Building Operational Efficiency Project

Fall 2015
ENGR333a
Calvin College
Prof. Heun

Last year, Calvin College spent $3,151,413.57 on utilities [energy (90%) and water (10%)], not including the seminary or off-campus properties. Most of those costs arise from building operations. Heating, cooling, and lighting are among the chief causes of building operations costs. With today's financial challenges, it is imperative to reduce these costs.

In the 2014-15 academic year, Cenergistic (http://www.cenergistic.com) offered Calvin College a deal: "we'll save $600,000 in energy and operations costs; you pay us $300,000." Calvin College turned down the offer in favor of internal efforts to save money through changes in its operations, including buildings. In fact, progress in the area of building operational efficiency is one of the performance metrics with which Physical Plant will be evaluated during the 2015-16 academic year.

Calvin College is not the only campus trying to save money through operational changes. As far back as 2003's *The Energy Smart Guide to Campus Cost Savings* (http://www.nrel.gov/docs/fy03osti/34291.pdf), the National Renewable Energy Lab was highlighting the importance of energy management to reduce expenses.

> Higher education executives today work in a climate as tough as that of any Fortune 500 company. The bear market took a heavy toll on many university portfolios. Budget shortfalls are a reality on many campuses. There continues to be a pressing need for new approaches to the oldest dilemma in education–how to do more with less, while not shortchanging students or demoralizing staff. In this high-stakes environment, business officers and facility managers play an increasingly important role, as they seek new technologies and methodologies for saving money. Energy management has emerged as a key area for these professionals.

Your question for this semester is:

> *What would it take for Calvin College to save $600,000/year on campus operations?*

To answer the primary question, you will find the need to explore several additional questions, including, but not limited to:

- What savings from energy efficiency are possible?
- What savings from student, faculty, and staff behavior changes are possible?
- What savings from operational changes are possible?
- What role does the "rebound effect" have on efforts to save money by changing campus operations?
- How can proposed savings be measured and verified?

You will pursue this question in groups of 4–5 students, each group focusing on a single campus building. Your response to the main question ("*What would it take…*") should take the form of a single report containing comprehensive and accurate information on your approach to achieving cost savings through operational changes at Calvin College. A single final written report must be submitted. A suggested outline is a main technical memo with one appendix for each campus building. Each appendix should be its own technical memo. Each appendix must be thorough and

provide Physical Plant with enough information to make wise decisions about how to pursue operations savings in each building.

The deliverables are:

(a) a final written report that provides a detailed description of your work during the semester and recommended operations changes and measurement and verification systems that can be implemented by Physical Plant,
(b) an Engineering department seminar on Tuesday, 8 December 2015 at 3:30 (venue TBD).
(c) one poster per group to be presented at the Calvin Environmental Assessment Program (CEAP) conference at 3:30 PM on **Thursday, 2 December 2015** (venue TBD).

Each ENGR333 student must attend either (a) the Engineering Seminar or (b) the CEAP Poster Session.

The final report for the project will consist of:

(a) paper copies of your final technical memo with extensive appendices,
(b) an electronic copy of your final report (.pdf format, one single file) to be posted at http://www.calvin.edu/~mkh2, and
(c) a DVD or flash drive containing electronic copies of all posters, presentations, programs, and software analysis tools that you developed during the project.

You must distribute copies of your final report (all three elements) to Physical Plant and your professor. Final reports are due at the end of the final exam time (Noon, Fri 18 December 2015). Each team must send notes of appreciation to each person who provided assistance during the semester.

Prior to the first class meeting each week (typically Monday), each student must submit a weekly timecard that includes

- hours worked on the project
- brief (1 paragraph) description of work accomplished.

During the first week, the class must coordinate which building each group will study. Each group must submit a 1-page description of their group and building by **Friday, 18 September 2015** before lecture. The 1-page description must include a photo of your group in front of your building.

Groups are encouraged to share relevant information throughout the semester. For example, you may find that many buildings would benefit from energy-efficient windows. As a class, you would do well to form a "windows" technology team consisting of one member from each group. The technology teams provide a forum to share insights and knowledge about common operational savings opportunities.

You may also want to form an executive team to coordinate the work of each group. Executive team members should be mostly relieved of group responsibilities.

You might consider a grid metaphor for your work breakdown structure.

		Technology Teams			
		Executive	Windows	HVAC	Scheduling
Groups	CFAC				
	Library				
	NVW				

An initial task for each group is to develop a schedule of your activities for the semester that recognizes the dates of important events throughout the semester. Schedules must be discussed during oral progress reports (see below). Mandatory tasks include brainstorming and reporting at least 10 operational efficiency ideas for each building under study.

A note about measurement and verification (M&V): One weaknesses of the Cenergistic proposal was savings verification. A significant aspect of each suggested operational savings strategy this semester *must* be a strategy for both measuring and verifying the savings. (Your experience in the Instrumentation lab, ENGR382, may be beneficial here.) If possible, operational savings strategies and M&V systems should be prototyped during this semester to provide estimates of potential cost savings. M&V could become very useful for Calvin's participation in STARS (https://stars.aashe.org).

There will be three short, in-class progress reports in the form of oral presentations. There will be a longer in-class final presentation that summarizes the results of the project. Each student must give either (a) a progress report presentation or (b) part of the final presentation. The presentations must be professional quality, must concisely report your progress, and must provide sufficient technical detail for customer, professor, and peer review of your progress. Only 1 student may participate in oral progress reports and 2 students (at most) may participate in the final in-class report.

The in-class progress reports must follow the following outline:

- Status relative to your schedule (and any re-planning that has occurred since your last report)
- Work accomplished since your last report (including technical and cost details)
- Issues or concerns (and plan for addressing them)
- Work planned for upcoming reporting period

The final in-class oral report should not follow the outline above. Rather it should summarize the final technical details of your work, how your technical work was used in the final recommendations to your customer, and the conclusions for your group.

You must bring printed copies (6-up, double sided to save paper) of all in-class presentations for customers and the professor.

The professor, in conjunction with our external resource persons, will select an exemplary student for a teamwork award at the end of the semester.

Despite the presence of an external customer for your work, the professor will assign final grades (in consultation with customers). Students will be assessed on (a) the quality of their team's report, (b) peer evaluation, and (c) hours worked.

Supporting Resources:

- Phil Beezhold, Physical Plant, Director: the customer
  (616) 526-6481, pdb2@calvin.edu
- Jack Phillips, Physical Plant, Assistant Director (Mechanical)

(616) 526-7074, jphill53@calvin.edu
- Previous ENGR333 design projects available from http://www.calvin.edu/~mkh2/thermal-fluid_systems_desig/
- Classroom learning on exergy, energy, economics, and thermal analysis
- Prior laboratory and lecture classes, especially ENGR382
- Independent research

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Groups

Group 1 (CFAC)
Carney
DeVries
Meindtersma
Rovedatti
Tarantowski

Group 2 (KHvR)
Ayoola
Niu
Talen
Veurink

Group 3 (Science Complex)
Bouma
Cha
DuBois
Milhorn

Group 4 (SE)
Jensen
Jung
Karr
Lander

Group 5 (SFC)
Cooper
Tenney
Van Strien
Veenstra

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Note: bold schedule items will include participation of customers.

Day	Date	Activity
Tue	**8 Sep**	**Project introduction, objectives, deliverables**
Fri	11 Sep	One-page building choices document due to Prof. Heun at class.
Tue	15 Sep	Discussion of STARS with Prof. Haney. Project work day (Meet in the classroom for group work)
Wed	**23 Sep**	**In-class group presentations (7 minutes + 2 for questions) Use required outline.**
Tue	29 Sep	Project work day (Meet in the classroom for group work)
Tue	**6 Oct**	**In-class group presentations (7 minutes + 2 for questions) Use required outline.**
Tue	13 Oct	Project work day (Meet in the classroom for group work)
Tue	20 Oct	Project work day (Meet in the classroom for group work)
Tue	**27 Oct**	**In-class group presentations (7 minutes + 2 for questions) Use required outline.**
Tue	3 Nov	Project work day (Academic Advising)
Tue	10 Nov	Project work day (Meet in the classroom for group work)
Wed	18 Nov	Project work day (Meet in the classroom for group work)
Fri	20 Nov	Project work day (Meet in the classroom for group work)
Mon	23 Nov	Project work day (Meet in the classroom for group work)
Tue	**24 Nov**	**Project final presentations (15 minutes + 5 for questions) Report on final results.**
Wed	**25 Nov**	**Project final presentations (15 minutes + 5 for questions) Report on final results.**
Mon	7 Dec	Peer and Project Evaluations due (3:30 PM)
Tue	8 Dec	ENGR Department Seminar 3:30 PM (SB010)
Thur	10 Dec	CEAP Poster Session, 3:30 PM (Venue TBD)
Fri	18 Dec	Final written report due at Noon

Building Operational Efficiency Project
Peer and Project Assessment

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Throughout this semester, you performed analyses and worked toward net-zero energy for homes int eh Grand Rapids area. Now, your professor would like your feedback about the process. Part of your grade for the Net-zero project will be determined by the quality of your submission. Your response is and will remain confidential. Peer and project assessments are due at **3:30 PM** on **Monday 7 December 2015** in Prof. Heun's office.

1) Write one paragraph identifying one or two members of the class who performed exemplarily during this project. Provide examples of their supererogatory efforts.

2) Write one paragraph answering these questions: If you put this project on a resume, would you list it as "community service?" Does engineering (as a discipline) value volunteer work and community service? Why or why not?

3) Write one paragraph describing if or how your participation in this project caused you to alter your behavior this semester. Did you see any connections between your own personal behavior and energy efficiency? If you didn't change your behavior at all, describe why not.

4) What nontechnical skills did you learn in the course of this project? Do you expect that these non-technical skills will be relevant to your future work as an engineer? If so, why? If not, why not?

5) Write three paragraphs addressing this question: what are the connections between (a) energy efficiency and (b) the twin challenges of (i) energy resource depletion and (ii) climate change caused by global warming?

6) Write one paragraph detailing your role and contributions to your small group team. Conclude the paragraph by assigning yourself a letter grade for your work on the project. Justify your grade.

7) Write one paragraph each detailing the roles and contributions of the three (or four) other team members. Conclude the paragraphs by assigning a letter grade for your teammates' work on the project. [Total of three (or four) paragraphs and three (or four) individual letter grades.]

8) Write one paragraph indicating any topics relevant to the content of ENGR333 that, in your opinion, would be interesting for future classes to study. Also provide any suggestions for improvements to the structure of this project in future years.

When writing paragraphs assessing yourself and your peers, you may wish to use the following rubric.

Did the individual:

- Research useful information for your group?
- Display punctuality in meeting deadlines?

- Thoroughly complete assigned duties?
- Share equally in work performed by the group?
- Perform work of high quality or did their work often require revision?
- Help direct the group in setting goals?
- Help direct the group in meeting goals?
- Encourage group members to share ideas?
- Display empathy during group discussions and work?
- Listen to ideas from other group members?
- Participate in helping the group work together better?