iPro 323

Fall 2009

Zero Energy Community

<u>FINAL REPORT</u>

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Prof. Steve Beck

Team Members:

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DESCRIPTION OF THE IPRO PROGRAM

The Interprofessional Projects (IPRO®) Program at Illinois Institute of Technology

An emphasis on multidisciplinary education and cross-functional teams has become pervasive in education and the workplace. IIT offers an innovative and comprehensive approach to providing students with a real-world project-based experience—the integration of interprofessional perspectives in a student team environment. Developed at IIT in 1995, the IPRO Program consists of student teams from the sophomore through graduate levels, representing the breadth of the university's disciplines and professional programs. Projects crystallize over a one- or multisemester period through collaborations with sponsoring corporations, nonprofit groups, government agencies, and entrepreneurs. IPRO team projects reflect a panorama of workplace challenges, encompassing research, design and process improvement, service learning, the international realm, and entrepreneurship. (Refer to http://ipro.iit.edu for information.) The iPro 323 team project represents one of more than 40 IPRO team projects for the fall '09 semester.

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1. Executive Summary

Energy usage is becoming an ever increasing concern, but economical solutions can be found if communities share infrastructure and energy generated on-site (e.g. solar, wind, geo-thermal). Zero Energy CommunIITy is a prototype which our team developed throughout the semester thanks to interest from the Planning Departments of Oak Park and Evanston, and the help of individuals including Steve Beck (iPro advisor) and Jeremy Poling (Senior Sustainability Analyst).

The challenge of our iPro team was to use technology and design as tools to reconsider modern methods for the construction and development of communities. Many faults can be cited in the current paradigms ranging from waste generated in construction to heating/cooling lost due to poor design.

The need for more economical ways of planning and constructing communities is not only coming from the developers and builders but, also from the dwellers. Keeping these key audiences in mind we began the process to develop a community which provided its dwellers with comfortable living conditions, its builders with reduced construction waste and thoughtfully planned modules, and its planner with 'economy through scale' (i.e. advantages gained through shared infrastructure).

The team felt it was crucial to establish a base from which to improve upon. To accomplish this extensive research on the 'typical' or average home is where our team began. We acquainted ourselves with the typical energy demands as well as typical zoning, density, and demographics. With this information we created a spreadsheet which allowed our team to easily identify areas which we saw as opportunities for improvement and innovation: planning/design, building technologies, building systems, and construction methods/materials. The team organized itself around these main focuses and began to consider the challenge we had in front of us.

IPro 323 committed immediately to the goals of:

1. creating a community with a higher density than the typical
2. creating a community which requires less energy than the typical
3. creating a community which collectively uses its available resources to produce energy unlike the typical.

Using established design guidelines - such as LEED - we developed a prototype community to be used as a tool to compare and contrast the paradigm of contemporary residential living/building/planning techniques. Our prototype was shaped by team members who sought out more sustainable but also more economical ways to build, live, and plan. Our prototype was conceived as an idyllic solution that could inform a shift in the current thinking in these areas.

2. Purpose and Objectives

Our purpose was to seek a union between living comfortably and living sustainably. We designed for a future Chicago-area community which minimizes its energy consumption and uses the most sustainable methods to fulfill the remaining needs of the inhabitants. Our objective was to develop a prototype community which challenges conventions within the fields of sustainable design, planning, engineering, and everyday living. This prototype also serves as an example to Chicago-area municipalities about the benefits of sustainable planning, design, and living.

The data our team gathered regarding the typical home and community is in reference to Oak Park as a typically planned and constructed community from which we extracted demographical information and real world examples of planning/design, building technologies, building systems, and construction methods/materials. This data was used as a base from which our iPro wanted to improve upon. A few preliminary goals we wanted to achieve were to reduce to net energy consumption to zero and increase the population density while reducing the energy needs.

The multidisciplinary makeup of our team served an integral role as we came together to brainstorm possible directions to take with our preliminary research. Subgroups were formed according to each member's background and personal interest; individuals placed themselves into the subgroups where they felt they could be the most effective. Our subgroups produced a plethora of research into emerging energy efficient and energy producing techniques and technologies. The following are the list that our team decided to pursue:

Planning and Design

1. Shared infrastructure
2. Solar orientation
3. Natural ventilation
4. Repeatable module
5. Reduce house size
6. Increase adjacent green space

Building Technologies

1. Energy-Star rated appliances
2. LED lighting
3. Instantaneous water heater
4. Daylighting controls

Building Systems

1. Photovoltaic solar collectors (i.e. solar panel)
2. Geothermal heat pump
3. Radiant flooring
4. Green roof

Construction Methods

1. SIP construction method
2. Precast concrete foundations and footings
3. High efficiency windows and doors
4. Consolidated plumbing/mechanical stack

While researching these topics the team came across several useful examples of this ideal put to trial. One recent project is the Beddington Zero Energy Development. This 99 house scheme utilizes renewable on-site sources to generate its power, the rooms were designed around the local solar cycle, windows are triple glazed, and the walls have high thermal insulation to prevent heat loss. Another example of this sort of community is Lafayette Park, conceptualized by Ludwig Mies van der Rohe. Lafayette Park utilized a repeatable townhome module resulting in a close-knit community with minimized utilities and maximized communal spaces. These projects can each be viewed as successful in a few regards. First, these projects each resulted in a new sense of community through unprecedented planning techniques. Second, both these projects used a multitude of passive and active systems to provide its dweller with a comfortable and economical life style. Using information gathered from these examples of past projects our team was able to define advantages and disadvantages of each. This proved to be useful when evaluating our own ideas.

The body of information and data we gathered helped us to more clearly define the ‘problem’ we were trying to solve. It showed us that in order to change the ways we live, build, and plan we must first change the way we think about these activities. This is why our main objective was to create a prototype community which challenges conventions within these fields and that could inform a shift in the current thinking of Chicago-area municipalities about the benefits of sustainable planning, design, and living.

3. Organization and Approach

The iPro 323 team came together to evaluate the advantages gained when communities are planned thoughtfully, carefully, and sustainably. The approach our team took was to plan a housing module that can be repeated to create a community. The design of this module is rooted in the research gathered by our team.

From the beginning the multidisciplinary makeup of our team served an integral role as we came together to brainstorm possible directions to take. According to each members background the team divided itself into smaller subgroups consisting of 3-5 members to research and develop more specialized areas of our project. Our subgroups were:

1. Planning/Design
2. Building Technologies
3. Building Systems
4. Construction Methods/Materials

The subgroups used a variety of ways to communicate and create an inclusive environment between all subgroups including IPRO's existing infrastructure (i.e. the igroups website). Each scheduled class meeting was organized around the agenda created by the *team leader* while in-class discussions were documented and archived by the *recorder/secretary*.

For the first part of the semester these meetings were dedicated to reporting found information and deciding what to do with the information. During this research phase of our design compiled all information gathered into a spreadsheet accessible to all members of the team. This was the main conduit through which knowledge and insight of the different disciplines was shared between the four subgroups.

As the semester progressed the class meetings became much more discussion based as we started to evaluate our findings. At this point each subgroup became a resource for the others; helping to inform their design decisions and choices. After the midterm review the meetings were used as an open forum where any member of the team could propose anything regarding any phase of the design. Each decision whether it be for unit layout or heating systems design was reviewed and critiqued by all members of the iPro team.

All work produced by this iPro was archived by its team members using the igroups website in such deliverables as the project plan, presentation slideshow, and final report.

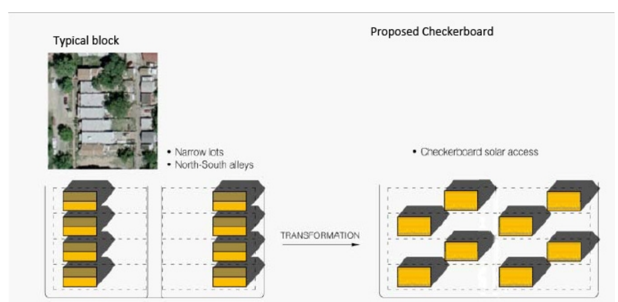
4. Analysis and Findings

The following are a few areas of research which our team felt were crucial to the development and understanding of our prototype community.

Passive Systems

One of if not the most important passive systems incorporated into our prototype is its site placement. It is vital because other passive systems rely heavily upon it. The primary goal is to provide the maximum solar gain for winter but also provide shading for summer months. Typical Chicago suburban homes are all placed at the front of narrow lots with small setback requirements. What this does is limit the structure to utilizing the short end walls for light and heat gain.

For our site we are using what is called the 'checkerboard' solar access plan. This staggers the placement of the structure on the lot. The first lot has the structure at the front setback line while the second lot has the structure at the rear setback line. This eliminates shadows from covering neighboring building facades.



Green Roof

For our prototypical home in our net zero energy community we chose to cover all remaining roof surfaces after the necessary space was allowed to mechanical systems with a green roof. We found many benefits in this decision over the average home. First is the green roof's ability to reduce the heating and cooling loads of our building. This is achieved through the additional R-Value a roof of this type provides. It also serves as a thermal mass and a means of evaporative cooling.

A second important benefit a green roof will provide to our design is its reduction is stormwater run off. The vegetation on the roof is able to capture and retain over 50% of the stormwater that falls on it. This means there is less water to store or move away from out structure as water sitting near a building is not good. Our use of a green roof saves over 8,600 gallons of water per year.

Our green roof with last longer then the average roof. Being a flat roof, our prototype requires extensive water proofing compared to the average roof that would shed water into a gutter system. Most typical flat roofs have a tar or rubber coating. This is especially bad if it is a dark color. In recent years buildings have started using white roofs as it will reflect the heat from the sun. A green roof is the best solution in reducing the extra heat a flat roof can create. This becomes important in areas of higher density, which our site planning calls for.

Hydrology/Landscape

We placed a grouping of four units, in two duplexes, situated on two typical Chicago suburban lots so they allow maximum flexibility. This is our 'module.' Depending on how much land is available, this module can be mirror and copied in a manner that consistently keeps the required spacing for our passive systems, but also further enhance the sense of community.

With our solution we eliminate the alley typically found in the center of the block. This allows us two very important features. The first is to create a central green corridor that connects all extents of the block. The second feature this allows us is to push back the rear setback currently required by most municipalities. By doing this we are able to properly separate our structures for maximum solar gain.

The extra green space gained from having a small footprint for our units, minimizing driveways, and removing the alley are used to enhance the community. There are shared features such as gardens where families can collectively grow their own vegetables, etc. There are also prairies or areas of natural vegetation that not only serve in reducing the amount of lawn needing maintained but also as an educational feature, showing what our land in this area was before construction occurred.

Other communal features include gathering space, a park for the communities and other communities' children and a centralized water feature that stores excess storm water and eliminates our communities' dependency on municipal storm water capture.

Finish/Cladding Material

For the exterior cladding of our prototypes we choose a new cladding material called EcoClad. EcoClad was chosen as the primary finish material for numerous reasons. Typical construction in the Chicagoland area is stick built with either a single wythe finish brick or some form of siding whether it be vinyl or wood. Our prototype is not using the typical stick framing system so it only seems fit to adjust our exterior cladding accordingly. The prototype uses SIP construction for the walls and roof. This is a structural system within itself so adding brick is unnecessary.

Our solution was to choose a cladding underneath which a water barrier will seal the house from possible moisture penetration. To match the concept of zero energy or sustainability EcoClad was chosen. EcoClad is comprised of a 50/50 blend of Forest Stewardship Council (FSC)-certified post-consumer recycled paper and wood fiber, as well as bamboo fiber, and bound together by a 100-percent water-based co-polymer resin, EcoClad is VOC- and benzene-free and can contribute to seven different credits within the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) building standards.

The EcoClad system of cladding also allows much flexibility in the appearance of our prototype. Its flexibility also makes it easy adaptable to both our prototype and carport system. EcoClad's versatile texture and design offers a modern yet timeless appearance. The product can be custom color-matched, but is also offered in 10 stock wood grains and five stock matte colors. There are 200 other wood grains that can be specified for large orders as well. EcoClad's color will not fade or lose consistency over time. The siding product is offered in 4'x 8' panels that can be cut into dimensions to suit any exterior cladding application. Custom 4'x12' panels can be specified for large orders.

Space Heating /Cooling and Domestic Hot Water System

The system chosen for the prototype townhouse is what is called a *Solar Combisystem*. This type of system provides space heating and domestic hot water from an array of solar thermal collectors and an auxiliary non-solar source(s); in this particular case, the auxiliary sources are a combination (forced-air/hydronic) ground source heat pump (GSHP) for heating and an instantaneous water heater for the domestic hot water. So, perhaps a more appropriate name for the system might be *Geo-Solar*

Combisystem.

Operation of System

The supplied municipal water held in a water tank(s) will be heated by a circulating hot mixture of water and glycol (antifreeze agent) that in turn was heated by the sun's energy collected by thermal collectors and/or by the GSHP. The transfer of energy is achieved through coiled tubes inside the tank(s). These are called heat exchangers.

Solar Thermal

The array of solar collectors are aluminum panels with copper tubes laid on their surfaces; the panels are covered by tempered glass allowing solar energy to heat the pipes and the fluid flowing through them; the underside of the panels are insulated to keep the heat from transferring to other surfaces. They are usually installed on the roof at an angle approximately equal to the location's latitude (about 42 degrees N Latitude for Chicagoland) to get maximum gain during cold months. When the sensors in the panels detect a set temperature (usually 60°F to 70°F), a controller allows the fluid mixture to circulate through the collectors and start the process of heating the water. However, what will happen during winter when there are significantly fewer hours of sun in addition to diminished solar intensity? What about cloudy or rainy days? This is when the other part of the combination system is employed.

The advantages of using solar-thermal are: It uses renewable energy, it doesn't use fossil fuels, thus reducing greenhouse gases; it expands building technologies and helps to inspire improvement or complete change of current processes in order to fully benefit from the energy used; provides financial savings since the energy used is not coming from the utility company.

The disadvantages are: The up front costs; excessive heating of water in the summer (which could be solved by using another method of heating the ground to be used as a source when necessary); overcast and rainy weather will interfere with the amount of solar energy collected from the sun.

Ground Source Heat Pump

Just like the solar thermal part of the system took advantage of solar energy, GSHPs take advantage of "energy" from the Earth by exploiting the constant temperature of about 50°F that exists below a certain depth. A heat pump is very similar to an air conditioner in that it pulls heat from the surrounding air or the ground to heat or cool a building. It uses a small amount of energy to function because of the high coefficient of performance (COP). A geothermal heat pump, as previously stated, uses the ground instead of the air as a heat source because the efficiency of such a device declines when the temperature difference between the heat source and the destination space increases. So, when the ambient air is cold, the COP drops dramatically, rendering the heat pump that utilizes air inefficient. That is why a GSHP is more efficient since the gap between the desired temperature and the temperature of the ground is smaller. There are two different methods of laying down the pipes that will carry the fluid used to extract the heat from the ground: One method bores holes vertically (usually 200 to 400 feet per ton of cooling capacity); the second method lays the pipes down horizontally (the depth is much less than the first method and is usually less expensive, but experiences seasonal temperature cycles). The heated fluid that comes back from the ground goes into the water tank(s) and provides additional heat when required.

This particular method was chosen because the prototype will utilize a radiant floor heating system that requires a lower water temperature in order to heat the house (this will be explained in more detail later on). A heat pump can also be reversed in order to cool a building. For this prototype, the heat pump being used is a dual heat pump. This means that it will also be used to cool the space using forced air.

The U.S. EPA has called the GSHP "…the most energy efficient, environmentally clear, and cost effective space conditioning system available."(See EPA 1993 Space conditioning: The Next Frontier – Report 430-R-93-004.EPA). As previously mentioned, the GSHP uses a small amount of energy that will be provided by photovoltaic solar panel system.

Unfortunately, the up front cost for this system is about 2 to 5 times the cost of a conventional system. However, the long-term maintenance costs are much lower, the system itself is cost effective, and there are currently tax credits offered homeowners for using this kind of system.

Instantaneous Water Heater

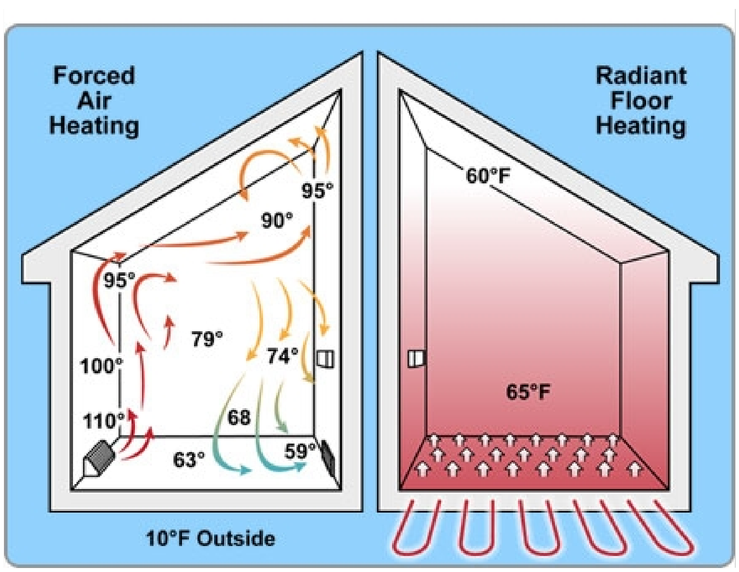
The domestic hot water requires higher temperatures (140 degrees) for use than the heating system. So, in order to boost the temperature of the water to the desired level, a tankless water heating system is the most efficient option since it only heats the water on demand. The energy savings come from the fact that the water at the inlet has been preheated (between 70 to 90 degrees) as opposed to water that is brought directly from the municipal supply at ambient temperature.

This small appliance uses electricity (which can be provided by the photovoltaic system).

Radiant Floors

Also known as a hydronic (uses water function) system, radiant flooring is a system that circulates hot water through a series of tubes which are on top of the subfloor in grooved panels or snap-in grids, clipped into aluminum strips on the underside of the floor, or embedded in poured concrete. The thermal energy that the water has is transferred by conduction to the flooring system, thus <u>evenly</u> heating the floor which in turn, heats the air via convection. The advantages of this system are: Lower energy consumption; it can be successfully coupled with the combisystem due to the lower operating temperatures; since the heat is rising from the floor (as opposed to the forced air system which would heat the upper part of the space leaving the floor cold), the temperature gradients are more even (as opposed to the gradients created by a forced air system). Other advantages include a silent heating system (no clanking, banging, or loud whooshing as with a furnace, baseboard hydronic system, or electric resistance heaters) and no unsightly (and often dangerous) equipment to hide. Additionally, the heating costs can be reduced by up to 40%.

Although the up front costs are high, they can be recuperated within 7 years, on average. If there are any maintenance issues, access is very difficult. There might be issues with some floor-covering options such as shag carpeting.



5. Conclusions and Recommendations

Over the course of the semester the team made great strides in the development of our prototype, the following are conclusions which we came to over our time working together.

- First and most importantly in order to create a truly sustainable result a comprehensive approach must be taken from the outset. The inclusion of all disciplines effected helps to more easily and quickly identify possible roadblocks or opportunities.

- Second, a thoughtfully planned unit layout should be the primary focus of the group before secondary systems are considered. Planning for local solar orientation, local climate, and local resources can reduce and in some cases eliminate secondary systems in order to provide a comfortable living environment. A well planned unit with carefully chosen technologies is a much more economical alternative than bandaging a poorly designed unit a myriad of 'green' elements.

- Third, economy of scale is an extremely important idea to consider when planning a more sustainable community. That is to say, great savings can be found if neighbors and neighborhoods share utilities and infrastructure. This savings can be seen from the perspective of the dweller as well as the city planner and construction company.

- Finally, our prototype is a well planned community which was produced to use as a catalyst to spark a change in the paradigm of modern and sustainable planning/building/living (not necessarily as plans that should or could be put in place today).

From developing our prototype recommendations for future iPro teams were formed. The Zero Energy Community idea is one that can be pursued in a number of ways, we of the iPro 323 team hope that future teams will use the prototype module that we developed and data we have collected as a starting point for their own solutions. Another avenue which our team believes would produce impactful solutions is introducing a commercial and retail aspect to the project. The focus of the next Zero Energy Community could consider all three zoning areas (residential, commercial, industrial) to take into consideration even more aspects of what defines a community.

Appendix

Team Roster

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Data Spreadsheet

Sunlight

Utility	Hours of Daylight	Sunny Days	Noon Sun Altitude	Energy/ sqft (unit?)	Information Source
January	10	*6*	30	*66.65*	
February	11	*7*	38.5	*78.07*	
March	12	*7*	49.5	*89.49*	
April	13	*7*	61	*100.91*	
May	15	*8*	70	*112.33*	
June	15	*8*	73.2	123.74	
July	15	*8*	70	*112.33*	
August	14	*7*	61	*100.91*	
September	12	*7*	49.5	*89.49*	
October	11	*7*	38.5	*78.07*	
November	10	*6*	30	*66.65*	
December	9	*6*	26.2	55.233	
TOTAL	147	84 Pure sun days		1073.873	
		320 days with some form of sun		*assume avg. change of 11.42 per month between givens: ((123.74-55.233) /6) = 11.42*	

Temperature

Utility	Avg. Temp.	Avg. Humidity			Information Source
January	32/18	78/69			Weather.com
February	38/24	78/67			
March	47/32	79/63			
April	59/42	77/57			
May	70/51	77/56			
June	80/61	79/57			
July	84/66	82/59			
August	83/65	86/60			
September	76/57	85/59			
October	64/46	81/58			
November	49/35	80/65			
December	37/24	80/71			
TOTAL		80/62			

Precipitation

		0.623	507	725	
Utility	Inches/ sqft	Gallons/ sqft	Roof	Green Roof	Information Source
January	2.17	1.35	684.45	978.75	Weather.com
February	1.77	1.1	557.7	797.5	
March	3.01	1.87	948.09	1355.75	
April	3.65	2.27	1150.89	1645.75	
May	3.7	2.31	1171.17	1674.75	
June	4.3	2.68	1358.76	1943	
July	3.68	2.29	1161.03	1660.25	
August	3.86	2.4	1216.8	1740	
September	3.21	2	1014	1450	
October	2.71	1.71	866.97	1239.75	
November	3.32	2.06	1044.42	1493.5	
December	2.63	1.66	841.62	1203.5	
TOTAL	38.01	23.7	12015.9	17182.5	
				8591.25	

Wind

Utility	Avg. Speed (mph)	Wind Direction (° from North)	Wind Prob. (%)	Avg. Air Temp. (c)	Information Source
January	11.6	270	89	-4	National Climate Data Center
February	11.4	315	81	-1	windfinder.com
March	11.8	112.5	70	4	
April	11.9	0	71	7	
May	10.5	90	65	15	
June	9.3	337.5	59	20	
July	8.4	0	39	22	
August	8.2	22.5	54	22	
September	8.9	180	59	21	
October	10.1	180	74	15	
November	11.1	180	80	5	
December	11	270	76	-3	
TOTAL	10.3				

Oak Park Demographics	
Statistic	**Number**
General	
Population	52,524 ppl
Families	12,970 families
Households	23,079 households
Population Density	11,173.4 ppl/sqmi
Housing Units	23,723 units
Housing Unit Density	5,046.6 units/sqmi
Average Household Size	2.26
Average Family Size	3.06
Age Breakdown:	
< 18	24.2%
18 - 24	6.7%
25 - 44	35.2%
45 - 65	24.4%
> 65	9.5%
Median Age	36
100 females to ___ males	86.9
Income	
Median Income/Household	$74,614
Median Income/Family	$103,840
Per Capita Income	$36,340
Household Breakdown:	
Children Under 18	29.5%
Married Couples	42.1%
Female w/o Husband	11.6%
Non-Families	43.8%
Individuals	37%
Individuals Over 65	8.6%
Ethnic Breakdown:	
Caucasian	68.78%
African-American	22.44%
Native-American	0.15%
Asian	4.15%
Pacific-Islander	0.03%
Hispanic/Latino	4.52%
2 or more races	2.82%
Other	1.63%

Source:
2000 Census

Prototype Home

Design Parameters

Floors/Ceiling	Square Feet	Structure	Finish		
Basement	323	Concrete	Concrete		
Crawl Space		Concrete	Concrete		
Slab-on-Grade		Concrete	Concrete		
First Floor	1232	SIP			
Second Floor	1232	SIP			
Third Floor	429	SIP			
Attic					
Roof	429	SIP			
Green Roof	196	SIP			
Balcony					
TOTALS	**3216**				

Walls	Linear Feet	Height	Square Feet	Structure	Finish
Exterior Wall				SIP	Plaster
Party Wall				SIP	
Interior Wall				Wood Stud	Plaster
Glazing	-	-	119	-	
Doors	-	-		-	
TOTALS	**7057**				

Glazing	*Btu/S.F./Hour	Square Feet	Total SF	Total Gain	
North Facade	305	170	1585	2060	
East Facade	1097	119	704	1920	
South Facade	601	535	1585	2721	
West Facade	1097	119	704	1920	
TOTALS				**8621**	
	*averages for clear summer day thru single pane of glass				

Average Home

Loads and Demands

Utility	Maximum Load	Yearly Total	Cost/ Unit	Yearly Cost	Information Source
Space Heating	N/A	3525 kWh	$0.138/kWh	$733	www.eia.doe.gov/emeu/recs/recs
Space Cooling	N/A	2796 kWh	$0.138/kWh	$275	www.eia.doe.gov/emeu/recs/recs
Water Heating	N/A	2552 kWh	$0.138/kWh	$407	www.eia.doe.gov/emeu/recs/recs
Electricity	920 kWh/month	11040 kWh	$0.138/kWh	$1523.5	
Water	90 gal/person/day	114975 gal	$0.00218/gal	$250.6	
Artificial Lighting	230 kWh/month	2760 kWh	$0.138/kWh	$380.4	
TOTALS				$3569.5	

Prototype Home

Loads and Demands

Utility	Maximum Load	Yearly Total	Cost/ Unit	Yearly Cost	Yearly Cost Savings	Information Source	
Space Heating	?Therms						
Space Cooling	?Tons						
Water Heating	?Therms						
Electricity	?KWH						
Water (potable)	?Gal						
Water (gray)	?Gal						use is optional
Artificial Lighting	?Lumens?						
TOTALS				0	0		

This is the definition of an average home for Oak Park

Energy Consumed

Utility	Appliance/ System	Natural Gas (Therms/year)	Natural Gas (Mbtu/year)	Electricity (KWH/year)	Water (Gal/year)	% Total Cost	Yearly Energy Cost	Yearly Cost (Utility Fees)	Cost of Appliance/ System	Appliance/ System Life	Cost/ Life Ratio	LEED Points	Information Source	Notes
Space Heating						0							www.eia.doe.gov/emeu/recs/recs	
	Main System	686	68.6	3525		30	$733							
	Secondary Equipment	15	1.5	503			$62							
Space Cooling						0								
	Condenser A/C	68	6.8	2796		11	$275							
Water Heating		263	26.3	2552		13	$407							
	Gas Tank							$360	$565	10 Years	$56.5/Year			
	Electric Tank							$485.76	$650	10 Years	$65/Year			
	Tankless Gas Heater							$252.96	$2000	20 Years	$100/Year	2		
	Tankless Electric Heater							$443.52	$1500	20 Years	$75/Year	2		
Lighting						0								
	Incandescent Bulbs			2760			$380.4							
Appliances						0								
	Washing Machine			228	5475		$31.5						http://www.aquacraft.com/Publications/re	
	Clothes Dryer			1076			$198.7							
	Refrigerator			1426			$308							
	Dish Washer			512	365		$16.6						http://www.aquacraft.com/Publications/re	
	Range			288			$39.7							
	Oven			300			$41.4							
Plumbing						0								
	Shower Head (6 GPM)				26280								http://www.energysavers.gov/your_home/wat	Assume 2.5 GPM, 1 showers/day/person 10 minute showers
	Toilet (6 GPF)				*24090*								*http://www.aquacraft.com/Publications/re*	*Assume 1.6 GPF, 5 flush/day/person*
	Sink (3.5)				*76650*									
	Outdoor Use				36500									
Cooking						0								
Computers						0								
TOTALS		**1032**	**103.2**	**15966**	**169360**	**54**	**$2493.3**	**$1542.24**	**$5015**			**4**		
	Rate ($/unit)	$0.00		$0.14	$0.00218									
	Sub-Total Cost	$0		$2,203	$369									

Prototype Home

the info in this section will be only the items we chose to use in the prototype home

this chart will display more efficient versions of existing utilities, such as 'Energy Star' appliances, and display the decrease in resource usage.

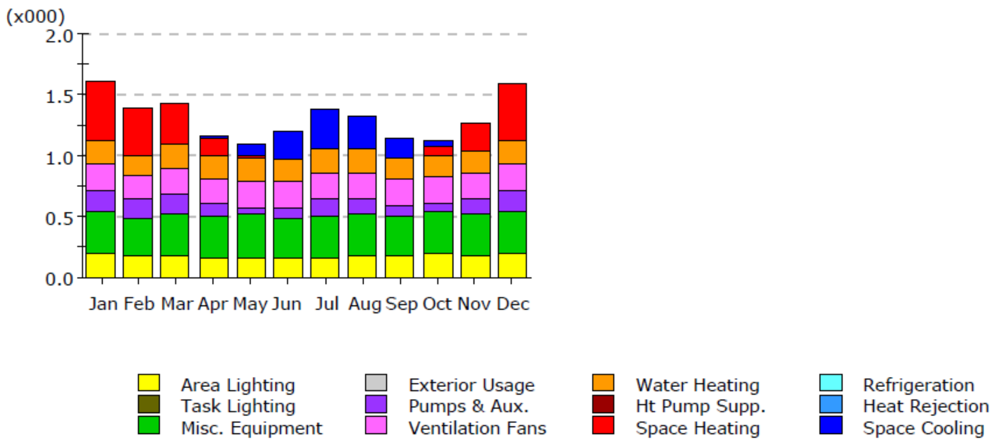
Energy Consumed

Utility	Appliance/ System	Natural Gas (Therms)		Electricity (KWH)	Water (Gal)	% Total Cost	Yearly Energy Cost		Yearly Energy Cost Savings	Cost of Appliance/ System	Payback Period	Appliance/ System Life	Cost/ Life Ratio	LEED Points	Information Source
Space Heating						0									
	Gas Furnace														
	Radiant Heat														
Space Cooling						0									
	Condenser A/C														
Water Heating															
	Gas Heater														
	Electric Heater			1856											
Lighting						0									
	LED														
Appliances						0									
	Washing Machine														
	Clothes Dryer														
	Refrigerator			450											
	Dish Washer			270											
	Range														
	Stove														
Plumbing						0									
	Shower				6570										
	Toilet				6424										
	Sink				32850										
Cooking						0									
Computers						0									
TOTALS		**0**		**2576**	**45844**		**0**		**0**	**0**				**0**	
	Rate	$/unit		0.14	0.00218										
	Sub-Total Cost			360.64	99.93992										

Energy Production	Increased Efficiency	Baseline (From "Average House") for Comparison			the info in this section will be any items we research	this chart will display active and passive systems and their effect on energy loads.		it should show all of our options, as opposed to the energy usage sheet which will only show our selected systems							
Utility	**Appliance/ System**	**Heating (Therms)**	**Cooling (Tons)**	**Heating (BTUs)**	**Electricity (KWH)**	**Water Potable (Gal)**	**Water Gray (Gal)**	**% Total Cost**	**Yearly Energy Cost Offset**	**Cost of Appliance/ System**	**Payback Period**	**Appliance/ System Life**	**Cost/ Life Ratio**	**LEED Points**	**Information Source**
Space Heating								0							
	Gas Furnace	.75 therms/hr		75000	0.8					1000-5000		25 yr			
	Dehumidifier								$20 yearly savings	319					
	Geothermal Heat Pump														
	Solar Hot Water														
	Green Roof														
	Insulation														
	Solar Orientation														
	Backup Heating														
Space Cooling								0							
	AC unit							$84 per year	9.5 energy ratio	889					
	Geothermal Heat Pump														
	Solar Hot Water														
	Green Roof														
	Insulation														
	Solar Orientation														
Water Heating															
	Solar Hot Water														
Lighting								0							
	Natural Daylighting														
	CFL				736				$30 savings		6 months				
	LED								75% less energy			12 years			
Appliances								0							
	Solar Electric														
	Acoustic Tile	NRC=1	CAC=25							$288/48 sq ft					
	38TXA A/C		2 to 5												
	Airtight Drywall														
	Bamboo Flooring														
	Washing Machine	front loader			142			$15 per year operating cost	141.6	999	savings from 10 year usage pays it off				energystar.gov
	Clothes Dryer		cuts drying time by 41%	cuts energy by 50%											
	Refrigerator	Maytag MTF2142EE[W]			$52/month savings			$61 per year operating cost	over $100 savings	750	2.5 years				
	Dish Washer				324			$35 per year operating cost	$40	1549					
	Range									2799					
	Stove														
Plumbing								0							
	Rainwater Collection														
	Gray Water Harvesting														
	Shower														
	Electricity				1441.508			$172.64							
	Natural Gas	77.3						$104.67							
	Toilet														
	Sink														
Cooking								0							
Computers								0							
TOTALS			0	75000	2644.308	0	0	$277.31	$181.6	7305				0	
	Rate	$/unit	$/unit	$/unit	$/unit	$/unit	$/unit								
	Sub-Total Cost														

Equest prototype vs. average home data

Electric Consumption (kWh)



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	0.01	0.08	0.22	0.33	0.27	0.17	0.06	0.01	-	1.15
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	0.49	0.39	0.33	0.15	0.03	0.00	-	-	0.00	0.06	0.23	0.47	2.15
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	0.19	0.17	0.19	0.19	0.19	0.19	0.19	0.19	0.18	0.19	0.18	0.19	2.25
Vent. Fans	0.22	0.20	0.22	0.21	0.22	0.21	0.22	0.22	0.21	0.22	0.21	0.22	2.55
Pumps & Aux.	0.18	0.16	0.16	0.10	0.06	0.09	0.14	0.13	0.08	0.07	0.13	0.18	1.48
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	0.34	0.31	0.34	0.33	0.34	0.33	0.34	0.34	0.33	0.34	0.33	0.34	4.01
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	0.19	0.17	0.18	0.17	0.17	0.16	0.16	0.17	0.17	0.19	0.18	0.19	2.11
Total	1.62	1.40	1.43	1.16	1.09	1.19	1.37	1.32	1.15	1.13	1.27	1.59	15.71

Gas Consumption (Btu)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool													
Heat Reject.													
Refrigeration													
Space Heat													
HP Supp.													
Hot Water													
Vent. Fans													
Pumps & Aux.													
Ext. Usage													
Misc. Equip.													
Task Lights													
Area Lights													
Total													