

Dormitory Heating and Cooling Design Project

Fall 2010
ENGR333a
Professor Heun

The dormitories at Calvin College are a singular point of energy inefficiency on campus. As we all know, control for the heating system involves opening and closing windows in the dead of winter. The dormitory heating systems are significant roadblocks to encouraging sustainable living among students. Students become cynical and ask, “if you (Calvin College) are so interested in sustainability, why must I leave my window open in January to remain comfortable?” Furthermore, Calvin’s CO₂ emissions continue to grow as shown in the following graph from the 2009 *Calvin Sustainability Scorecard*.

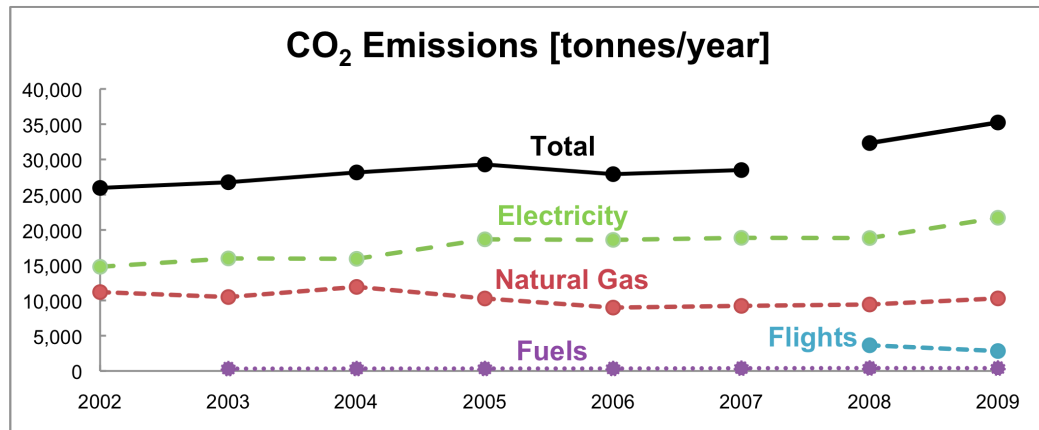


Figure 1. Calvin College annual CO₂ emissions.

Calvin, like most organizations, weighs the long-term economic benefits of any project against the initial costs for such projects. Often, these tradeoffs lead to decision-making that focuses on short-term issues and favors lower initial costs, even when higher initial costs would lead to long-term savings as well as environmental and social benefits. Energy efficiency retrofits usually carry high up-front costs and provide insufficient long-term economic benefit to justify commencement of such projects.

Calvin has instituted the *Calvin Energy Recovery Fund (CERF)* to assist with these issues. Money from CERF can be used to implement energy efficiency projects on campus. Verified cost savings from those projects (relative to a baseline) are routed back into the fund for a period of 5 years after the project is paid off, thereby growing the size of the fund. Increasingly large energy efficiency projects can then be undertaken with the fund.

During this Fall 2010 semester, the ENGR333 class has an opportunity to make a positive contribution to making Calvin College more sustainable by addressing the following question in a semester-long design project:

What would it take to retrofit the Bolt-Heyns-Timmer (BHT) dormitory heating and air-conditioning systems in a manner that achieves LEED certification?

The goal for the heating system renovation is a 30% reduction in energy use compared to the existing system.

Corollary questions include:

- At what rate do the existing BHT heating and air-conditioning systems consume energy?
- What design options should be considered for the renovation project?
- On what criteria will you assess the design options?
- How does the existing campus infrastructure constrain the renovation project?
- Are there opportunities to utilize CERF funds for the renovation project?
- How can we monitor and audit the energy performance of the renovation?
- What other schools have successfully implemented a dormitory energy efficiency renovation project?
- What external funding is available for such a project?

Your answer to these questions should take the form of a comprehensive and realistic design for a renovated heating and air-conditioning system. Elements of your proposed design should include:

- Design of the heating and cooling systems, including component selection and integration with the rest of the campus infrastructure
- An evaluation of the “cost” or “savings” of the renovation in terms of dollars, energy, and CO₂ emissions
- Steps required for LEED certification of the project and the differential cost for taking those steps
- A list of which design options you reject and the reasons why you reject them

Your deliverables are:

- (a) a final report that provides a detailed description of your design,
- (b) two posters to be presented at the Calvin Environmental Assessment Program (CEAP) conference at 3:30 PM on Thursday 2 December 2010 (location TBD)
- (c) an Engineering seminar on Tuesday 7 December 2010 at 3:30 PM in SB010

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

Your final report will consist of:

- (a) a paper copy of your final technical memo with extensive appendices (the tech memo must be a single report for the entire class),
- (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 CD or DVD containing electronic copies of all posters, presentations, programs, and analysis tools that you developed during the project.

The ultimate customer for your final report is Calvin’s Vice-President for Finance, Henry DeVries. The final written report should follow the technical memo format, including a two-page summary with conclusions followed by extensive appendices. Each group (see below) must provide a detailed appendix (in technical memo format, of course) to the overall technical memo that describes the analyses performed by and the contributions from each group.

You must distribute copies of your final report (all three elements) to the VP for Finance, your supporting resources (from Calvin College administration and GMB), and your professor. The final report is due on Friday, 17 December 2010 before Noon. As a class, you must also send a note of appreciation to each resource for their assistance during the semester.

To develop the required design, you must develop (as an entire class) several design options for the heating and cooling systems within the first 2 weeks of the semester. You must develop ideas on your own *and* in consultation with your resources. You must present your list of ideas during your first progress presentations. Thereafter, you will analyze and assess the options.

Another initial task for each group is to develop a schedule of your activities for the semester that coordinates with the schedules of other groups. The schedule must show milestones corresponding to points of interaction with other groups. Schedules must be presented during the first oral progress reports (see below).

You will pursue this project in small groups of approximately 5 students each. The groups will address the following topics:

- LEED certification (investigates LEED requirements and energy modeling)
- Financial and CERF (tracks all financial concerns and CERF opportunities)
- Heating system (including controls)
- Cooling system (including controls)
- Infrastructure/Power Plant (investigates resources available from and constraints due to the rest of the campus infrastructure; investigates all energy issues)

You should consider forming an executive council consisting of representatives from each of the five groups discussed above. The executive council could be responsible for coordinating and planning the final report and for writing the introductory two pages of the report, among other things.

The professor will select students to fill the groups. To apply for one of the available groups, prepare a cover letter and resume and deliver it to your professor on Wednesday 8 September 2010 before lecture. Your cover letter should indicate the group in which you are interested and why you are qualified for that position. Group assignments will be announced via Moodle in the evening of Wednesday 8 December 2010.

As a class, you may find it necessary to adjust the topics being addressed by each group or redistribute the workforce among the groups as the semester progresses. You may simply make the change, inform the professor, and supply justification.

All groups must arrange a tour of Calvin's existing heating and cooling infrastructure with Paul Pennock (see *Supporting Resources* below). Significant discussions during your tour must be noted in an oral progress report.

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 renovation project. Each student must give either (a) part of the progress report presentations 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.

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 need not follow the outline above. Rather it should summarize the final technical details of your work, how your work was used in the final design for the renovation project, and the conclusions for your group.

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

Although the customer for this report is the VP for Finance, your professor will assign final grades (in consultation with the resources for the project). Students will be assessed on (a) the quality of their team's contribution to the overall effort of the class and (b) peer evaluation. The professor, in conjunction with our external resource persons, will select an exemplary student for a teamwork award at the end of the semester.

Supporting Resources:

- Dr. Henry DeVries, VP for Finance: the ultimate customer
(616) 526-6148, hdevries@calvin.edu
- Paul Pennock, Physical Plant: contact for information about the existing campus HVAC systems
(616) 262-9230 (mobile), ppennock@calvin.edu
- Dan Slager, Physical Plant: contact for Calvin College energy purchasing
(616) 526-6267, slagda@calvin.edu
- Ashley Baker, GMB: contact for information about implementation of physical plant projects
(616) 796-0200, ashleyb@gmb.com
- Shane Muller, CERF intern: contact for information about CERF
smm27@students.calvin.edu
- Emma DeVries, Sustainability Coordinator in the dorms: contact for dorm and student info
ehd3@students.calvin.edu
- CERF documentation, including
http://www.calvin.edu/~mkh2/thermal-fluid_systems_desig/2008_ceef_final_report.pdf
http://www.calvin.edu/~mkh2/thermal-fluid_systems_desig/2008_ceef_seminar.pdf
CERF policies (available from Shane Muller)
- 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
- Independent research

ENGR 333 Dorm Heating/Cooling Project Schedule

Fall 2010

Full-group project meetings are held Tuesdays 11:30–12:20 in SB102

Note: bold schedule items will include participation of the customer and resources

Day	Date	Activity
Tue	7 Sep	Project introduction, objectives, deliverables, introduction to resources
Wed	8 Sep	Cover letters and resumes due to Prof. Heun at class. Groups assigned.
Tue	14 Sep	Project work day (Meet in the classroom for group work)
Tue	21 Sep	In-class group presentations (7 minutes + 2 for questions) Use required outline.
Tue	28 Sep	Project work day (Meet in the classroom for group work)
Tue	5 Oct	In-class group presentations (7 minutes + 2 for questions) Use required outline.
Tue	12 Oct	Project work day (Meet in the classroom for group work)
Tue	19 Oct	Project work day (Meet in the classroom for group work)
Tue	26 Oct	Project work day (Academic Advising)
Tue	2 Nov	In-class group presentations (7 minutes + 2 for questions) Use required outline.
Tue	9 Nov	Project work day (Meet in the classroom for group work)
Tue	16 Nov	Project work day (Meet in the classroom for group work)
Wed	17 Nov	Project work day (Meet in the classroom for group work)
Fri	19 Nov	Project work day (Meet in the classroom for group work)
Mon	22 Nov	Project work day (Meet in the classroom for group work)
Tue	23 Nov	Project work day (Meet in the classroom for group work)
Wed	24 Nov	Project final presentations (13 minutes + 2 for questions)
Mon	29 Nov	Project final presentations (13 minutes + 2 for questions) Report on final results.
Thur	2 Dec	CEAP Poster Session, 3:30 PM (Location TBD)
Tue	7 Dec	ENGR Department Seminar 3:30 PM (Location TBD)
Fri	17 Dec	Final report due at Noon