

IPRO 317

High Performance Green Homes

net **ZERO** 

Design based in Green
Philosophy for a better future.

Sponsored by Jimmy Eng

The Problem

- ✿ Conventional home design is inadequate in price, resource, and time which as a result puts a significant strain on the environment



Conventional Practice

- ✿ Excessive Air Circulation
- ✿ Reliance on Mechanical Systems
- ✿ No consideration for environmental impact from CO₂ emissions and draw on grid.
- ✿ Lack of passive solutions
- ✿ Construction Materials

Goals

- ✿ Design 3 flat residential home with zero net electric draw on the grid in Chicago
- ✿ Research and move beyond existing technologies and thought paradigm
- ✿ Collaborate and Communicate effectively
- ✿ Zero Carbon Emissions
- ✿ Creating a template for Green Home Design

Team Organization

- ✿ Groups
- ✿ Three phases
 - ✿ Research
 - ✿ Compilation
 - ✿ Design
- ✿ Deadlines
- ✿ Leadership
- ✿ Communication



Our Research Criteria

- ✿ Identify the most cost effective and energy efficient materials, construction methods, and products for this project
- ✿ Prove that the cost for net zero energy home might be the same as any regular construction
- ✿ Employ Latest software technologies to the design of net zero home, such as eQUEST, Revit, ArchiCad

As-built Case Study

Habitat for Humanity/ NREL

2005 Colorado

1,200 sf

3-bedroom/2-bath

LEED Platinum

Energy

1st year: produced 24% more energy than consumed, and 12% the second year

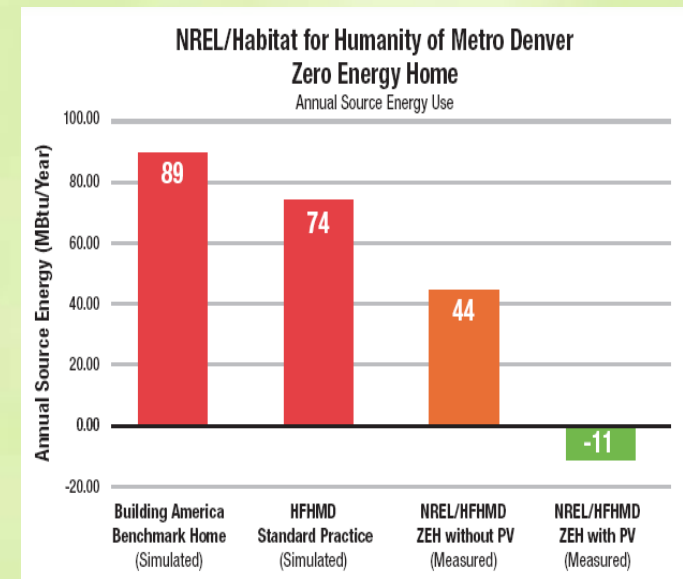
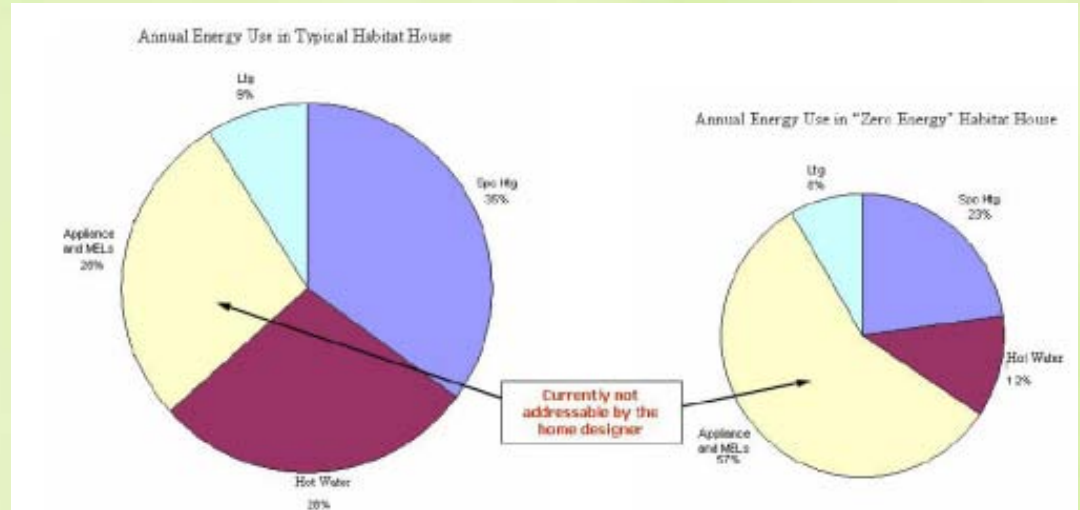
Passive solar elements

Super insulated:

R-40 Walls, R-30 Floor, ceiling R-60

-construction cost

\$90/square foot



Building Form and Energy Research

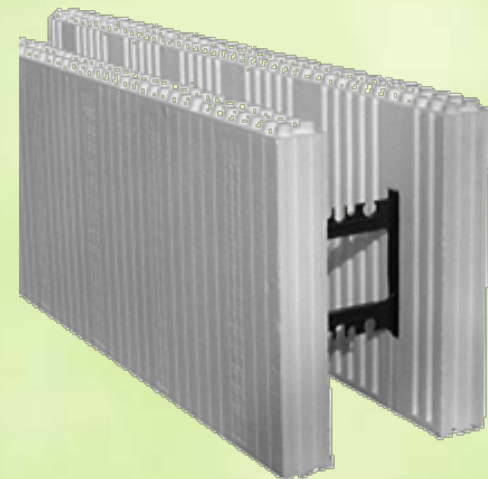
✿ ICFs from Logix

✿ High impact green product

- ✿ No thermal bridging
- ✿ Constant R value for life
- ✿ Wind rated up to 200 mph
- ✿ Fire rated up to 4 hours

✿ Energy Sources

- ✿ Solar
- ✿ Wind
- ✿ Hybrid



Mechanical Systems

- ❖ Radiant Heat

 - ❖ Pex Tubing

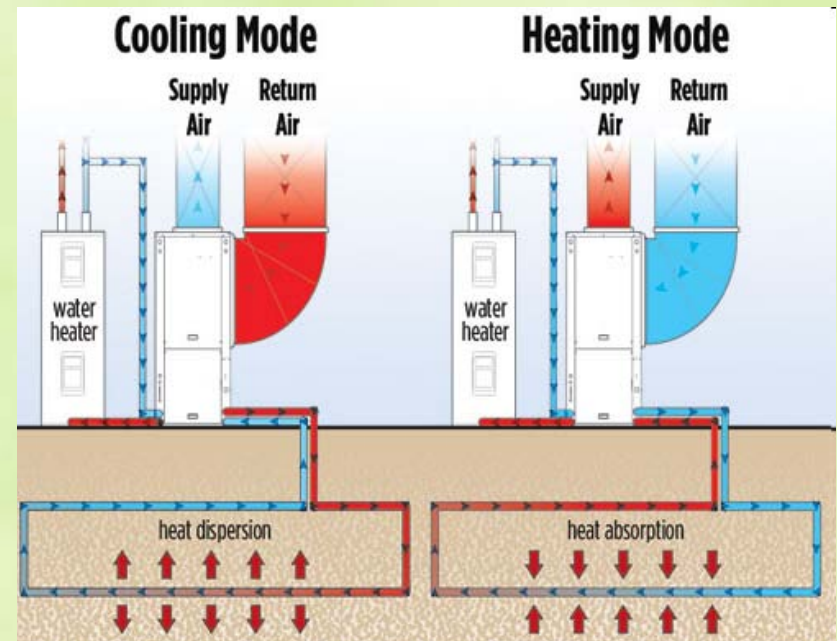
- ❖ Geothermal Heat Pump/Turbine

- ❖ Indirect Heating

 - ❖ Condensing Boiler

- ❖ LED Lighting

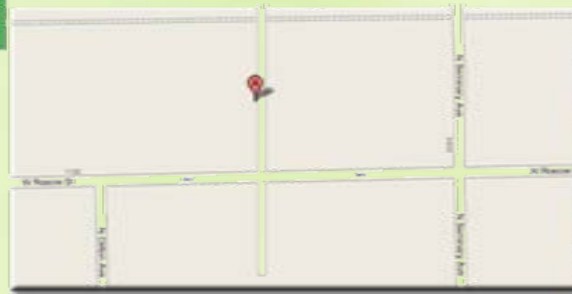
 - ❖ Motion Sensors



Site Analysis

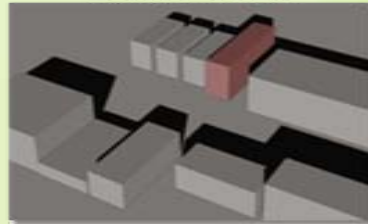
SITE ANALYSIS

1114 WEST ROSCOE
CHICAGO, ILLINOIS



SUN STUDY
GENERATED FORMS

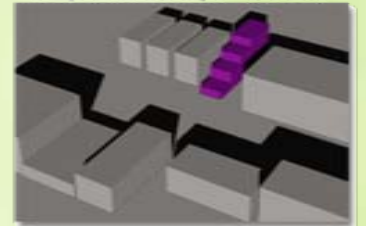
BOX FORM



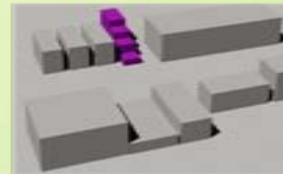
ATRIUM FORM



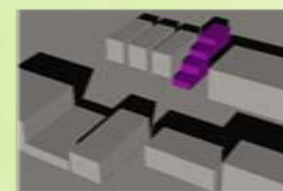
TERRACE FORM



FINAL SUN STUDIES
TERRACE FORM



SUMMER



WINTER

Heating and Cooling Load Tables

East Wall (Btu's/Hour)-1-1

	R-13	R-30	R-50
Heating	1,984	860	516
Cooling	992	430	258

West Wall (Btu's/Hour)-1-1

	R-13	R-30	R-50
Heating	1,984	860	516
Cooling	992	430	258

South Wall (Btu's/Hour)-1-1

	R-13	R-30	R-50
Heating	403	173	104
Cooling	242	104	52

North Wall (Btu's/Hour)-1-1

	R-13	R-30	R-50
Heating	615	226	160
Cooling	307	133	80

East Windows/Panels (Btu's/Hour)-1-1

	R-3	R-7	R-14
Heating	600	257	128
Cooling	300	128	64

West Windows/Panels (Btu's/Hour)-1-1

	R-3	R-7	R-14
Heating	600	257	128
Cooling	300	128	64

South Windows/Panels (Btu's/Hour)-1-1

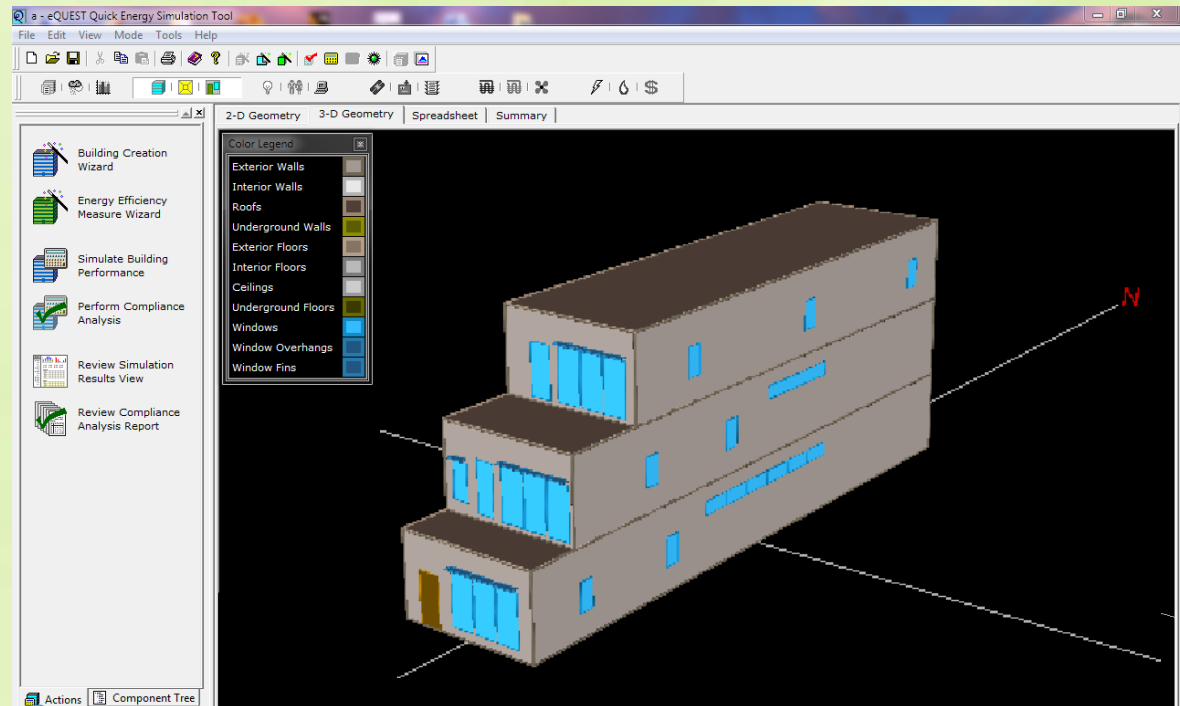
	R-3	R-7	R-14
Heating	920	396	237
Cooling	552	237	119

TOTAL Third Floor Heating Load (R-50 WALL, R-3 WINDOW) = 3,418 Btu's/h = 1 kWh
 TOTAL Third Floor Cooling Load (R-50 WALL, R-3 WINDOW) = 1,800 Btu's/h = .53 kWh

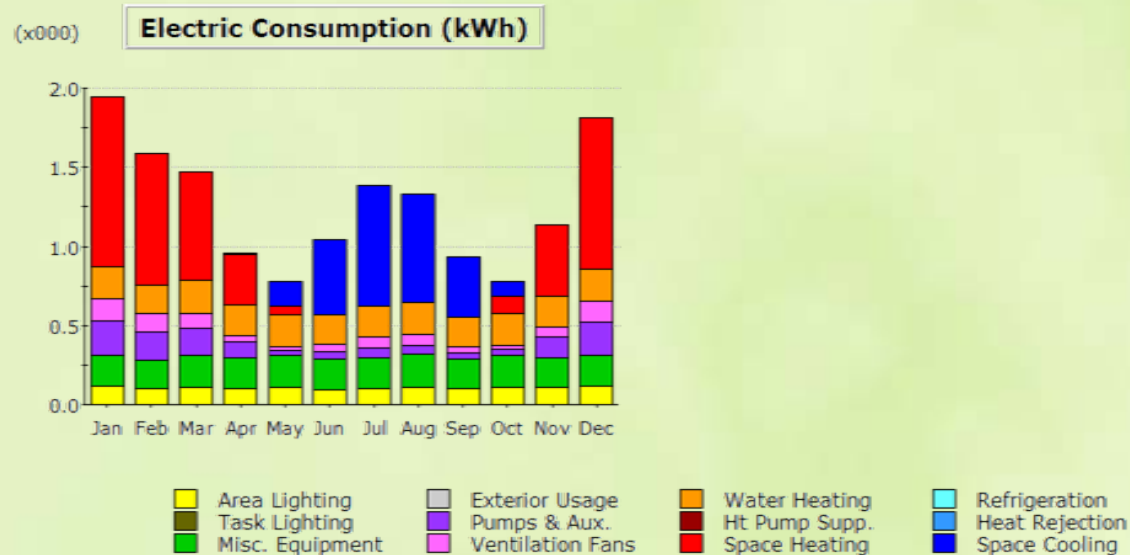
TOTAL BUILDING Heating Load (R-50 WALL, R-3 WINDOW) = 14,821 Btu's/h = 4.28 kWh
 TOTAL BUILDING Cooling Load (R-50 WALL, R-3 WINDOW) = 7,462 Btu's/h = 2.19 kWh

eQUEST Profile

- ✿ Weather Data
- ✿ Building Shell, Structure, Materials
- ✿ Scheduling
- ✿ Internal loads
- ✿ HVAC



eQUEST Results



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	0.01	0.15	0.48	0.76	0.68	0.38	0.09	0.00	-	2.55
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	1.08	0.83	0.68	0.31	0.05	-	-	-	0.00	0.11	0.45	0.96	4.48
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	0.20	0.18	0.21	0.20	0.20	0.19	0.19	0.20	0.19	0.20	0.19	0.20	2.36
Vent. Fans	0.14	0.11	0.09	0.04	0.02	0.05	0.07	0.07	0.04	0.02	0.06	0.13	0.87
Pumps & Aux.	0.22	0.18	0.17	0.10	0.03	0.04	0.06	0.06	0.04	0.04	0.13	0.21	1.28
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.19	0.18	0.20	0.19	0.20	0.19	0.20	0.21	0.19	0.20	0.19	0.20	2.35
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	0.12	0.10	0.11	0.10	0.11	0.10	0.10	0.11	0.10	0.11	0.11	0.12	1.27
Total	1.95	1.59	1.47	0.96	0.77	1.05	1.38	1.33	0.93	0.78	1.14	1.81	15.15

Providing Energy

<u>Solar Insolation</u>		
3.72	hrs/day	<-- Average

<u>Monthly Energy Needed</u>
2135.71

<u>Roof Area</u>		
1380 sqft =	128.21	m ²

Solar Panels

#	Brand	Model #	# of panels	Watts Per Panel	Kwh per Month Per Panel	Total kwh Provided	Panels Needed	Dimensions of 1 panel		Total Area m ²	Cost/set	Total Cost
								Length (m)	Width (m)			
1	Kyocera	210	20	210	23.76	475.23	90	1.50	0.99	133.83	\$12,600.00	\$63,000.00
2	Kyocera	KC40T	1	40	4.53	4.53	472	0.53	0.65	162.00	\$265.00	\$125,080.00
3	Kyocera	205	20	205	23.20	463.92	93	1.50	0.99	138.29	\$11,890.00	\$59,450.00
4	Kyocera	180	20	180	20.37	407.34	105	1.34	0.99	139.49	\$10,440.00	\$62,640.00
5	Applied Solar	4ft	1	48	5.43	5.43	394	0.44	1.14	200.18	\$400.00	\$157,600.00
6	Applied Solar	3ft	1	34	3.85	3.85	556	0.43	0.91	219.53	\$300.00	\$166,800.00
7	Applied Solar	STP200	1	200	22.63	22.63	95	1.22	1.22	141.21	\$1,000.00	\$95,000.00
8	Applied Solar	STP400	1	400	45.26	45.26	48	1.22	2.44	142.70	\$2,000.00	\$96,000.00

Providing Energy Cont.

Wind Turbines

#	Brand	Model #	Kwh/month Per Turbine	Turbines Needed	Cost Per Turbine	Total Cost
1	Abundant Renewable Energy	ARE 442	1890.00	2	\$39,600.00	\$79,200.00
2	Abundant Renewable Energy	ARE 110	420.00	6	\$12,650.00	\$75,900.00
3	Air Breeze	Land Generator	38.00	57	\$699.00	\$39,843.00
4	AirX	48 VDC	38.00	57	\$725.00	\$41,325.00
5	Helix Wind	S594	280.17	8	\$8,000.00	\$64,000.00
6	Helix Wind	D361	264.00	9	\$5,000.00	\$45,000.00
7	Southwest Windpower	Whisper 500	538.00	4	\$7,810.00	\$31,240.00
8	Southwest Windpower	Whisper 200	158.00	14	\$3,015.00	\$42,210.00

Providing Energy Cont.

Power Attainable off of Current Roof

Area

Solar Panel #	Total Panels	Kwh Per Month	Additional Kwh needed	Solar Panel Price
1	86	2043.49	92.23	\$63,000.00
2	373	1688.20	447.52	\$98,845.00
3	86	1994.83	140.88	\$59,450.00
4	96	1955.23	180.48	\$52,200.00
5	252	1368.66	767.05	\$100,800.00
6	324	1246.46	889.25	\$97,200.00
7	86	1946.18	189.53	\$86,000.00
8	43	1946.18	189.53	\$86,000.00

Connected Load

Solar Solution	Connected Load (Watts)
1	18060
2	14920
3	17630
4	17280
5	12096
6	11016
7	17200
8	17200

*Negative values indicate surplus

Providing Energy Cont.

Solar Solution #	Wind Solution							
	1	2	3	4	5	6	7	8
1	1	1	3	3	1	1	1	1
2	1	2	12	12	2	2	1	3
3	1	1	4	4	1	1	1	1
4	1	1	5	5	1	1	1	2
5	1	2	21	21	3	3	2	5
6	1	3	24	24	4	4	2	6
7	1	1	5	5	1	1	1	2
8	1	1	5	5	1	1	1	2

Output

<u>minimum cost</u>	\$55,695.00
<u>max power (kWh/month)</u>	3,933.49

Final Design

Walls

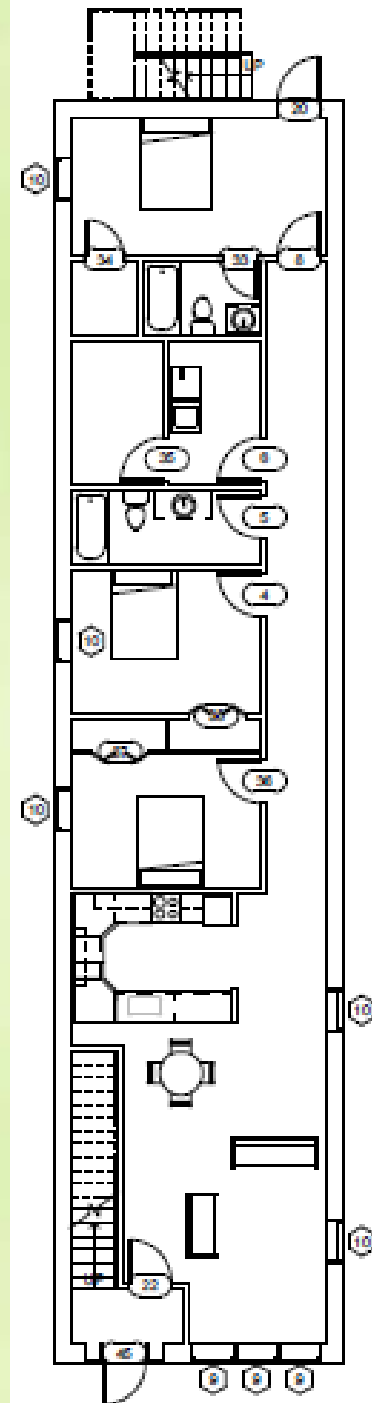
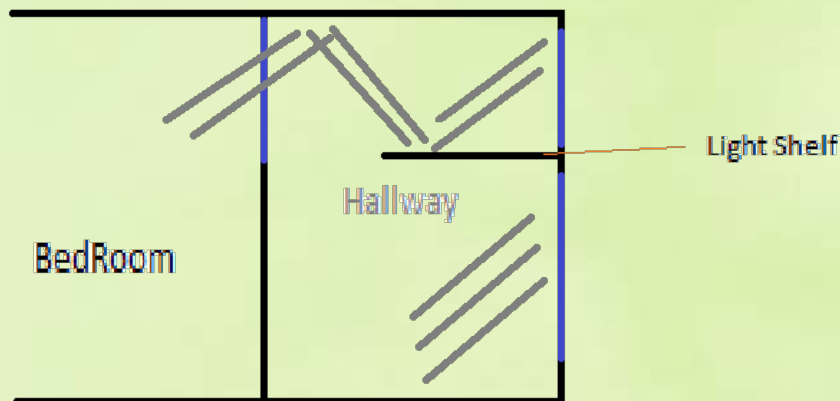
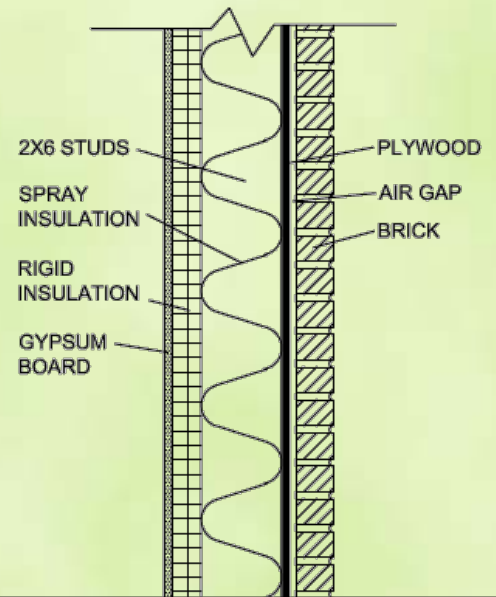
- R50*

- ICF's

- Quad Low E
Windows

Efficient floor Plan

Light Shelves



* Total value including walls and windows

Final Design Cont.

- ✿ Design Development

- ✿ Specs

 - ✿ 4735 sq ft

 - ✿ 30% Circulation & Mechanical

- ✿ Tiered Design for passive solar

- ✿ Trellis with Ivy on South side



Achievements

- ✿ We successfully modeled the house in eQUEST
- ✿ How this will effect the industry
- ✿ Recommendations for Future Research

