IPRO Team 357

Greenleaf

Final Report

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Executive Summary

In the latter half of the last decade, a new crop of young conscious potential homeowners has emerged from the recession. By capitalizing on this new wave demographic, our team has designed an energy efficient community that could very well be the template for townships and villages across the country in the future. The GREENLEAF project involves the use of energy efficient technologies and cost efficient construction to create housing that is both affordable and attractive to the prospective buyer.

Our purpose builds upon the progress of a previous team's research into a zero energy community by taking its best features and making the community a cost effective reality. The GREENLEAF team will present our final proposal to prospective investors and current industry representatives. Our main fiscal figures will come from the energy savings obtained from the conscious technologies implemented along with a design that toes the line between economical interest and aesthetic appeal. Future teams can use this model and build on the project's viability by exploring more ways to make it more financially accessible to the general public.

The main design of the community is centered on dual attached residences that share one wall and certain utilities. This is a good balance between encouraging mutual resource allocation and also preserving some individuality between neighbors. There will be seven such planned residences on the proposed lot on Dodge and Greenleaf. The base price of the house will have upgrade options including technologies such as solar and green roof technologies, geothermal heat pumps, sage glass, and structural insulated panels for construction.

Our project will be judged by industry professionals, previous team leaders, and outside judges who will determine the strengths and weaknesses of our proposal. We and future teams will make adjustments to the sustainability of the project accordingly.

Purpose and Objectives

Team Purpose

The purpose of our IPRO is to design a community for Evanston, IL, specifically located at Dodge Street and Greenleaf Avenue, which is economically and environmentally conscience. Our team was provided a working model from the IPRO group of fall 2009 which was only concerned with being environmentally friendly; cost was not a parameter they were working with. Our team studied their model, found the strengths and weakness, and applied what we discovered to our community. We also looked at the current housing market in Evanston and found a budget for our houses. Our final community was composed of two different duplexes, a 2 bedroom unit and a 3 bedroom unit, a communal area with a playground and a garden area, innovative systems to reduce the energy consumption while keeping the units economically feasible.

Objectives

- Research economically viable sustainable methods for fulfilling the energy needs of a mixed use building in Evanston.
- Conduct a market research of the average buyer and determine the baseline cost of this single family residential unit.

- Develop a financial plan that summarizes cost analysis and building Performa.
- Test our solution by comparing its energy consumption/costs with the average home of today.
- Present our solution clearly and truthfully as a catalyst for change in design and implementation of mixed use buildings.

Organization and Approach

At the start of the project, our team was able to use research from the previous team, IPRO 323. However, this project required much additional research from all three teams. Here, it will be broken down by team, what research was done, and what methods were used.

Architecture Team

The architects on our team had to research a few things. First, they had to research the zoning requirements on our lot. This research really dictates the design; size of the lot that can be used, offsets, allowable height and floors, among other requirements. These requirements are obtained from official documents on the City of Evanston website.

Besides that research, the architects also had to do sun studies and come up with a design that was pleasing to the team, advisors, as well as the target market. In order to come up with this, the architects used software such as AutoCad and Revit.

Engineering Team

The engineers on our team were responsible for designing the different systems that were used in our design. The research that had to be done for this end came from various sources. Product specifications came from product manufacturers. The behavior of the components in our design came from analysis using software such as eQuest and SAP2000. Another form of research required was to find out how much our designs would cost to be constructed. For this, the engineers used methods learned in our cost estimating classes, and we utilized Means CostWorks cost estimating software.

Business Team

The business team needed to perform research to discover what our target market is, the cost of similar properties in the area, and whether our product would sell in the City of Evanston. The business team decided that the best way to find all this information was to meet with a person that deals with this on a daily basis, so we sought the help of a real estate agent in the City of Evanston. From this agent, we were able to obtain data on demographics, salaries, household sizes, property values, property sizes, as well as other information that really dictated what we could do with our design.

Analysis and Findings

Architecture Team

The architects were faced with a few different issues. Given the lot size and the required setbacks, they had to determine how many units could be placed on the lot. They also had to determine how many stories each unit should be, whether to have a garage or not, maximize space, and make the design aesthetically pleasing.

Engineering Team

The engineers analyzed all the systems that were considered, weighed the options based on initial and payback costs, as well as other benefits to the residents and investors. Analysis on each system can be found here.

Green Roof

The engineers considered using a green roof with our design. Green roofs help cool a home during the summer, and provide added thermal resistance during the winter. They also serve the purpose of adding beauty to a home. In our case, a buyer must choose whether to have a green roof or solar panels. It is not possible to have both, since they are both located on the roof. Taking this into consideration, one must consider which option is a better investment. The green roof will add an initial cost of 2-3 thousand dollars, and result in a payback period of 18-19 years.

Structural Insulated Panels

The unknowns when dealing with Structural Insulated Panels (SIP's) is what kind of thermal resistance do they provide, and how cost effective are they. Also, another issue is whether they are structurally adequate. The manufacturer specifications from many manufacturers consistently prove that SIP's provide a higher R-value than conventional wood framing. SIP's offer a whole wall R-value of 30, as opposed to a value of 20-21 for wood framing with polyurethane insulation. The energy savings offered by SIP's is reflected in the energy graphs in the appendices, and the cost added by these is the "Rough Carpentry" in the Pro-Forma. As far as the structural system utilizing SIP's, this was done according to the 2003 International Building Code, which the City of Evanston currently utilizes.

Electrical System

The electrical layout and all of the electrical calculations for Greenleaf Community in Evanston, Illinois were prepared based on National Electric Code 2008.

The outlets are placed on the perimeter of the walls no further than 12 feet apart. An outlet was places within 6ft of all fixed equipment like refrigerator, stove and washing machine. At least one outlet was positioned in hallways. The receptacles in the bathrooms, near kitchen countertops, in the garage and outdoors have a ground fault interrupter (GFI) built in to protect against ground faults like short circuit from a phase wire ground. All receptacles in the bedrooms are protected by arc fault circuit interrupters (AFCI). AFCI outlets protect against arc faults in case the wires get punctured by a nail and a formed arc will begin to destroy insulation and cause fire. NEC 210.50 and 210.52 require bathroom and laundry circuits to be on a separate branch circuit. For a family dwelling at least two receptacles are required to be installed outside, one in front and one in back. Outdoor receptacles are GFCI protected

and have a plastic cover to protect them from the elements. At least one of the receptacles in every room and hallway is wall switch controlled.

The design allows the consumers to choose if they want to install photovoltaic panels on the roof to provide 50% of the lighting load on the sunny days. The solar panels will most likely be useless during the winter months due to very low solar energy availability. All the energy saving calculations are based on 6 months of solar energy availability of 3.86 kWh/m². It is best to design the system to provide 50% of the lighting load because of the balance of the energy savings, payback period, and up front costs of the panels. The target payback period was set at 5 years and was met with the selected panels. Almost 70% of panels' total cost is covered by state and federal tax credits.

Plumbing System

Plumbing: Taking the advantage of the duplex design, the plumbing system is shared by each of the two attached family units. A water heater is located in the mechanical room, and the main plumbing pipes are located in the shared plumbing wall. Water comes from the city is ducted through the water heater and distributed into each family, with a meter installed on each branch to record the water usage of the family. The sizes of the pipes were determined based on the *2009 International Plumbing Code*. The size of the water heater was determined based on several statics: 1) the water consumption was 15 gallons per person per day; 2) according to the census result, we estimated that there would be 4 to 5 people in each family. Namely 8 to 10 people would live in each unit; 3) the pre-heating temperature of the water was 40 degrees while the post-heating temperature was 140 degrees. Thus, a water heater with a minimum tank volume of 160 gallons was required. And the heating energy would be provided by natural gas.

Two types of water heaters were under consideration: the instantaneous water heater and the solar water heater. The features of these two types of water heaters are listed below:

	instantaneous water	Solar water heater
advantages	Flexible control of energy usage	Reduce or eliminate the gas consumption
disadvantages		The solar panel efficiency is low and largely depends on the sunlight, which means during the winter the solar panels can hardly produce energy due to the lack of sunlight
		Installation is more expensive
		The solar panels take up significant amount of space

The average natural gas bill of the residents in Evanston was calculated based on the gas price introduced by *nicor*, the natural gas supplier of Evanston, as well as the energy model analysis of *equest*. The estimated annual gas bills are listed below:

	2-bedroom unit	3-bedroom unit
Gas consumption (therm/yr)	22.04	20.93
Unit price ($/therm)	0.43	0.43
Annual bill	94.8	90
Solar water heater cost	6882.6	6882.6

Geothermal Heat Pump

The questions that need to be answered when dealing with geothermal is whether there is enough space on our lot to excavate for the vertical loops, and also to determine the size of the pump that is needed to heat/cool the home. The analysis of our engineers is included in this appendix.

Business

Scope of			Size of the Lot			53,482	s.f.
	Development		Permitable Lot Coverage			80%	
			Permitable Square Footage			42,786	s.f.
			No. of Allowable Units			10	
			Height Restriction			3 stories	
			Required Parking			2 spaces per unit	
Proposed			No. of Residential Units			7	
	Development		Total Residential Square Foot.			24,792	s.f.
			Average Residential Unit Size			3,542	s.f.
			Commercial Square Footage			0	s.f.
			Height			3	
			No. of Parking Spaces			14 min.	

No.	Unit Type	Units Size	Unit Price	Price/S.F	Feature
1	2 Bedroom	2634	424,074.00	161.00	Garage, green roof, geothermal heating and cooling
2	2 Bedroom	2634	424,074.00	161.00	Garage, green roof, geothermal heating and cooling
3	2 Bedroom	2634	424,074.00	161.00	Garage, green roof, geothermal heating and cooling
4	2 Bedroom	2634	424,074.00	161.00	Garage, green roof, geothermal heating and cooling
5	3 Bedroom	4752	645,072.00	135.75	Patio, green roof, geothermal heating and cooling
6	3 Bedroom	4752	645,072.00	135.75	Patio, green roof, geothermal heating and cooling

7	3 Bedroom	4752	645,072.00	135.75	Patio, green roof, geothermal heating and cooling
	Total	24792	3,631,512.00		
	Average	3542	518,787.43		
	TOTAL		3,631,512.00		

Revenue						**3,701,512**
Expenses		1	Lot			1,000,000
		2	Site Preparation			184,427
		3	Construction			1,618,552
		4	Lender Inspections			15,000
		5	Architecture			62,602
		6	Legal/Accounting			10,559
		7	Financing/Appraisal			2,500
		8	Title Insurance			15,000
		9	Insurance			7,040
		10	R.E. Taxes/Fees			13,300
		11	Marketing			170,000
		12	Survey/Testing			5,550
		13	Contingency			5,000
		14	Developer Fees			49,277
		15	Interest			56,317
			Total			**3,215,125**
Project Profit						486,387
Capital						1,125,294
Rate of Return						43%
Annualized Return						26%
Sources and Uses of Funds						
Sources						
General Partner Contribution:						1,125,249
Construction Lender:						3,146,097
Proceeds from Residential:						3,701,512
Total						**7,972,858**
Uses:						
Soft Costs:			(Land & Marketing)			1,596,572
Hard Costs:			(Construction)			1,618,552
Return of Bank Loan:						3,146,097
Return of Principal:						1,125,294
Distribution of Profit:						486,387
Total						**7,972,903**

Conclusions and Recommendations

Architecture

After trying many different layouts and consulting the rest of the team and advisors, the architects decided that the best solution would be to have 7 units on the lot. There are two different designs; a two bedroom and a three bedroom design. The two bedroom design is three stories high, and will have a garage on the first floor. The three bedroom design is two stories high, and will have parking in the driveway; it will not have a garage. It will have a bedroom on the first floor, and this will make it accessible to handicapped individuals. Both designs will feature a stairway gallery that will add beauty to the design.

Engineering

Engineers concluded that a green roof will be offered as an option to buyers, but the better investment is installing solar panels. Although solar panels add over 6 thousand dollars to the initial cost, they have a much shorter payback period. The recommendation is to select solar panels, unless a person really appreciates the beauty of a green roof.

The engineers concluded that the energy savings would provide a short enough payback period to justify using SIP's.

The conclusion on the solar panels is that it is best to design the system to provide 50% of the lighting load because of the balance of the energy savings, payback period, and up-front costs of the panels. The target payback period was set at 5 years and was met with the selected panels. Almost 70% of panels' total cost is covered by state and federal tax credits.

The conclusion on using a solar water heater is that, from the data above we estimated the payback period for the solar water heater to be 60 to 70 years. This payback period is too long to attract the buyers. Therefore we determined that the instantaneous water heaters would be used, and not the solar water heaters.

The engineers determined that a 2 ton heat pump was required for the two bedroom home, and a 3 ton pump is required for the 3 bedroom home. We will need to excavate from 150-190 feet, and the size of our lot is adequate to provide this requirement for all 7 units on our lot. The payback period of five years is also adequate for the scope of our project.

Business

More detailed analysis is needed to confirm the financial viability of this project. More detailed information on the soft costs is needed and some construction costs are also missing. Probably the most glaring need is if a loan would be given out from a bank and what rate it would be issued at. Another

consideration is whether the project should continue on with 2 bedroom units, 3 bedroom units, or a combination of both. The 2 bedrooms units might sell quicker but will come with a lower profit margin. The 3 bedroom units might take longer to sell but will come with a much greater profit margin. A final recommendation would be to look into alternate methods to finance a home including the rent to buy option.

Appendix A

References

Illinois Department of Commerce and Economic Opportunities:

http://www2.illinoisbiz.biz/communityprofiles/profiles/EVANSTON.htm

Nicor Inc.

http://www.nicor.com/en_us/residential/gas_cost/price.htm

2009 International Plumbing Code

2003 International Building Code

City of Evanston

http://www.cityofevanston.org/

eQUest Software

Means CostWorks Estimating Software

AutoCad and Revit

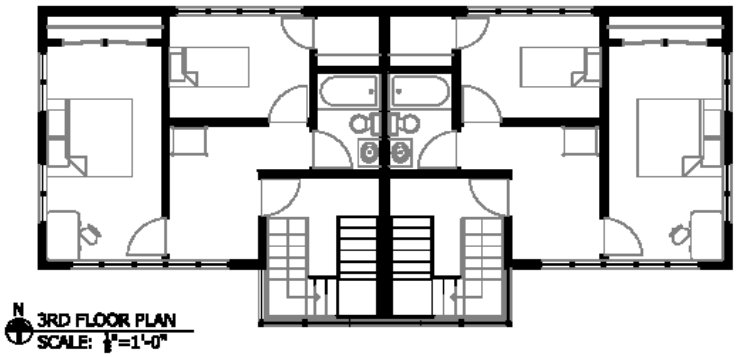
Expenses

Item	Cost
Means CostWorks Subscription	$35.00
Total	**$35.00**

Team Members

Team Member	Major	Advisors
Chris Anglin	Business	Professor Mark Snyder
Namrata Hegde	Architecture	Professor Steve Beck
Alexander Mathai	Civil Engineering	Professor William Paschal
Samantha Prokop	Architecture	
Samir Qaisar	Civil Engineering	
Jorge Rueda	Civil Engineering	
Svetlana Semenova	Architectural Engineering	
Woo Shin	Civil Engineering	
Yao Xiao	Architectural Engineering	
Joong Geun Yun	Civil Engineering	

Appendix B



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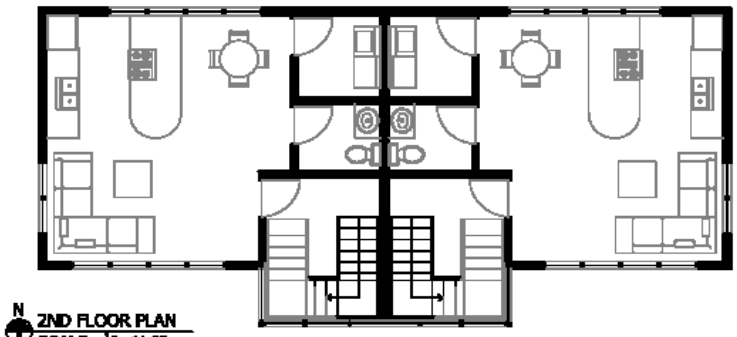
3RD FLOOR PLAN
SCALE: 1/8"=1'-0"



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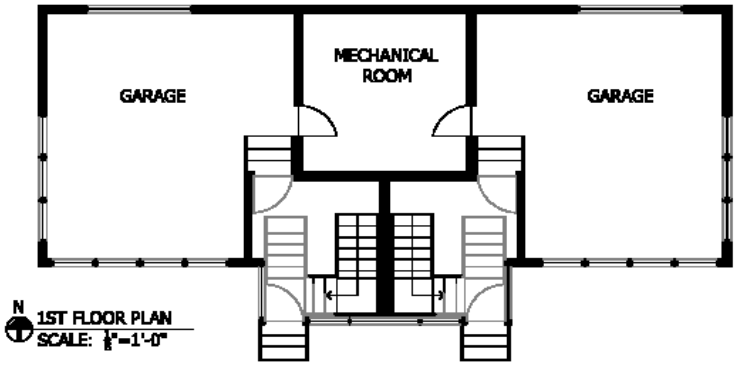
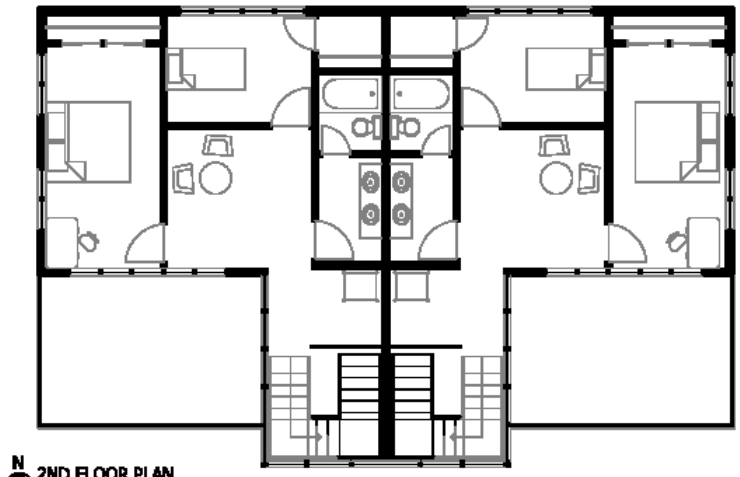
2ND FLOOR PLAN
SCALE: 1/8"=1'-0"



N
1ST FLOOR PLAN
SCALE: 1/8"=1'-0"

2 Bedroom Floor Plan



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2ND FLOOR PLAN
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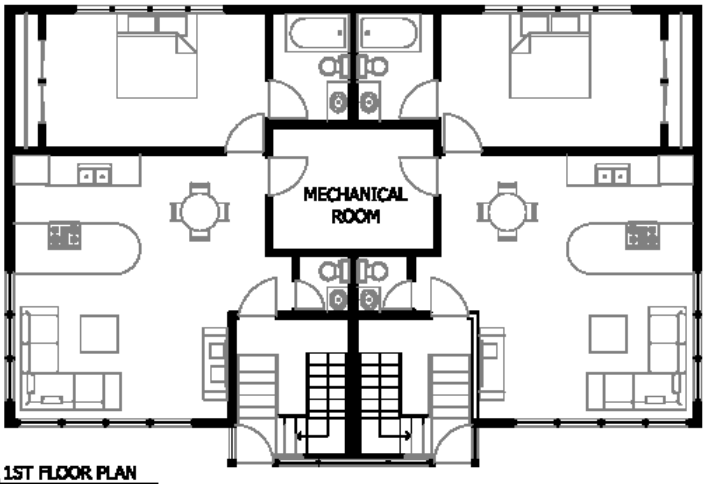
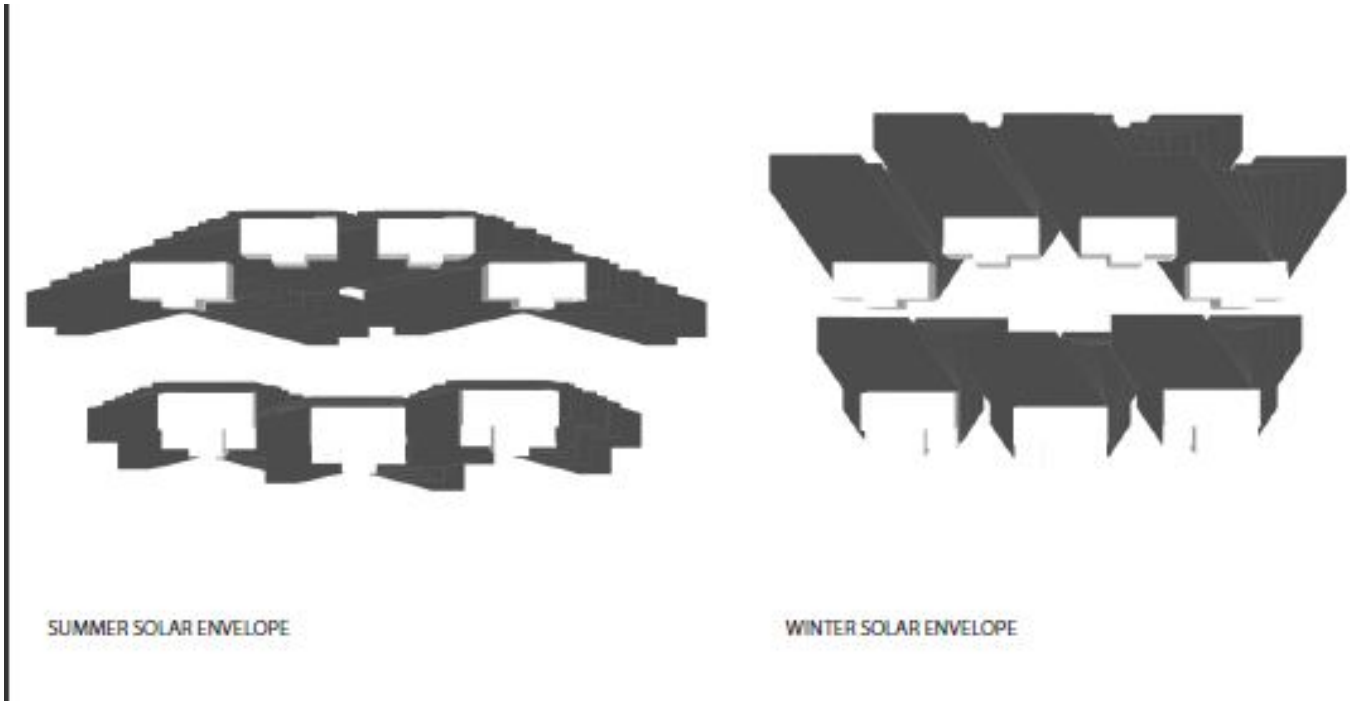


N
1ST FLOOR PLAN
SCALE: 1/8"=1'-0"

3 Bedroom Floor Plan

Site Plan



Solar Envelope

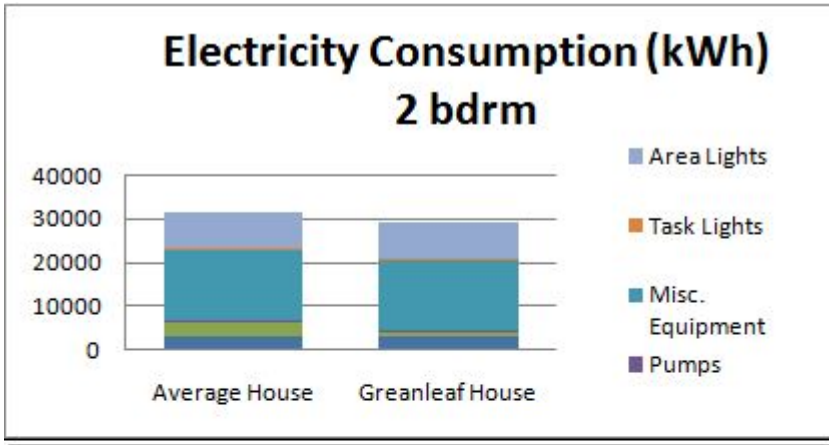
2 Bedroom Model

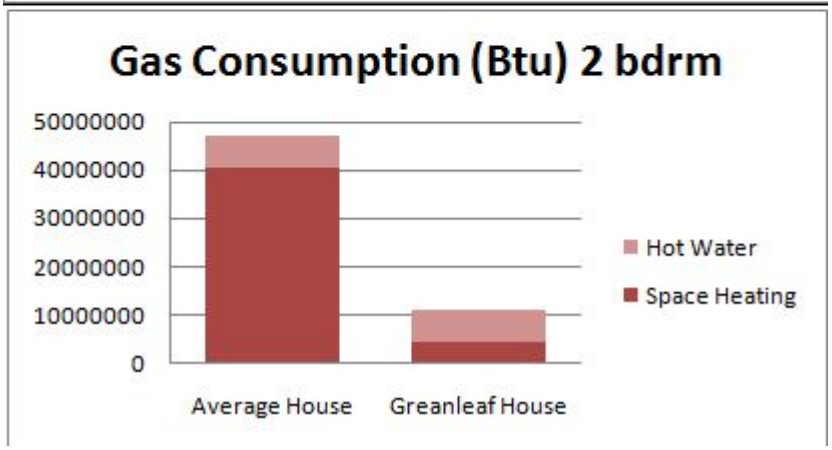
3 Bedroom Model

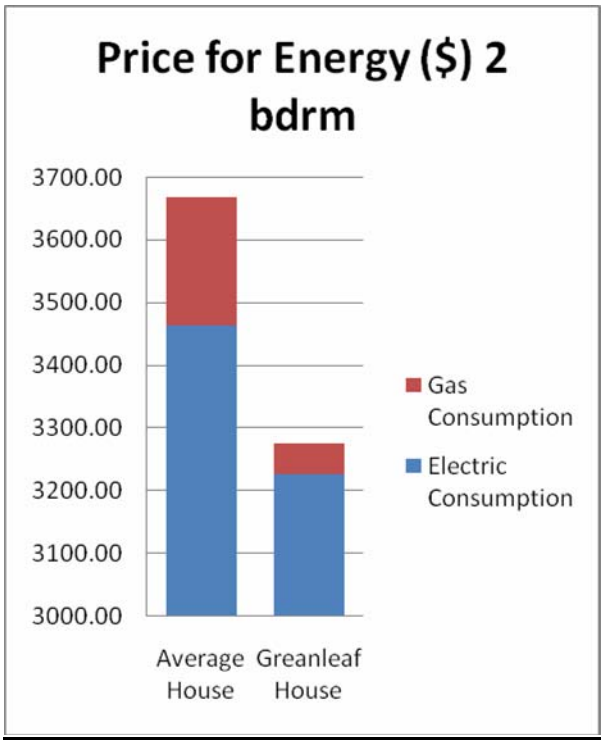
Appendix C

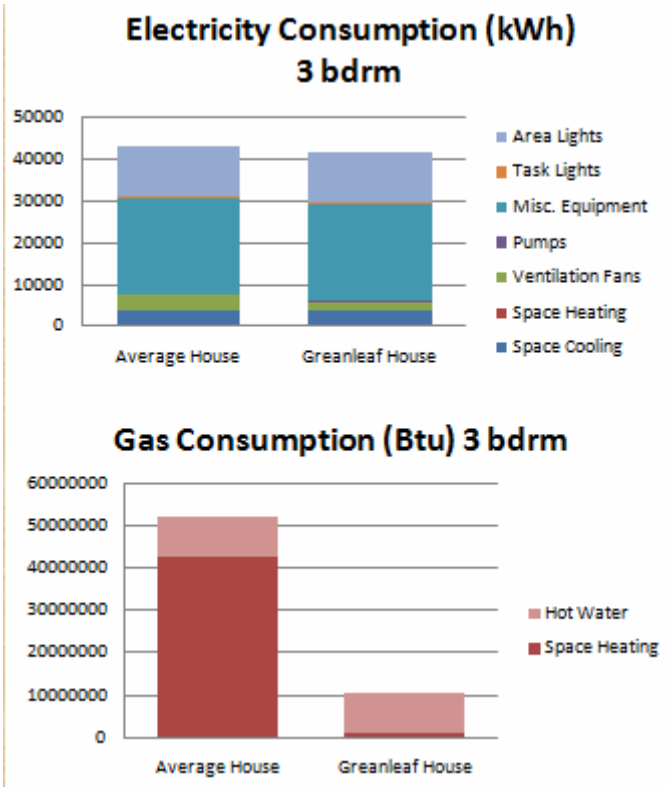
		SageGlass	PV panels	Green roof
2-bedroom houses	Energy saving (kWh/yr)	1350	17810	1136
	money saving ($/yr)	$150	$1,600	$125
	Additional cost ($)	$2,800	$6,600	$2,400
	Pay back period (yr)	19	5	19
3-bedroom houses	Energy saving (kWh/yr)	1160	12720	1518
	money saving ($/yr)	$130	$2,350	$170
	Additional cost ($)	$7,000	$9,400	$3,200
	Pay back period (yr)	54	5	18

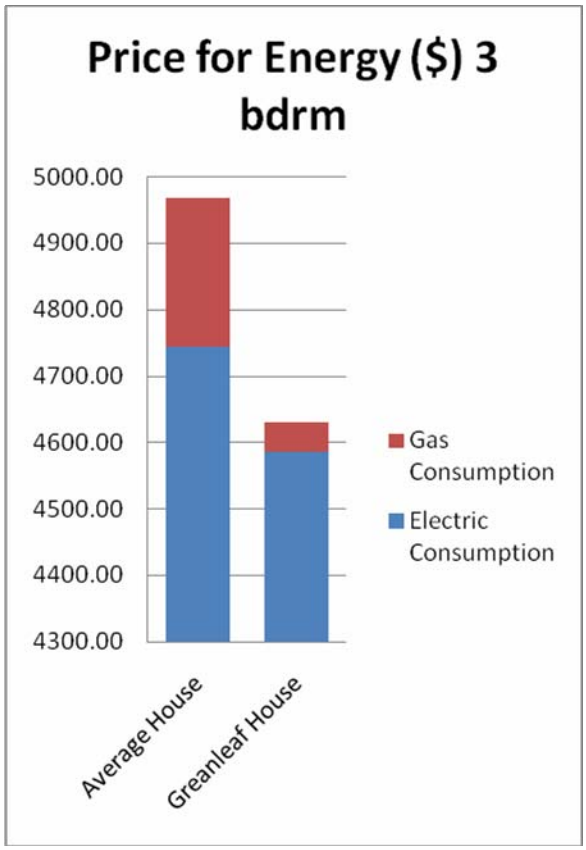
Energy and Savings








Electricity Consumption (kWh) 3 bdrm
50000
40000
30000
20000
10000
0
Average House
Greanleaf House
Area Lights
Task Lights
Misc. Equipment
Pumps
Ventilation Fans
Space Heating
Space Cooling
Gas Consumption (Btu) 3 bdrm
60000000
50000000
40000000
30000000
20000000
10000000
0
Average House
Greanleaf House
Hot Water
Space Heating

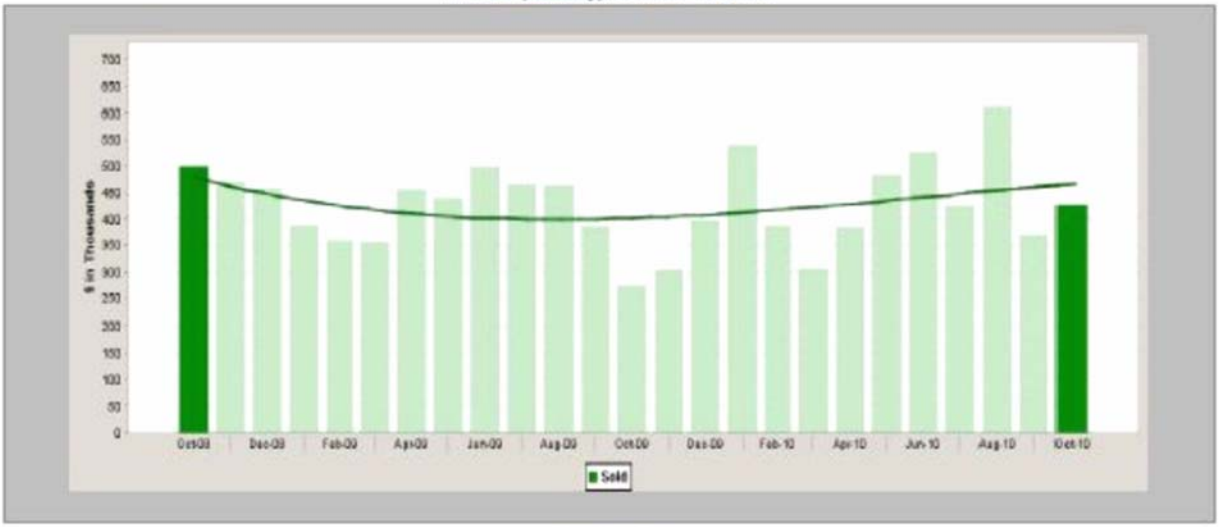

Price for Energy ($) 3 bdrm
5000.00
4900.00
4800.00
4700.00
4600.00
4500.00
4400.00
4300.00
Average House
Greanleaf House
Gas Consumption
Electric Consumption

Appendix D

Market Dynamics

Coldwell Banker Residential

Median Price (Sold)
2 Years (Monthly) 10/01/08 - 10/31/10



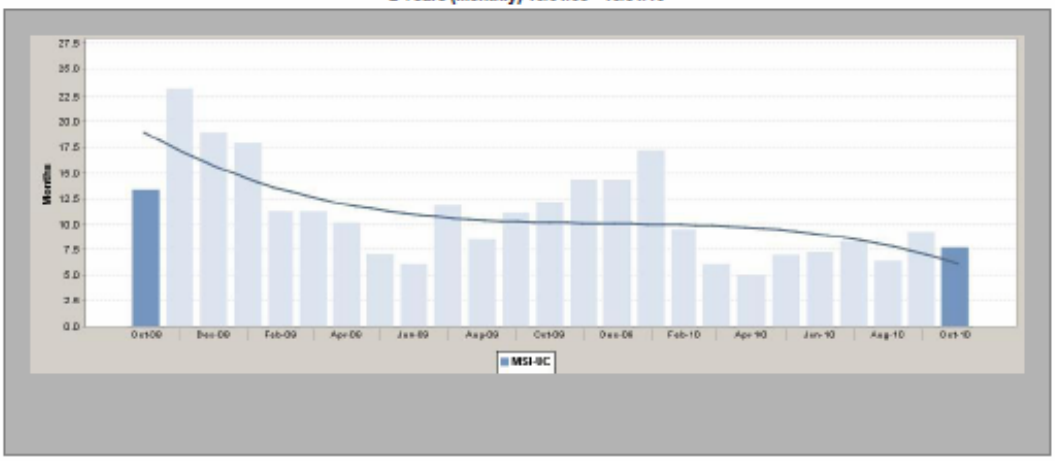
KEY INFORMATION

	Oct-08	Oct-10	Median Price Change	Percent Change
Sold	498,750	427,000	-71,750	-14.4

MLS: MRED | Period: 2 Years (Monthly) | Price: All | Construction Type: All | Bedrooms: All | Bathrooms: All | Lot Size: All
Property Types: Residential (Detached Single) | Sq Ft: All
Cities: Evanston

Coldwell Banker Residential

Market Dynamics
Months Supply of Inventory (UC Calculation)
2 Years (Monthly) 10/01/08 - 10/31/10



KEY INFORMATION

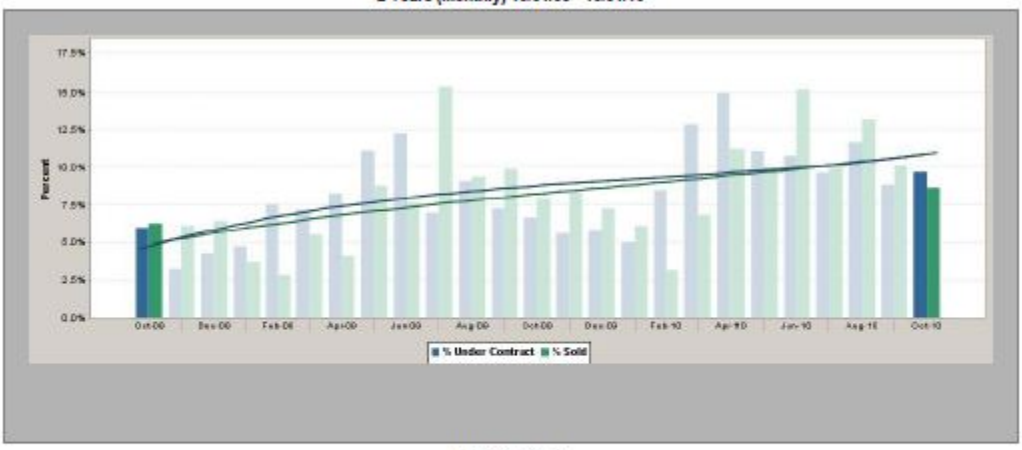
	Oct-08	Oct-10	MSI Change	Percent Change
MSI-UC	13.4	7.7	-5.7	-42.3

MSI UC -42.3%

MLS: MRED | Period: 2 Years (Monthly) | Price: All | Construction Type: All | Bedrooms: All | Bathrooms: All | Lot Size: All
Property Types: Residential: (Detached Single) | Sq Ft: All
Cities: Evanston

Coldwell Banker Residential

Market Dynamics
Sales Absorption
2 Years (Monthly) 10/01/08 - 10/31/10



KEY INFORMATION

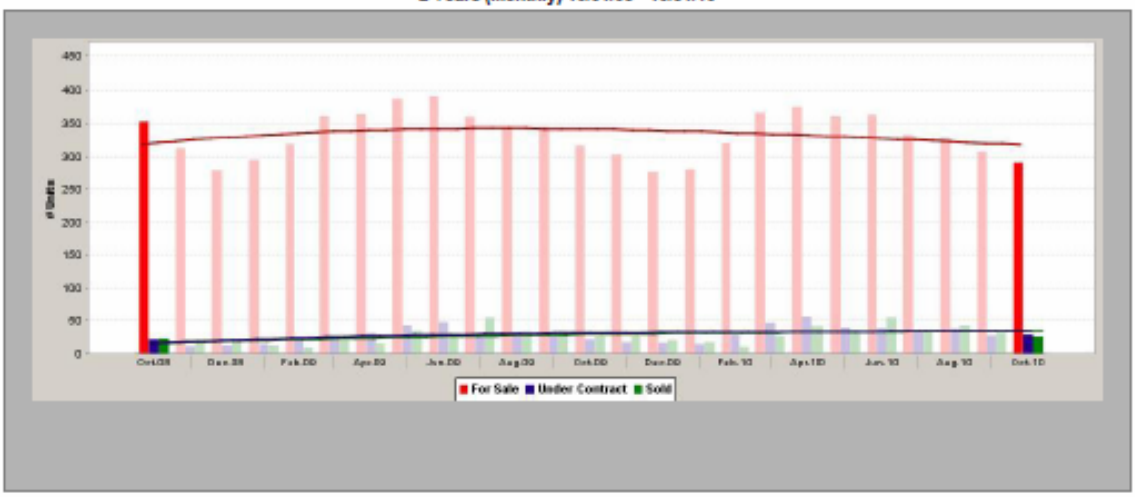
	Oct-08	Oct-10	Change	Percent Change
% Under Contract	5.98	9.69	3.71	61.9
% Sold	6.27	8.65	2.38	38.0

MLS: MRED | Period: 2 Years (Monthly) | Price: All | Construction Type: All | Bedrooms: All | Bathrooms: All | Lot Size: All
Property Types: Residential: (Detached Single) | Sq Ft: All
MLS Areas: 201

Market Dynamics

Coldwell Banker Residential

Supply & Demand - # Units (FS, UC, Sold)
2 Years (Monthly) 10/01/08 - 10/31/10



KEY INFORMATION

	Oct-08	Oct-10	# Units Change	Percent Change
For Sale	353.0	291.0	-62.0	-17.6
Under Contract	21.0	28.0	7.0	33.3
Sold	22.0	25.0	3.0	13.6

MLS: MRED | Period: 2 Years (Monthly) | Price: All | Construction Type: All | Bedrooms: All | Bathrooms: All | Lot Size: All
Property Types: Residential: (Detached Single) | Sq Ft: All
Cities: Evanston

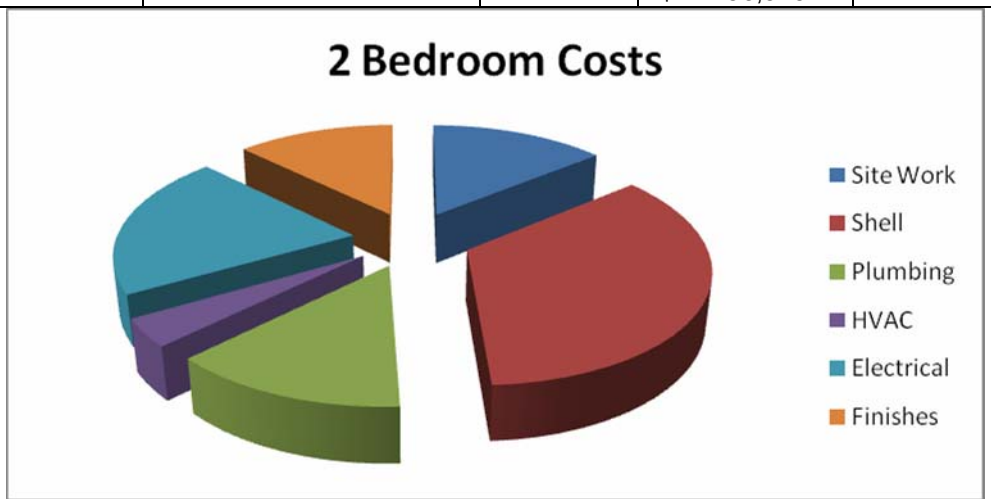
AgentMetrics®

1 of 2

11/23/10

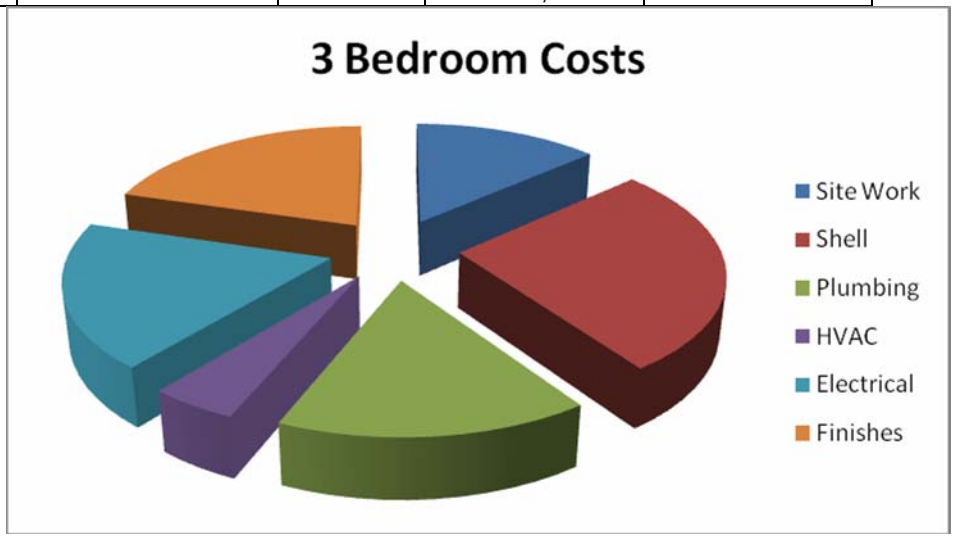
2 Bedroom Hard Costs

			Budget	
No.	**Item**		**Per Unit**	**Unit Total**
02070	Demolition		$ 16,863	$ 67,452
02300	Grading/Excavation		$ -	$ -
02610	Paving		$ -	$ -
02700	Underground		$ -	$ -
02900	Landscaping		**$ 7,100**	**$ 28,400**
03100	Concrete		$ 2,472	$ 9,888
04100	Masonry		$ 4,104	$ 16,414
06100	Rough Carpentry		$ 35,849	$ 143,398
06150	Finish Carpentry		$ 5,278	$ 21,114
06200	Cabinets		$ 1,678	$ 6,713
07100	Water Proofing		$ 5,085	$ 20,340
07300	Insulation		$ 2,112	$ 8,448
07350	Siding		$ 16,141	$ 64,564
07400	Roofing(includes green roof)		$ 2,368	$ 9,471
08300	Garage Door		$ 2,000	$ 8,000
08400	Door/Hardware		$ 5,445	$ 21,781
08600	Windows		$ 8,821	$ 35,284
09100	Drywall		$ 11,328	$ 45,311
09150	Painting		$ 5,268	$ 21,072
09200	Tile		$ 3,177	$ 12,709
09300	Carpeting		$ 1,672	$ 6,687
10400	Bath Accessories		$ 2,171	$ 8,684
10500	Closet Accessories		**$ 4,332**	**$ 17,328**
11100	Appliances		**$ 4,332**	**$ 17,328**
15200	Plumbing		$ 25,357	$ 101,426
15300	HVAC		$ 7,345	$ 29,381
16100	Electrical		$ 38,724	$ 154,896
16200	Security System		**$ 4,332**	**$ 17,328**
Contingency				**-893,417**
TOTAL			$ 196,919	



3 Bedroom Hard Costs

			Budget	
No.	**Item**		**Per Unit**	**Unit Total**
02070	Demolition		$ 16,863	$ 50,589
02300	Grading/Excavation		$ -	$ -
02610	Paving		$ -	$ -
02700	Underground		$ -	$ -
02900	Landscaping		**$ 7,100**	**$ 21,300**
03100	Concrete		$ 2,266	$ 6,798
04100	Masonry		$ 3,456	$ 10,368
06100	Rough Carpentry		$ 25,911	$ 77,732
06150	Finish Carpentry		$ 3,202	$ 9,607
06200	Cabinets		**$ 8,300**	**$ 24,900**
07100	Water Proofing		$ 7,322	$ 21,967
07300	Insulation		$ -	$ -
07350	Siding		$ 12,340	$ 37,020
07400	Roofing		$ 3,067	$ 9,202
08400	Door/Hardware		$ 5,997	$ 17,991
08600	Windows		$ 6,931	$ 20,793
09100	Drywall		$ 12,121	$ 36,362
09150	Painting		$ 9,504	$ 28,512
09200	Tile		$ 3,400	$ 10,199
09300	Carpeting		$ 1,789	$ 5,366
10400	Bath Accessories		$ 2,323	$ 6,969
10500	Closet Accessories		**$ 8,300**	**$ 24,900**
11100	Appliances		**$ 8,300**	**$ 24,900**
15200	Plumbing		$ 31,047	$ 93,142
15300	HVAC		$ 8,892	$ 26,676
16100	Electrical		$ 36,247	$ 108,741
16200	Security System		**$ 8,300**	**$ 24,900**
Contingency				**-492,185.12**
TOTAL			206,749.06	



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