

IPRO 317

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



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:

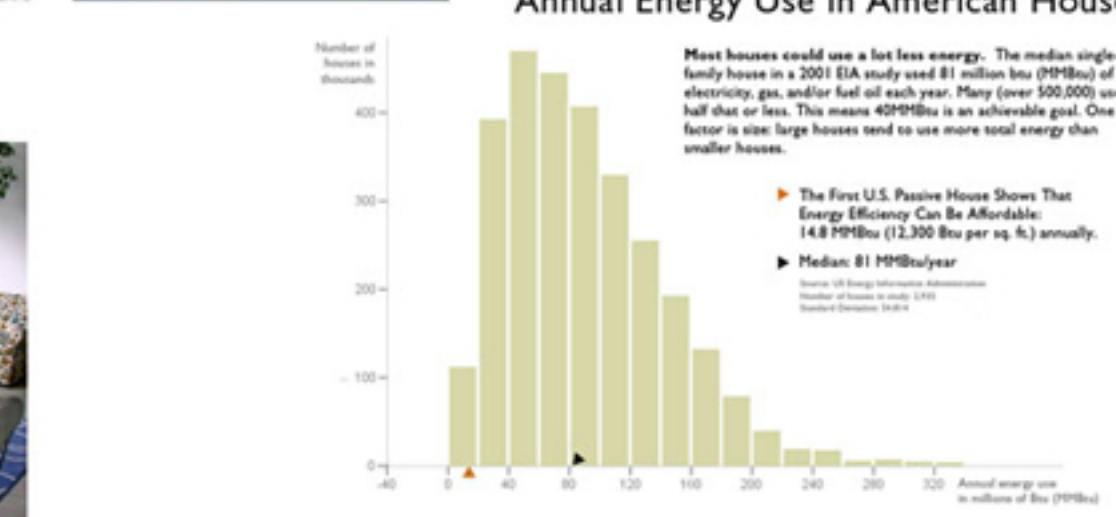
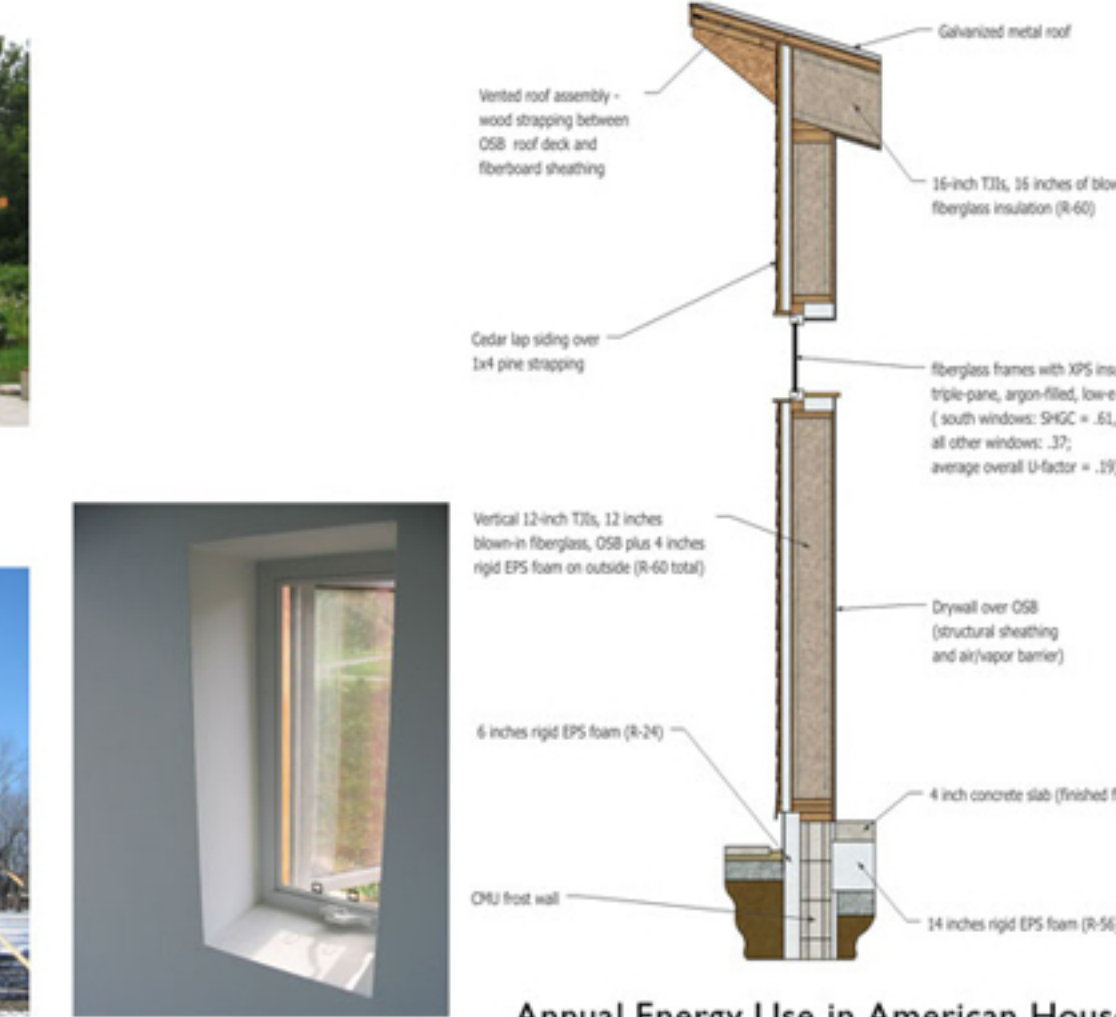
- “non-disposable” design with a minimum three hundred year design life.
- lower maintenance fees over the lifespan of the building
- maximum physical and psychological comfort
- zero energy use and zero carbon emission
- looking beyond existing building codes and technologies
- cost of construction 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.

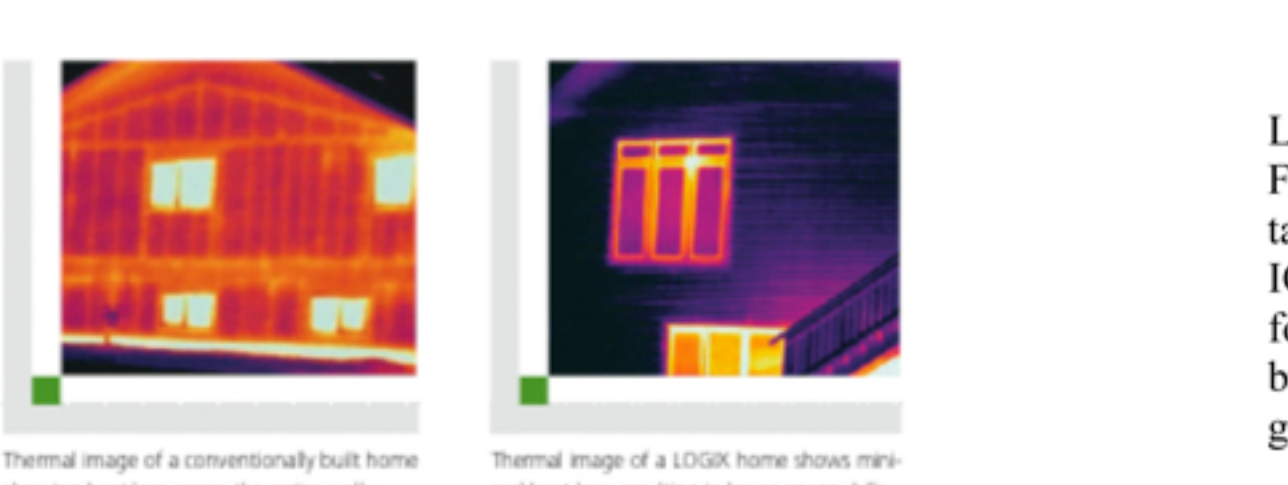
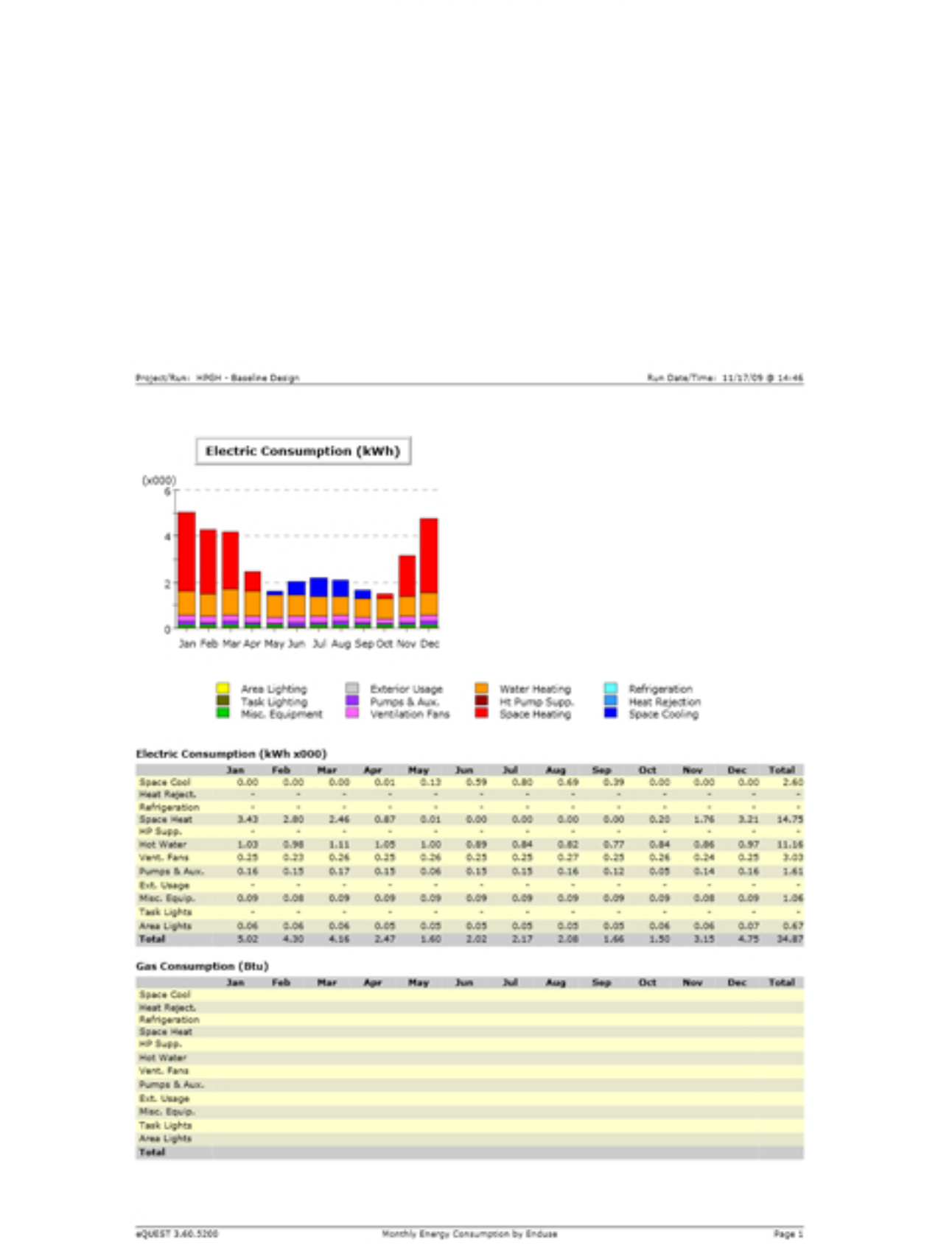
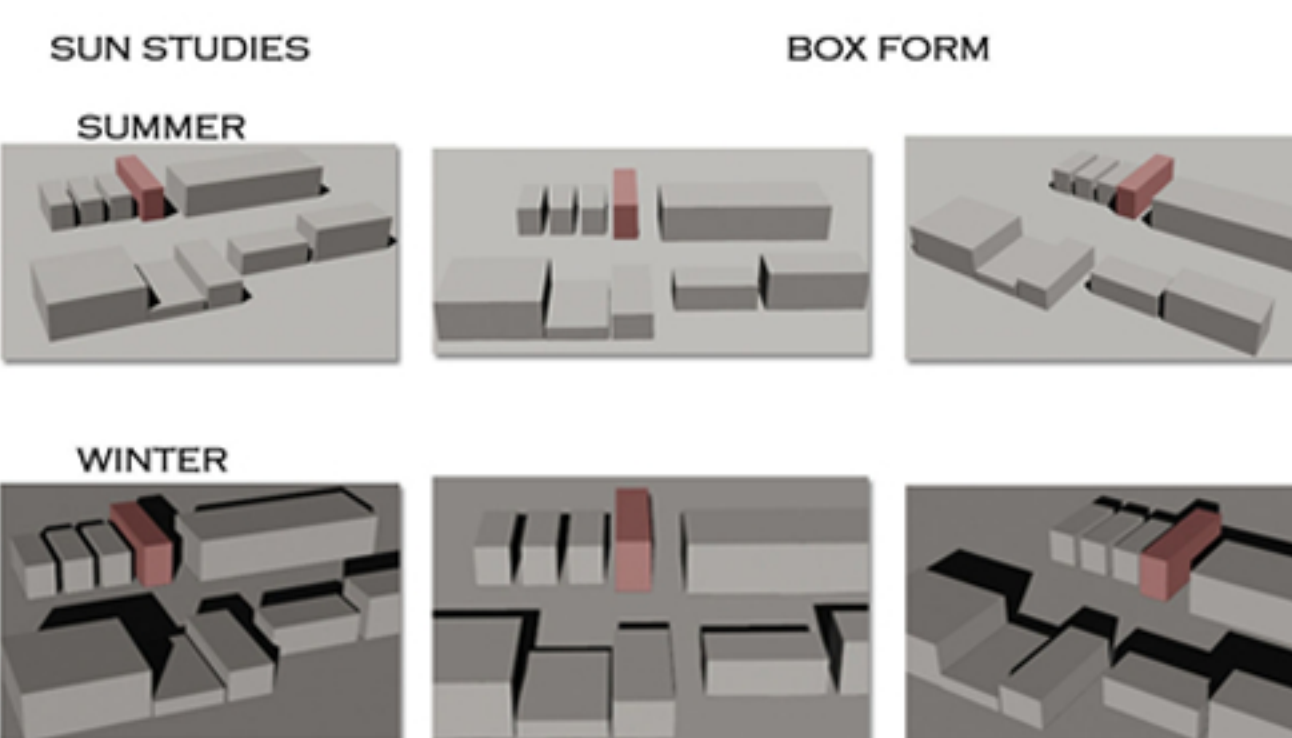
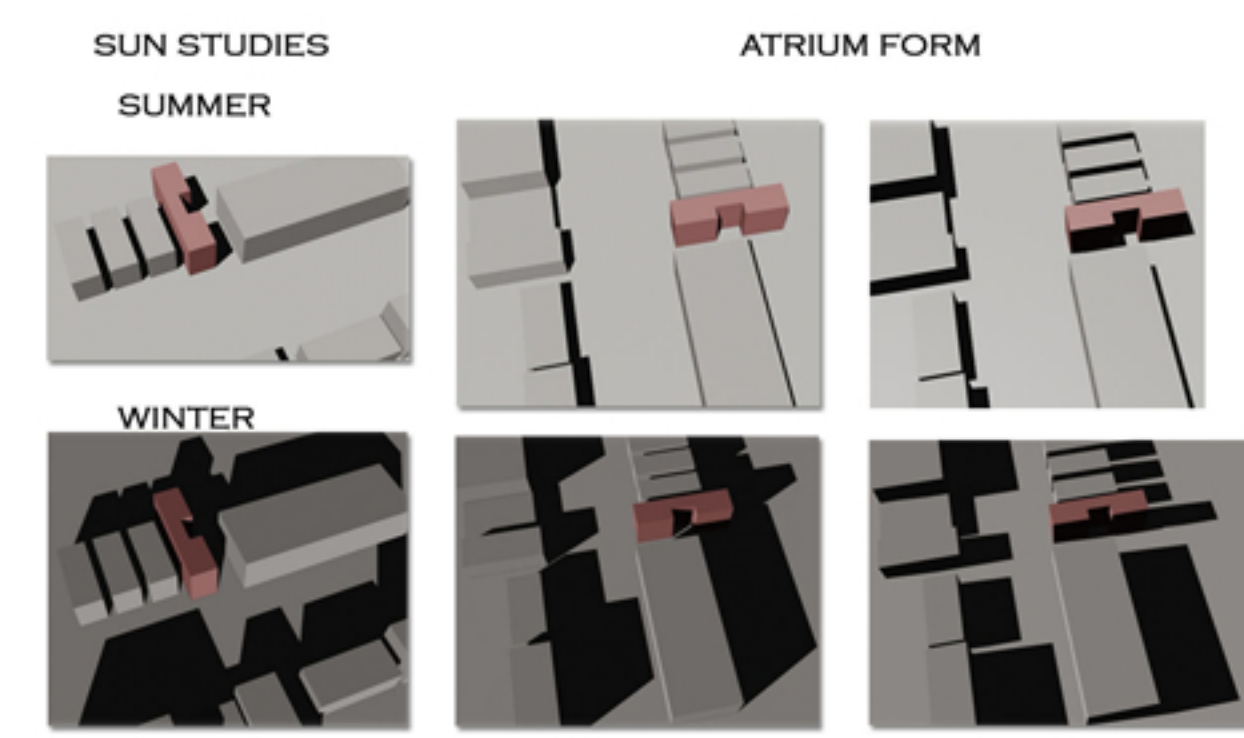
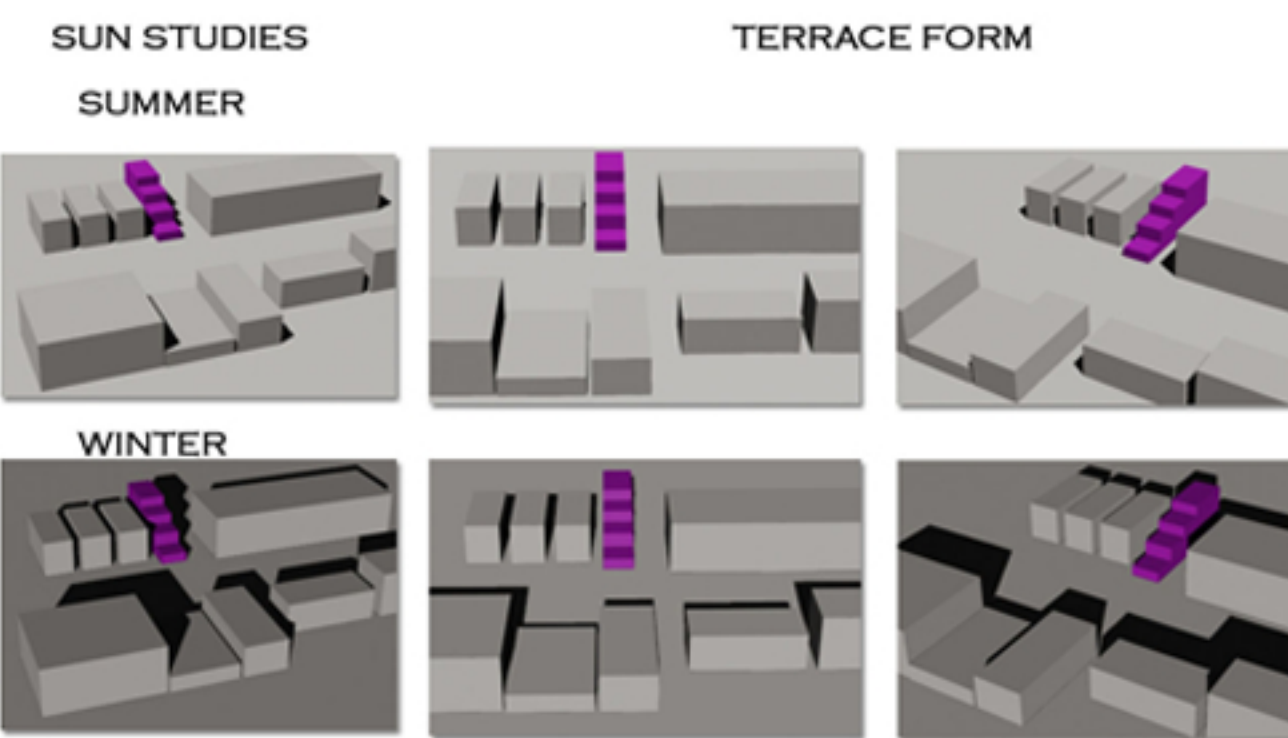
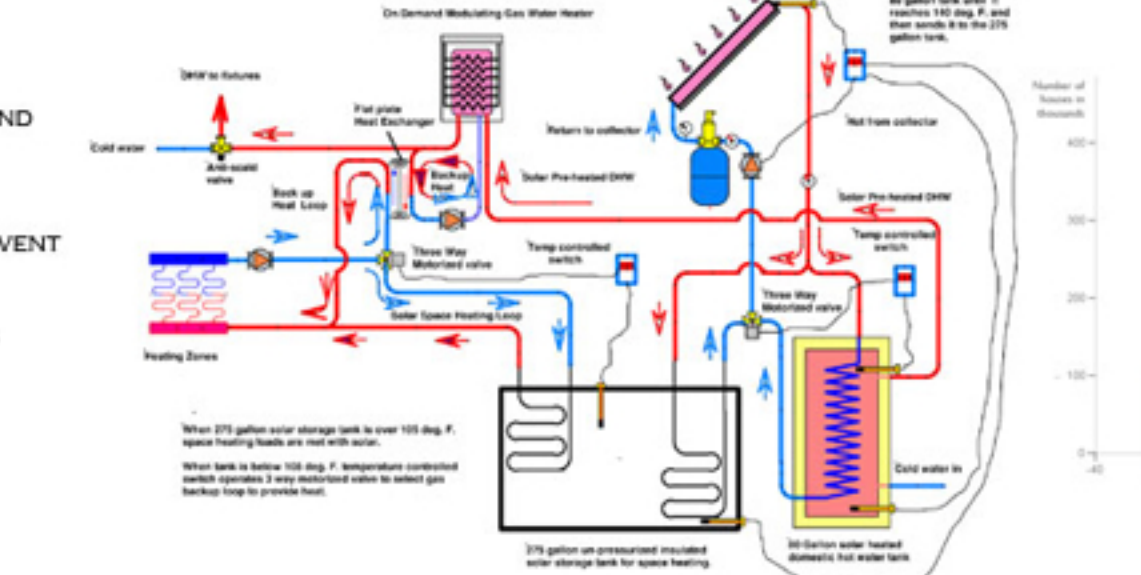
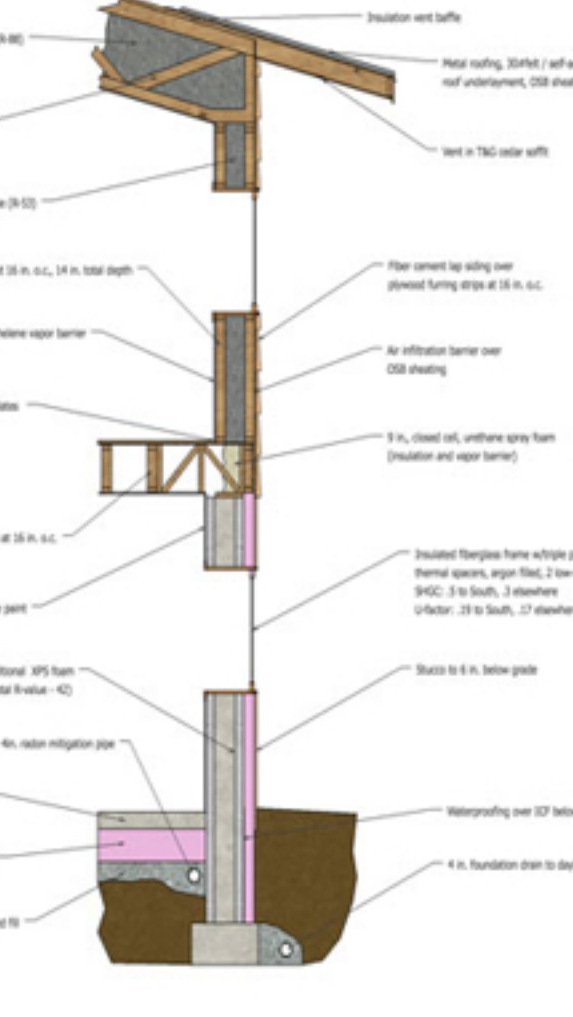
CASE STUDY # 1

SMITH HOUSE (PASSIVHAUS)
URBANA, ILLINOIS
EDWARD SHINDLER BUILDERS
KATRIN KLUMBERG AND NICOLAS SMITH ARCHITECTS
2 BEDROOMS AND 2 BATH
1,200 SQ. FT.
COST = \$84 PER SQ. FT.
ANNUAL ENERGY USE = 14.8MMBTU
INDOOR AIR QUALITY:
HRV CONSTANTLY EXCHANGES AIR
LINED 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 COLLECTION SYSTEM
ENERGY:
COOLING: HRV WITH 1,000 WATT ELECTRIC RESISTANCE HEATING ELEMENT COUPLED TO AN 8 INCH DIAMETER 100 FT LONG EARTH TUBE BURIED 8 FT, BELOW GRADE.
WATER HEATING: A TANKLESS WATER HEATER WITH SPIKE 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 = 80
VERTICAL: 12 IN. JOISTS WITH 12 IN. BLOWN FIBERGLASS INSULATION + 4 IN. EPS FOAM OVER THE EXTERIOR TO BRIDGE SAPS
ROOF = R = 80
16 IN. JOISTS WITH VENT CHANNELS ABOVE THE SHEATHING AND 16 IN. OF BLOWN FIBERGLASS INSULATION
WINDOWS = U-1 .19
TRIPLE-PANE, ARGON FILLED LOW-E, FIBERGLASS FRAMES WITH XPS INSULATION
MATERIALS:
DURABLE, RECYCLABLE GALVANIZED-STEEL ROOF
CMU FOOT WALL + ON-GRADE CONCRETE SLAB ARE MATERIAL AND LABOR EFFICIENT
RECYCLED TUB, FIXTURES AND MEDICINE CABINETS
FOUR REGIONALLY SOURCED WOOD (PINE, CEDAR) AND CEDAR
RECYCLED SLATE CLADDING ON THE FOUNDATION
RECYCLABLE BLOWN-FIBERGLASS INSULATION



CASE STUDY # 2

DULUTH, MN
J AND R SUNDBERG BUILDERS
WAGNER ZAIN ARCHITECTURE
3 BEDROOMS AND 2 BATH
2,660 SQ. FT.
COST = \$84 PER SQ. FT.
ANNUAL ENERGY USE = 19.4 MMBTU
INDOOR AIR QUALITY:
WHOLEHOUSE 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 COLLECTION AIR ROUTE BACK UP HEATING FROM A GASIFIED 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, 1/2 IN. OF EXTERIOR OSB, AND 1/2 IN. INTERIOR OSB. THE INTERIOR IS STUFFED WITH DENSE-PACK CELLULOSE INSULATION
ROOF = R = 88
2/6 IN. DEEP PARALLEL CHORD TRUSSES WITH CONTINUOUS VENT CHUTES AND 24 1/2 IN. OF BLOWN CELLULOSE INSULATION
WINDOWS = U-1 .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 BEAM METAL ROOF



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 in the table). These ICFs are very durable, thus aiding in meeting our goal of durability. The ICFs do not lose 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.

	Wood-frame wall system	LOGIX ICF construction
Energy Efficiency	<ul style="list-style-type: none"> Thermal bridging Gaps in insulation Emission of R value 	<ul style="list-style-type: none"> No thermal bridging Continuous insulation Constant R value for life Up to 50% Energy Savings
Environmental Impact	<ul style="list-style-type: none"> Minimal reduction in greenhouse gas emissions Service life 30 to 50 years maximum 	<ul style="list-style-type: none"> Reduces greenhouse gas emissions by up to 1/3 or 3 tons annually Will last for generations
Air Quality	<ul style="list-style-type: none"> May contain adhesives and VOCs that off-gas Wood and moisture provide an ideal environment for mold 	<ul style="list-style-type: none"> EPS and concrete are non-toxic and do not off-gas No radon source exists in structure for mold growth
Durability	<ul style="list-style-type: none"> Floor wind rating Fire rating in minutes 	<ul style="list-style-type: none"> Wind rated up to 250 mph Fire rated for up to 4 hours Up to 4X Stronger Up to 4X More Sound Resistant



Heating and Cooling Load Tables First Floor

East Wall (Btu/hour)	East Windows/Panels (Btu/hour)	West Wall (Btu/hour)	West Windows/Panels (Btu/hour)	South Wall (Btu/hour)	South Windows/Panels (Btu/hour)	North Wall (Btu/hour)	North Windows/Panels (Btu/hour)
Heating: 2,813 1,219 615	Heating: 2,333 1,219 615	Heating: 1,575 369 369	Heating: 393 129 129	Heating: 813 813 813	Heating: 393 129 129	Heating: 615 229 149	Heating: 393 129 129
Cooling: 1,575 369 369	Cooling: 393 129 129	Cooling: 813 813 813	Cooling: 393 129 129	Cooling: 289 129 129	Cooling: 393 129 129	Cooling: 615 229 149	Cooling: 393 129 129

TOTAL First Floor Heating Load (R-90 WALL, R-3 WINDOW) = 6,884 Btu/h = 1.96 kW
TOTAL First Floor Cooling Load (R-90 WALL, R-3 WINDOW) = 3,345 Btu/h = .97 kW

Heating and Cooling Load Tables Second Floor

East Wall (Btu/hour)	East Windows/Panels (Btu/hour)	West Wall (Btu/hour)	West Windows/Panels (Btu/hour)	South Wall (Btu/hour)	South Windows/Panels (Btu/hour)	North Wall (Btu/hour)	North Windows/Panels (Btu/hour)
Heating: 2,813 1,219 615	Heating: 1,139 499 299	Heating: 1,575 369 369	Heating: 393 129 129	Heating: 813 813 813	Heating: 393 129 129	Heating: 615 229 149	Heating: 393 129 129
Cooling: 1,575 369 369	Cooling: 393 129 129	Cooling: 813 813 813	Cooling: 393 129 129	Cooling: 289 129 129	Cooling: 393 129 129	Cooling: 615 229 149	Cooling: 393 129 129

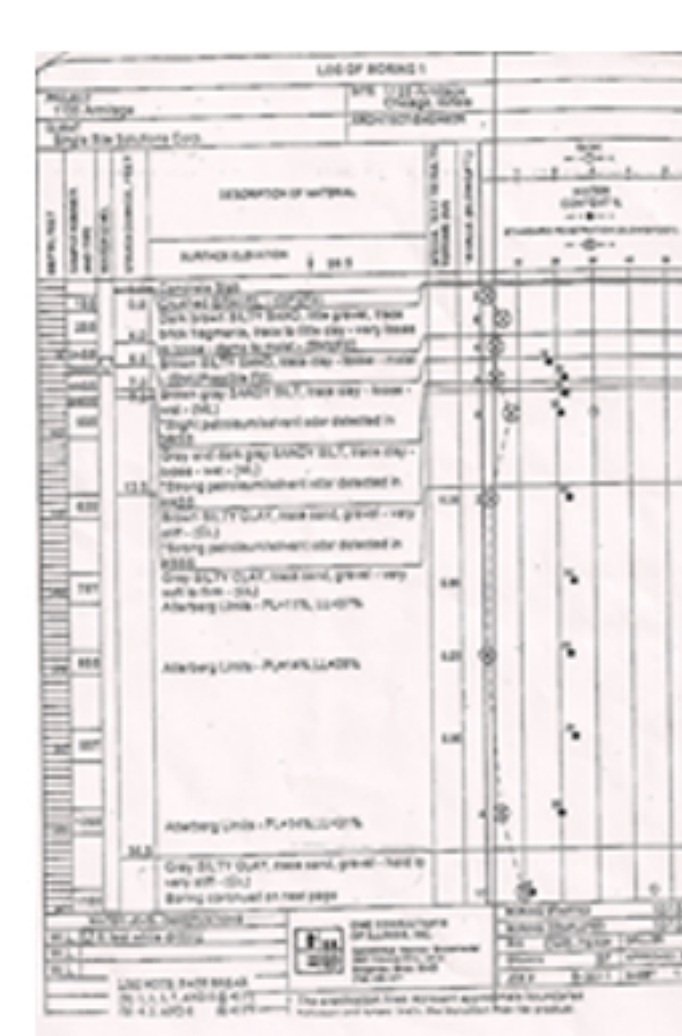
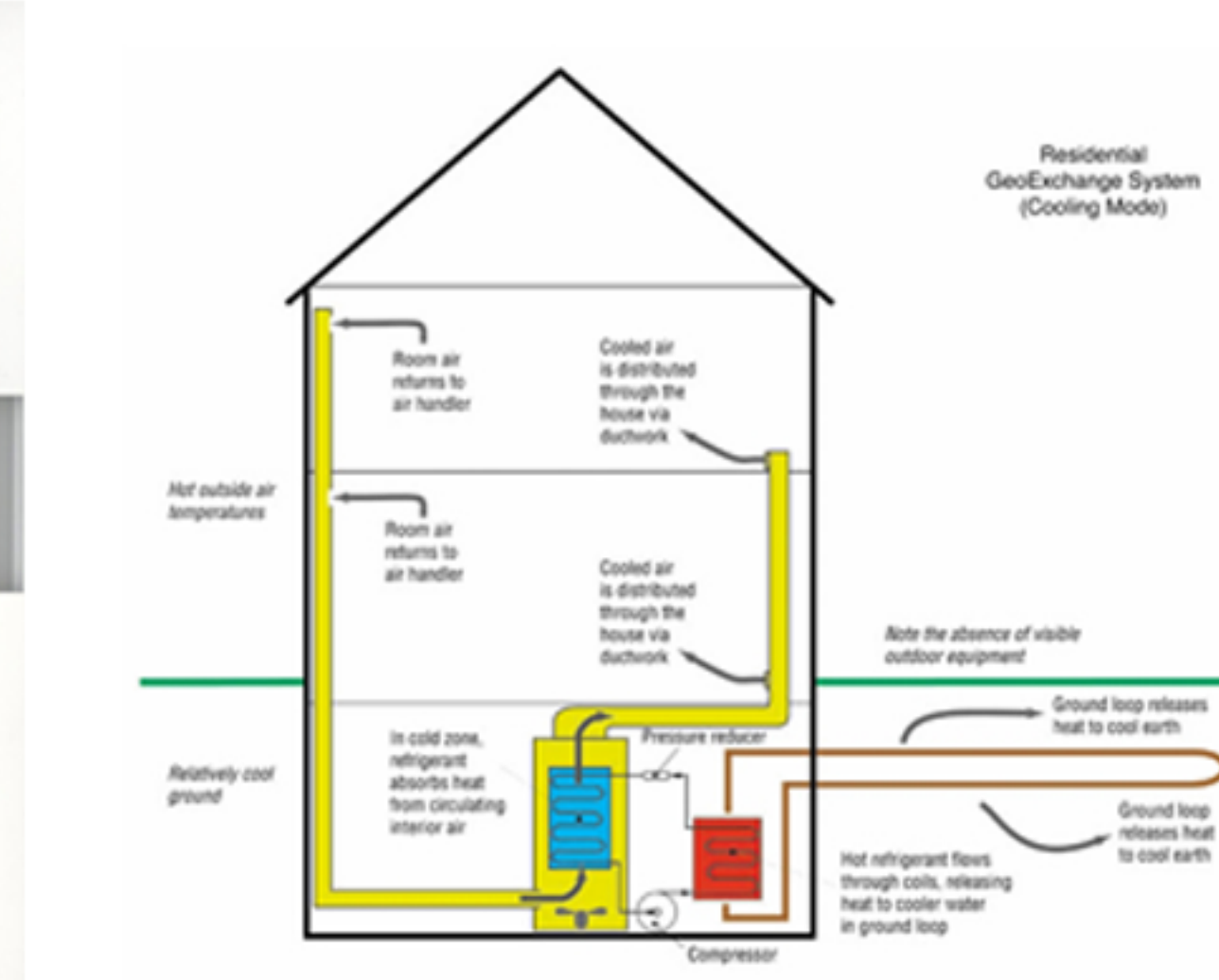
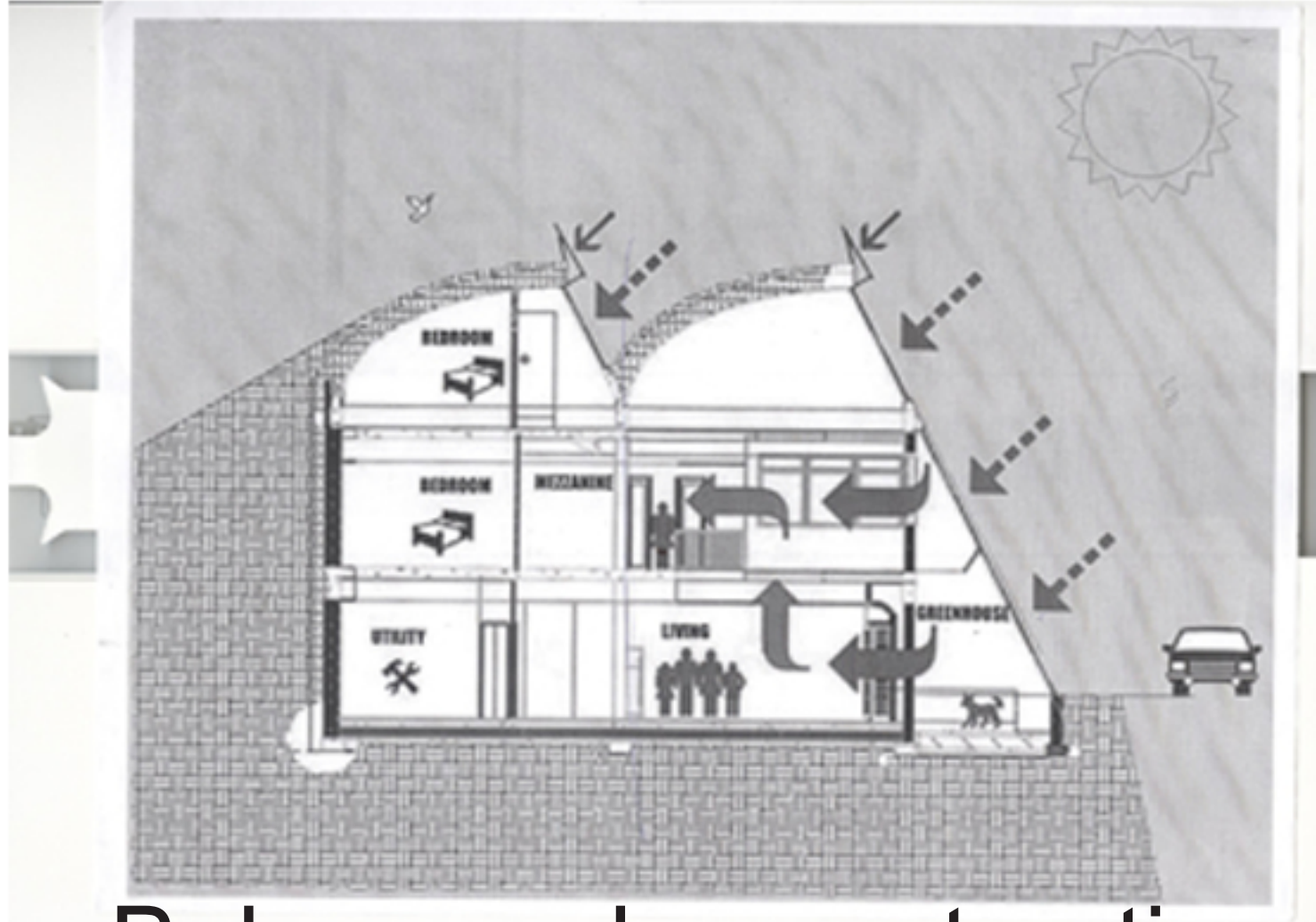
TOTAL Second Floor Heating Load (R-90 WALL, R-3 WINDOW) = 4,511 Btu/h = 1.32 kW
TOTAL Second Floor Cooling Load (R-90 WALL, R-3 WINDOW) = 2,547 Btu/h = .69 kW

Heating and Cooling Load Tables Third Floor

East Wall (Btu/hour)	East Windows/Panels (Btu/hour)	West Wall (Btu/hour)	West Windows/Panels (Btu/hour)	South Wall (Btu/hour)	South Windows/Panels (Btu/hour)	North Wall (Btu/hour)	North Windows/Panels (Btu/hour)
Heating: 2,813 1,219 615	Heating: 1,139 499 299	Heating: 1,575 369 369	Heating: 393 129 129	Heating: 813 813 813	Heating: 393 129 129	Heating: 615 229 149	Heating: 393 129 129
Cooling: 1,575 369 369	Cooling: 393 129 129	Cooling: 813 813 813	Cooling: 393 129 129	Cooling: 289 129 129	Cooling: 393 129 129	Cooling: 615 229 149	Cooling: 393 129 129

TOTAL Third Floor Heating Load (R-90 WALL, R-3 WINDOW) = 4,416 Btu/h = 1.28 kW
TOTAL Third Floor Cooling Load (R-90 WALL, R-3 WINDOW) = 1,800 Btu/h = .52 kW

TOTAL BUILDING Heating Load (R-90 WALL, R-3 WINDOW) = 14,821 Btu/h = 4.28 kW
TOTAL BUILDING Cooling Load (R-90 WALL, R-3 WINDOW) = 7,492 Btu/h = 2.13 kW



Below grade construction

Geothermal

Soil Test

Zoning Map

Load Tables

Case Studies

Site Analysis

Research