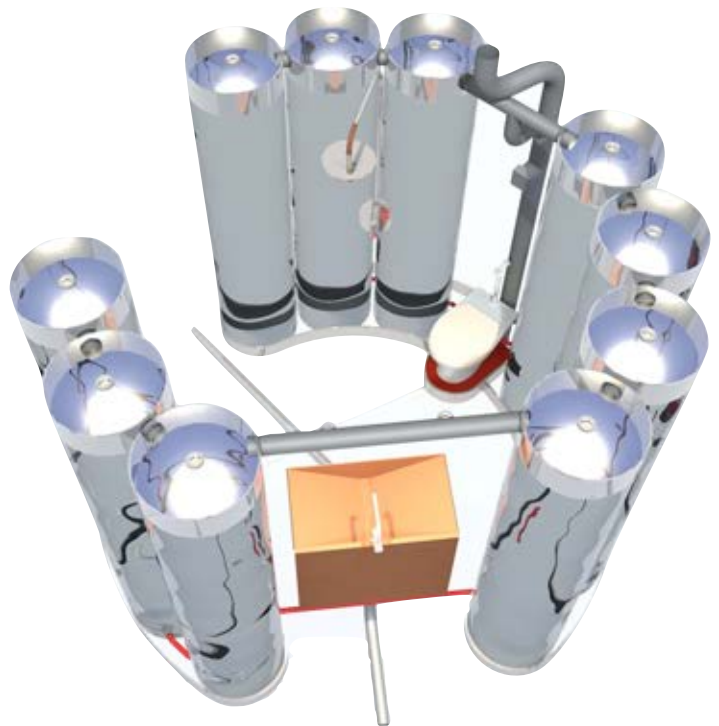
Wind

The "Windspire" turbine generates 1200w at peak wind speed.



Rain

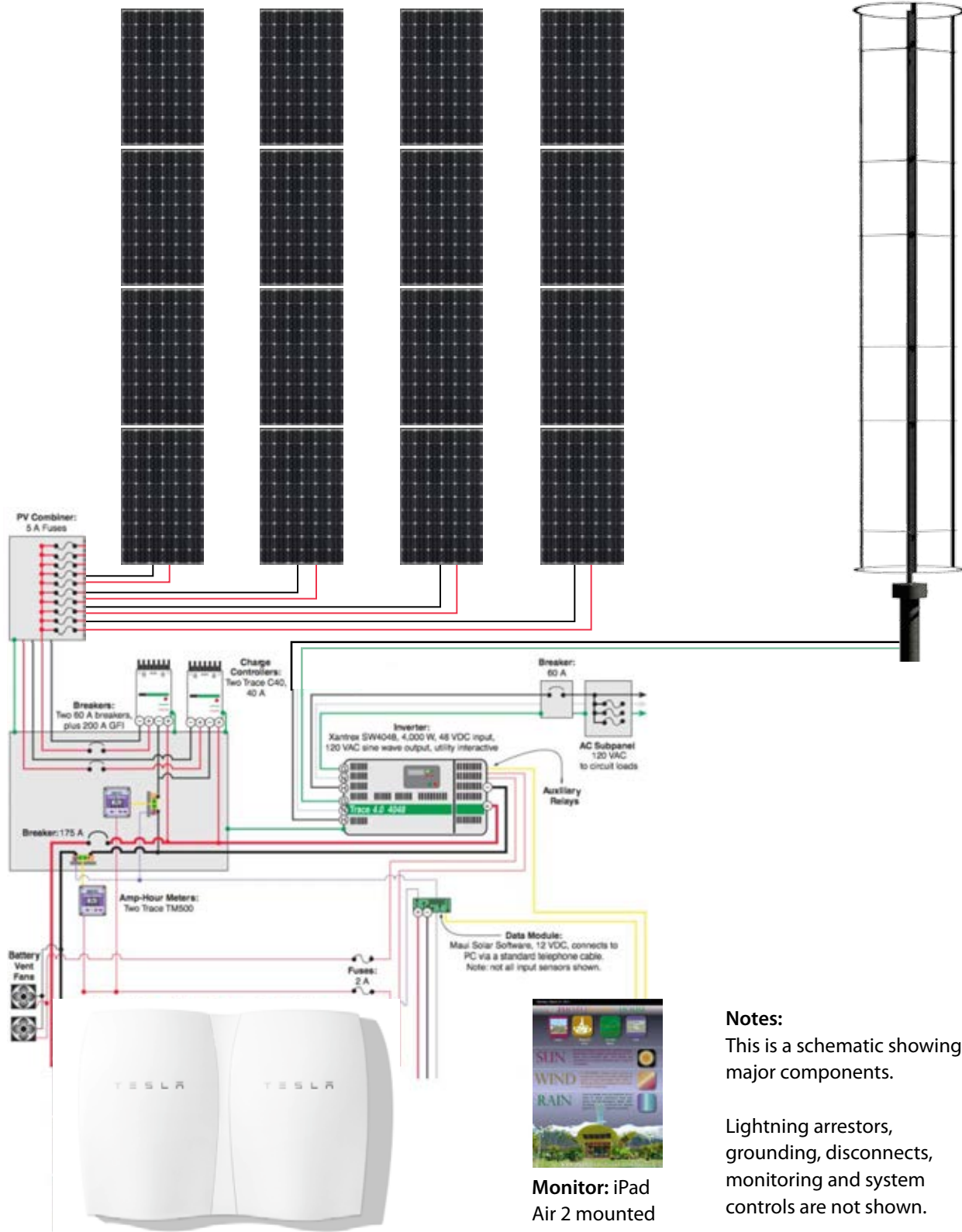
Water is harvested from the roof and petals, stored until needed in ten fiberglass tubes forming a bathroom.



PV & Wind Schematic

Photovoltaics: 16 LG 305 "MonoX Neon", 305W, 32 VDC nominal each, wired for 4880 W total at 48 VDC

Wind turbine: "Windspire" Series IV 2000, wired for 1200 W output at 208 VAC



Batteries: 2 Tesla 10 kWh PowerWall units, 350-450 v, 5.8 a, 2.0 kW continuous, 3.3 kW peak



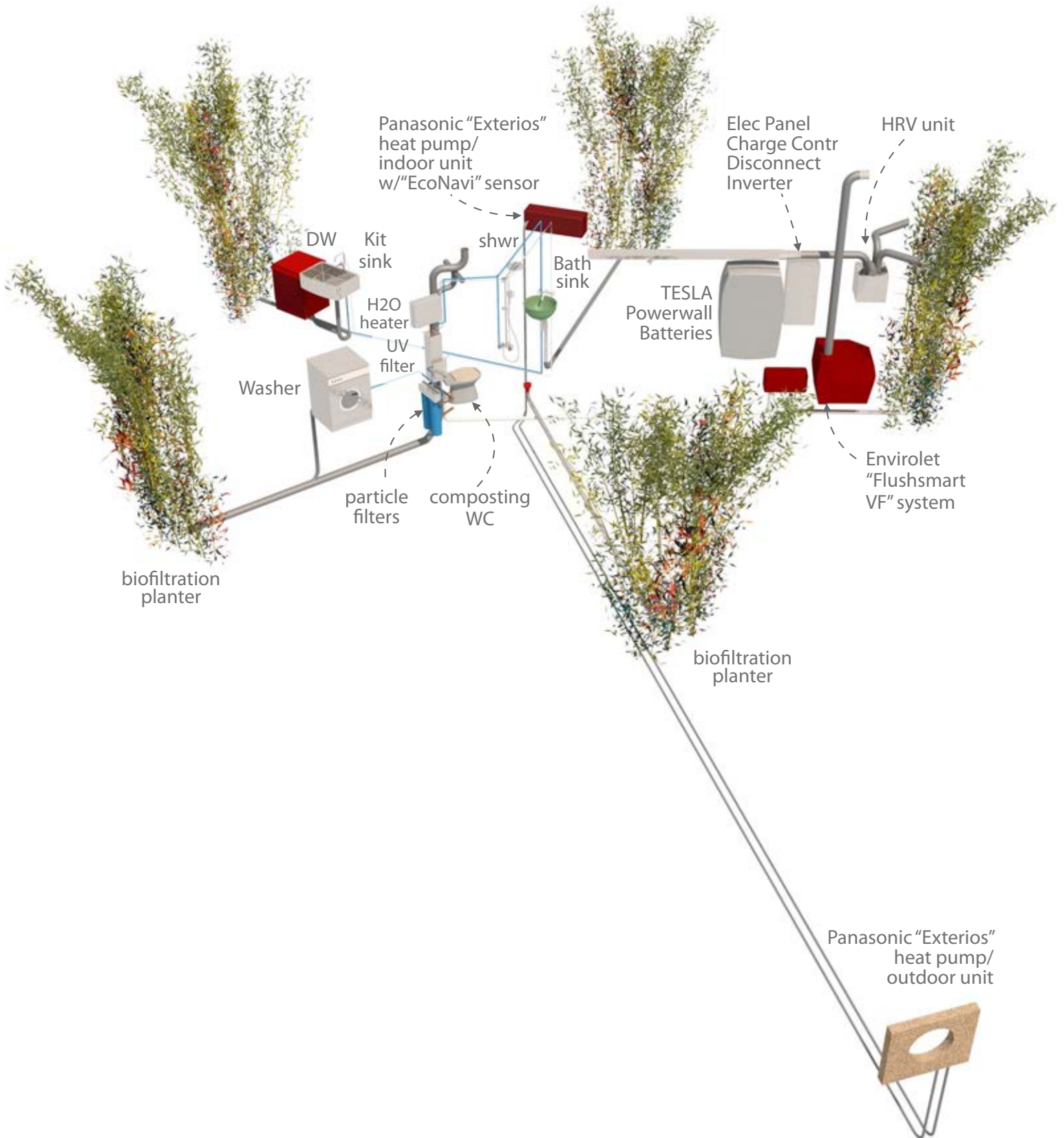
Monitor: iPad Air 2 mounted on refrigerator door

Notes:

This is a schematic showing major components.

Lightning arrestors, grounding, disconnects, monitoring and system controls are not shown.

Systems



Specifications

PRODUCTION					
Photovoltaic leaves					
Daily hrs of sun	4.0	5.0	6.0	7.0	8.0
Panel wattage	305.0	305.0	305.0	305.0	305.0
Number of panels	16.0	16.0	16.0	16.0	16.0
Array output kw	4.9	4.9	4.9	4.9	4.9
Daily KWH output	19.5	24.4	29.3	34.2	39.0
Annual KWH output	7,124.8	8,906.0	10,687.2	12,468.4	14,249.6
Wind turbine					
Annual KWH @ 12.5 mph ave.	4,250.0	kwh			
Daily KWH output	11.6	kwh			
LOADS					
House					
Average daily requirement	3.1	kwh/day			
Automobile					
Annual miles	8,000.0	mi/yr			
Tesla Model 3/ Chevy VOLT	5.0	mi/kwh			
Average daily requirement	4.4	kwh/day			
Heat Pump					
Annual requirement	626.6	kwh/year			
Annual KWH @ COP = 4	156.7	kwh/year			
Average daily requirement	0.4	kwh/day			
Peak load @ 90ΔT	6.4	kwh/day			
Totals					
Average daily requirement	7.9	kwh/day			
Annual KWH requirement	2,888.3	kwh			
Total average daily KWH output	31.2	36.0	40.9	45.8	50.7
STORAGE					
Days of autonomy	5.0				
Daily requirement w/o auto	3.5	kwh			
Total required kWh storage	17.6	kwh			
Tesla PowerWall per battery	10.0	kwh			
Total batteries	2				
Wednesday, August 5, 2015					

RAINWATER HARVEST				
catchment area/sf	rainfall/inch/yr	gal/yr	gal/month	ave. gal/day
1,650.0	24.0	24,750.0	2,062.5	67.8
1,650.0	30.0	30,937.5	2,578.1	84.8
1,650.0	36.0	37,125.0	3,093.8	101.7
1,650.0	42.0	43,312.5	3,609.4	118.7
1,650.0	48.0	49,500.0	4,125.0	135.6
# tanks	gal/tank	total storage	gal/day	use days
10.0	90.0	900.0	24.0	37.5
			30.0	30.0
			36.0	25.0
			48.0	18.8

THERMAL *International Passive House Association standards			
PassiveHouse* space heating	no more than	15.00	kwh/m2/yr
	equals	1.39	kwh/sf/yr
Better Performance			
Heating/ Charlotte	usage	0.83	kwh/sf/yr
	equals	0.40	btu/sf/DD
PassiveHouse* primary energy	no more than	120.00	kwh/m2/yr
	equals	11.15	kwh/sf/yr
Better Performance			
Primary energy/ Charlotte	usage	6.47	kwh/sf/yr
	equals	22.08	btu/sf/yr
	equals	3.15	btu/sf/DD
PassiveHouse* airtightness	max @ 50Pa	0.60	air changes/hr
to be measured and verified w/ onsite pressure test during construction			

Thermal Performance

Temperate climate
Charlotte, Vermont



Key Values

General Project Data

Project Name:	Phototropic Project
City Location:	Charlotte
Latitude:	44° 20' 54" N
Longitude:	73° 15' 49" W
Altitude:	252.62 feet
Climate Data Source:	Strusoft server
Evaluation Date:	Dec 23, 2014, 11:41:19 AM

Thermal Resistances

R value	[sq ft,F,hr/Btu]
Building Shell Average:	16.22
Floors:	16.43 - 14.92
External:	80.00 - 8.96
Underground:	--
Openings:	7.31 - 3.55

Building Geometry Data

Gross Floor Area:	769.53	sq ft
Treated Floor Area:	755.33	sq ft
External Envelope Area:	1915.34	sq ft
Ventilated Volume:	6474.27	cu ft
Glazing Ratio:	19	%

Specific Annual Values

Net Heating Energy:	0.83	kWh/sq fta
Net Cooling Energy:	0.00	kWh/sq fta
Total Net Energy:	0.83	kWh/sq fta
Energy Consumption:	2.55	kWh/sq fta
Fuel Consumption:	1.96	kWh/sq fta
Primary Energy:	6.47	kWh/sq fta
Fuel Cost:	--	USD/sq fta
CO ₂ Emission:	0.00	lb/sq fta

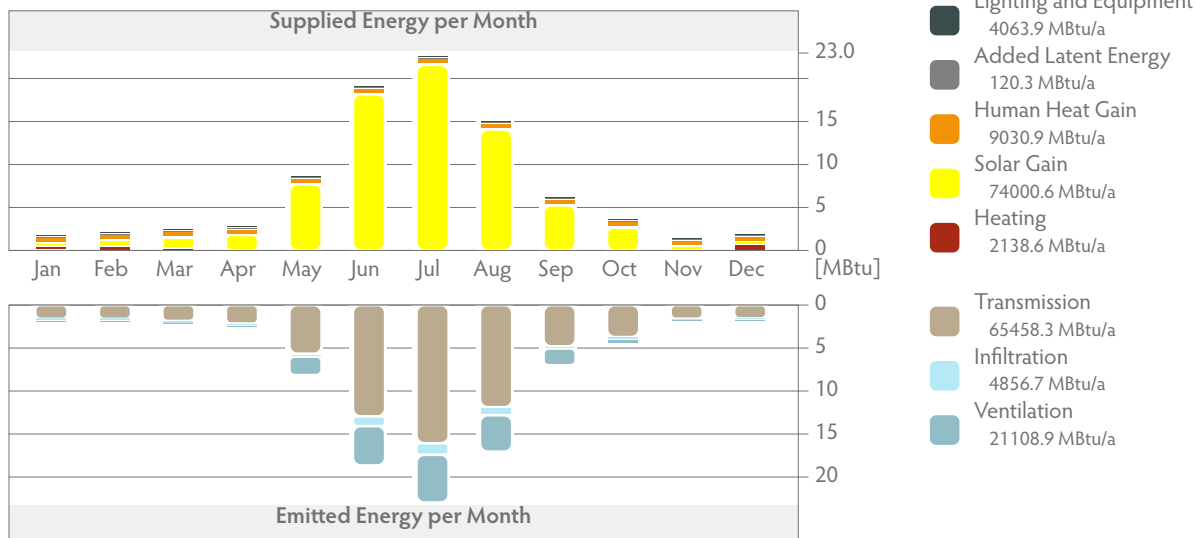
Building Shell Performance Data

Infiltration at 50Pa:	1.66	ACH
Outer Heat Capacity:	6.18*10 ⁻⁴	Btu/sq ft,F

Degree Days

Heating (HDD):	6999.75
Cooling (CDD):	977.47

Project Energy Balance



Energy Consumption by Targets

Target Name	Energy			CO ₂ Emission lb/a
	Quantity kBtu/a	Primary kBtu/a	Cost USD/a	
Heating	2138	3377	0	0
Cooling	0	0	0	0
Service Hot-Water	0	0	0	0
Ventilation Fans	368	1105	0	0
Lighting & Appliances	4063	12191	0	0
Total:	6570	16674	NA	0

Thermal Performance

Tropical climate
Kaua'i, Hawai'i



Key Values

General Project Data

Project Name:	Phototropic Project
City Location:	Kaua'i
Latitude:	22° 13' 29" N
Longitude:	159° 27' 11" W
Altitude:	6.56 feet
Climate Data Source:	Strusoft server
Evaluation Date:	Dec 23, 2014, 11:45:14 AM

Thermal Resistances

Building Shell Average:	R value	[sq ft,F,hr/Btu]
Floors:	16.22	
External:	16.43 - 14.92	
Underground:	80.00 - 8.96	
Openings:	--	
	7.31 - 3.55	

Building Geometry Data

Gross Floor Area:	769.53	sq ft
Treated Floor Area:	755.33	sq ft
External Envelope Area:	1915.34	sq ft
Ventilated Volume:	6474.27	cu ft
Glazing Ratio:	19	%

Specific Annual Values

Net Heating Energy:	0.00	kWh/sq fta
Net Cooling Energy:	0.00	kWh/sq fta
Total Net Energy:	0.00	kWh/sq fta
Energy Consumption:	1.72	kWh/sq fta
Fuel Consumption:	1.72	kWh/sq fta
Primary Energy:	5.16	kWh/sq fta
Fuel Cost:	--	USD/sq fta
CO ₂ Emission:	0.00	lb/sq fta

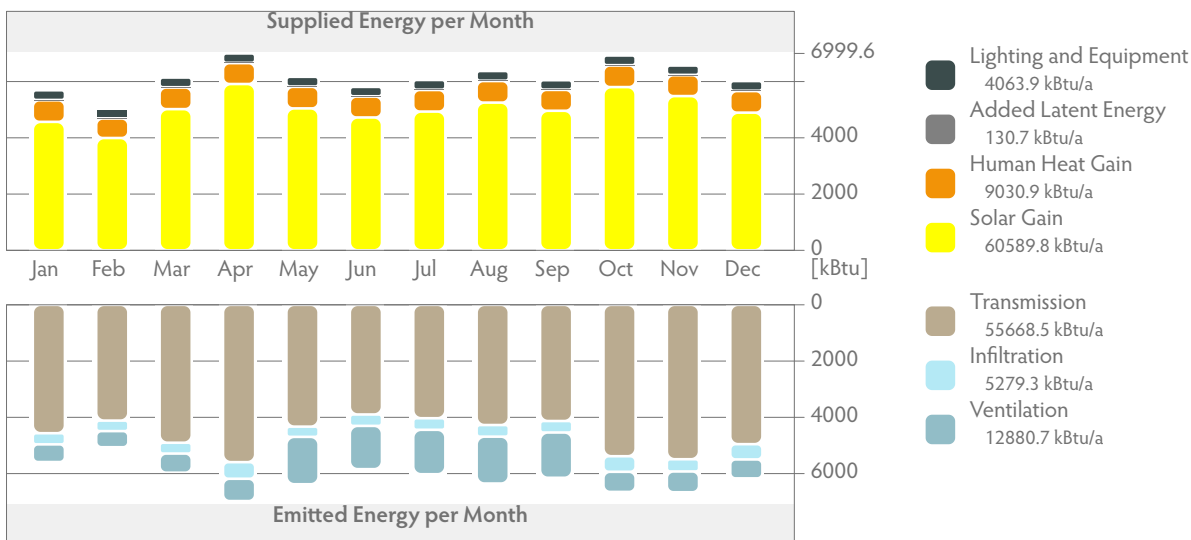
Building Shell Performance Data

Infiltration at 50Pa:	1.66	ACH
Outer Heat Capacity:	6.18*10 ⁻⁴	Btu/sq ft,F

Degree Days

Heating (HDD):	6.70
Cooling (CDD):	4608.90

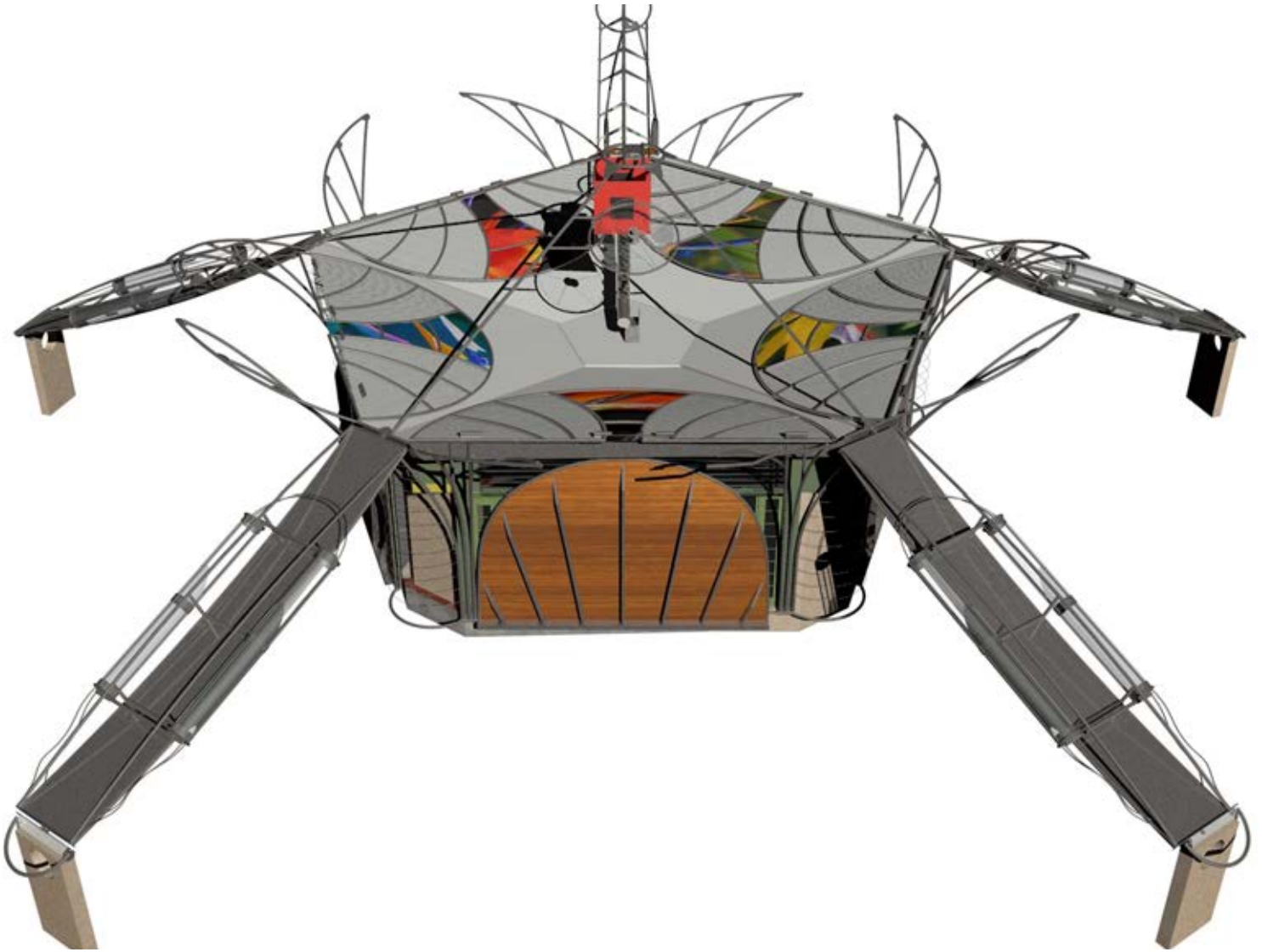
Project Energy Balance



Energy Consumption by Targets

Target Name	Energy			CO ₂ Emission lb/a
	Quantity kBTu/a	Primary kBTu/a	Cost USD/a	
Heating	0	0	0	0
Cooling	0	0	0	0
Service Hot-Water	0	0	0	0
Ventilation Fans	368	1105	0	0
Lighting & Appliances	4063	12191	0	0
Total:	4432	13296	NA	0

Protection



Engineered to survive Category 4 hurricane winds

Decks, petals, PV leaves, and wind turbine all fold and lock down when a damaging storm threatens.

Structural Engineering

Servidio Engineering, Burlington VT

Steel Fabrication

Reliance Steel, Colchester VT

Goals

Vision

Understanding how we consume energy and resources has never been more important. Living in a well conceived structure can provide just such an awareness.

A low impact, zero energy, carbon neutral home, living lightly on the land, harvesting rainwater, generating and storing electricity, and charging electric vehicles, has a place in today's housing market.

Design & Engineering

Our designs address a variety of climates, from tropical to temperate. Prototypes to be field tested, tweaking mechanical and electrical systems for optimal performance.

Community & Education

Tours and open houses, especially catering to students of high school and college levels, will be conducted to demonstrate our projects.

Carbon neutral

The project is designed as carbon neutral* and supports the goal of the 2030 Challenge to achieve carbon neutrality for all new buildings and major renovations by 2030.

Mission

As a socially and environmentally responsible design and fabrication company, our mission is to create innovative buildings that meet the needs of several markets.

Our buildings do not require connections to utility infrastructure. They use replenishable materials, emerging technologies, and only the sun, wind and rain for power.

Marketing & Sales

The housing marketplace continues to evolve. Empty nesters, childless parents, and new couples are all looking for options in smaller, less costly housing. We offer thoughtful solutions.

We also see opportunities in the expanding ecotourism industry.

We anticipate selling licenses to reproduce our residential and commercial products.

Net Zero

The wind and photovoltaic systems are sized to produce adequate electrical energy on-site for appliances, lighting, hot water, electric car charging, while maintaining human comfort.



*CO2 emissions from occasional wood burning are offset by using surplus energy to power a free, on-site charging station for neighborhood electric automobiles, scooters and bicycles.





the **SUN, WIND & RAIN COMPANY**

created by

Groundswell Architects

477 Ten Stones Circle • Charlotte VT 05445 • 802-425-7717

www.groundswellarchitects.com

ted@groundswellarchitects.com

This document contains confidential and proprietary information
belonging exclusively to the Sun, Wind and Rain Company.

Copyright © 2015 GroundSwell Architects v8.13.15