Chattanooga SMART Park

Education of Graduate Students Through the Use of Real World Projects

Philip D. Kazemersky[1] / Katherine H. Winters[2]

Abstract

Chattanooga, Tennessee is developing an eco-industrial park, SMART Park, based on sustainable development principles. This paper discusses the use of this project as a teaching tool giving real world experience to its graduate students. This paper also discusses the research and grant opportunities provided by a project of this nature. The paper, furthermore, discusses the use of computer based technology in the daily activities of the project.

Introduction

At the University of Tennessee at Chattanooga, UTC, a Master of Science in Engineering Management is offered to potential students with a background in engineering or science that have or expect to have managerial responsibilities. "There is focus on strategy, technology issues, human resources, products and services, quality control and reliability, engineering economics, product design and development, cost analysis and other management issues. Also there is emphasis on decision making, integration of management and engineering sciences, and communications." (UTC, 1997) There are four focus areas required of all students which include quantitative, human, economic and financial, and planning and operating. In addition a capstone project requiring comprehensive analysis is required for graduation. The capstone project consists of a written report and an oral defense. The University is always looking for opportunities to integrate real world problems and projects into the context of their curriculum.

The University is located in the downtown area of Chattanooga, Tennessee and has close ties with the community. Chattanooga is in the process of redefining itself and has partnered with private businesses, community leaders, and the citizens to revitalize its downtown based on sustainable development principles. A 640-acre area located in the city's southside is the current focus of the revitalization effort. The University is located on the fringes of this area and has a strong desire to see the redevelopment succeed.

One project resulting from that redevelopment is an eco-industrial park called SMART Park™ for Sustainable Manufacturing, Agricultural, and Recycling Technology. This project is just completing its phase one feasibility study. The SMART Park project is somewhat unique in its organizational structure and its funding. The Chattanooga Institute for

---

[1] University of Tennessee at Chattanooga
2 University of Tennessee at Chattanooga

Sustainable Development along with 20 industries provided the project. A multi-disciplinary team was formed composed of The University of Tennessee at Chattanooga, Team Associates, Hitec, the Tennessee Valley Authority and Cornell University. This team conducted the study and its conclusions were reviewed by a national peer review group composed of leaders in the area of sustainable development.
The lead on the project is Team Associates who holds the trademark for both SMART Park and CMERF. HITEC, Inc., a local Chattanooga company, provided the technical leadership of the project particularly in the areas of heating and cooling. The University of Tennessee at Chattanooga through the College of Engineering and Computer Science provided technical expertise in the areas of resource optimization and data collection, presentation and management. The college believes the SMART Park project provides an excellent opportunity for students to gain experience with a real project. Cornell University provided expertise in operational and community involvement issues.

Sustainable development is one of the concepts in the environmental movement that holds the greatest promise for overall acceptance. By definition it provides an approach to implementation. Sustainable development is "doing things right today so that in the future our kids will have at least as good as it is right now." (Vasilash,1994) For a project to be sustainable it must improve economic efficiency, protect and restore ecological systems, and enhance the well being of all peoples. The concepts of the SMART Park project seem to be a natural way of applying those sustainable development principles and revitalizing the area.

The concept of SMART Park is an innovative model designed to integrate the inflows and outflows of energy, water and waste streams for multiple businesses in a sustainable and synergistic manner. It focuses on improving the collaboration of business practices among companies, communities, and organizations to achieve more efficient operations and systematic approaches for identifying cost reduction, pollution prevention, and new product development opportunities. One of the unique and consolidating features of the park would be a Central Material and Energy Recovery Facility or CMERF TM and a series of underground utility tunnels to link the CMERF with the participating businesses. The central energy facility would provide an economic supply of district heating, cooling, and service water to the area. The entire CMERF facility would consist of a municipal solid waste sorting facility and gas and/or fiber fueled furnaces for energy generation. Also proposed to be a part of the facility would be an ethanol plant.

A phase one feasibility study was just completed for the project. It consisted of several activities: project management, existing business assessment, new business assessment, CMERF and ethanol evaluation, social and operational considerations and future plans. The University and its graduate students planed a role in all phases of the project but concentrated their involvement in the existing business assessment, new business assessment, CMERF and ethanol evaluation activities. Cornell University took the lead in the social and operational considerations. The Cornell activities will be discussed but the major interest will lie in the activities in which UTC was directly involved. The rest of this paper will concentrate on UTC's participation in the project and its potential for future research and grant projects.

Project Discussion

Existing Business Assessment

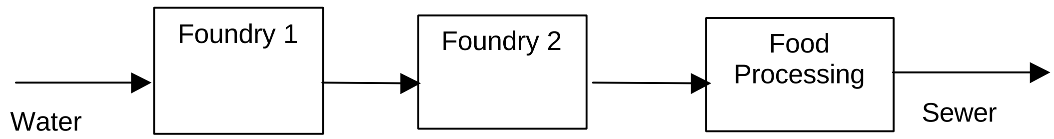
The assessment of existing businesses concentrated on what if any integration could occur. The companies participating in the study were surveyed for information detailing raw material input, waste disposal use patterns, and operating patterns. The technical data received through these surveys along with follow up site visits provided the foundation for the existing business assessment. This phase of the project provided an excellent opportunity for the graduate students to interface with the community and gain real world experience in acquiring information from companies. The students participate in the data gathering and subsequent follow-up site visits. After the initial attempts at gaining the information did not prove successful, the students were involved in the evaluation and redesign of the surveying instrument.

Several conclusions were reached as a result of a review of the data collected from the existing businesses. Most of the solid wastes are discarded into receptacles for collection as municipal solid waste (MSW). The existing manufacturing and processing industries in the southside area recycle that waste resulting from their production processes. The only substantial non-product output generated was wood primarily in the form of wooden pallets, shoring and shipping supports, cardboard boxes, assorted paper wastes, and industrial sand. The quantity of wood and paper was one and 1.3 tons respectively. There appeared to be limited opportunity for sharing among the existing businesses. The survey data did indicate there were opportunities to exchange waste process water and waste process heat.

Industrial Economics, Inc. developed for the Environmental Protection Agency a group of decision-making tools designed to aid an eco-industrial park planner in making efficient structured decisions. One of the tools, Designing Industrial Ecosystems Tool (DIET) is a computer program that includes a linear programming optimization model. It was designed to aid decision-makers and planners in finding matches for economic and environmental consideration. Among other things this program assesses environmental and economic benefit/costs of a facility locating at the park versus locating outside the park and provides an estimate of eco-efficiency from co-location of facilities. The students were given the assignment to assess the effectiveness of using this tool in the decision–making process. In areas where the model did not meet the needs of the project students were required to either find innovative solutions to the problems incurred or write optimization models that solved the problems. Simultaneously analytical calculations were being performed to provide validity to the results of the tools.

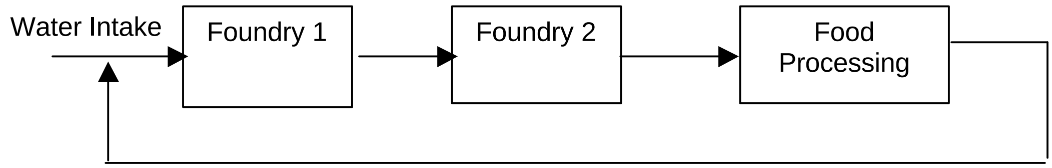
As stated earlier, there appeared to be limited opportunity for process waste material sharing among the existing businesses. The survey data did indicate there were opportunities to exchange waste process water and waste process heat. These exchanges offered an opportunity for substantial savings to the current businesses. Follow up discussions with officials of three primary employers in the southside further confirmed the exchange of these two waste streams to be technically and economically feasible.

Three scenarios for water sharing were developed. The first scenario involved connecting the two foundries with the food processing plant. This scenario took advantage of some of the foundry thermal energy in the food processing plant and took advantage of reducing some of the water being purchased and the amount of water now being discharged in to the city's sewer system. This scenario represented connecting the three facilities together in what is basically a once through system as seen below.



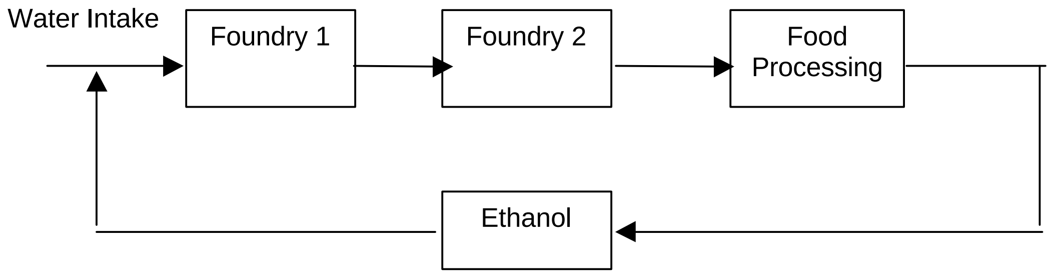
Scenario 1

The second scenario also involved connecting the two foundries and the food processing plant. This scenario tool advantage of some of the foundry thermal energy in the food processing plant, and took advantage of reducing some of the water being purchased as well. This scenario represented connecting the three facilities together in what is basically a closed loop system for a major portion of their water use.



Scenario 2

The third scenario involved connecting the two foundries and the food processing plant but added a connection to the ethanol plant. This scenario took advantage of some of the foundry thermal energy in the food processing plant, and took advantage of reducing some of the water being purchased as well. Advantage was also taken for using the food processing scald water into the acid dilution step in the ethanol plant. This scenario represented connecting the four facilities together in what is basically a closed loop system for a major portion of their water use.



Scenario 3

Due to the sensitive nature of the final financial results, exacting costs savings can not be reported. However, scenario two provided the best savings opportunities in the $1 million range, annually.

Both the DIET program and analytical calculations were used for this analysis. With a great deal of manipulation of the input parameters of DIET, similar results were reported by both methods. For DIET to be an effective tool, substantial work needs to be done to accommodate water-cascading, thermal dynamic calculations piping distance calculations and other technical considerations. An excellent aid would be the use of Geographic Information System technology to assist in the piping routing and distance calculations. All of the additional work to DIET that is needed provides both graduate level projects and study opportunities as well as opportunities to acquire grants to develop a tool to be used for eco-industrial parks in general.

New Business Assessment

Two goals of sustainable development projects such as SMART Park are job creation and waste reduction. These two goals should have provided the initial criteria for the incorporation of new businesses into the park. As noted earlier in this paper, the existing businesses had little waste and by-products that were not otherwise being sold or recycled, therefore, waste reduction had little to contribute in terms of assessing new business. The second criteria, new job creation, to be most effective to the surrounding community, had to match job requirements with skill and education levels of the community. This is was a very impoverished area and the skill and education of the inhabitants required the creation of low skill jobs. However, one of the prime criteria was the ability to take advantage of the opportunity to exchange water and energy.

Another component of the tool set developed by Industrial Economics, Inc. was the FAST, (Facility Synergy Tool), model. It was " a decision support tool created to aid planners, communities, and facility personnel in identifying potential materials exchanges, energy trading, and purchasing coordination opportunities among industrial and non-industrial facilities." (Industrial Economics, 1998) This model was evaluated for its effectiveness in providing the necessary information and facility optimization for this project. As with the DIET model, the student performed an evaluation of the effectiveness of the model. Results of the model were assessed in relation to information gained through research.

The FAST model was used, as a starting point, to identify new industries to incorporate in the industrial park that would provide the maximum benefits and synergy to the industrial park. FAST matches inflows, outflows, and waste streams from existing industries with those from an included database to provide matches for waste exchanges. Like the DIET model, FAST does not include matches based on water process waste streams nor does it consider energy savings for matching purposes. The information provided by the existing industries on the initial surveys served as the input to the model. In this case, input from all of the responding companies regardless of their size was used as input. There were no matches found for the use of the foundry sand. Two types of industries were identified as being suitable for inclusion into the park, a commercial fish farm and a greenhouse. These two industries also were good fits in terms of the City's plans for the area. One of the advantages of these two businesses would be to provide fresh fish and vegetables to the restaurants in the area. One of the abandoned buildings in the area is of historical significance. This site was identified as a possibility of a location of a museum concentrating on the history of industry and power in Chattanooga. The city already has office buildings, a trade center expansion, and a new hotel in the planning stages. These are slated to be located in the southside.

The FAST model proved to be a useful tool. It does have some shortcomings however. There simply are not enough industries listed in the database. As this tool is put into use in more planning activities the plans are to incorporate the information in terms of inflows, outflows, and waste stream. This additional information will come from existing industries that are included in the decision making. Again this work provides opportunities for the graduate students.

CMERF and Ethanol Evaluation

One of the strong points in favor of establishing the SMART Park was the potential to locate a central group of facilities that supported energy and water as their core functions. Initially, the thought was to locate a MSW – to – ethanol conversion plant as a source of clean fuel. The ethanol from this facility could be used as fuel for the city's bus fleet and as a commercial product. One of the by-products of the ethanol process is residual cellulose (mainly lignin) that would serve as fuel for a fluidized bed furnace to produce steam. A portion of the steam was needed in the ethanol plant process and the remainder would then be available for other customers requiring steam or hot water.

The CMERF would consist of one or more FBF boilers fueled by fibrous material derived from a MSW classification system. The CMERF would form the core of a central Southside heating and cooling system as well as being able to produce steam and hot water for expansion of existing industry and /or new industry. An underground utility distribution tunnel system would form the backbone of the distribution to the southside occupants. In order to analyze the feasibility of this addition to the SMART Park, it was necessary to establish several sets of technical and economic data for the financial analysis. It was decided to express the financial aspects of this phase as customer avoided costs. That is to say, if the customer chose to be served by the CMERF what costs would not have to be incurred by the customer.

The first step in this process was to measure the heating and cooling load under consideration. Based on discussion with officials of the existing companies, local governments, and drawing on the collective expertise of the feasibility study team, a project customer growth was established. It was estimated that the equivalent heating and cooling square feet for year one would be 480,000, year two 940,000, year three 1,360,000 and year four 1,490,000.

Steam loads required to meet the heating and cooling needs for the project additional square feet were also calculated. Based on the estimated customer cooling and heating loads, the CMERF needed a 2,000 ton chiller with its associated pumping system for delivering chilled water and a 400 gallon per minute pumping system for delivering heated water. These system loads depend heavily on the configurations employed. Four different options were developed each with a slightly different configuration of the components. The following table shows these four options and the components of each.

CMERF Configuration Options

	Option 1	Option 2	Option 3	Option 4
Steam Driven Chillers	No	Yes	Yes	Yes
Steam Driven Pumps	No	No	No	No
Natural Gas Boilers (pph)	3 – 50,000	1 – 50,000	1 – 50,000	1 – 50,000
Fiber Fuel Furnace (pph)	No	1 – 150,000	1 – 150,000	1 – 150,000
Ethanol Plant	No	No	Yes	Yes
MSW System – capacity (tons)	No	No	500	1000

pph – pounds per hour

The next step in the process was to make estimates of the costs that the customer would have to bear to include the energy equipment and systems during the construction of the building or facility. There are some inherent assumptions in these costs. It is assumed that each building will cost $100 per square foot for construction, which include land purchase and site preparation. It was assumed that the cost of the cooling and heating equipment would equate to 4 and 3 percent respectively of the facility costs. The cooling load was assumed to occur for 8 months of the year and heating for the remaining 4 months.

An abandoned building located in the southside area was selected as the location of the CMERF. This location would considerably reduce the construction costs associated with the project as well as make use of and abandoned site. The CMERF's location needed to be considered carefully because of its potential impact to the neighborhood. Several aspects of the project have the potential to cause concern among local community stakeholders and need further analysis. These include the combustion of fuels, truck traffic, especially if MSW becomes a source of fuel, smell and noise, air quality, and proximity to Tennessee River. A CMERF will likely benefit the surrounding community if it can demonstrate that there are tangible environmental advantages for the project. Local employment generation that provides good jobs for area residents can be an additional inducement for community support. A commitment up front to positive involvement with the community and a clear avenue for communication of concerns will help create a positive framework for community support.

EDUCATIONAL OPPORTUNITIES AND INTEGRATION INTO THE UTC ENGINEERING GRADUATE PROGRAMS

At the University of Tennessee of Chattanooga, the college of Engineering and Computer Science views Engineering Management as the integration of the technical, economic, human, and planning factors affecting any engineering or technical project. Using this point of view, the SMART Park project provides an excellent example of such integration. Each of these core focus areas of engineering management is present and evidenced in one project providing an excellent teaching opportunity.

The technical arena provides an opportunity to expand and development practical applications of engineering through teaching the concepts of energy and mass balance as evidenced in the different scenarios associated with the use of water as a material of exchange. These scenarios provide addition opportunity for the use of thermodynamics as the transportation of water and its associated energy losses are explored. Pumping costs, heat loss, pipe sizing, as well as environmental and ecological considerations are necessary parts of the technical analyses necessary for this project and thus provide an large area of teaching and research opportunities. Computer related issues could also effectively be taught using SMART Park. Consideration of issues such as data management, data base development, optimizing techniques, and decision making tools are a part of the technical analysis arena.

The economic analyses associated with SMART Park provide the same kind of opportunities to study the economic factor of engineering management. Students are given the opportunity to assess the effects of different facility configurations, capitalization, and operational scenarios and their affect on the project outcome.

The planning factor is inherent in the project. Proper planning is such an essential portion of the project that poor or ineffective planning can be responsible for the failure of the project. Good project management skills can be demonstrated as well as taught using the SMART Part project.

One frequently overlooked area of engineering management is the human factors. This is an area engineers call the “fuzzy” area. There are not often clear cut or clean answers when dealing with human factors. The answers can not be calculated and are frequently gray, not black and white. This gives engineers problems. The teaching of these concepts is difficult but can be greatly enhanced with hands on experiences. This project provides that opportunity. Not only can the student study organizational issues, but also teamwork between all participants can be observed. SMART Park provides an opportunity to put textbook concepts into practice. This is a wonderful opportunity for the University and the college.

One of the classes required by all Engineering Management graduate students at the University of Tennessee at Chattanooga is optimization. The faculty teaching this course is proposing to center the entire course on the SMART Park project and optimization decisions needing to be made. This change is cirrocumuli will be made in the fall of 1998. This will provide a concrete and visible way of teaching optimization based upon a viable and current project.

Similar projects to SMART Park can be assimilated into the graduate program of any university. There are three basic approaches that can be taken. The first method is using the concurrent engineering approach. This is recommended because of its use by industry. Using this method a multi-discipline team of students would be formed to work on the project. Students would work on the aspects of the project within their area of study and meet with the team to discuss issues, determine progress, and assist one another as necessary. A second approach would be to separate the project along discipline lines and students would work only on the parts of the project within their disciple. A third approach follows the Problem Based Learning concept. Each student would examine the entire project or a discipline subset of the project and determine the area in which their knowledge needed to be enriched. The students would learn some fundamentals in the unknown area. These three approaches can be applied to any large multi-disciple project based on the instructor's objectives. Using any of the approaches project similar to SMART Park give students the opportunity to be exposed to the wide area of issues facing engineers and other technical employees in real world projects.

Acknowledgements

The authors would like to thank and acknowledge Team Associates, Inc. for allowing The University of Tennessee to participate in such a program. Team Associates is the prime contractor for the project. Team Associates also hold the copyright for the two terms, SMART Park and CMERF. Specifically, the authors would like to acknowledge Ken Aupperly of Team Associates for his project management of the entire project. The authors would also like to acknowledge HITEC and Mike High specifically as the technical lead on the project. Lastly the authors would like to acknowledge the Chattanooga Institute as the facilitator of the project.

References

Industrial Economics (1998) *Tools for Eco-Industrial Park Planning: Manual*, Industrial Economics, Inc., Cambridge, Massachusetts.

UTC (1997), *The University of Tennessee at Chattanooga Graduate Catalog*, The University of Tennessee at Chattanooga, Chattanooga, Tennessee.

Vasilash, Gary S. (1994) "The Environment at Saturn", *Production*, Saturn Corporation.

Philip D. Kazemersky

Associate professor of engineering, Acting Director Engineering management, Manufacturing and Industrial Engineering, and director of the Cranston B. Pearce Center for applied Engineering at the University of Tennessee at Chattanooga. He received his Ph.D. and MS at the Ohio State University and BS at the Worcester Polytechnic Institute. He has conducted research on technology application, assessment, and implementation. He has 18 years experience in the electric power industry and its related research projects. Dr. Kazemersky can be reached at: phone (423) or email Phil-Kazemersky@utc.edu.

Katherine H. Winters

Received her BS in Computer Science and MS in Engineering Management from the University of Tennessee at Chattanooga. She has 20 years experience in the electric power industry providing various engineering and data management services primarily in the environmental area. Ms. Winters was a part of the SMART Park project team working in the optimization and database development areas of the project. Ms. Winters can be reached at: phone (423) 842-3969 or email KWINT0319@aol.com.