

Calvin College Energy Independence Thermo-economic Analysis Project

Fall 2004
Engr 333
Prof. Heun

Calvin College both purchases and generates electricity for use on its Knollcrest campus. Electricity purchases are made from “the grid.” Electricity is generated on-site by converting natural gas into electricity using Calvin’s Co-generation system, located in the basement of the Commons.

There are many benefits to being energy independent, i.e. “off-grid”: providing options for lowest-cost electricity generation among multiple sources, independence from traditional electricity sources for extreme events such as storms and power failures, and protection of critical infrastructure. There are also drawbacks, chiefly up-front capital investment in infrastructure and ongoing maintenance requirements.

Your challenge for this semester-long project is to construct a realistic plan to get Calvin off the grid, meaning that Calvin would own and operate on-site facilities that generate all the electricity that the campus consumes. If your plan were to be implemented, Calvin would no longer buy electricity from the grid.

Your deliverables are (a) a single final report from each section that proposes a feasible plan for getting Calvin off the grid, (b) a single poster from each section (2 posters total) to be presented at the Calvin Environmental Assessment Program (CEAP) conference on 2 December 2004, and (c) a departmental seminar given by the classes (each section has 30 minutes) on 3 December 2004.

Elements of your proposed plan should include:

- Evidence of thorough research into technology options for reaching the goal, including both print and online resources
- A schedule showing a timeline for construction of facilities
- Proposals for implementation of alternative and/or renewable energy technologies to help Calvin reach this goal
- Proposals for locations of any new facilities required to meet the goal
- A realistic plan to finance capital projects
- A financial evaluation of the economic advisability of your “off the grid” plan. The timeline for this financial analysis should be 30 years.

The customer for this thermo-economic analysis project is Calvin’s Vice-President for Finance, Henry DeVries.

Working independently, each section of ENGR 333 (i.e., section A and section B) will develop its own plan. Each section of the course will divide into 4 groups of 3–5 students each. One group in each section will be an “integration” group, responsible for overall planning and structure of the project. The 3 other groups will be “technology” groups, each being responsible for evaluating and developing a specific plan for implementing one technology option for alternative energy generation.

Suggested technology options for alternative energy sources include

- Solar electric (photo-voltaic solar cells)

- Electric generators running on natural gas or another traditional energy source (similar to Calvin's co-gen system)
- Fuel cells using hydrogen or natural gas as an energy source (similar to MAREC's system)
- Wind (turbines and generators)
- Solar thermal (similar to Solar I and Solar II)
- Geothermal

The responsibilities of the integration group include

- Quantifying and communicating Calvin's energy usage to the technology groups. This will allow the technology groups to "size" their electricity production facilities.
- Working with the technology groups to obtain cost, efficiency, and site information for the various electricity generating technologies.
- Evaluating the optimal mix of generating capacity from each technology.
- Investigating options to reduce energy usage on campus and therefore reduce capital costs for generating capacity. (Options might include installation of double-glazed windows everywhere on campus, green roofs, etc.)

The responsibilities for the technology groups include

- Parameterizing the costs and efficiencies of technologies as a function of generating capacity and communicating this information to the integration group.
- Identifying the site needs for technologies and assessing the impact on Calvin's physical plant and physical resources.
- Developing financing proposals for technologies, including loans, incentives, and grants.

All groups must perform thermo-economic analyses in their area of responsibility; that is, there must be both thermodynamic (broadly construed as conversion of energy from one form to another) and economic components to your work.

All groups must arrange a tour of Calvin's co-gen plant with Paul Pennock and participate in a tour of the facilities at the Michigan Alternative and Renewable Energy Center (see *Resources* below).

There will be three short, in-class progress reports in the form of oral presentations. There will be one in-class final presentation that summarizes the results of the Calvin off the grid thermo-economic analysis. Each student must give one of the presentations. The presentations must be professional quality, must concisely report your progress, and provide sufficient technical detail for peer and professor review of your progress.

The in-class progress reports must include the following elements:

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

The final in-class oral report should provide the final technical details of your analysis, how your technical analysis was used in the final plan for the section, and the final conclusions for your group.

The written final report should follow the technical memo format, including a two-page summary with

conclusions. The integration group is responsible for the introductory two pages. All groups (integration and technologies) should provide a detailed appendix (in technical memo format, of course) to the overall technical memo that describes the analysis performed and the proposals developed by the group. Students will be graded on the quality of their group's contribution to the overall effort of their section.

As stated above, the audience for the final written report is the Calvin College Vice President for Finance, although the final grade will be assigned by the professor. Your final report will consist of (a) a paper copy of a technical memo with extensive appendices and (b) electronic copies of any programs or analysis tools that you developed during the project. You must distribute copies of your final report to the VP for Finance, your resources (see below), and the professor. You must also send a note of appreciation to your resources for their assistance during the semester.

Resources:

- Paul Pennock, Calvin Physical Plant: contact for co-gen plant tours and information
(616) 262-9230 (mobile)
pennockp@aol.com (email)
- Dan Slager, Calvin Physical Plant: contact for finance and purchasing information
(616) 526-6267
slagda@calvin.edu
- Henry DeVries, VP for Finance, hdevries@calvin.edu, 6-6148
- Michigan Alternative and Renewable Energy Center (MAREC) at GVSU: contact for information on fuel cells
- Calvin's interpretive center (<http://www.solar.calvin.edu>)
- Calvin's solar thermal demonstration project (<http://www.solarthermal.calvin.edu>)
- Classroom learning on exergy, economics, and thermal analysis
- Prior laboratory and lecture classes

You must (on your own) organize a tour for your group at the Calvin Co-Gen plant. We will visit the new Interpretive Center. We will (as a class) visit MAREC during the semester.

Group selection will be conducted by the professor. To apply for one of the available positions, prepare a cover letter and resume and turn it in to the professor by **Friday 10 Sept 2004**. Your cover letter should indicate your interest in either an integration position or a technology position. If you are applying for a technology position, please indicate two technologies that you are interested in. Below are the job postings:

Power Systems Integration Engineer

The Advanced Thermal Design group at Calvin College requires part-time work on system design for an off-grid power system for Calvin's Knollcrest Campus. Initial tasks will include (a) quantifying and communicating Calvin's energy usage to other team members, (b) working team members to obtain cost, efficiency, and site information for the various electricity generating technologies, (c) evaluating the optimal mix of generating capacity from various technology options, and (d) investigating options to reduce campus electricity demand.

Successful candidates will have excellent group communication skills, three years of undergraduate experience focused on Mechanical Engineering, and a strong desire to provide system-level engineering expertise to a challenging and dynamic engineering group. Candidates must already be enrolled in ENGR 333 for the Fall 2004 semester. Apply if you desire professional growth through an innovative R&D project. Equal opportunity employer. Participate in creating your own future.

Power Systems Technology Engineer

The Advanced Thermal Design group at Calvin College requires part-time work on power system design for alternative and renewable technologies for an off-grid power system for Calvin's Knollcrest Campus. Initial tasks will include (a) parameterizing the costs and efficiencies of power generation technology options as a function of generating capacity, (b) identifying the site needs for various power generation technologies and assessing the impact on Calvin's physical plant and physical resources, and (c) developing financing proposals for power generation technology options.

Technology options to be evaluated and assessed include, but are not limited to (a) solar electric (photovoltaic solar cells), (b) local generators from natural gas or another traditional energy source, (c) fuel cells, and (d) wind (turbines and generators).

Successful candidates will have excellent group communication skills, three years of undergraduate experience focused on Mechanical Engineering, and a strong desire to provide system-level engineering expertise to a challenging and dynamic engineering group.

Candidate must already be enrolled in ENGR 333 for the Fall 2004 semester. Apply if you desire professional growth through an innovative R&D project. Equal opportunity employer. Participate in creating your own future.

To apply for these positions, send your resume by Friday 10 September 2004 to:

Prof. Matthew Kuperus Heun
Engineering Department
Calvin College
Grand Rapids, MI 49546

Calvin Off-Grid Project Schedule (2004)

Day	Date	Activity
Wed	8 Sep	Calvin Off-grid project introduction, objectives, deliverables
Fri	10 Sep	Cover letter and resume due
Mon	13 Sep	Group assignments announced
Tue	14 Sep	Calvin Off-grid project work
Tue	21 Sep	In-class group presentations (10 minutes + 2 for questions) Report on objectives, work schedule, and proposed analysis approach
Tue	28 Sep	Calvin Off-grid project work
Tue	5 Oct	In-class group presentations (10 minutes + 2 for questions) Report on analysis performed to date
Tue	12 Oct	Calvin Off-grid project work
Tue	19 Oct	Calvin Off-grid project work
Tue	2 Nov	In-class group presentations (10 minutes + 2 for questions) Report on preliminary results
Tue	9 Nov	Calvin Off-grid project work
Wed	17 Nov	Calvin Off-grid project work
Fri	19 Nov	Calvin Off-grid project work
Mon	22 Nov	Calvin Off-grid project work
Mon	23 Nov	Calvin Off-grid project final presentations (20 minutes + 3 for Qs)
Tue	24 Nov	Calvin Off-grid project final presentations (20 minutes + 3 for Qs) Report on final results
Thur	2 Dec	CEAP Poster Session
Fri	3 Dec	ENGR Department Seminar
Thur	16 Dec	Off-grid project final written report due at 4:30 PM