

Proposal for a Sustainability Designation on the concentrations in the BSE degree program

PROPOSAL

An Engineering student who fulfills the requirements for the BSE degree in any one of the four concentrations (Chemical, Civil & Environmental, Electrical & Computer, or Mechanical Engineering) and has also obtained all of the following:

- 1 – Completion of a 1 semester hour “sustainability challenges” course (see separate proposal),
- 2 – Completion of a 3-4 semester hour sustainability-themed course selected from a list of existing courses (see details below).
- 3 – Completion of a 1 semester hour “analysis of sustainability engineering systems” course (see separate proposal). Prerequisites: “Sustainability Challenges”, Engineering 202, 204, and 209.

will receive a degree designated (on the transcript) as:

- BSE with a concentration in Chemical Engineering, Sustainability, or
- BSE with a concentration in Civil and Environmental Engineering, Sustainability, or
- BSE with a concentration in Electrical and Computer Engineering, Sustainability, or
- BSE with a concentration in Mechanical Engineering, Sustainability.

BACKGROUND

The Calvin College engineering department has a long history of commitment to sustainable engineering practices that arise from our identity as a Christian engineering program for which care of God’s Creation is a central theme. Among the prominent actors in that history are Jim Bosscher (the patriarch of Grand Rapids municipal recycling), Paulo Ribiero (IEEE fellow and renewable energy and electrical power quality expert), and many current faculty members whose teaching and research covers groundwater, wastewater treatment, food, recyclability, life-cycle analysis, renewable energy, etc. A number of senior design engineering projects over the years have focused on sustainability, and two renewable energy projects in the last decade obtained grants from the State of Michigan.

In Spring 2011, we added sustainability to our revised mission statement as both a departmental distinctive and an educational objective (see Appendix 1). One way to fulfill the sustainability component of our new mission statement is to intentionally integrate sustainability more deeply into our curriculum by:

- Developing a *Sustainability Designation* (this proposal),
- Encouraging Engineering faculty to attend *Sustainability Across the Curriculum Workshops*, (current Calvin College Program), and
- Establishing a *Program for Sustainability Engineering (PSE)* to provide funding for and coordination of sustainability-related activities within the Engineering Department (separate proposal). The director of the PSE will also be the faculty member advising students seeking the Sustainability Designation.

The *Sustainability Designation* proposed here would be similar to the existing International Designation to the Bachelor of Science: something extra, but short of a minor, for students to pursue.

This proposal seeks to encourage the study of sustainability within the context of the Engineering program at Calvin. At the college level stewardship/sustainability is also a focus. The document describing the core curriculum at Calvin College proposes a number of “Core Virtues” that should “play a special role in the life of the mind and the building of community, both at Calvin and in the world at large”. One of these virtues is stewardship. The document states, “Where appropriate, issues of stewardship should be addressed in our classrooms; where possible, students should be invited to participate in activities on and off campus that manifest care for God’s creation--mending what is broken, cleaning what is soiled, nurturing the frail, conserving the scarce, saving the valuable.”

In 2007 the Faculty Senate and the Board of Trustees approved the Statement on Sustainability. This statement commits the college to advance sustainability principles in all aspects of its daily operations. Implementation guidelines are provided for all areas of campus life including teaching and research. The document lists the following suggestions for implementation:

- Develop a Biblical understanding of stewardship as it relates to sustainability activities both in our personal and institutional lives.
- Strengthen and prioritize environmental studies and research.
- Teach energy and environmental literacy to all students.
- Develop a connection to the environment; when people feel connected to and have knowledge about their environment, they will take better care of it.
- Expand opportunities for using the campus physical plant and business operations as a “learning lab” for students.
- Develop community and neighborhood energy and environmental education programs and participate in public dialogue on energy and environmental issues in the wider community.
- Increase opportunities for informal learning about environmental/sustainability issues for students, faculty, staff and public.

This proposal seeks to do many of these.

A recent survey was conducted both among current freshman and senior level engineering students regarding the possibility of obtaining a Sustainability designation. Of the 38 seniors surveyed 26 either strongly agreed or agreed that they would have pursued the Sustainability designation had it been available at the time they started Calvin. Of the 101 freshman surveyed 57 agreed or strongly agreed. Given this level of interest there may be some marketing potential to prospective students.

RATIONALE FOR THE DESIGNATION

- 1) A focus on sustainability is coincident with the mission of the college and the mission of the Engineering program.
- 2) Potential employers and graduate schools are looking for formal indications of special exposure and experience.
- 3) Starting in 2012-13, The Accreditation Board for Engineering and Technology (ABET) will modify the student outcomes criteria to include sustainability. The “Design” outcome will now read “An ability to design a system, component, or process to meet desired needs within realistic constraints

such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability “.

It is not uncommon for Calvin College to give recognition on transcripts for requirements fulfilled above and beyond normal degree requirements. This is done for students who have graduated with Honors in a program. Within the Engineering Department students can already receive an International designation on their transcript.

COMPARISON TO OTHER INSTITUTIONS

Appendix 2 provides a list of sustainability programs at a wide variety of institutions from community colleges to major research universities. Several things can be noted:

- There are a wide variety of programs at many different levels. Nova Scotia Community College offers training in sizing, specifying, and commissioning alternative energy systems while institutions like University of Illinois and Michigan offer graduate programs.
- Most programs have some interdisciplinary character. University of Michigan, for example, offers the program as a dual master’s degree between the College of Engineering and the College of Natural Resources. University of California at Berkeley offers a graduate certificate in Engineering and Business for Sustainability.
- Emphases tend toward manufacturing, energy systems, and water systems (see University of Michigan).
- Options range from training, to (graduate and undergraduate) certificates, to undergraduate minors, to graduate specialization, to interdisciplinary master’s degrees, to dual degree master’s programs.
- Most of the programs are in engineering but some also exist within the humanities.
- Calvin’s program proposed here would be most like some of the certificate options in Appendix 2.
- Other CCCU schools with engineering programs are beginning to offer sustainability-related courses, concentrations, and programs

This listing of other programs shows that sustainability is being recognized as an important area of specialization across engineering (and other) disciplines. Calvin would certainly not be the first institution to institute a sustainability option, but it would likely be at the leading edge. This will give us a competitive advantage when recruiting students.

OUTCOMES

The Mission of the Engineering Department at Calvin College identifies sustainability as one of its distinctive features:

Sustainable: Advocating a thoughtful framework for technological development that stewards the resources of the world to enable the long term flourishing of human and non-human aspects of God’s creation.

The Sustainability Designation provides a means for students to pursue the concept of sustainability in depth. The following outcomes are expected for a student who completes the designation.

I. Outcome: Able to describe sustainability

A. Definitions

Student will be able to understand common definitions of sustainability and put in own words, including:

- Calvin College Statement on Sustainability
- Definitions from Brundtland Commission Gandhi (need/greed), ASCE, etc.
- Triple Bottom Line, three pillars of sustainability (economy, society, environment)

B. Concepts and Measures

Student will be able to define basic concepts and measures related to sustainability, including:

- Climate change
- Global warming
- Resource scarcity, peak oil
- Carbon footprint
- Sustainable engineering
- Precautionary principle
- Lifecycle, “cradle-to-grave”
- Global warming potential, acidification potential, eutrophication potential, photochemical ozone creation potential, (human) toxicity potential, abiotic depletion potential (and equivalent units for each.
- Global carbon and sulfur cycles

C. Critical Thinking

Student will be able to critique definitions and terms related to sustainability, including:

- Identifying implicit biases
- Identifying implicit worldview
- Evaluate in light of Biblical principles such as stewardship and justice
- Evaluate in light of principles in Reformed Christianity such as the cultural mandate, God’s sovereignty, and the themes of creation-fall-redemption

II. Outcome: Able to articulate how individual and collective actions relate to sustainability

A. Individual Action

Student will be able to identify personal decisions, actions, and behaviors that contribute or detract from sustainability, including:

- Qualitatively and quantitatively summarize personal resource usage
- Estimate personal energy usage
- Estimate own carbon footprint

B. Collective Action

Student will be able to identify how policies of communities, governments, and corporations contribute to or detract from sustainability, including:

- Identify how collective policies constrain individual behavior

- Identify examples of legislation or agreements (from local to international) that impact sustainability

III. Outcome: Able to identify sustainability interrelationships

C. Triple Bottom Line Relationships

Student can identify and analyze the interconnections between:

- Politics and sustainability, including regional politics, policy decisions, legal issues, and international diplomacy.
- Environment and sustainability, including environmental justice, stewardship, interdependence of humans with environment, and global capacity.
- Economics and sustainability, including concepts of supply and demand, free market economics, resource scarcity, and green jobs.

D. Biblical Virtues

Student can identify and analyze the interconnections between:

- Justice and sustainability, including social justice, environmental justice, the precautionary principle, intergenerational equity, geographical equity, participative design, respect for stakeholders, and human rights.
- Stewardship and sustainability, including creation care, shalom, and the cultural mandate.
- Charity, greed, and sustainability, including a critique of the perceived need for economic growth and increasingly more material goods

IV. Outcome: Able to demonstrate the need for interdisciplinary approach to sustainability

Student can identify how multiple disciplines contribute to the study of sustainability issues, including sciences and humanities. Student can identify diverse contributions to the study of sustainability issues, including understanding that historical development of the disciplines themselves has left no single discipline sufficient to address today's sustainability challenges

V. Outcome: Able to compare and contrast sustainable engineering practices and technologies

E. Goals

Student will be familiar with the goals of sustainable engineering, including:

- Health & Safety for humans and non-humans
- Pollution and waste management
- Energy – efficiency, conservation, distribution, renewable sources
- Non-energy resources and renewables
- Quantification of Material Intensity of an industrial ecosystem using AIChE sustainability metrics

F. Methods

Student will be familiar with the methods of sustainable engineering, including:

- Life Cycle Assessment
- Green construction
- Design for recyclability, disassembly, durability, reusability
- Holistic design
- Quantification of embodied energy of engineering artifacts.
- Energy Return on Investment (EROI) metrics

G. Technology

Student will be familiar with the technologies of sustainable engineering, including:

- Renewable energy
- Low power systems
- Ecofriendly materials, (e.g., lead-free Printed Circuit Board manufacturing)
- Biofuels

Curricular Map

Outcome	Challenges Course	Sustainability Themed Course	Analysis of Sustainability Engineering Systems Course	General Engineering Curriculum
I. Able to describe sustainability				
A. Definitions	R, A	*		R
B. Concepts and Measures	R, A	*		
C. Critical Thinking		*	R, A	
II. Able to articulate how individual and collective actions relate to sustainability				
A. Individual Action	R, A	*	R	
B. Collective Action	R	*	R, A	
III. Able to identify sustainability interrelationships				
A. Triple Bottom Line Relationships	R, A	*	R	
B. Biblical Virtues	R, A	*	R	R
IV. Able to demonstrate the need for interdisciplinary approach to sustainability	R, A	*	R	R
V. Able to compare and contrast sustainable engineering practices and technologies				

	A. Goals	R, A	*	R	R
	B. Methods	R	*	R, A	
	C. Technology	R	*	R, A	R

R = Required Content

A = Assessed in this course

* = The Sustainability Themed course must cover at least 4 of the 11 outcomes listed in the Curricular Map in order to be counted for the designation. The Director of the Engineering Sustainability Program will maintain a list of currently approved courses (and also make determinations for student-proposed options, including honors projects focused on sustainability).

IMPLEMENTATION

Courses: Two of the courses are new – “Sustainability Challenges” (1 s.h.) and “Analysis of Sustainability Engineering Systems” (1 s.h). Proposals for these two courses are provided in separate documents. The sustainability-themed course can be any course that has a significant focus on sustainability and addresses at least four of the outcomes listed above. This can include courses on- or off-campus. It can include regular semester or Interim courses. It can include both engineering and non-engineering courses. It can include courses taken at other institutions. A list of pre-approved Calvin College courses will be maintained by the PSE Director. Students wishing to use other courses must seek approval from the PSE director. The initial list of pre-approved courses could include the following:

- BIOL 364: Global Health, Environment, and Sustainability
- ECON 232: Environmental and Natural Resources Economics
- ECON 233: Economics of Energy and Sustainability
- ENGR W80: Advanced topics in Chemical Engineering (last offered in 2012).
- ENGR W82: Sustainable Energy Systems (last offered in 2012)
- ENGR W81: Stormwater Management (with modifications) (last offered in 2012)
- ENGR WXX: Site Development and Design (proposed for Interim 2013)
- ENST 210: Human Impacts on the Environment
- STNL 230: Toward Environmental Sustainability in the Netherlands: Historical Perspectives and Contemporary Practices (Off-campus)
- Students may also work with a faculty member to pursue an honors project related to sustainability in any appropriate course, with the approval from the PSE director.

The PSE director will review and update this list on a regular basis.

Students who choose to pursue a Sustainability designation for their BSE degree would work with the PSE director to select an appropriate sustainability-themed course. Students would then complete a declaration form (similar to a major or minor declaration). Once signed by the PSE director the forms will be delivered to the registrar and the engineering department office. When the requirements are completed (as determined via the AER) the designation can be automatically assigned.

CATALOG COPY

The college catalog will read:

Sustainability Designation

Students may receive a sustainability designation to their concentration (e.g., “BSE Sustainability Mechanical Concentration”) by completing all of the following courses: 1) Engineering 1XX Sustainability Challenges, 2) a 3- or 4-semester hour sustainability-themed course, and 3) Engineering 3xx Analysis of Sustainability Engineering Systems. The sustainability-themed course can be any one of Biology 364: Global Health, Environment, and Sustainability, Economics 232 Environmental and Natural Resources Economics, Economics 233: Economics of Energy and Sustainability, Engineering W80: Advanced topics in Chemical Engineering, Engineering W8X Sustainable Energy Systems, Engineering W8X Stormwater Management, Engineering W8X Site Development and Design (proposed for Interim 2013), Environmental Studies 210 Human Impacts on the Environment, and Semester in the Netherlands 230 Toward Environmental Sustainability in the Netherlands: Historical Perspectives and Contemporary Practices. Other courses may qualify with the permission of the Program for Sustainability Engineering director. For additional details, please contact the department Chair or the Program for Sustainability Engineering director.

OTHER DESIRED OUTCOMES

This document lists the educational outcomes for the designation. It is anticipated that there will be other outcomes as well. These include the following:

- Highlight issues of sustainability within the Engineering Department and the college.
- An increase in the number of students interested in attending Calvin due to this designation.
- More engineering students developing sustainability related senior design projects.
- Other

RESOURCES

It is anticipated that there will be one section each of the Challenges and Solutions courses offered each semester. This will require an additional 4 semester hours of teaching each year. All of the sustainability-themed courses are existing courses. It is not anticipated that there will be sufficient additional enrollment in these courses to require additional sections.

Funds to develop and teach the two new courses, “Sustainability Challenges” and “Analysis of Sustainability Engineering Systems”, are being provided by an outside donor to the college for the first two years of operation. A proposal is being submitted to the administration to initiate a fund raising effort beyond the first two years.

Appendix 1

Mission of the Calvin College Engineering Program

Calling

The engineering program equips students to glorify God by meeting the needs of the world with responsible and caring engineering.

Distinctives

Our program is marked by these features:

Christian

Integrating Christian faith into the curriculum as a foundation for understanding the role of technology in society and for forming engineers with a vocation of service to the world, including underserved populations

Global

Providing opportunities to prepare graduates for participation in the international marketplace and in addressing the challenges faced by people in the developing world

Innovative

Encouraging the cultivation of an entrepreneurial mindset, business acumen, and the leadership and life-long learning skills that contribute to the growth of enterprises that build communities

Interdisciplinary

Emphasizing that today's complex problems require integration and analysis across engineering disciplines, the sciences, and the liberal arts to inform engineering design decision-making, extend critical thinking, and advance communication skills

Practical

Infusing the classroom with real-world engineering experience, challenging students to address open-ended design problems with multiple constraints in a team environment, and facilitating internships for students

Student-Focused

Creating a learning community that features small class sizes and a faculty committed to undergraduate teaching and mentoring

Sustainability

Advocating a thoughtful framework for technological development that stewards the resources of the world to enable the long term flourishing of human and non-human aspects of God's creation

Educational Objectives

The BSE degree from Calvin College is designed to provide a foundation for productive engineering work in God's world. The objectives of the program are that recent graduates will...

...apply and develop the basic principles and skills necessary for engineering (including mathematics, the sciences, business, and the humanities) for appropriate assessment and analysis of current and complex problems.

...creatively generate innovative solutions to problems and move them toward successful implementation.

...contribute and communicate ideas successfully in multidisciplinary environments, exhibiting awareness of cultural context and team dynamics.

...demonstrate commitment to social responsibility, sustainability, and the continued learning necessary to address the pressing problems of our contemporary world.

In the long term, our graduates will be kingdom servants whose faith leads them to lives of integrity and excellence, called to leadership with a prophetic voice advocating for appropriate technologies.

Appendix 2 - Other programs in Sustainability Engineering

Institution	Category	Description
University of Wisconsin, Energy Institute	Certificate in Engineering for Energy Sustainability	Students take 16 credits from listed courses in 3 categories
Carnegie Mellon University, College of Engineering	Minor in Environmental Engineering and Sustainability	Students take 7 listed courses – 2 sustainability, 3 technical, and 2 policy.
University of Illinois, College of Engineering	Graduate degree option	Option available within multiple departments. Students from non-engineering departments can also participate. Students take 2 common introductory courses then select from a list of existing courses to obtain both breadth and depth.
University of Michigan, School of Natural Resources and Environment and College of Engineering	Dual degree Master's program.	Students take 25 credits in Natural Resources and 29 credits in one of three departments - Civil and Environmental, Mechanical, or Chemical Engineering. Specializations are then available (depending on major) in sustainable design and manufacturing, sustainable energy systems, or sustainable water systems.
CUNY, Schools of Architecture and Engineering	Master of Science in Sustainability	This is a 30 credit hour master's program. It includes 5 core courses for all students followed by elective courses in either architecture or engineering.
Nova Scotia Community College, School of Trades and Technology	Energy Sustainability Engineering Technology program	Training in sizing, specification, and commissioning of solar photovoltaic, solar, thermal, wind, biomass, geothermal, tidal, and other sustainable engineering systems.
University of Colorado, Denver, College of Engineering and Applied Science	Graduate specialty in Environmental and Sustainability Engineering	Offers 2 master's programs: MS in Environmental and Sustainability Engineering and MEng in Sustainable Infrastructure.
San Diego State University, College of Arts and Letters	Social Science Major in Environmental Studies and Sustainability	This is an emphasis within the social science major.
University of New Haven, multiple colleges (including engineering)	Bachelor of Science degree in Sustainability Studies.	They offer an interdisciplinary major. It includes a balanced curriculum across science, engineering, business, and humanities.
Tufts University, School of Engineering	Specialty courses	They identify a long list of courses with sustainability focus on their website.
University of Pittsburgh, Department of Civil and Environmental Engineering	BSCE specialization in Construction Management & Sustainability	They have a two course sustainability specialization within a construction management program.
University of California Berkeley,	Engineering and Business for Sustainability certificate.	This is a certificate offered to students in any graduate program at UC Berkeley. All students must complete a 1 credit Technologies for Sustainable Studies courses and 3 courses in other sustainability themed areas.
Saginaw Valley State University, College of Science, Engineering and Technology	Masters of Science – Energy and Materials (MEM)	This is a 30 credit interdisciplinary master's program incorporating courses in chemistry, physics, and electrical and mechanical engineering.

A review of our closest competitor CCCU engineering programs reveals the following:

Institution	Curricular Sustainability Programs	Comments
Cedarville University	None	
Dordt College	Sustainable Energy Systems Design course	This course is the only mention of “sustainable” in the Dordt engineering curriculum
John Brown University	Renewable Energy concentration	John Brown is the only CCCU school that offers a renewable energy concentration. See http://www.jbu.edu/majors/engineering/renewable_energy/
Geneva College	Environmental concentration	http://www.geneva.edu/object/egr_environmental
Messiah College	Environmental concentration	A mature biodiesel research project is underway. http://www.messiah.edu/features/pdf/BiodieselBrochure.pdf
LeTourneau University	Wind Energy Engineering and Sustainable Energy engineering courses	No larger curricular coordination
Seattle Pacific University	Appropriate and Sustainable Engineering (ASE) concentration	http://www.spu.edu/depts/ee/academics/general.asp