All in on Student Competitions:
LCC's MacZero Net-Zero house on Mackinac Island

GREENER DELTA: April 24, 2010

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MacZero!

- An intensive student made, student run Build UP! Michigan Competition of 7 colleges and universities from throughout the State of Michigan
- 16 students with a diverse background, an infinite energy source, and unbridled enthusiasm!
- Winning house to be built beginning October 2010

MacZero Preparation

Hands-on analysis of leading Net Zero Homes:

- The Gable Home in Champaign, the University of Illinois DOE Solar Decathlon Home, 2nd overall in 2009
- A Passive Institute Home in Urbana
- The Phoenix House in Saline, “Behind the Drywall” tour
- A Cobblestone Home in Bay City, featuring emerging Dow Solar Systems

MacZero Teamwork

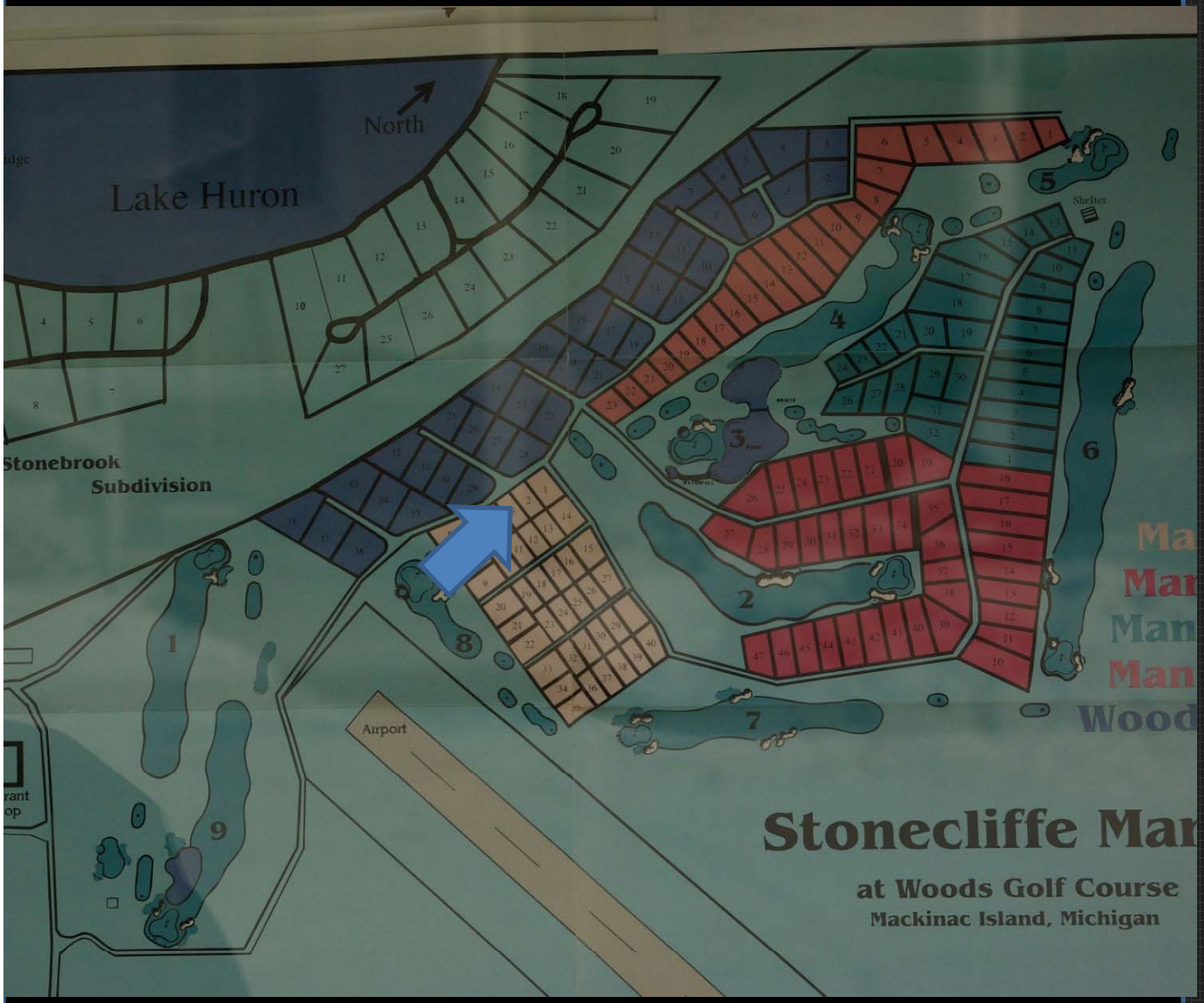
- Team travel and small group projects worked to emphasize teamwork
- Each student started with site plan and zoning, and competition information, and created and optimized their own floor plans
- Consensus method s allowed good as well as strong ideas to take root
- Collaboration from each student created and optimized the design

MacZero Influences

- Mackinac Island's Newest house, along the road up to the Grand hotel at the top of the ridge
- Our site is a charming few miles further up the road
- No cars, no attached garages

MacZero Influences

- Grand Hotel Cupola!



MacZero Site Info

- Stonecliffe Manor Lot 3 at the blue arrow, which also points north
- The Direction North is towards the upper right
- The long direction of the lot orients towards the north and south
- Nearby golf course, airport, lake bluff
- Smaller lots on a partially wooded bluff

MacZero at Stonecliffe

- West Facing Bluff
- Lot #3 set back over bluff , hard to see water
- Wind studies suggest good recoil on the prevailing westerly wind
- Stony soils on top limit topsoil to 12”, trees to under 50’
- View from airplane just after takeoff

MacZero at Stonecliffe

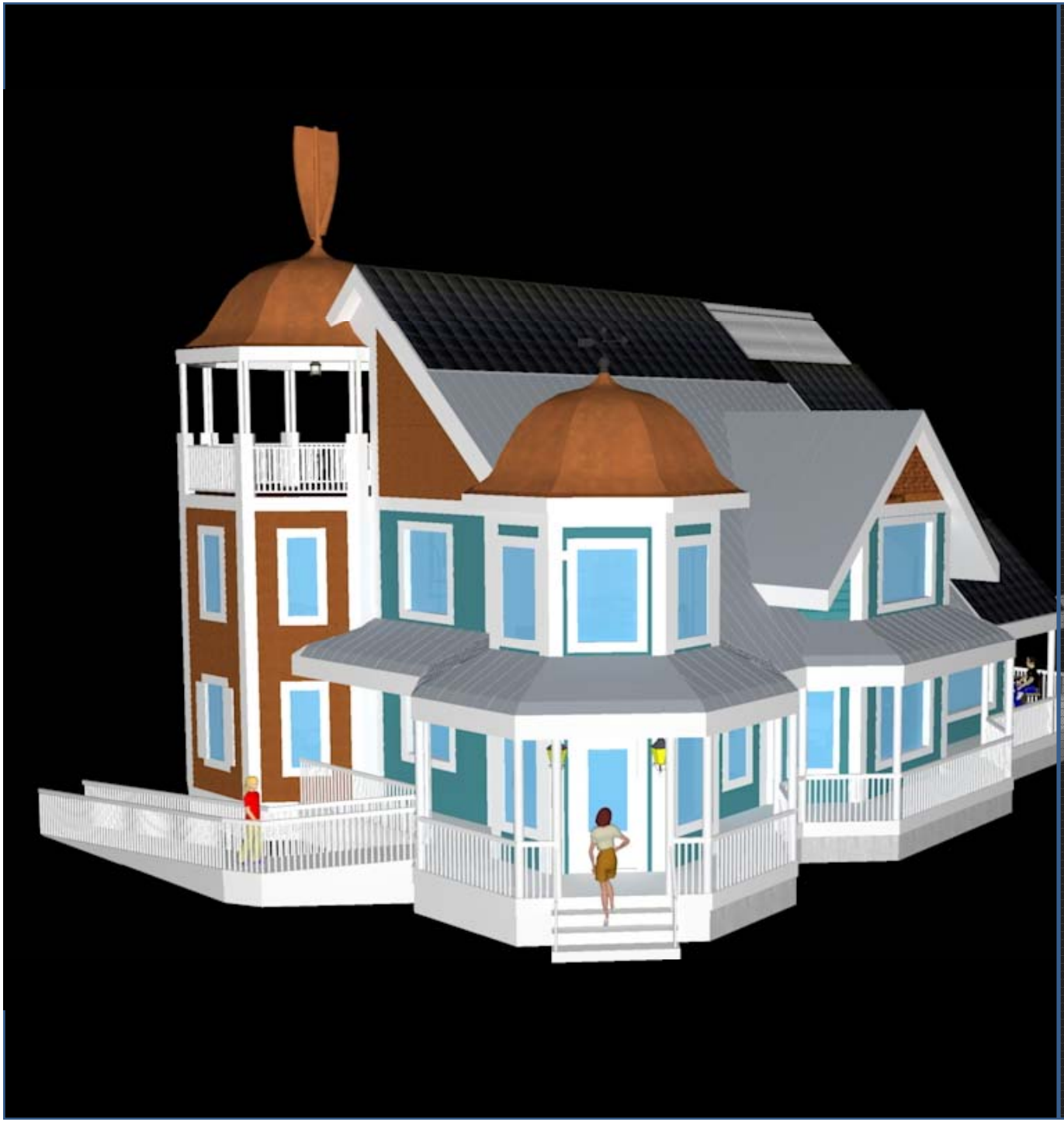
- First house seen in our neighborhood coming from town or from the airport
- Faces south out over the airport's open, winding west end of the runway
- Significant noise from daily propeller as well as jet airplanes

MacZero Site

- Looking Southeast to the big “Hippie” house
- Note bright winter sun
- Note trees removed
- Note scrappy trees in very shallow soils

MacZero Site

- Looking south from the center of our lot around solar noon to our low winter sun, below 20 degrees at noon
- Developers anticipate homes on of most of the lots around us over time, removing most trees
- Solar shading studies on our house from an identical home placed due south do not cast shadows on our roof or upper windows



MacZero

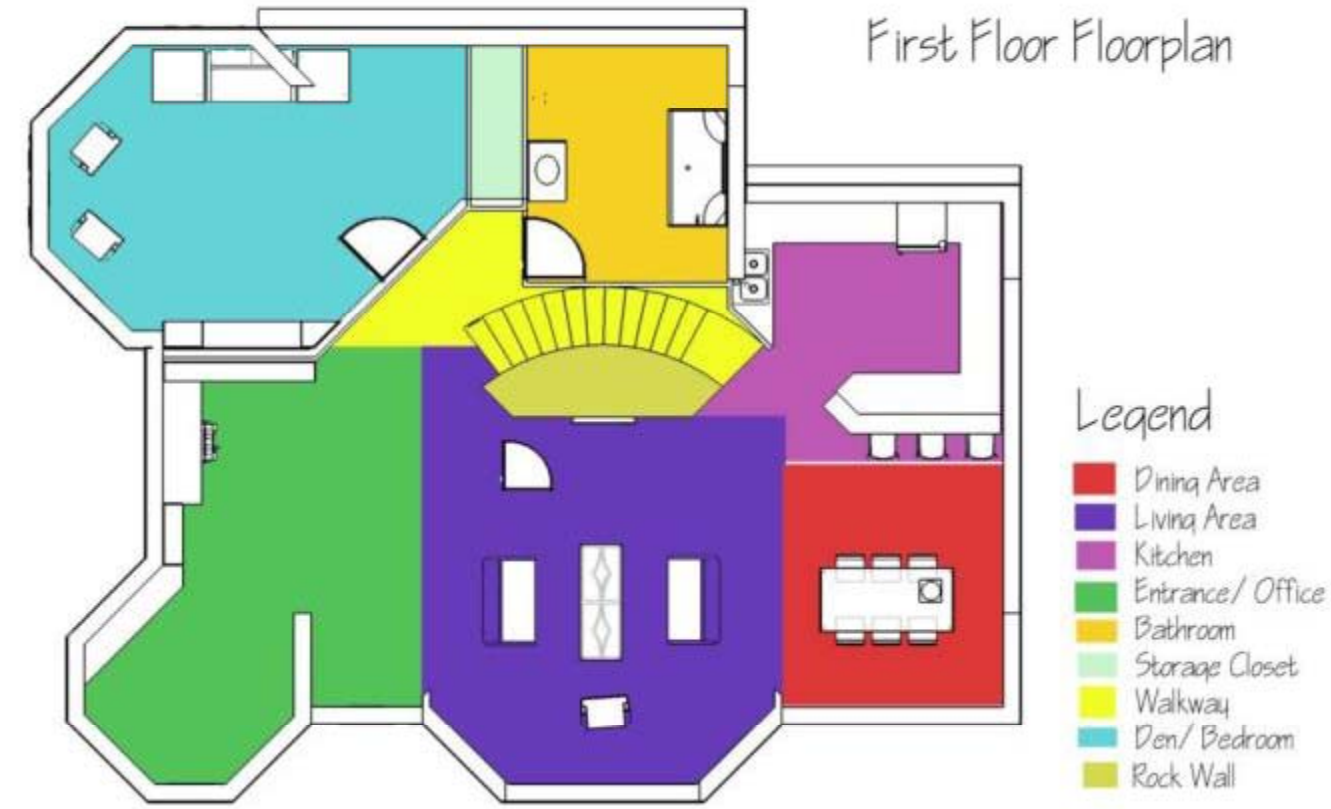
- Signature Features
  - •Victorian Style as required, With Local Influences
  - •Generous 3075 s.f.
  - •2.5 Story
  - •2-3 Bedrooms
  - •2 ¾ Bath
  - •Convertible first floor Bedroom/Den
  - •Continuous Wrap-around Porches
  - •3rd Story Look Out
  - •Building Integrated Wind Turbine
  - •Building Integrated Solar Systems
  - •$248,000 cost of Materials only

MacZero Southeast

- Multiple Large Windows for Interior Daylighting, Solar Heat Gain
- Dormer to Provide Light to Second Floor Interior
- Generous Roof Area for Integrated Solar Systems

MacZero North Turret

- Roof Cupola Design based on Grand Hotel, Mackinac Island Victorian flavor, R.A.M. Stern
- 3rd Floor Lookout for Views of the Straits and Bridge
- Cooler, stronger breezes for elevated porch
- Serves as an elevated Base for Wind Turbine



MacZero 1st Floor

- Features
  - To serve as a small conference facility
  - Fully Handicap Accessible
  - Open Floor Plan
  - Built in Office
  - Den
    - Separate area for meetings
    - Murphy bed for use as third bedroom
  - Full Bath
  - Copious Kitchen
  - Flexible Dining
  - Central Stair and Thermal Mass

MacZero 2nd Floor

- Features
  - Master Suite
  - Loft Area overlooking central Open Area
  - 1 ¾ Baths
  - 2nd Bedroom

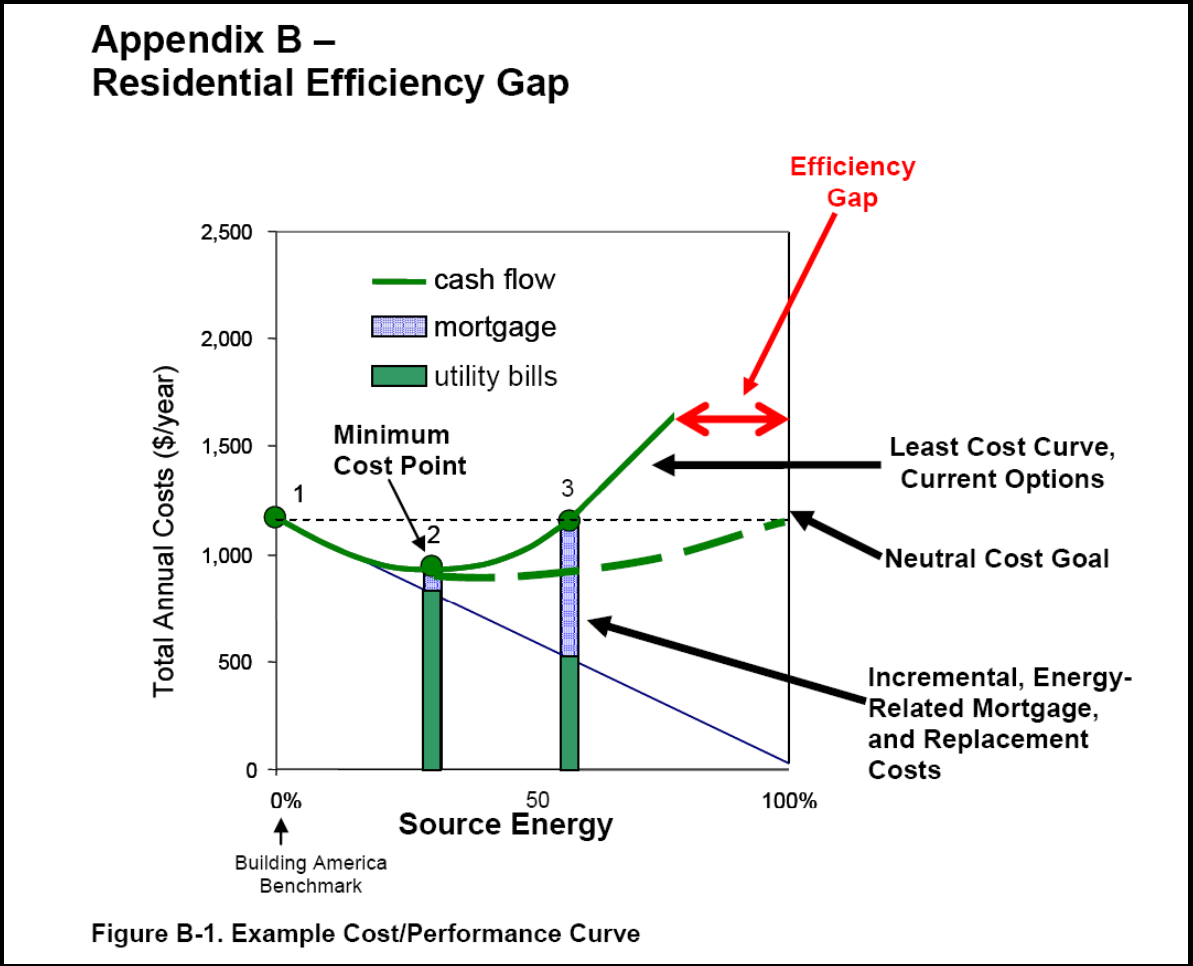
MacZero Framing

- Working Model
- Used to aggressively stay on 2’ module, eliminate waste
- Provided accurate material numbers for estimating, off-site fabrication
- Used advanced framing techniques and methods to eliminate thermal bridging at corners
- Lightweight steel framing with 3/8” R3.75 Aerogel tape thermal isolation w/ R4.25 continuous sheathing
- Allows free form, copious corners

MacZero Software

- 3 Dimension Modeling
  - Google Sketchup
  - Revit
- Energy Modeling
  - PHPP
  - Rem Rate / HERS
  - Energy Plus
    - w/in Sketchup
  - Virtual Wind
    - w/in Sketchup
- Sustainability Inventory
  - LEED for homes

At a certain minimum cost point, we may still be paying for energy, but the total cost will be the least:



Maximizing Residential Energy Savings," R. Anderson, NREL/TP-550-44547, November 2008

MacZero

So what is "Net-Zero?"

- DOE offers a wide range of definitions from different perspectives.
- Build UP! Michigan Competition references DOE energy definitions: Produce energy equal to your consumption.
- DOE recognizing high cost of Net Zero Energy vs. Incremental Energy related Mortgage cost

To meet current U.S. Department of Energy zero-energy home (ZEH) performance goals, new technologies and solutions must increase whole-house efficiency savings by an additional 40% relative to those provided by best available components and systems. An expanded research program is needed to develop the key ZEH technologies and systems to fill this performance gap

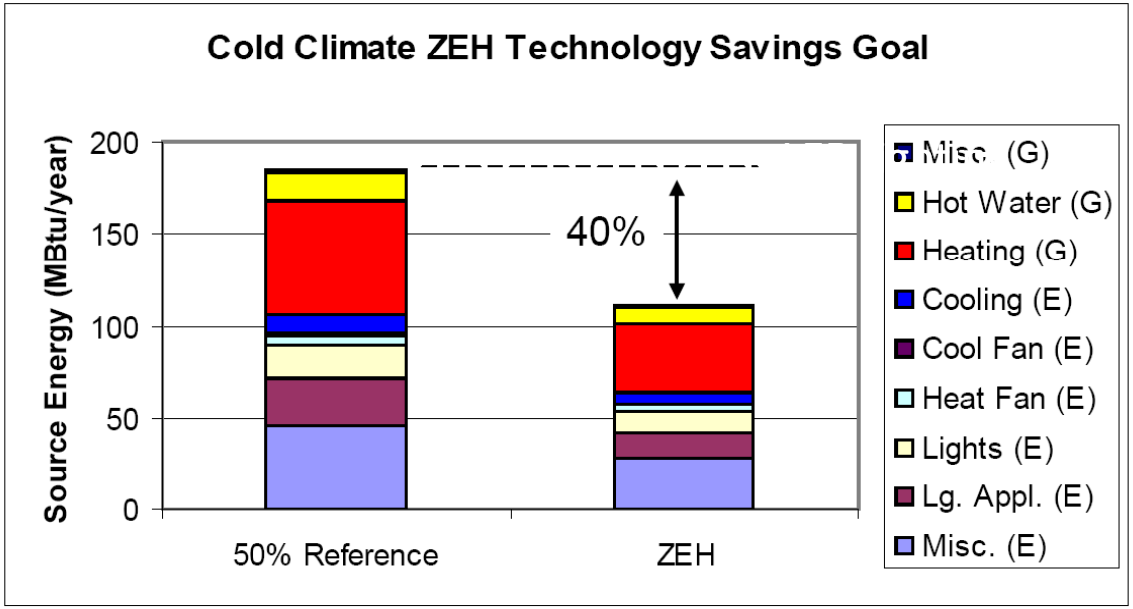


Figure 8. Energy Savings to Be Provided by an Expanded ZEH Technology Research Program (see Appendix C for a summary of energy saving opportunities in other climates)

"Maximizing Residential Energy Savings," R. Anderson, NREL/TP-550-44547, November 2008

MacZero Net Zero?

- Efficiency Savings, where natural gas and LP are not readily available:
- Clustered Hot Water
- Wastewater HR Tubes
- Evacuated Tube SHW
- Natural cooling only
- 92% MVHR ventilation
- Maximized daylighting
- Minimized artificial lighting levels
- Maximize CFL's, LED's
- Certified ENERGY STAR efficient appliances:
  - Induction cooktop
  - Convection oven
  - 32" LED television
  - Small refrigerator

The following systems represent a minimum set of efficiency improvements required to achieve cost-effective net ZEHs:

• High-R Wall Systems – Durable high-R wall systems for cold, northern marine, and mixed climates, leading to development of an R-30+ wall assembly with an incremental cost of $2/s.f. floor area relative to an R-19 2 × 6 wall.

• Cold Climate Domestic Hot Water (DHW) – DHW system with $2000 incremental system cost and 30% reduction in annual energy use relative to a gas tankless hot water system with efficiency factor (EF) = 0.8.

• Cold Climate R-10 Window Assembly – R-10 window assembly with a minimum solar heat gain coefficient (SHGC) of 0.3 and a cost of $20/s.f.
(incremental cost of $4/ft2 relative to current low-e windows).

"Maximizing Residential Energy Savings," R. Anderson, NREL/TP-550-44547, November 2008

MacZero Net Zero?

Efficient Cost-Effective Features:

- R34.9 in 2x6 wall assembly with insulating sheathing
- Gas not available: Used next best Evacuated Tube SHW, thermal mass
- South & north windows are R7.7 Solar Gain glazing, while east & west windows are R6.6 Solar Shade glazing; better SHGC =0.2

THERMOMAX

SOLAR COLLECTORS

Sault Ste. Marie ON

System Sizing Guide

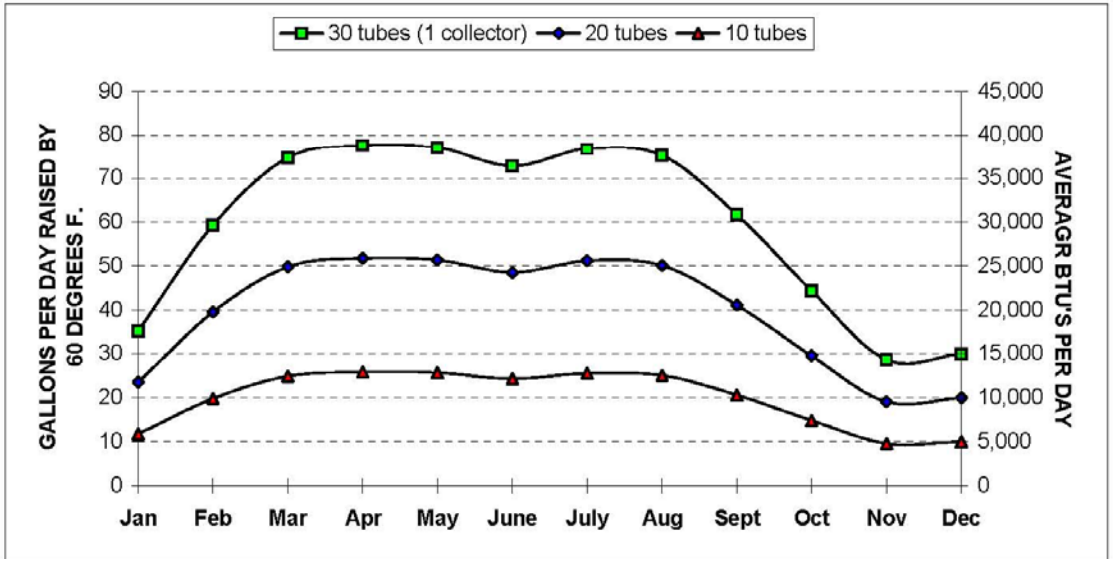
www.solarThermal.com

Latitude:	46 Degrees
System Tilt	46 Degrees
Orientation	180 Degrees

	Mean daily Radiation *		Average Daily Thermomax Output ** BTU's and US Gallons heated by 60F					
			10 Tubes 1 square meter		20 Tube Collector 2 square meters		30 Tube Collector 3 square meters	
	MJ/ sq.m	BTU/ sq.m	BTU	Gallons	BTU	Gallons	BTU	Gallons
Jan	8.843	8,388	5,871	12	11,743	23	17,614	35
Feb	14.873	14,107	9,875	20	19,750	39	29,625	59
Mar	18.739	17,774	12,442	25	24,884	50	37,325	75
Apr	19.477	18,474	12,932	26	25,864	52	38,795	78
May	19.345	18,349	12,844	26	25,688	51	38,532	77
June	18.262	17,322	12,125	24	24,250	49	36,375	73
July	19.269	18,277	12,794	26	25,587	51	38,381	77
Aug	18.863	17,892	12,524	25	25,048	50	37,572	75
Sept	15.468	14,671	10,270	21	20,540	41	30,810	62
Oct	11.119	10,546	7,382	15	14,765	30	22,147	44
Nov	7.183	6,813	4,769	10	9,538	19	14,307	29
Dec	7.514	7,127	4,989	10	9,978	20	14,967	30
Annual Mean	14.911	14,143	9,900	20	19,800	40	29,700	59
Annual Totals BTU		5,162,302	3,613,612	7,227	7,227,223	14454	10,840,835	21,682
							Gallons Heated in 25 years	542,042

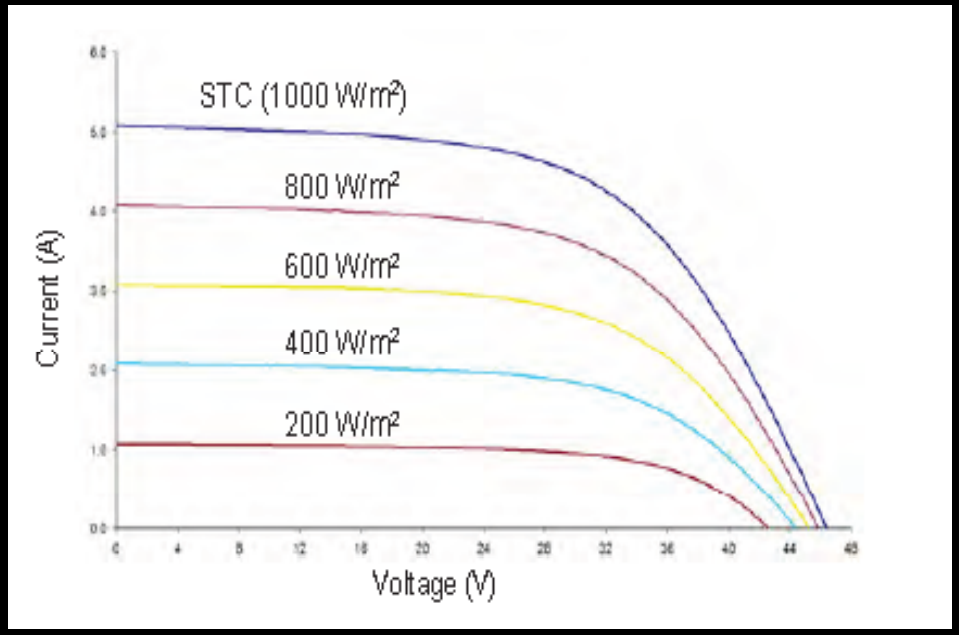
* Radiation figures from "Solar Radiation Data Analysis for Canada 1967-1976"

** Collector efficiency 70% of average daily radiation.



MacZero Solar Hot Water (SHW)

- Evacuated Tubes
- Thermomax
- 70% efficiency
- Edge mounted for improved efficiency
- 2 prefabricated panels each 3 square meters
- 21,681,670 BTU's
- 21.7 MBTU's
- Converts to 6.35 kW
- Used for house heating and domestic hot water
- Vertical column of water in central thermal mass element



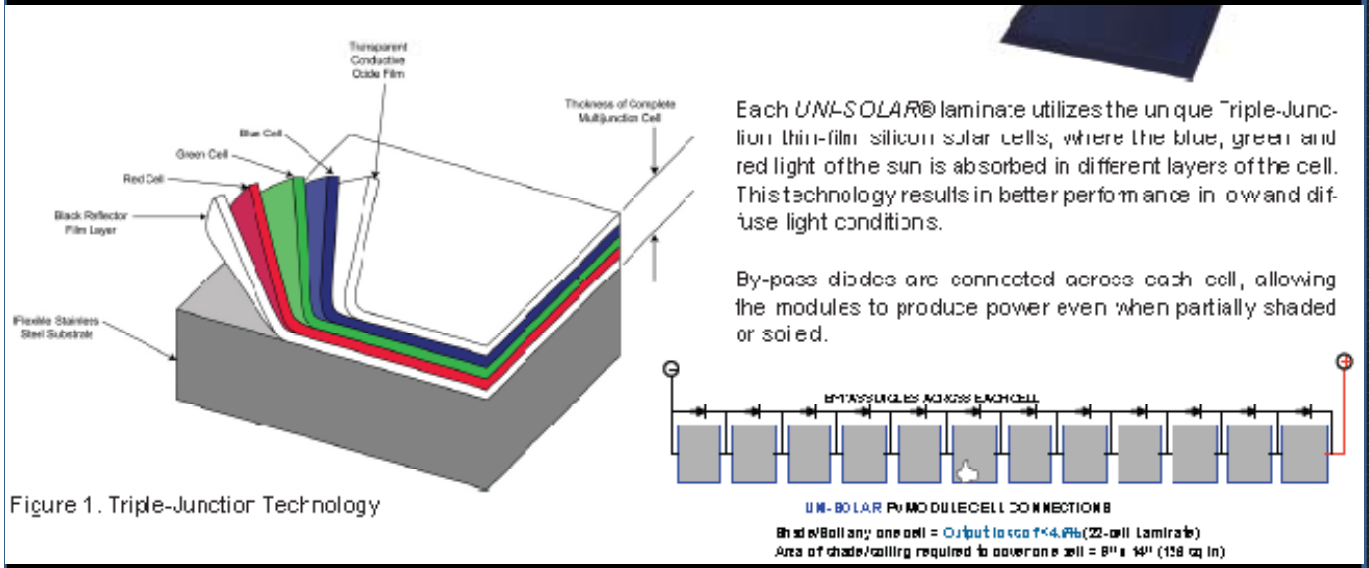


Figure 1. Triple-Junction Technology

Each *UNI-SOLAR®* laminate utilizes the unique Triple-Junction thin-film silicon solar cells, where the blue, green and red light of the sun is absorbed in different layers of the cell. This technology results in better performance in low and diffuse light conditions.

By-pass diodes are connected across each cell, allowing the modules to produce power even when partially shaded or soiled.

UNI-SOLAR PV MODULE CELL CONNECTIONS

Shade/Ballast one cell = Output loss of 4.4% (22-cell Laminate)
Area of shade/ballast required to cover one cell = 8" x 14" (112 sq in)

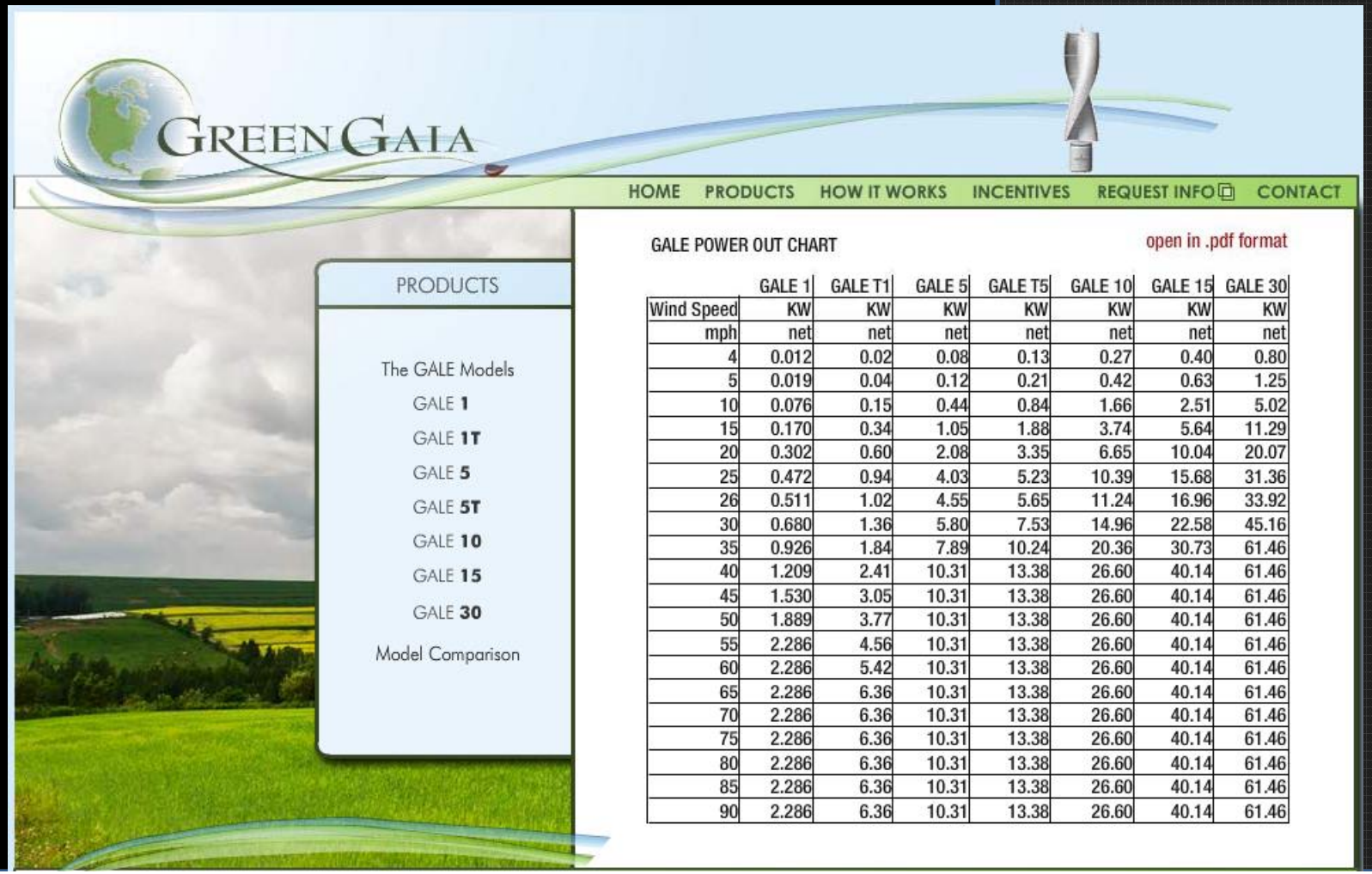
www.UNI-SOLAR.com

MacZero Solar PV Photovoltaic

- Thin Film UNISOLAR Building Integrated Panels
- Silicon solar cells in amorphous sheets, directly adhered to metal roofing
- Made in Greenville, Michigan
- Recommending shift to new 13% efficient Dow Powershingles

MacZero Wind Turbine

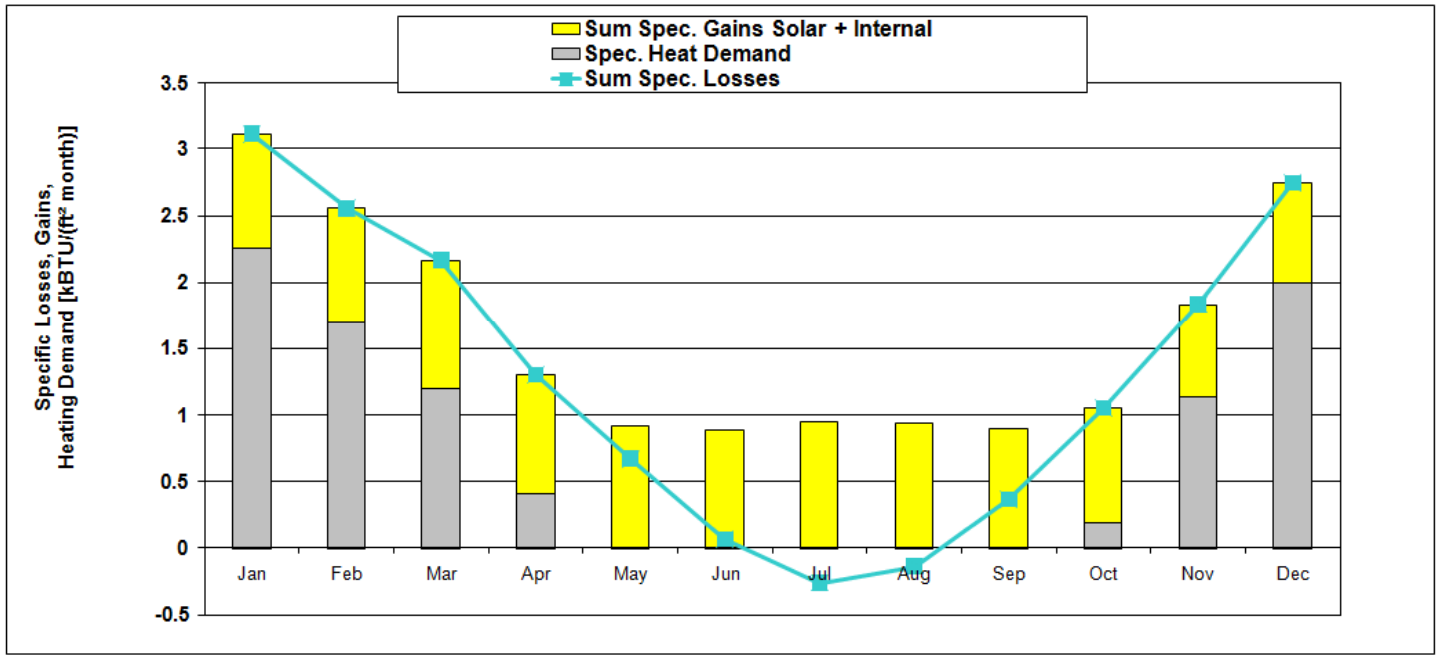
Tangarie Gale 5, mounted 45’ high as a decorative element on main turret.
Uses the Grid as a battery!
www.tangarie.com



Wind Speed mph	GALE 1 KW net	GALE T1 KW net	GALE 5 KW net	GALE T5 KW net	GALE 10 KW net	GALE 15 KW net	GALE 30 KW net
4	0.012	0.02	0.08	0.13	0.27	0.40	0.80
5	0.019	0.04	0.12	0.21	0.42	0.63	1.25
10	0.076	0.15	0.44	0.84	1.66	2.51	5.02
15	0.170	0.34	1.05	1.88	3.74	5.64	11.29
20	0.302	0.60	2.08	3.35	6.65	10.04	20.07
25	0.472	0.94	4.03	5.23	10.39	15.68	31.36
26	0.511	1.02	4.55	5.65	11.24	16.96	33.92
30	0.680	1.36	5.80	7.53	14.96	22.58	45.16
35	0.926	1.84	7.89	10.24	20.36	30.73	61.46
40	1.209	2.41	10.31	13.38	26.60	40.14	61.46
45	1.530	3.05	10.31	13.38	26.60	40.14	61.46
50	1.889	3.77	10.31	13.38	26.60	40.14	61.46
55	2.286	4.56	10.31	13.38	26.60	40.14	61.46
60	2.286	5.42	10.31	13.38	26.60	40.14	61.46
65	2.286	6.36	10.31	13.38	26.60	40.14	61.46
70	2.286	6.36	10.31	13.38	26.60	40.14	61.46
75	2.286	6.36	10.31	13.38	26.60	40.14	61.46
80	2.286	6.36	10.31	13.38	26.60	40.14	61.46
85	2.286	6.36	10.31	13.38	26.60	40.14	61.46
90	2.286	6.36	10.31	13.38	26.60	40.14	61.46

Passive House Institute US, Urbana, IL
www.passivehouse.us

MacZero PHPP



kBTU/(ft²yr) 1.58
kBTU/(ft²yr) 0.00
1.58
kBTU/(ft²yr) 14.77
kBTU/(ft²yr) 3.94
kBTU/(ft²yr) 1.93
kBTU/(ft²yr) 5.87
kBTU/(ft²yr) 5.87
kBTU/(ft²yr) 8.90

Annual Heat Demand: Comparison

EN 13790 Monthly Method	27366	kBTU/yr	8.9	kBTU/(ft²yr) Reference to habitable area
PHPP, Heating Period Method	27765	kBTU/yr	9.0	kBTU/(ft²yr) Reference to habitable area

Month	1	2	3	4	5	6	7	8	9	10	11	12	Annual Total	Heating Period Method
Days	31	28	31	30	31	30	31	31	30	31	30	31	365	205
Ambient Temp. (°F)	12	18	31	46	58	68	74	71	60	49	33	18	45	29
North Radiation (kBTU/(ft²*month))	3.8	5.1	8.2	10.5	14.3	16.2	16.2	12.4	9.2	6.7	4.4	3.5	110	39
East Radiation	13.6	15.8	23.5	26.3	33.9	34.9	38.0	32.7	23.8	18.1	10.8	10.5	282	151
South Radiation	38.0	38.0	39.3	31.7	30.4	28.2	30.7	33.0	34.2	35.2	27.6	30.7	397	220
West Radiation	12.4	15.8	24.4	27.6	31.7	32.3	34.6	31.1	25.4	18.1	11.1	10.5	275	91
Hori. Radiation	17.4	24.1	36.8	44.7	56.1	59.3	62.1	52.9	38.7	27.3	16.2	13.3	449	165
Tsky (°F)	-21	-13	2	18	32	45	51	50	39	26	9	-12	19	32
Ground Temp (°F)	47	45	45	48	53	62	66	69	68	62	57	52	56	51

Window / WinType / Shading / Ventilation / Annual Heat Demand / **Monthly** / Heat Load / Summer / Shading-S / SummVent / Cooling / Cooling Units / Cooling Load / DHW / SolarDHW

MacZero Net-Zero!

Annual Energy Estimates in MBTU / year:

•Photovoltaic	13.8
•Evacuated Tube	21.7
•Wind Turbine	13.9
•Solar Heat Gain	11.5
•Intern. Heat Gain	5.7
•Heat Loss	44.9
•Hot Water	13.9
•Electricity	7.8

•Net Zero: 0.0

Where:
3413 BTU's = 1 kW

Interiors Products	Sustainability & Details	Certification & Standards	Manufacturer Location	Retailer Location	Amount	Price
InPro Armorwall 300 (Paint)	Contains an EPA antimicrobial additive, and 100% acrylic, water based	Green Seal standards	Muskego, WI (421.6 mi)	Muskego, WI (421.6 mi) (InPro Corp.)	9640 sq ft (25 gal)	$777.50 (InPro)
Paperstone "Certified" (kitchen & bath countertops)	Uses 100% post-consumer recycled paper, and petroleum-free resin	FSC certified and Smartwood certified	Hoquiam, WA	Ann Arbor, MI (277 mi) (BgreenToday.com)	Kitchen: 63 sq ft Bath: 33 sq ft	$3,360.00 (Andrews) (PaperStone)
Crystal Cabinets Green Quest (kitchen & bath cabinetry)	100% recycled, low-emitting, and rapidly renewable components	FSC certified, ESP certified,	Princeton, MN	Traverse City, MI (124 mi)	53 linear ft	16,250.00 (Crystal)
Viridian recycled glass tile (bathroom)	98% recycled glass	SCS certified	Scotts Valley, CA	Scotts Valley, CA (modwalls.com)	206 sq ft	$2,667.70 (Modwalls)
Keracolor U (tile grout)	BioBlock antimicrobial protection	LEED qualified	West Chicago, IL	Petoskey, MI (Lowe's)	206 sq ft (3 bags)	$56.25 (Lowe's)
Safecoat MexeSeal (grout sealer)	Low VOC's and waterbased	SCS certified	San Diego, CA	Ann Arbor, MI (277 mi) (BgreenToday.com)	206 sq ft	$43.90 (Bgreen)
Maxxon 1 1/4" Therma-Floor (concrete flooring)	Local sand and water, recycled content (fly ash), and low-emitting materials	Greenguard IAQ certified	Camden, NJ	Hamel, MN (Maaxon Corp.)	3075 sq ft	$4,913 (Maxxon)
Taylor 2033 - Clear Thin Spread Tile Adhesive	Solvent free and low odor	Greenguard certified	Dalton, GA	(affordafloors.com)	206 sq ft (1 gal)	$114.00

MacZero Carbon Neutral

- Careful, thoughtful selection of appropriate materials

7) Excavation:
   a. Work primarily from east end of site, up to 2' lower than west end.
   b. Cut and fill to be balanced on-site.
   c. Use stone excavated as masonry for the exposed thermal mass element.
   d. Use gravel spoils as decorative ground treatment (1/2" to 1 ½") as well as the aggregate in the grout (1/2" and under).
   e. Backfill to be pre-crushed on-site and compacted to 95% proctor density.

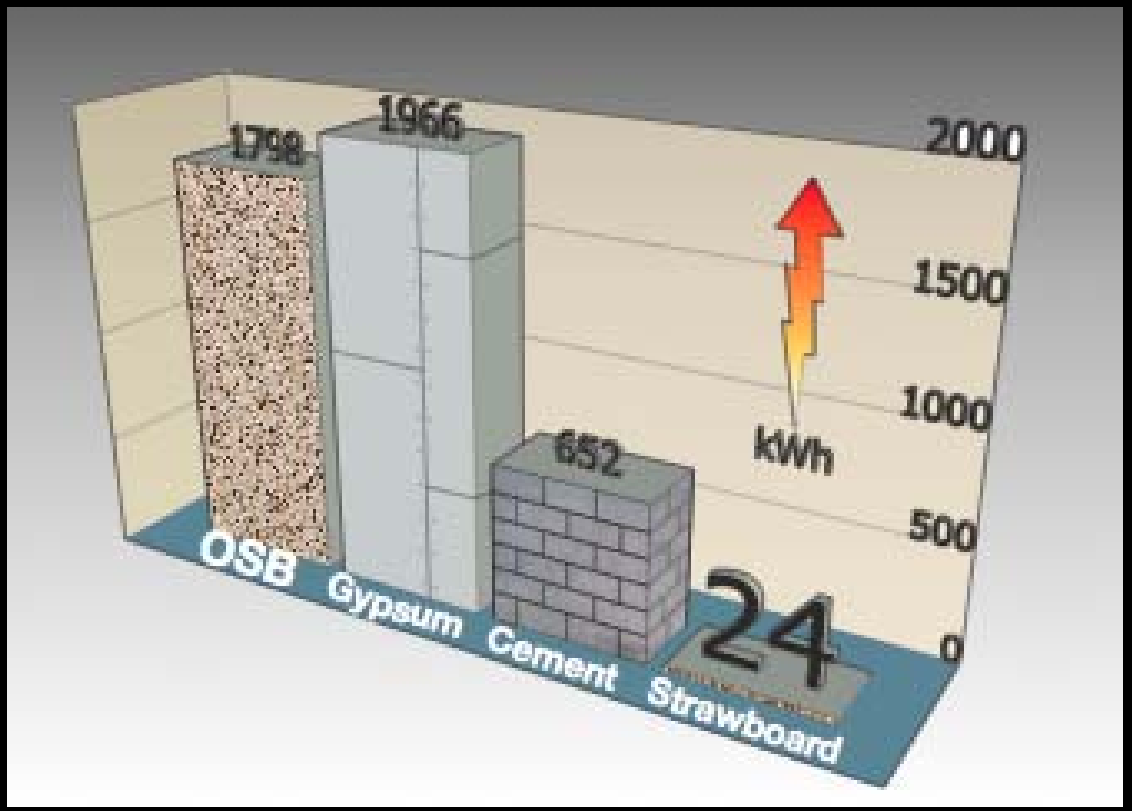
8) Footings:
   a. Confirm stable stone or virgin soil base. 42" below grade except wehre the walls intersect stable bedrock.
   b. 3000 PSI footing concrete to be mixed on-site and formed in place over irregular stone strata.
   c. Reinforce footings with (2) #4 bars with 3" min. cover. Provide 2x4 keyway.

9) Foundation:
   a. 12" x 12" x 24" Durisol cement bonded wood fiber ICF masonry block with rigid fibrous insulation. Pre-formed 90 degree corners, miter all 45 and 135 degree angles. Crawlspace with (3) 12" courses.
   b. Reinforce with #4 epoxy coated bar vert. @ 4'-0" o.c. tied to 2'x1' #4 epoxy coated dowels aligned below.
   c. Grout with high-slump 7" thick concrete (7-9" slump), vibrated into place w/ max 4' lifts. Use of clean gravels from on-site excavation permitted as the aggregate, limited to ½" & under, amended by 50% pea stone.
   d. Interior face of blocks to be left exposed and kept tidy and regular.

10) Waterproofing System:
   a. Tremco TREMproof 201/60 fluid-applied, elastomeric waterproof membrane System, 60 mils full height. One-part moisture curing elastomer in viscosity R, VOC compliant containing 95 g/L volatile organic compounds. Manufactured in Toronto, Ontario. Recycled content for 5 gallon pails on a pallet is 4.17% of which 3.77% is post-industrial.
   b. 3/4" Warm-N-Dri Tremco/Owens Corning rigid fiberglass insulation/drainage/protection board full height, adhered to waterproofing before it dries (no mechanical fastening permitted).

MacZero Specs and Notes

- 6 pages of outline architectural specifications
- Environmentally appropriate materials as well as methods and site practices



www.enviroboard.com

MacZero Sheathing

• Organic panels made from agricultural and wood products waste have extremely low embodied energy as compared to traditional construction materials.

•Strawboard has 75 times less energy than oriented strand board (OSB) sheathing

•Strawboard has 82 times less energy than gypsum board (drywall)

•Well insulated wall assemblies STC 31 and R4.25 per 2”board

for Homes

LEED for Homes Simplified Project Checklist

Builder Name:	*Meadowlark Builders*
Project Team Leader (if different):	
Home Address (Street/City/State):	*Lot 3 Stonecliffe Manor, Mackinaw Island, Michigan*

Project Description:

Building type: *Single detached* Project type: *Custom*

# of bedrooms: *3* Floor area: *3075*

Adjusted Certification Thresholds

Certified: *57.5* Gold: *87.5*

Silver: *72.5* Platinum: *102.5*

Project Point Total

Prelim: *113 + 30 maybe pts* Final: *109*

Certification Level

Prelim: *Platinum* Final: *Platinum*

Final Credit Category Total Points

ID: 4 *SS: 20* *EA: 38* *EQ: 19*

LL: 5 *WE: 6* *MR: 16* *AE: 1*

date last updated :
last updated by :

					Max Points	Project Points Preliminary Y/Pts	Maybe	No	Final Y/Pts
Innovation and Design Process (ID)			(No Minimum Points Required)		Max	Y/Pts	Maybe	No	Y/Pts
1. Integrated Project Planning		1.1	Preliminary Rating		Prereq	Y			Y
		1.2	Integrated Project Team		1	1	0		1
		1.3	Professional Credentialed with Respect to LEED for Homes		1	1	0		1
		1.4	Design Charrette		1	1	0		1
		1.5	Building Orientation for Solar Design		1	1	0		1
2. Durability Management Process		2.1	Durability Planning		Prereq	Y			Y
		2.2	Durability Management		Prereq	Y			Y
		2.3	Third-Party Durability Management Verification		3	0	3		0
3.Innovative or Regional Design		3.1	Innovation #1 _____		1	0	0		0
		3.2	Innovation #2 _____		1	0	0		0
		3.3	Innovation #3 _____		1	0	0		0
		3.4	Innovation #4		1	0	0		0
				Sub-Total for ID Category:	**11**	4	3		4
Location and Linkages (LL)			(No Minimum Points Required)	*OR*	Max	Y/Pts	Maybe	No	Y/Pts
1. LEED ND		1	LEED for Neighborhood Development	**LL2-6**	10	0	0		0
2. Site Selection		2	Site Selection		2	2	0		2
3. Preferred Locations		3.1	Edge Development	**LL 3.2**	1	0	1		0
		3.2	Infill		2	0	2		0
		3.3	Previously Developed		1	1	0		1
4. Infrastructure		4	Existing Infrastructure		1	1	0		1
5. Community Resources/ Transit		5.1	Basic Community Resources / Transit	**LL 5.2, 5.3**	1	0	0	N	0
		5.2	Extensive Community Resources / Transit	**LL 5.3**	2	0	0	N	0
		5.3	Outstanding Community Resources / Transit		3	0	0	N	0
6. Access to Open Space		6	Access to Open Space		1	1	0		1
				Sub-Total for LL Category:	**10**	5	2		5
Sustainable Sites (SS)			(Minimum of 5 SS Points Required)	*OR*	Max	Y/Pts	Maybe	No	Y/Pts
1. Site Stewardship		1.1	Erosion Controls During Construction		Prereq	Y			Y
		1.2	Minimize Disturbed Area of Site		1	1	0		1
2. Landscaping		2.1	No Invasive Plants		Prereq	Y			Y
		2.2	Basic Landscape Design	**SS 2.5**	2	2	0		2
		2.3	Limit Conventional Turf	**SS 2.5**	3	3	0		3
		2.4	Drought Tolerant Plants	**SS 2.5**	2	2	0		2
		2.5	Reduce Overall Irrigation Demand by at Least 20%		6	0	0		0
3. Local Heat Island Effects		3	Reduce Local Heat Island Effects		1	1	0		1

MacZero In the LEED

- "Leadership in Energy +Environmental Design"
- It's Energy, and it's more than just Energy
- Worth its weight in LEED Platinum – 110 points anticipated

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Please Visit MacZero.org

MacZero Discussion

- A mountain of work and reward.
- Phenomenal student efforts and successes!
- Competition results to be announced May 7.