IPRO 317

Net Zero Zero Energy Home
1114 W. Roscoe Ave. Chicago, Il

netZERO

Conclusion:

Energy consumption in a building is greatly affected by the amount of energy used by the residents. The residents must be conscious about how much energy they are using because the use of every day appliances makes a large impact on energy consumption.

Secondly, one must consider the site. After extensive site analysis we were able to determine that one cannot simply throw together all the most efficient products and materials and end up with a green home. The orientation, dimensions, and location of a site can greatly affect the area. One must take into consideration the soil composition, water table, north-south facing vs east-west for sun exposure, and height restrictions just to name a few of the issues that arise from having a bad site. After analyzing a site and determining what you can and cannot use there, you need to determine what you should use. This is a complicated and involved step as we learned that with every positive aspect of a design there is a negative one to counteract it and that you must learn to determine when the goods outweigh the bad.

Furthermore, you need to take into consideration the envelope or the shell of the house. The envelope will affect the choices you make for the electrical and heating and ventilation systems. So it is important to chose an optimal material for the house that optimizes your net usage. Designing and optimizing the envelope also depends on the number and placement of windows, minimizing exterior wall area, orientation et cetera. This is why we turned to the energy modeling software.

In order to get started, we found you need to start with a base design for a building. This design doesn't need to be perfect as you will modify the design and through an iterative process of modeling and revising the design you can reach your energy goal. This process also helps in determining the positive and negative effects of certain systems.

Another issue we had to deal with is effective communication between the large amount of people involved. We found that dividing into smaller subgroups and delegating each group a task for coming up with various green solutions of specific categories, you can then do the iterative modeling tests and come up with a final design.

Acknowledgements:

Advisor: Nancy Governale-Hamill
Sponsor: Jimmy Eng
Equest Consultant: Keith Swartz

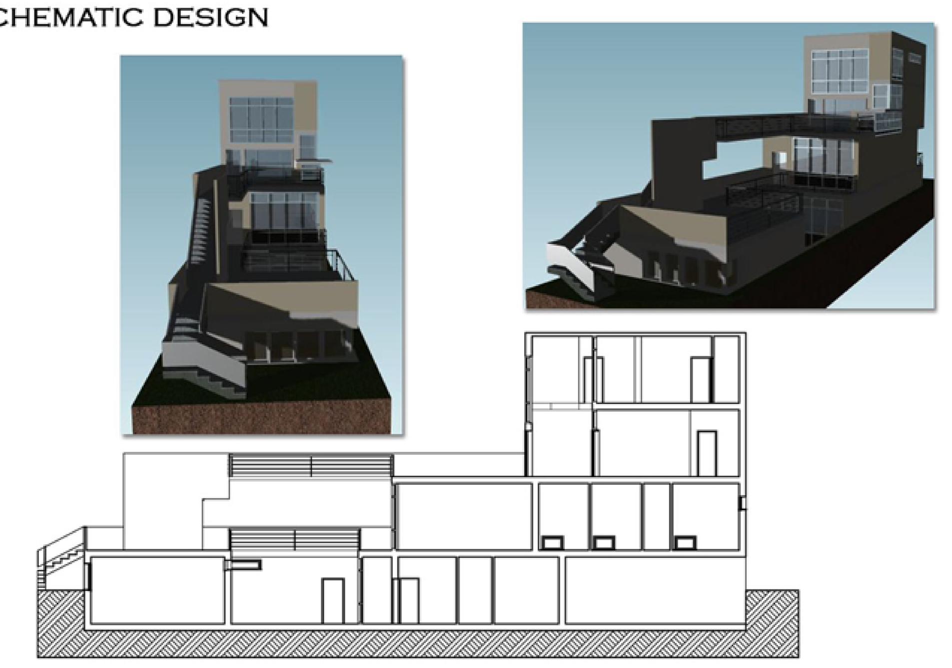
eQUEST
Quick Energy Simulation Tool

Future work:

The Future of This IPRO is to move towards the design-build phase, actually constructing a test structure as designed, and observe the resulting data to compare projected cost and energy savings and realistic energy savings.

Schematic Design

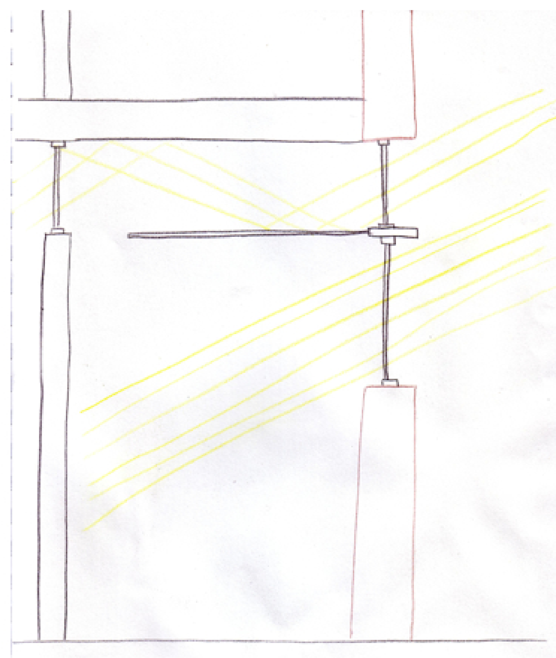
SCHEMATIC DESIGN

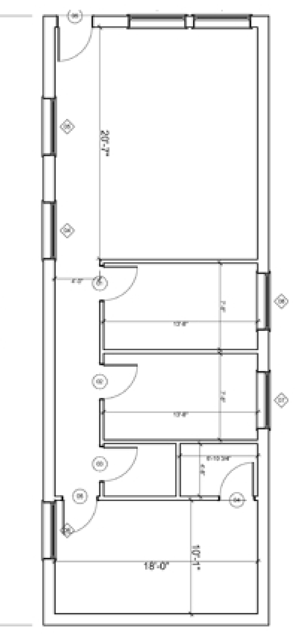


ZONING ANALYSIS — CLASSIFICATION: RT-4

17-2-0103 RT, Residential Two-Flat, Townhouse and Multi-Unit Districts. The primary purpose of the RT districts is to accommodate detached houses, two- flats, townhouses and low-density, multi-unit residential buildings at a density and building scale that is compatible with RS districts. The districts are intended to be applied in area characterized by a mix of housing types. The districts are also intended to provide a gradual transition between RS districts and higher density RM districts. The RT districts are differentiated primarily on the basis of allowed density (minimum lot area per unit) and floor area ratios. The RT4A designation is intended to accommodate and promote multi-unit buildings containing accessible dwelling units

Residentail Uses Allowed:	Detached House, Elderly Housing, Two-Flat, Townhouse, Multi-Unit Residential (3+ units), Single Room Occupancy
Minimum Lot AreA:	1,650 SQUARE FEET
Minimum Lot Frontage Standards :	Average front yard depth of nearest two properties. Minimum of 12' dimension
Minimum Rear Yard Open Space:	65 square feet per dwelling unit or 6.5% of lot, whichever is greater. Minimum of 12' dimension
Maximum Floor Area Ratio:	1.20
Maximum Building Height:	38'

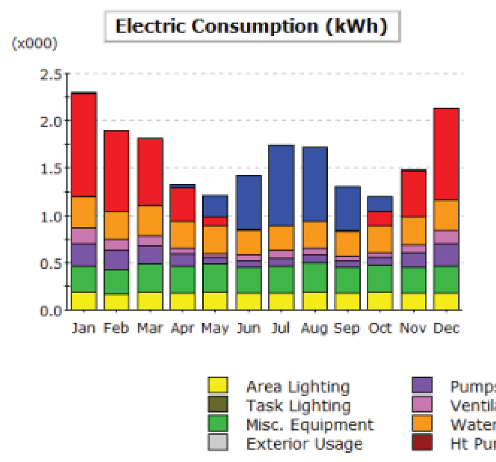




Results:

Zero Energy Green Home

-R50 exterior wall construction
-HVAC: DX Coils with Ground Source Heat Pump
-Energy Efficient Lighting
-Quadruple Low-E Glazing
-Daylighting Controls
-Each unit uses about 550 kWh per month



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	0.00	0.00	0.00	0.03	0.24	0.57	0.86	0.79	0.46	0.15	0.01	-	3.11
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	1.10	0.85	0.71	0.36	0.09	0.00	-	-	0.01	0.15	0.49	0.97	4.73
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	0.33	0.30	0.32	0.29	0.29	0.26	0.26	0.27	0.26	0.29	0.30	0.33	3.50
Vent. Fans	0.16	0.13	0.11	0.06	0.04	0.06	0.08	0.08	0.05	0.04	0.08	0.15	1.02
Pumps & Aux.	0.23	0.20	0.19	0.13	0.08	0.07	0.09	0.08	0.07	0.09	0.16	0.23	1.61
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.28	0.26	0.29	0.28	0.29	0.28	0.28	0.30	0.27	0.29	0.27	0.28	3.39
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	0.19	0.17	0.19	0.18	0.19	0.17	0.18	0.19	0.17	0.19	0.18	0.18	2.18
Total	2.29	1.90	1.82	1.33	1.21	1.42	1.74	1.72	1.30	1.20	1.48	2.14	19.55

After calculating the energy required for the home to fuction, we plug the number of kilowatt hours needed per month into the solar panel datasheet, which gives us the cost and required roof square footage to supply the residence with enough power.

Solar Panels

#	Brand	Model #	# of panels	Watts Per Panel	Kwh per Month Per Panel	Total kwh Provided	Panels Needed	Sets needed	Dimensions of 1 panel Length (m)	Dimensions of 1 panel Width (m)	Area m^2	Total Area m^2	Total Area ft^2	Cost/set	Total Cost
1	Kyocera	210	20	210	23.76	475.23	74	4	1.50	0.99	1.49	110.04	1184.46	$12,600.00	$50,400.00
2	Kyocera	KC40T	1	40	4.53	4.53	387	387	0.53	0.65	0.34	132.83	1429.76	$265.00	$102,555.00
3	Kyocera	205	20	205	23.20	463.92	76	4	1.50	0.99	1.49	113.01	1216.47	$11,890.00	$47,560.00
4	Kyocera	180	20	180	20.37	407.34	86	5	1.34	0.99	1.33	114.25	1229.80	$10,440.00	$52,200.00
5	Applied Solar	4ft	1	48	5.43	5.43	323	323	0.44	1.14	0.51	164.10	1766.41	$0.00	$0.00
6	Applied Solar	3ft	1	34	3.85	3.85	455	455	0.43	0.91	0.39	179.65	1933.75	$0.00	$0.00
7	Applied Solar	STP200	1	200	22.63	22.63	78	78	1.22	1.22	1.49	115.94	1248.00	$0.00	$0.00
8	Applied Solar	STP400	1	400	45.26	45.26	39	39	1.22	2.44	2.97	115.94	1248.00	$0.00	$0.00

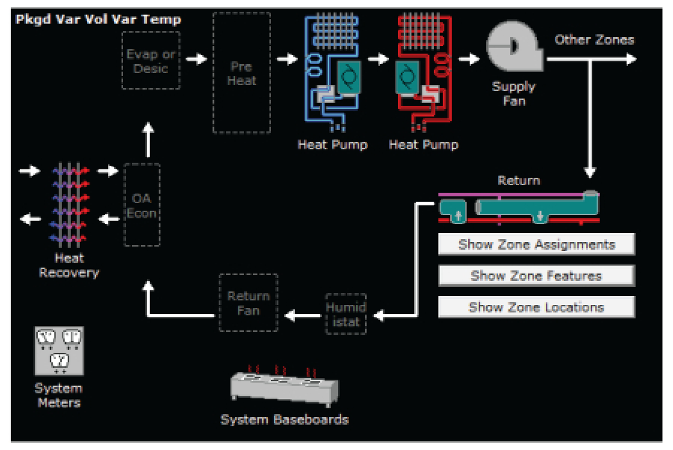
Prices with links are due to different bulk prices than single unit prices

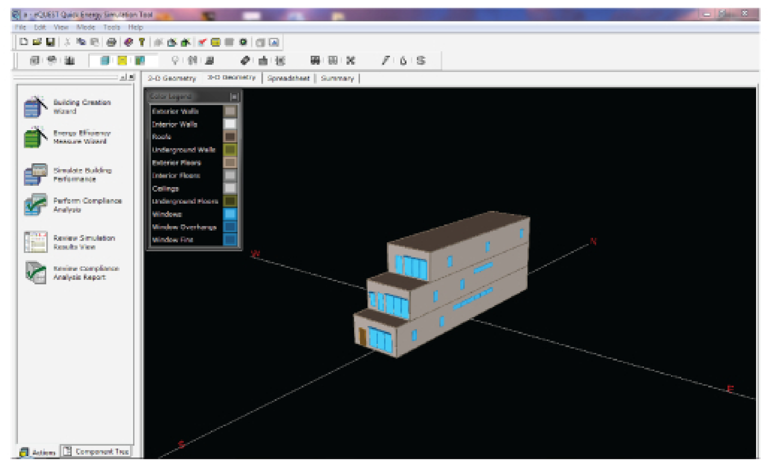
Monthly Energy Needed	
1750	kwh

Roof Area		
660 sqft------>	61.32	m^2

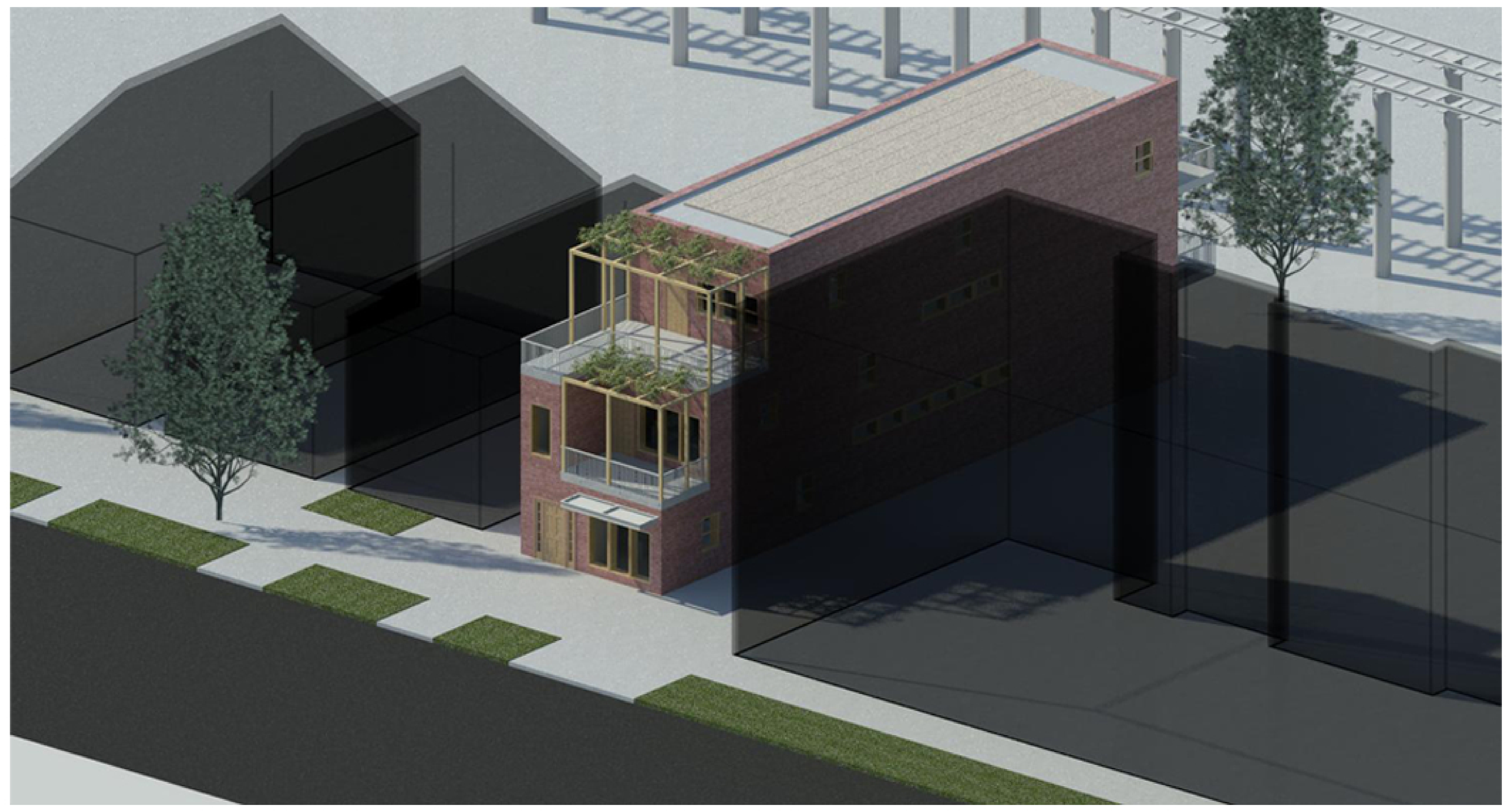
Solar Insolation		
3.72	hrs/day	<-- Average

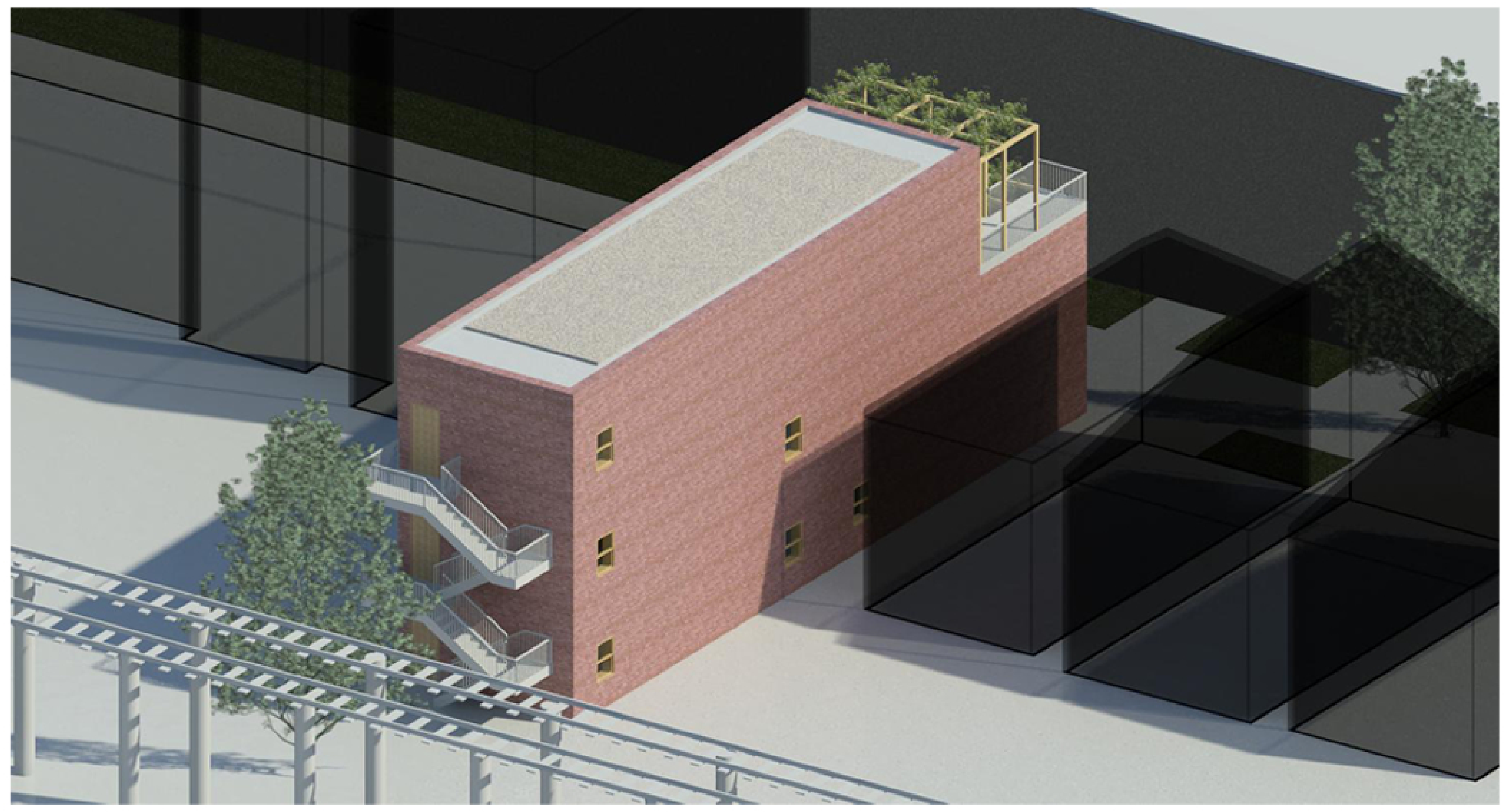
Unit converter		
inches to	centimeters to	meters
96	243.84	2.4384

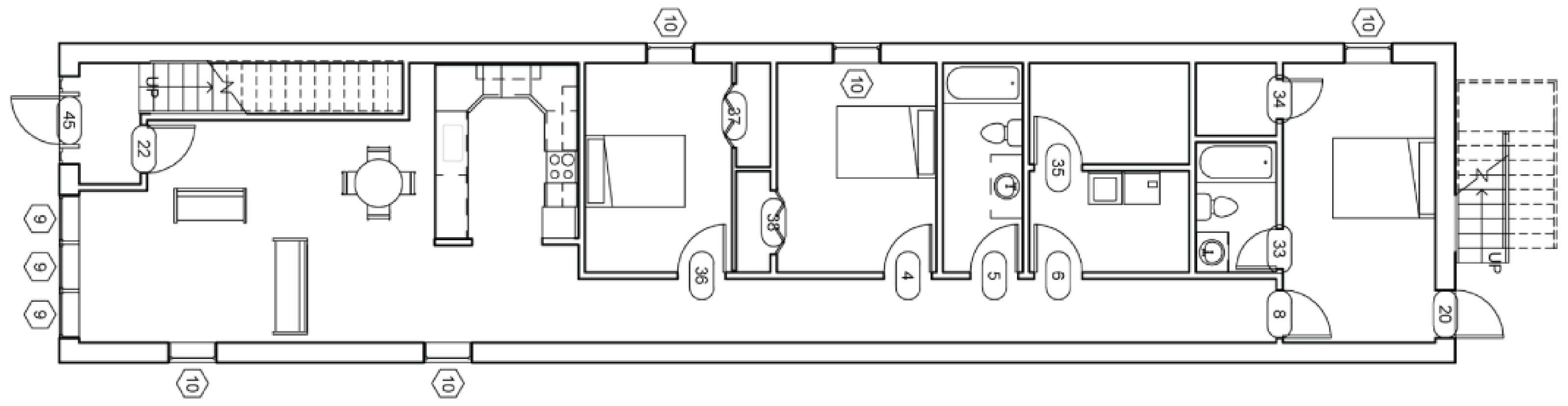




Final Design

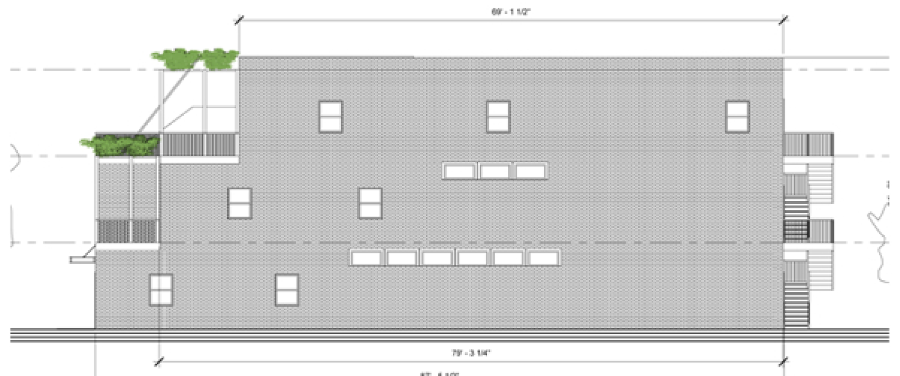






Ground Level Plan

South Elevation



East Elevation

IPRO 317

Net Zero Zero Energy Home
1114 W. Roscoe Ave. Chicago, Il

netZERO

Problem:
To design a net zero energy, zero carbon emission, high efficiency green home at a competitive cost relative to neighboring units.

Background:
This IPRO was sponsored by Mr. Jimmy Eng who presented the group with the problem of designing a zero energy home. Homes today are still being built with the same construction techniques that have been in use for hundreds of years, and yet this architecture is temporary rarely surviving fifty years before it would need to be torn down and rebuilt. All over the world groups are trying to solve the problem everyone around the world is experiencing of limited natural resources and land. This IPRO took a step closer to finding the solutions this semester.

Objective:
Our goal was to design a three-unit condominium building on a specific 100 ft. by 25 ft. Chicago-style lot with the following conditions in mind:
- “non-disposable” design with a minimum three hundred year design life.
- lower maintenance fees over the lifespan of the building
- maximum physical and psychological comfort
- zero energy use and zero carbon emission
- looking beyond existing building codes and technologies
- cost of construction be comparable to similar sized structures in the area ($1.7 million construction cost for a three flat building)

Methodology:
The IPRO team was split into multiple subgroups under subgroup team leaders to accomplish specified goals throughout the course of the semester. Information from existing green technologies, literature, and journals pertaining to the strength of materials, as well as other relevant design information available, were gathered and used as part of our research. Each team consulted with experts in the fields when needed to supplement their research. Throughout the course of our research and investigations, a variety of different software was used to aid in our design. Equest (Energy Modeling Software) was used to estimate and analyze the overall energy usage of the building. MathCAD assisted in any structural calculations that needed to be done as well as calculating the overall R-values for the building. AutoCAD was utilized to draft all elements of the building, which include architectural and structural components. Revit and ArchiCAD were also used for 3D modeling and architectural problem solving. Additionally, the building was designed in accordance with the Chicago Building Code. Other codes accepted by the city of Chicago were used as well.

Case Studies

CASE STUDY # 1
Smith House (Passihaus)
Urbana, Illinois

Edward Sindelar Builders
Katrin Klingenberg and Nicolas Smith Architects

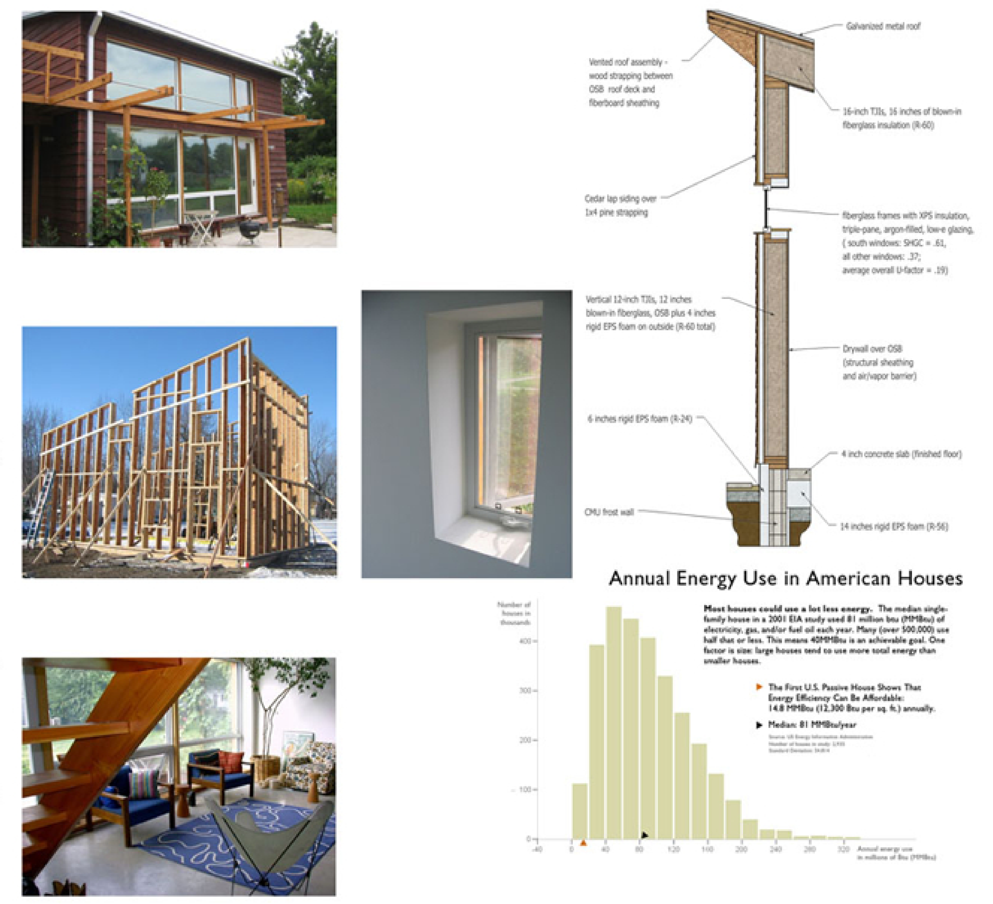
2 bedrooms and 1 bath
1,200 sq. ft.
Cost = $94 per sq. ft.
Annual Energy Use = 14.8MMBtu

Indoor Air Quality:
HRV constantly exchanges air
Linseed oil floor finish
Water-based sealant on the concrete floors
Non-VOC wall paints
Solid wood countertops

Water:
Toilets and laundry will eventually be fed by a rainwater colleciton system

Energy:
Cooling: HRV with 1,000 watt electric resistance heating element coupled to an 8 inch diameter x 100 ft. long earth tube buried 6ft. below grade.
Water Heating: A tankless water heater with spare conduit for a solar thermal system to be installed later.
Superinsulation:
Foundation = R – 56 + R – 24
4 in. concrete slab over 14 in. EPS foam surrounded by a Concrete-block foundation wall covered in 6 in. of EPS foam
Walls = R – 60
Vertical 12 in. I-joists with 12 in. blown-in-fiberglass insulation + 4 in. EPS foam over the exterior to bridge gaps
Roof = R – 60
16 in. I-joists with vent channels above the sheathing and 16 in. of blown-in-fiberglass insulation
Windows = U - .19
Triple-pane, argon filled low-e, fiberglass frames with XPS insulation

Materials:
Durable, recyclable galvanized-steel roof
CMU frost wall + on-grade concrete slab are material and labor efficient
Recycled tub, fixtures and medicine cabinets
100% regionally sourced wood (fir, pine, and cedar)
Recycled slate cladding on the foundation
Recyclable blown-in-fiberglass insulation



CASE STUDY # 2
Duluth, MN

J and R Sundberg Builders
Wagner Zaun Architecture

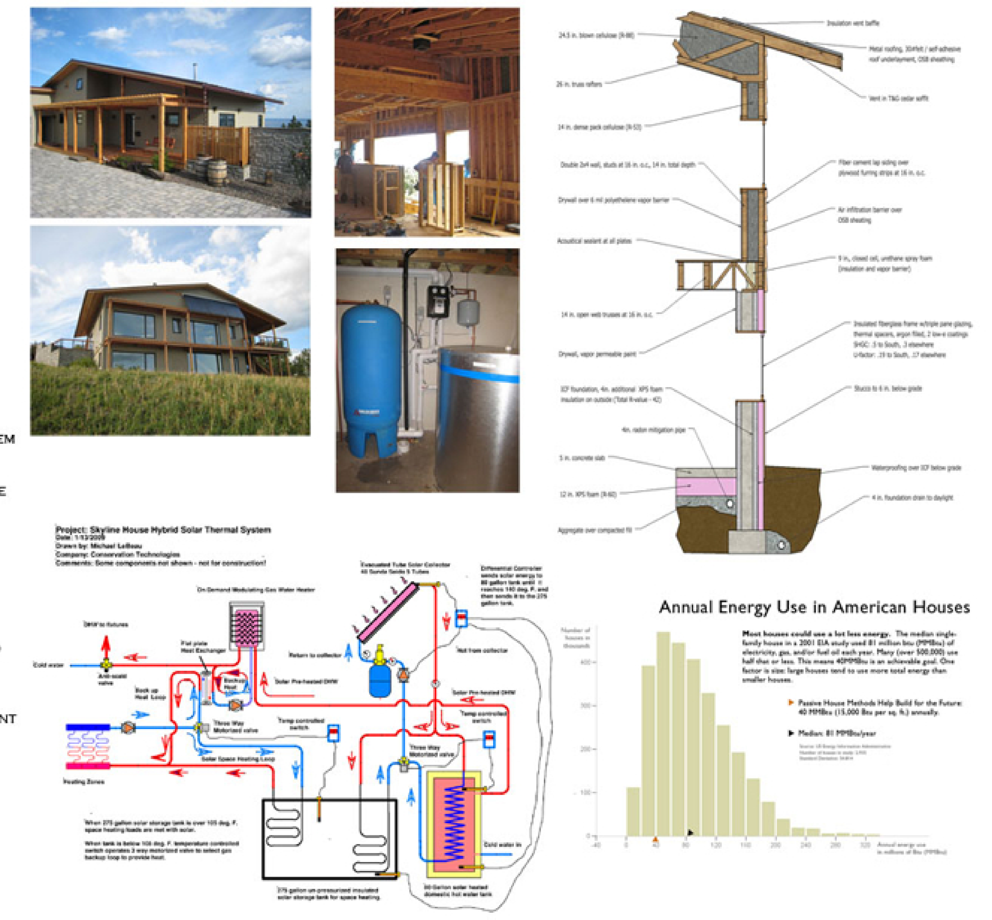
3 bedrooms and 2 bath
2,660 sq. ft.
Cost = $94 per sq. ft.
Annual Energy Use = 19.4 MMBtu

Indoor Air Quality:
Whole-house HRV
No carpeting

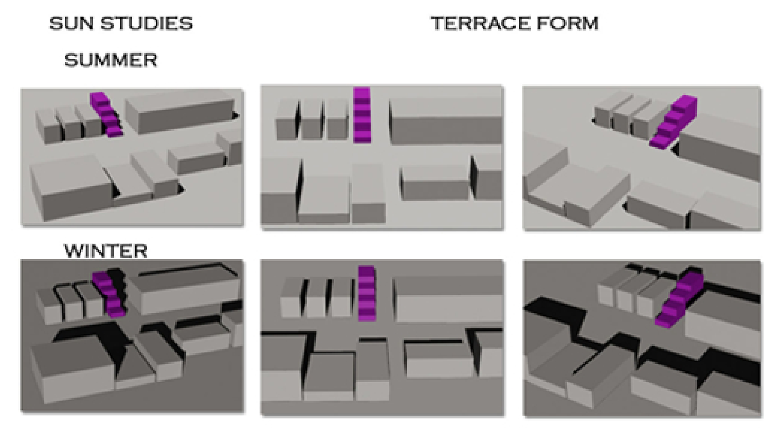
Water:
Dual-flush toilets
Low-flow faucets
Rain barrels for roof water collection
Bathrooms are stacked close to the mechanical room

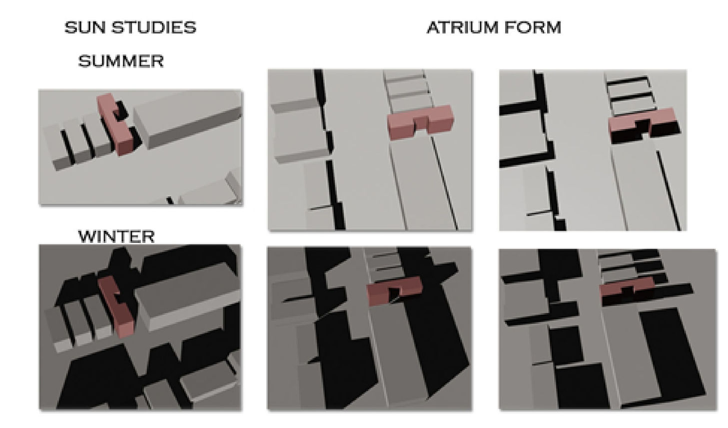
Energy:
Heating and cooling: evacuated tube solar collection system with a 275 gallon insulated tank.
Radiant heating
EPA-rated wood stove with a dedicated combustion air route
Back up heating from a gas-fired Takagi
No air conditioning
Superinsulation:
Foundation = R – 40 + R – 60
ICF with 8 in. poured walls + 4 in. XPS exterior insulation
5 in. concrete slab over 12 in. XPS
Walls = R – 53
14 in. thick with wood 2x4's, ½ in. of exterior OSB, and ½ in. interior gypsum. The interior is stuffed with dense-pack cellulose insulation
Roof = R – 88
26 in. deep parallel chord trusses with continuous vent chutes and 24 ½ in. of blown cellulose insulation
Windows = U - .17/.19
Triple-pane, argon filled low-e, insulated fiberglass frames with thermal spacers

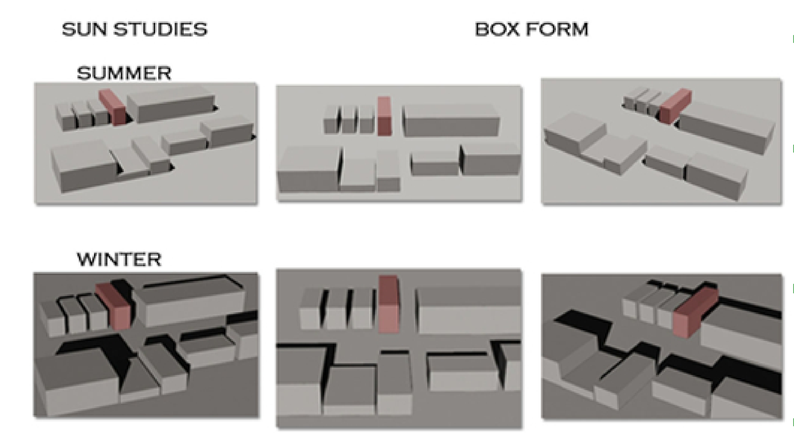
Materials:
Bamboo flooring on the main level
Water-based concrete stain on the lower floor
Cellulose insulation
Standing seam metal roof



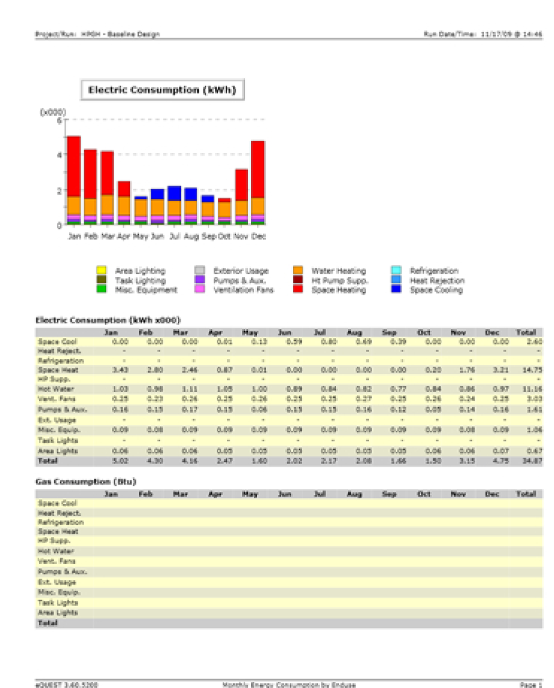
Site Analysis

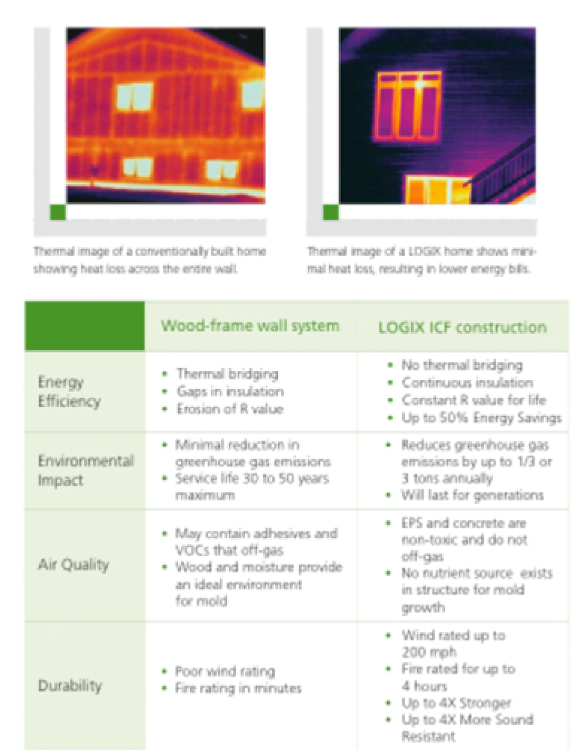




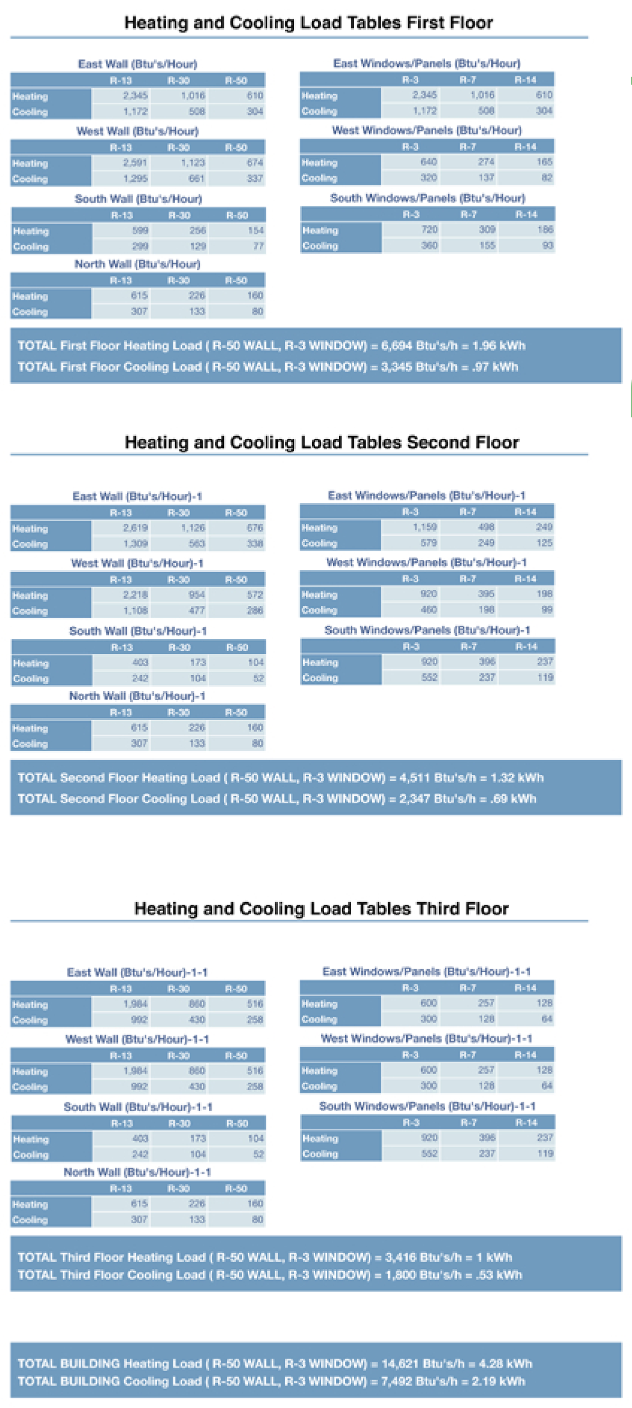


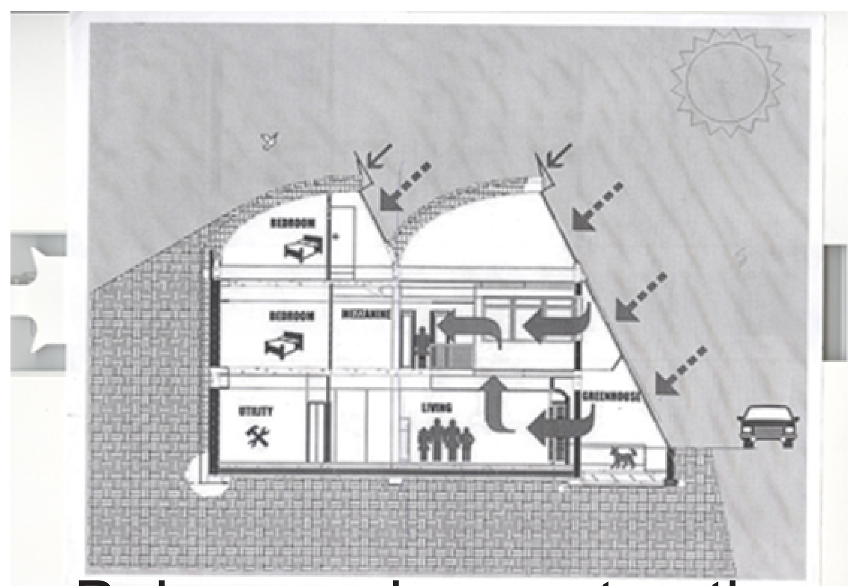
Research



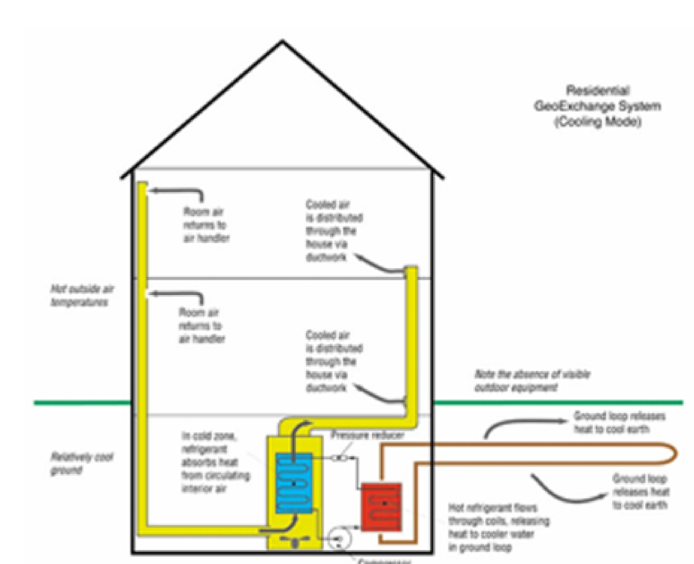


Logix was the decided company for furthered research regarding Insulated Concrete Forms (ICF) for the central layers of the exterior walls (Please reference the ICF on the table). These ICFs are very durable, thus aiding in meeting our goal of durability. The ICFs do not loose their R-value over time which means that the thermal envelop created for the housing unit will be consistent over time. Unlike over insulating a wood-framed building and creating a ‘sick home,’ the Logix walls provide no environment for mold growth. This means that the home is green, healthy and durable.

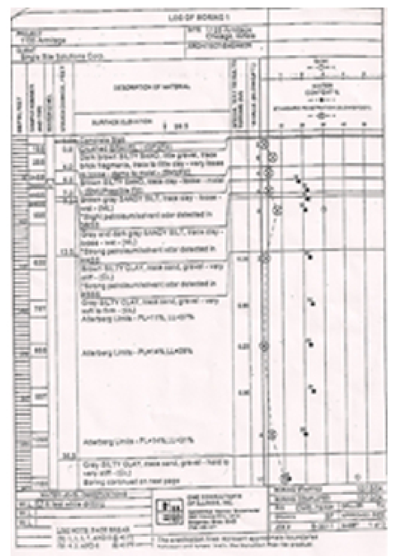




Below grade construction



Geothermal



Soil Test

Zoning Map

Load Tables