2009

GREEN BUILDING

IPRO 335

Final Report

Spring 2009

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1. Abstract

This project was an innovative design that involved the latest green technology in building systems. Students of IPRO 335/Green Building took on the task of designing an art studio that complied with Chicago building codes. The problem we are facing is the environmental unfriendly skyscrapers and large structures that eat up the world's energy and leave a large impact on the planet. By studying, learning, and getting comfortable with green solutions, designers of tomorrow can be more eager to use these ideas. The project was not given a limited budget. This gave an opportunity of more possible solutions. Restrictions came from codes and compliance of systems chosen for the project.

2. Background

This project of a green art studio targeted artists of the Chicago land area. The new construction contained art studio spaces and a gallery showroom both with prospect to be rented. Our project in general also reached out to any contractors or building engineers interested in the use of green technologies. In previous IPROs for green building, it was decided to renovate an existing building and to convert and add to the building's systems for green solutions. For example in spring 2008 students did a renovation on Alumni Hall that included an addition of a green roof and upgrading and converting the heating and cooling (HVAC) system.

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A large problem that the planet faces is the environmentally unkind impact of large structures. IPRO 335 deals with this concern by researching and implementing energy saving building systems. This technology is sometimes overseen as an extremity instead of a necessity. Green solutions are however becoming better known and widely used. For example, one of the main parts of this project was the geothermal system. Geothermal is a renewable energy source for the HVAC system. The technology is relatively simple and has actually been around for awhile. The project also called for the use of solar panels. Although solar panels are not a new technology, the uses of them are still predominantly seen on the west coast and are not seen to often in the Midwest. As technology advances the efficiency ratings have gone up considerably. This creates a quicker payoff for the equipment, making it a more usable design in the Midwest. To our knowledge the biggest problem with green solutions is educating the consumer. Although, green technology is becoming more widely known, the initial building cost is sometimes greater than expected. For some building owners and developers it is sometimes hard for them to find it in their budget to fit the environmentally friendly systems.

3. Objectives

Our team's objective for the semester was to design an energy efficient working building that will be marketed as an art studio. Our building site selected is a blank palate for a new construction. Being that in previous semester the green building IPRO has never dealt with a new construction, our team one hundred percent came up with our own course of action. The IPRO class broke its students into initial teams that covered the major bases of designing a new construction. The teams' main objective was to build an environmentally consciences structure according to the Leadership in Energy and Environmental Design (LEED) ratings.

The team worked thoroughly on the development of the project to produce a detailed design that could in fact be a marketable building to the public. The following criteria was considered and shaped the project:

Energy Saving Solutions for

- Ventilation system
- Plumbing

Low maintenance equipment and overall systems

Adequate space for artists to work

Sophisticated design to establish creative atmosphere

4. Team Structure and Assignments

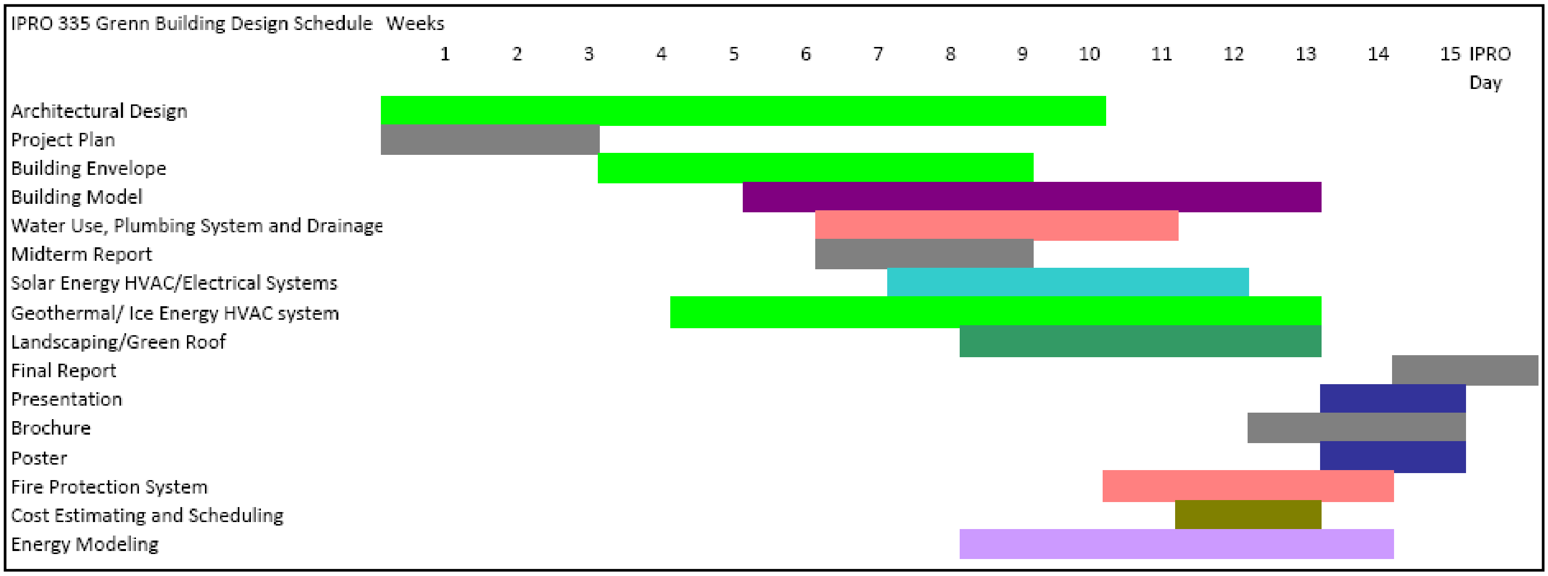
IPRO team split the members into the following groups:

1. Architectural Design
2. Building Materials
3. Plumbing Systems and Drainage
4. Solar Energy/Electrical Systems
5. Geothermal/HVAC System
6. Landscaping/Green Roof
7. Fire Protection
8. Cost Estimating & Scheduling
9. Energy Modeling

All team divisions stayed the same throughout the semester. However, certain projects leaked into other groups due to the common students within the different groups. The architectural design team and the building materials team had common team members so the groups somewhat converged into one group. The plumbing and fire protection had a lot to due with each other and also had common team members, so again the groups converged. Another example was the solar panel placement design was partially done by the building materials and architectural design team due to its great influence on the look of the façade.

5. Methodology

The Gantt chart below shows the actual schedule followed during the semester.



Significant changes to the schedule were made throughout the semester. Although the initial design was completed well within the first couple of weeks into the semester the Architectural Design group continued working well into the 10th week due to floor plan adjustments that need to be made for the building's systems. Other teams found it necessary to start ahead of schedule dates to allow for enough time for changes. The team roster further explains what each student's active part was within the project.

TEAM ROSTER

Antol, Marcin

- Team leader of Solar/Electrical Group
- Part of HVAC/Geothermal Group
- Researched case studies on building using geothermal technology
- Researched different solar panel technologies
- Created a presentation on two different solar technologies we can use:
  - Using Solar Wall PV/T
  - Using only the most efficient solar panels out today (we chose this one)
- Calculated the total power the building consumed
- Calculated how many solar panels we can fit on the south wall and roof, and how much power they would provide to the building
- Voluntarily logged classroom activities when necessary
- Did the receptacle layout for the building

- Wrote conclusion for the solar group
- Calculated the total cost of our final solar panel design

Balkany, Grahm

- Sketch floor plans
- Accepted Proposal for Building Massing
- Creation of the Digital 3-D Model
- Design of the North, West, and East Elevations
- Design Concept for South Elevation
- Wall Section Details for North and South Elevations
- "Sketch" Base Renders.
- Reviewed other aspects of the design, such as structural layout, elevations, and building floor plans, throughout the duration of the project.

Block, Shawn

- Development of plumbing
- Research on green plumbing technology
- Class presentation on existing plumbing systems
- Made poster diagrams for plumbing section

Campbell, Brittanie

- Scheduled meetings and delegated specific duties for green roof team
- Collaborated with the geothermal and solar panel groups to discuss spatial needs for the green roof and landscape designs.
- Researched the comfort zone section of the psychometric chart for Chicago in the years of 2005 -2009 in TMY data in order to determine whether natural ventilation is feasible for our project.
- Identified wattages of building equipment in order to determine the proper heating and cooling loads necessary for each room/space in the building.

Hart, Carl

- Preliminary consideration of natural ventilation, and HVAC design.
- Geothermal research
- Involved bringing in a sales representative to discuss geothermal systems.
- Review of:
  - The relevant literature and design guides regarding geothermal systems was conducted
  - Computational fluid dynamic (CFD) software was conducted in order to analyze possible natural ventilation strategies
- Designed for the third floor HVAC system complete with diffusers, equipment and sized ductwork.

Hodgson, Ashley

- Participated in the Architecture, Building Materials, and Landscape/Green roof groups.
- Active in the project and site selection, as well as the form that the building would take.
- Spent time researching different types of interesting businesses; chosen was an art studio and gallery
- Collaborated and developed plans and elevations along with a diagram of the southern façade and its materials.
- Helped delegate the research on different green materials and did extensive research on solar heating panels.
- Rendered a diagram of the façade and the roof plan and landscape, for easier understanding
- Did a lot of research in plant materials suitable for our climate, as well as a green roof.
- Determined where the main drainage pipes would fall.
- Helped to give the Midterm Presentation
- Also for the final, I submitted a flyer of information that would serve as an advertisement in lieu of a website
- Lastly, submitted information for the final paper as well as some slides for the PowerPoint.

Korbus, Tracy

- Complied beginning of semesters Project Plan
- Created the mid term presentation
- Collaborated and developed the Final Presentation
- Complied and wrote Final Report
- Designed brochure
- Assembled poster

Limpinyakul, Jutarop

- How geothermal systems work presentation
- How chilled beams work presentation
- Radiant floor research
- Indie Energy Chicago Case studies presentation
- Contacting Indie
- SolarWall PV/T research
- Stirling Engines for solar applications research

Lis, Tom

- Involved in the building materials group
- Assisted with building model
- Worked on group poster
- Participated in green roof design team

Llakmani, Anton

- Researched solar panel equipment
- Developed roof solar panel design
- Participated in architectural design

Macklin, Brandon

- Compilation of HVAC research and Information for our building type
- Geothermal Heat Pump Data/Research-manual files
- Compilation of loads for building type (Art Studio)
- Researched Outside Air/Ventilation Requirements
- Calculated Heating Loads for entire building
- Calculated Cooling Loads for entire building
- Design of HVAC Mechanical System
- Selected all equipment
- Geothermal Heat Pump Unit (based upon loads)
- Geothermal Heat Pumps (based upon loads)
- Layout of all ductwork/equipment
- Compilation of HVAC schedules

McGuire, Luke

- Completed a detailed energy model using a one-year, hourly simulation
- Assisted in determining the potential LEED credits the building would achieve

Modi, Nishant

- Illumination plan
- Researching the most energy efficient methods of lighting for commercial spaces.
- Assessing how many lumens were required in each space.
- Developed a table of what types of bulbs and how many of them were needed in each location.
- Exterior lighting and emergency exist lighting
- Calculated necessary amount of wattage for lighting
- Produced an illumination layout drawing and a written report
- Assisted with construction of the physical model.
- Produced several eye-catching renderings showing our building form and materiality.

Nguyen, Linh

- Contributed to the building materials groups
- Involved with the solar panel research and design
- Researched and developed green roof drainage system
- Retrieved roof drainage samples from JDR
- Contributed to completed final renderings

Nigamatzyanov, Tagir

- Organized class trip to Thermal Chicago
- Developed an initial project schedule
- Assisted in geothermal planning
- Cost estimated the job and compared results
- Involved with creating and giving final presentation

Palomo, Kaye

- Researched information on chilled beams
- Researched information on underfloor air distribution (UAD) system
- since we thought we might consider using it and also the Architects
- have expressed their opinion of not wanting a dropped ceiling and a
- plenum
- Researched a natural ventilation case study which was the Loyola
- University Information Commons here in Chicago
- Designed the HVAC system for the 2nd floor of the building (drew the
- mechanical layout and filled out the ventilation and equipment
- schedules)
- Drew a schematic drawing of a heating and cooling cycle on AutoCAD to illustrate how our system works

Ramey, Ronald

- Feasibility study for natural ventilation being a supplementary cooling system.
- Research into chilled beams as well as geothermal heat pumps responsible for the layout of the 4th floor.
- Involved in the design for diffuser selection, diffuser placement (dependent upon the throw and overlap), duct sizing based on the CFM and velocity requirements, picking and sizing heat pumps, and filling in the required schedules for the equipment and comparing the CFM provided in the system to the minimum required by code for the space type.
- Research on the holding tank for the rainwater system and sizing the tank for our site location.
- Helped in looking at low flow fixtures and figuring out which of the fixtures would work for the project.

Saracino, Anthony

- Heading up the Water/Fire Protection sections
  - Delegated group tasking
- Focus on the Solar Assisted Hot Water system
- Analysis upon the LEED® New Construction v 2.2 rating system (LEED® NC)
  - As a certified LEED®AP; graded proposed structure

Sochor, Daniel

- Assisted in the location of the site
- Developed the building's function and program
- Collaborated on the building's shape
- Did all major floor plan designs
- Developed Building Materials
- Presented all plan revisions to the architecture team and the class for review and suggestions for further development
- was a mid-term presenter
- Fielded most questions from the IPRO presentation reviewers
- Continued to review the impact of other teammates contributions to the plans
- Guided others as to what they should focus on for the poster Fielded many architectural questions as to what Helped to develop materials for all facades and collaborated with HVAC group to establish the energy efficient triple glaze window specifics.
- Recreated all floor plans for poster
- Coordinated with other groups for their poster plan representations
- Assisted with design of poster layout
- Cleaned up graphics for poster

Tan, Sophia

- Preliminary sun studies
- Revision of solar plans
- Envelope/skin research and group meetings
- South facade study
- Physical model

Williams, Jeremy

- Researched:
  - Engineering soils
  - How to make fire suppression systems "green"
- For green roof I looked into the different types, the various components, as well as some of the general benefits of green roofs.
- And for fire protection I looked at what designs have been used in the past and what the various options are and then I decided what techniques would make the most sense for our particular building.

6. Budget

The expenditures were not sufficiently large by any means. The greatest expense from the team was the educational trip to SpanCrete. There was an additional trip to a chilled beam distributor in downtown Chicago called Thermal Chicago. This trip however was very minimal in its cost that and there was no reimbursement necessary.

Semester Expenses		
Item		Cost
SpanCrete Visit		$706.20
Model		$ 50.00
	Budget Total	**$756.20**

SpanCrete - precast concrete manufacturing company in Waukesha, WI
Model- scaled model of proposed building

7. Code of Ethics

The overarching standard that guides the principle of this project would be professional codes. In the work of an engineer, it is primarily guided by professional codes and regulations. These codes are designed to protect inhabitants of the building, so it is very important and ethical to follow them.

Another important ethical factor that affects building design would be the surrounding community. It is essential to a building's preservation that it is located in a logical place. For instance you would not put an industrial warehouse next to a neighborhood park. Personal relations are another ethical issue that hurdles this project. Without proper communication between adjoined groups, progression is not as efficient and can hold up success of the project. Designers must always clearly communicate with one another and complete work in a timely manner.

8. Results

Geothermal

By use of the internet, HVAC system selection manuals (McQuay, Titus, etc.), it was discovered that geothermal heat pumps are an under-used technology, only because few people are aware of its potential. They may feel it is “too new” to determine whether or not it should be used. However, through its induction to this Green building design situation it yields positive results. Chilled Beam technology was sought after and researched by way of the internet, but because of potential problems such as condensation from beams causing spillage on equipment, people, etc, that idea was not implemented. By employing the geothermal heat pumps there is an achievement of less energy usage than a traditional VAV system. This energy usage amounted to a reduction of 30%. Through the process of selection and use of the system, there were no ethical, moral issues that occurred within the teams during investigation of selecting an appropriate HVAC system. Each team coordinated with each other to blend suitable designs. By executing that proficient organization of checks and balances, an accurate exhibit of building system integration was procured.

Solar Conclusion

The solar group in the green building design was in charge of determining a system that would produce sufficient energy through solar power for use in our building. We began by researching different solar panels and panel systems from different companies. We came across some new and innovative technologies like the Solarwall PV/T design which increased PV efficiency by providing it cooling. In conclusion, we chose to use the Sunpower 315 Solar Panels. We found these to be the most efficient panels that are commercially available. They have an efficiency of 19.3% and provide a peak power of 315 watts. The roof area was divided into three separate regions: one for solar panels, one for a solar water heater, and the last one for a green roof. We were able to fit 60 panels in the assigned space. This provided the building with a peak power of 18.9 kW. More panels were put on the south side wall of the building. With help from the architectural group, we were able to develop an innovative panel layout for our design, as seen on the south wall. The idea was to get them custom made into triangle shaped panels. Our design resulted in the custom shaped panels generating 31.58 KW of peak power giving the building a total peak power of 50.48 kW of solar power. Solar photovoltaic array capacity factors are usually under 25%. Therefore, a good estimate on how much average solar power the building receives is 20% x 50.48 kW = 10.1 kW. This amount was compared against amount the building would consume after developing lighting layout drawings. Throughout the semester, we became more familiar with solar technology and their systems. This is valuable knowledge as society pushes towards using sustainable technologies in everyday life.

Fire Protection

When designing a green building, the fire protection system is certainly not the first system that is considered in order to provide a more green building. Although there are many other systems that are focused on in order to green a building, the sprinkler system should not be overlooked in this area.

First, one should not use a suppression system containing ozone-depleting materials. The use of water, foam, and carbon dioxide are the most common ways to avoid these harmful materials (VanBuskirk para 5). Our system in particular will use water as the fire suppression method.

Second, some green buildings decide to use nonpotable stormwater reclamation for their fire suppression systems. This can be a useful way to reduce the amount of potable water used in a building. For our building in particular, we decided it would be best to not use stormwater for various reasons. One reason is that we will be using stormwater for other uses throughout our building, and therefore we prefer that it not be used by the fire suppression system. Also, the life of a sprinkler system using stormwater can be greatly reduced due to sediment build-up within the pipes as well as micro-biologically influenced corrosion. These problems can be fixed by using chemicals in the water supply, but this is not an environmentally friendly solution (VanBuskirk para 7).

Another option for the “greening” of fire suppression systems is the use of water mist systems (Mahlman para 19). Water mist systems use water in small droplets in order to put the fire out. The flames are cooled by the droplets heating and evaporating, oxygen is depleted by steam expansion, and surfaces are wetted in order to prevent the fire spreading (Xu 2). These systems require less water than the conventional fire suppression system. In our building, we decided to stay with a conventional sprinkler system. It seemed most logical to use a reliable and simple system because fire suppression systems are not used on a regular basis. The water is simply there in case of an emergency, in which case it is acceptable to use large amounts of water in order to suppress the fire more quickly and efficiently.

Green Roof & Landscaping

Research on Green Roof Design was implemented by certain team members. We compiled data about soil types, plants viable for use on green roof, drainage product solution, and a final composition and design of the Green Roof. The needs for Landscaping were determined and implemented into our design. The green roof design team collaborated well and in result came with an innovative solution for our design. The team members that participated were responsible and prompt with their deliverables. Overall, we exceedingly accomplished our goals with dedication.

General Conclusion

Our team is very pleased with the resulting product of our efforts and the work produced. The fact that the building is a coherent design, both conceptually and in execution is demonstrative of the fact that our team functioned well as a cohesive unit. Had it not, the building would appear much more to be an assemblage of parts and not a convincing whole. Overall, I think we all can be proud of our accomplishments, to have created a visually striking and very environmentally efficient structure that is still practical. It would certainly be among Chicago’s most noteworthy Green Buildings, were it constructed today.

9. Obstacles

The team had to discover the best possible solution for each mechanical design that would work well with the other buildings systems and would be the most cost effective. Along with the challenge of designing under the conditions of inexperienced individuals, there was the challenge of working with students of different majors. This particular batch of students has a conflicting outlook on the project due to the realistic opposing occupations. The main basis of the classes is made of architects and engineers. There is a common obstacle in real life projects between these specific groups. Hopefully the work that goes on in this project simulation will assist the dividing groups in better understanding one another on actual job sites. One way that our team over came these obstacles was the team divisions did not segregate the different major. Not all architects were on the architectural design and building materials groups. And not just the engineers picked up the building system teams. This gave the students an opportunity to work with new people and learn different traits.

Another obstacle the team dealt with was the time constraint of 15 weeks to design a complete building fit for proposal. Although the task is evidently not impossible, the resulting product in its design efforts is somewhat stifled. The allotted time would be sufficient, but another obstacle the students in this IPRO face is organizing everyone involved to put there required valued time into the project. So often there are a handle full of students that dedicate many of their hours to the project and many that dedicate the minimum time required to be undisturbed. By appointing team leaders to the individual groups this assisted with keeping the greater picture on schedule.

10. Recommendations

The project however might have been exceedingly more successful if there had been a tighter integration between the architectural groups and the engineering groups. The project took on a typical step-by-step approach, which is a proven method of accomplishing things within our field. However, mixing engineers and architects from the beginning is a very potent combination, and exciting buildings can and do result from time to time from this approach. I feel that most of the engineering groups took a “wait and see” approach to the building’s outcome, which is not the most effective way to capitalize on this kind of arrangement.

A possible solution to the time constraint mentioned earlier is challenging the students with more guidelines at the beginning. Time was spent deciding whether or not the class would rather renovate or start a new construction. If each class must begin with a new project, then it would be best to have 2 or three choices for the project/site to make the decision process more guided and democratic. It might also be worth exploring whether or not a “building” is necessary, the project could simply be a showcase of different technologies and strategies to keep the students current and focused on the field of sustainability and green technology

In future IPROs it is also recommended that the cost estimating group should bulked-up, to have the chance to examine the actual costs. This would compare beautifully with the energy analysis our group performed, and help to explain the cost-to-benefit ratio of green technologies as proposed in the project.

11. References

Mahlman, Ronald J. “Fire Protection/Life Safety in a Sustainable Design World”. <http://www.fpemag.com/articles/article.asp?i=314>.

VanBuskirk, Lisa E. “Can Fire Protection and Life Safety Lead to LEED points?” <http://www.iccsafe.org/news/green/pdf/0807BSJ31.pdf>.

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12. Acknowledgements

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