Campus Carbon Neutrality as an Interdisciplinary Pedagogical Tool

Keynote Session: 14h00 – 14h45

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Domestic Use of Energy Conference 2009
Cape Peninsula University of Technology
15 April 2009
Topics

- Setting the context
- Calvin College Carbon Neutrality (CCCN) project
- Carbon Emissions Trading Simulation (CETS)
- Surprises and Lessons Learned
- Conclusion
Setting the Context

- Background
- Sustainability
- Institution
- Liberal Arts
- Pedagogy
Earth’s Carbon Cycle

- Many Emission Sources
- Many Sequestration Sinks
- Total Human Emissions 7.1 GtC/yr
- Net: 3.2 GtC/yr human emissions remain in the atmosphere

http://earthobservatory.nasa.gov/Library/CarbonCycle/carbon_cycle4.html
Keeling Curve


CO₂ (parts per million)

Year

Mauna Loa Observatory

2.2 ppm/yr
Global Warming

- Fossil fuel combustion puts extra $\text{CO}_2$ (a greenhouse gas) into the atmosphere

- \[ \text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} \]
Carbon Timeline

- 1700s: 280 ppm
- 1974: 330 ppm (~half of extra carbon)
- 2008: 389 ppm
- 2059: 500 ppm (at 2.2 ppm/yr)  
  “Dangerous Anthropogenic Interference”
Definition

- Climate change
  - Long-term significant change in the expected patterns of average weather caused by human activities
- Negative consequences
  - Sea level rise
  - Altered vegetation patterns
  - Desertification
A Very “Hot” Topic

http://www.ipcc.ch
Definition

- Sustainable: using only your fair share of natural resources
  - Consider spatial distribution of resources
  - Consider temporal distribution of resources
Sustainability Context

• Grand Rapids, MI
  • Most LEED certified buildings per capita
  • Community Sustainability Partnership
  • UN University Regional Center for Expertise in Education for Sustainable Development (2006)

• Calvin Statement on Sustainability (2007)
  • Goal: “To raise the level of environmental and sustainability discussions in the campus community.”
  • Covers 13 areas of institutional/community life
Institutional Context

• Comprehensive **Liberal arts** institution

• Founded 1876 by Calvinist immigrants

• 4000 students

• ENGR Department

• Phys. Plant
Liberal Arts Context

• “Big questions are the lifeblood of liberal arts education with its emphasis ... [o]n the connections between the disciplines. Liberal arts education, at its best, goes beyond simply knowing ... and acquiring competence in some field.”
  (Curry, Heffner, and Joldersma, 2007)

• Knowing → Responsibility

• Competence → Caring
Definition

• Pedagogical: of or related to teaching
Pedagogical Context

• Sustainability commitments are a good fit for Service Learning

• Calvin Service Learning Center

• Calvin Environmental Assessment Program (CEAP)
  • Integrate sciences with service learning
  • Invigorate curriculum
  • Embrace multiple intelligences/learning styles
  • Provide service to institution
Learning at Calvin

Academics (Classes)

Service Learning

Academically-based Service Learning
CEAP
BIOL 357
ENGR 333

Community-based Service Learning

Student Life
Context Summary

• Sustainability makes sense in this context
  • Climate Change is a big question and “hot” topic
  • suitable for liberal arts inquiry at Calvin College
  • using existing pedagogical resources.

• What in your context provides impetus for sustainability activities?
How Engage Students and Organization?

- Given the above context (yours will be different), how one engage the institution on the issue of climate change caused by global warming?
- Understand the context and use the available resources
  - An institution that respects and responds to service-learning
  - Free students
Calvin College Carbon Neutrality Project
The Question

• What would it take to make Calvin College carbon neutral?

• This is a “Grand Challenge” issue that will impact students over their lifetimes on many different levels.

• Amenable to service learning.

• BIOL and ENGR students spent a semester working toward an answer.
Pedagogical Design

Activities
- Traditional Lectures
- CCCN
- CETS

Levels of Inquiry
- Global
- Institutional
- Personal

Arrows:
- A
- B
- C
- D
- E
- F
- G
Calvin College Carbon Neutrality (CCCN) Project
(Institutional Level of Inquiry)
Group Formation

- Students aligned groups with Statement on Sustainability
  - Energy Use and Purchasing
  - Land Use and Waste Water Management
  - Recycling and Solid Waste Management
  - Construction and Renovation
  - Transportation

- Students “applied” for a group by submitting a resume (C.V.) and cover letter

Professors formed groups
Carbon Footprint
Definitions

• Carbon footprint: inventory of carbon emissions and sequestration by an organization

• Carbon neutral: when CO$_2$ emissions and sequestration are equal

• Carbon negative: when CO$_2$ sequestration exceeds emissions

http://mingled.co.uk/designs/carbonfootprint.htm
Calvin College Carbon Emissions

- Building Energy Use: 22,781 tCO$_2$/year
- Transport: 1,756 tCO$_2$/year
- Land: 1,134 tCO$_2$/year
- Construction: 258 tCO$_2$/year
- Waste: 42,000 tCO$_2$/year

(Data from CCCN Project)
Calvin College Emissions Details

- Building Energy Use: 42,000 tCO₂e/year
- Transport: 22,781 tCO₂e/year
- Other: 14,839 tCO₂e/year
- Commuting: 5,852 tCO₂e/year
- Air: 2,090 tCO₂e/year
- Service Vehicles: 10,080 tCO₂e/year
- Electricity: 31,920 tCO₂e/year

(Data from CCCN Project)
Calvin College Sequestration

Metric Tons CO₂ Sequestered/year (Data from CCCN Project)

- Maintained Lawn: 21.7 metric tons
- Shrub: 9.4 metric tons
- Mature Forest: 8.2 metric tons
- Edge: 5.8 metric tons
- Prairie Grassland: 10.1 metric tons
Calvin College Carbon Footprint

Emission
67,929 tCO₂/year

Sequestration
55 tCO₂/year

(Data from CCCN Project)
Calvin’s Carbon Footprint

**Emission**
- Transport: 22,781 tCO₂/year
- Building Energy: 42,000 tCO₂/year
- Other: 3,148 tCO₂/year

**Total Emission**: 67,929 tCO₂/year

(Data from CCCN Project)

**Sequestration**: 55 tCO₂/year
Carbon Neutrality Action Plan
# Analysis of Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Cost</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly EV gift for students</td>
<td>$240,000.00</td>
<td>$17,454.55</td>
</tr>
<tr>
<td>Calvin owned bikes</td>
<td>$80,000.00</td>
<td>$7,575.76</td>
</tr>
<tr>
<td>Adding Lake Dr. Bike lane and path</td>
<td>$3,000.00</td>
<td>$2,385.38</td>
</tr>
<tr>
<td>Full Rapid Subsidization</td>
<td>$21,000.00</td>
<td>$1,407.00</td>
</tr>
<tr>
<td>Renewable Energy Production</td>
<td>$94,492.00</td>
<td>$358.53</td>
</tr>
<tr>
<td>Green Energy purchase*</td>
<td>$820,000.00</td>
<td>$76.00</td>
</tr>
<tr>
<td>Carbon Offset purchase</td>
<td>$724,000.00</td>
<td>$37.00</td>
</tr>
<tr>
<td>Temperature Drop</td>
<td>$172,000,000</td>
<td>$(48.00)</td>
</tr>
<tr>
<td>Energy commutes with increased miles</td>
<td>$83,000.00</td>
<td>$(122.58)</td>
</tr>
</tbody>
</table>

*Green energy is not completely carbon-neutral.


[http://www.germes-online.com/catalog/26/12/876/121739/sell_glass_tube_thermometer.html](http://www.germes-online.com/catalog/26/12/876/121739/sell_glass_tube_thermometer.html)
Action Plan

- Increase awareness
- $ savings from efficiency gains

- Renewable generation
- Purchase offsets

CCCN Impacts

• First footprint assessment

• First time administration envisioned the difficulty of carbon neutrality

• Jordan: “I now believe that mere technical advances cannot alter the course on which we are heading. I believe that if there is any hope for achieving carbon neutrality, major lifestyle changes need to be made.”
Carbon Emissions Trading Simulation (CETS) (Personal Level of Inquiry)
Definitions

• Carbon credit: a permit to emit CO$_2$
• Carbon market: a place to trade carbon credits
Carbon Emissions Trading Simulation (CETS)

- Model cap-and-trade carbon market
- Daily activities assigned point values
- Students (and profs) track behaviors
- Emission credits traded on a “market”
- Market winners fund pizza party
- v1: activity-based: generated by profs
- v2: students applied CCCN learning to develop new (mass based) credit values
<table>
<thead>
<tr>
<th>Credits</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Ride in a car on a one-way trip anywhere: to campus, to the store, home, etc. (Two people in same car retires one credit per person.)</td>
</tr>
<tr>
<td>1</td>
<td>Watch TV for an hour. (Two people watching the same TV retires 0.5 credits per person.)</td>
</tr>
<tr>
<td>6</td>
<td>Operate air-conditioning in your house for a day. (No pro-rating for housemates.)</td>
</tr>
<tr>
<td>4</td>
<td>Operate the furnace in your house for a day. (No pro-rating for housemates.)</td>
</tr>
<tr>
<td>1</td>
<td>Eat a piece of fruit grown outside Michigan</td>
</tr>
<tr>
<td>1</td>
<td>Use or leave a computer on for 2 hours</td>
</tr>
<tr>
<td>Credits</td>
<td>Activity</td>
</tr>
<tr>
<td>---------</td>
<td>------------------------------------------------------------</td>
</tr>
<tr>
<td>40</td>
<td>Consume 1 gallon of unleaded gas in a car</td>
</tr>
<tr>
<td>1</td>
<td>Watch TV (2 hr)</td>
</tr>
<tr>
<td>1</td>
<td>Play video game (1 hr. includes having TV on)</td>
</tr>
<tr>
<td>80</td>
<td>Operate AC (1 day)</td>
</tr>
<tr>
<td>40</td>
<td>Operate Furnace (1 day)</td>
</tr>
<tr>
<td>4</td>
<td>Eat a piece of fruit from outside Michigan</td>
</tr>
<tr>
<td>40</td>
<td>Eat meat (1 lb beef)</td>
</tr>
<tr>
<td>1</td>
<td>Use or leave a computer on (2 hr)</td>
</tr>
<tr>
<td>12</td>
<td>50 lbs trash</td>
</tr>
<tr>
<td>14</td>
<td>Machine dry clothes</td>
</tr>
<tr>
<td>-10</td>
<td>Install fluorescent light bulbs (saved per light bulb)</td>
</tr>
<tr>
<td>100</td>
<td>Plant a tree (2 ft tall) linear scale: 1 ft = -50 credits</td>
</tr>
</tbody>
</table>
CETS v2 Results

**Credits Retired**

- Carbon Credits on the y-axis.
- Date on the x-axis.
- A trend line showing an increase over time.

**Credits Sold**

- Carbon Credits on the y-axis.
- Date on the x-axis.
- A trend line showing a peak at a specific date with fluctuations around it.
Market Behaviors

- Panic (end of v2)
- Speculation (may I buy now and sell later?)
- Insider trading (professor)
- Claims of injustice (commuters)
- Behavior awareness (“Accounting systems change behavior”)
CETS Impacts

- Walked, ran, biked, and carpooled more
- Watched movies on their computer instead TV
- Watched TV with friends to split the credits
- Delayed laundry until larger loads were possible
- Organized tree planting activities
- Chose to eat locally-grown fruit when possible
Surprises and Lessons Learned
Surprises

- Flawed expectations
  - Carbon neutrality would be easy
  - Carbon neutrality could be achieved by planting more trees
- Disciplinary biases already deeply entrenched among students
Challenges and Joys

• Getting biologists and engineers to work together!
• Inter-group communication (units)
• Managing student frustration levels on an open-ended project
• Seeing “weaker” students excel
• Learning with students
• Moving from assignment to responsibility
From Assignment to Responsibility

• Student names were attached to the project

• Results were very public
  • Poster session
  • Campus-wide seminar
  • Final report posted online

• Big project that attracted attention

• Administrative involvement
Institutional Effects

• “Creation Care” res. floor: Jess is resident assistant

• Ecological mitigation activities: Peter employed as project manager

• Led to
  • “Focus the Nation” activities
  • First-ever Sustainability Summit
  • Sustainability Coordinator faculty release time
  • Calvin Energy Efficiency Fund
Lessons Learned

• Christina: “Engineers viewed the situation as a problem that we are to find a solution for. The biologists viewed it as a learning opportunity. [Biologists] viewed it as an opportunity to get the public to see the effect they are having on the environment. I think both views are important.”

• Adebo: “Through cooperation between classes, I realized more that reducing carbon emissions will require an effort from all fields, not just engineering… The lesson I learned from [the biologists] is that coming up with a solution to a problem does not entirely depend on calculations. In my opinion, the biologists came up with more creative ideas on how to make Calvin’s campus carbon neutral.”
Conclusion
Conclusion

• Campus carbon neutrality is a potent educational tool

• Pedagogy: Provided a interdisciplinary science division service learning opportunity for students to engage a “grand challenge” issue on several levels of inquiry.

• Sustainability: Helped institution to envision what a sustainable future might entail.
Acknowledgements

- Students of BIOL354 and ENGR333
- Paul Pennock, Physical Plant
- Chuck Holwerda, Electronics Shop Technician
Further Information

- Carbon Neutrality Report
  http://www.calvin.edu/~mkh2

- Statement on Sustainability
  http://www.calvin.edu/admin/provost/environmental/sustainabilitystatement.html