AC 2008-1366: WORKING WITH LOCAL DEVELOPERS IN AN ENERGY SYSTEMS DESIGN COURSE

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Working with Local Developers
in an Energy Systems Design Course

The Energy Systems Design Project Course: Goals and Objectives

The Energy Systems Design Project course is an elective course scheduled early in the undergraduate senior year. The course is also open to graduate students with additional course requirements. For the past several years, the course has consisted of a single 10-week project assigned to the entire class. The project is intended to be a comprehensive study. The course focus is unambiguously design. Analysis is used as a tool in the design process.

The course goals and objectives are provided in written form to the students at the beginning of the course. They consist of the following:

Goals:

1. To utilize the tools of thermodynamics, fluid mechanics, and heat transfer to create a conceptual energy systems design for an existing structure, or for a proposed structure or development
2. To generate a report that can be of value to developers, planners, or other interested parties.

The objective of the course is to give the students experience in the following areas:

1. Integrated application of the principles of thermodynamics, fluid mechanics, and heat transfer.
2. Development of a scope of work and timeline for a project.
3. Working as part of a team on a complex project.
4. Identifying and working within design criteria and constraints.
5. Written reporting, including creation of a single seamless document for the design team.
6. Oral reporting.

Green Development in the City of Milwaukee

Recent years have seen a growing interest in "green" development in the City of Milwaukee. Some of this interest has been truly grass-roots, and home-grown. It exists at the non-profit, government, and corporate levels. The current mayor of Milwaukee has made energy-efficient development in the city a priority.

Some examples of resources that are available in the Milwaukee area are described below. By building relationships with these groups, it has been possible to identify potential projects.

Growing Power

Growing Power is a local non-profit organization and land trust that promotes "sustainable food systems", including urban agriculture. Many of its projects are quite imaginative. Established by Will Allen, Growing Power provides hands-on training, demonstrations, outreach, and technical assistance to help people grow, process, market, and distribute food in a sustainable manner.

It also acts as a conduit for the flow of information between entrepreneurs and other interested parties. The energy specialty at MSOE has developed an ongoing collaboration with this organization.

Urban Ecology Center

Established in 1991, the Urban Ecology Center inspires people to understand and value nature through education and outreach. It is capable of providing resources for those in the community who wish to design or build in a sustainable way.

Menomonee Valley Partners

The Menomonee River Valley, comprising 1200 acres in total, is located adjacent to the downtown area of Milwaukee. In the last century, it was at the heart of the manufacturing base of the city. The central shops for the Milwaukee Road railroad were located here. With the loss of manufacturing from the city's economy over the last 20 years, much of the Valley reverted to brownfields. Planning for redevelopment of the area began in earnest about 12 years ago. The city promoted a comprehensive planning process, with involvement by the widest possible group of stakeholders. Menomonee Valley Partners was organized as a result.

Menomonee Valley Partners continues to be closely involved in the ongoing redevelopment efforts in the Valley.

Trolling for Projects: the "Ground-up" Approach

In seeking projects for this course, emphasis has been placed on finding those that are not yet far along in their development. Very often, engineering of the energy systems for these projects has occurred late in the project, when many decisions affecting energy use and waste streams have already been made.[1] Thus the energy engineer is constrained, and standard off-the-shelf technology is often the result. This does not provide a good experience for the students, who would like to explore possibilities unencumbered by prior decisions.

The best choice for a potential project is an open field, or a vacant building, a site that provides a blank slate upon which energy systems can be applied. These systems can then be optimized, and recommendations given to a developer before crucial decisions are made. There are challenges in this approach. With no detailed drawings available, and with building layout and use only loosely defined, it is not possible to produce a highly detailed analysis. Instead, the emphasis is on establishing trends in the use of energy systems, with enough flexibility so that the results can be adapted as plans develop further.

Contact with groups such as those listed above has proved to be key to finding projects that are both relevant to the community and timely.

Descriptions of projects covering three years of the course are provided in the Appendix. The scope of the project varied from year to year, but each one involved integrating a complex set of factors into a total energy design. The descriptions will give the reader a sense of the scale of each project.

Course Structure

The class size for each of the three years varied from 9 to 15. Contact time with the class (three hours per week) was spent in a variety of ways. The first week included details of the project assignment and a discussion on the best way to approach the problem. Subtopics were identified and students assigned to them. It was made clear to the students that the role of the instructor was to provide oversight and advice. The students would have primary responsibility for the smooth functioning of the team. A project timeline was created. The students then proceeded to the information-gathering phase, while the instructor used class time over the next several weeks to discuss various aspects of the design process: synthesis of ideas, criteria and constraints, the role of analysis in the design process, the identification and ranking of alternatives. In the middle section of the course, the students performed engineering analysis, including considerations of cost. Much of the class time later in the course was spent in facilitated coordination of the different working groups, and in developing a framework for evaluating alternative designs. This last task was particularly challenging because of the large scale of the project. For example, there might be four alternatives for lighting, but lighting might be only one of seven or eight different aspects of the design. A full matrix of possible designs numbered in the hundreds, and these needed to be organized in a meaningful fashion for evaluation. One method for doing this was grouping of alternatives with similar characteristics; for example, daylighting versus artificial lighting. The framework was actually created by the students in the classroom, with advice from the instructor. Class time was allotted for the students to debate their alternatives. This has proven to be one of the most interesting parts of the process. Once decisions were made, attention turned to the preparation of reports.

The students were required to maintain a log book for the duration of the project. This log book could be examined by the instructor at any time. Two interim written reports were required. At the conclusion of the project, an oral presentation was given, in which all of the students participated. Finally, after a short space of time for a final edit based on comments from the oral presentation, a final written report was submitted.

The students received both an individual and a team grade for the course. The individual grade was based on the student's performance within the team, as evaluated both by the instructor and by the student's peers. Peers twice submitted evaluations, with comments, of their fellow team members. The interim reports and the final written and oral reports were graded. The team grade was based on how well the design process was executed.

The graduate students fulfilled all of the requirements of the undergraduates. They were given additional responsibilities that varied by project and number of graduate students in the class (between two and four). The project descriptions in the Appendix provide details. Each graduate student was required to complete an oral examination at the conclusion of the course.

Assessment

The students have supplied a substantial amount of written feedback on the course. Some examples of positive feedback:

> "Really good to have a real world problem to work on. The fact that this is an actual project made it much more interesting and stressed the importance."
>
> "I learned more group skills. I learned how to compromise solutions." "If I ever buy a home or business, I'll definitely use these technologies."
>
> "Data mining was a huge learning experience."
>
> "Very relevant to current world energy situations. Improves student's ability of looking at the 'big picture'."

Students have expressed considerable pride at what they were able to accomplish in the short time available. One of the graduate students expressed to the author his interest in pursuing engineering management as a career following his experience with the course.

Some examples of negative feedback:

> "[Provide] clearer guidelines at the beginning of the course."
>
> "Class seemed to be made up as time went by. Little structure."
>
> "More guidance at the beginning would yield a better result."

The negative comments reflect perhaps the biggest challenge in a course of this type. A balance must be struck between the need for structure and the goal of an "open-ended" design experience. The author continues to work at refining this balance. In fact, it is often difficult to know where the design process will lead for a particular project. Since no two projects are the same, this balance must be reevaluated each year. An important lesson learned is that care must be taken to establish a realistic timeline for the project, and the students must be held fairly strictly to this timeline, through interim reports, for example. There is considerable risk that workload will pile up at the end of the quarter, particularly because the students do not have a good sense of what will ultimately be required to complete the work.

The participation of the developers has been crucial to the design experience for the students. In the first year, the Menomonee Valley Redevelopment, contact with the stakeholders was not emphasized, so that this resource was not used to full advantage. This oversight was corrected in the second and third years. In years two and three, the instructor solicited feedback from the developers at the conclusion of the course. Their evaluation of the project results was positive. The developers saw this exercise as an opportunity to obtain engineering expertise at no cost to them. In each case, critical aspects of the design were identified by the project teams. Because the developers are not engineers, these critical components had often not been identified.

For those in the community who are promoting sustainable development, these projects have provided the opportunity to broaden awareness of their efforts. For example, project summaries have been posted on the website of Growing Power.

Conclusion

It is certainly possible to replicate this type of project in other communities. It is necessary to establish relationships with the groups in the community that monitor development projects. Patience is also required. If a project is chosen months in advance of the course, the results cannot be presented in a timely manner. The KK River Village project (detailed in the Appendix) was identified four days before the start of the course. The reward for waiting until the last minute is a project that is of most value to the stakeholders.

References

1. Confidential conversation with a LEED certified engineer employed by a mechanical contractor, September, 2007.

Appendix

The Projects:

2004 ---- Menomonee Valley Redevelopment

In the first year of this course model, the design class considered the redevelopment of the Menomonee River Valley. At the time, little of the vacant land had been developed. A tentative site map was in hand, but no streets or utilities had been installed. The layout of the site differed markedly from east to west sides, and so the project team was divided geographically. The east side was partially developed, with a checkerboard of vacant parcels. The west side was almost entirely vacant. Soil contamination was a significant issue. The developers made the decision to cap the contaminated soil and raise the ground level by several feet using fill.

The design team looked at both supply and demand for resources, including electrical, thermal, water and waste systems. Valley-wide recommendations included a central cogeneration plant for the West Side, storm water retention, and "station cars". Because it was not known what buildings would ultimately appear on the various parcels, the team generated recommendations that could be used to guide the systems to be chosen for the buildings, including such features as green roofs. The developers of the overall project had little control over the actual decisions to be made by the building owners, so economic justification of the recommendations was considered to be key.

As of this writing, the cogeneration plant was not included in the final development, but storm water retention and natural filtration have been implemented. The "station car" concept may still be implemented as more of the space is developed.

The additional role assigned to the two graduate students in this project was to act as liaisons between the east and west side working groups, to ensure that a consistent methodology was being used, and that the recommendations from the two working groups were compatible.

2006 ---- The Urban Fish Farm

In this project a local developer with experience in outdoor fish farming in Central America proposed building an indoor fish farm in an abandoned warehouse in the city. It was hoped that the fish farm could be self-sufficient from the local sale of mature fish. The project was also imagined as an educational tool for inner city residents, as well as an employer in the central city. The developer did not have formal engineering training. A site had not yet been identified, so one existing building that was being considered as a possible location for the fish farm was chosen as the project site.

The model for this facility was a small demonstration fish farm with aquaponics operated by Growing Power on the northwest side of the city. The specific objective for this project was to identify energy use, input and output streams (food, water, waste, and the like), and to cost out the energy usage for the proposed facility. In this way the developer would get a good picture of critical aspects of the design from an energy standpoint.

The design class was divided into working groups. Each working group considered one or several aspects of energy usage for the proposed facility. It was discovered early in the project that it would be necessary to understand the biology of the fish and the water, because this was going to be a factor in the energy design. Fortunately, one of the student team members had a background and an interest in looking at this aspect of the project, so this became his task. Perhaps the most important result of the analysis that was done was the critical role that lighting would play in the viability of the project, specifically for the growing of plants. Because the developers wish to utilize an existing building in the city, there is little opportunity to design for natural lighting. The analysis results showed the potentially high energy cost for providing artificial lighting.

In addition to their duties as part of the team, the graduate students were responsible for creating a template for economic analysis for energy use for the project. The template that was created is interactive, so that design parameters for the fish farm can be changed, and their effects on the energy economics evaluated.

At the conclusion of the project, a one hour oral presentation was made to the developers and interested faculty members. A copy of the final written report, along with the economic model, was provided to the developers, who are using it in their efforts to raise capital for the project.

2007 ---- KK River Village

KK River Village is a planned residential development on the near South Side of the city. It is conceived as a “green” development. The developer is already in possession of 6 ½ acres, with an additional two acres in negotiation. The site has been light manufacturing, and soil contamination is not a serious issue. The current plan is for about 60 single or two-family structures, and one apartment building. The developer will be constructing all of the units, and then selling them. In this way, the developer is in control of design decisions for the units. Part of the site is currently vacant, and part is still occupied, with leases running out to 2010. The site will be developed in stages, with groundbreaking anticipated for summer of 2008. The site plan, including roads, alleys, and location of utilities, had not yet been finalized at the time that the study was carried out.

The design team was asked to carry out a comprehensive study of all resource and waste streams for the development, and to recommend systems that would provide optimum resource utilization with minimum waste streams, within realistic cost constraints. The design team stayed in touch with the developer during the project, to ensure that constraints and criteria were being applied appropriately.

The design team was divided into four working groups: agricultural, waste streams, HVAC/water, and electrical/lighting. The project report contains 15 separate recommendations.

Because of the large scope of this project, and the total number of students in the course, the additional role assigned to the four graduate students was to provide overall project management, facilitating information flows between working groups, and assuring a coherent result.

At the conclusion of the project, a one hour oral presentation was given to the developer, faculty members, and other interested parties. The presentation summarized the recommendations and provided justification for the decisions made by the design team.