TEACHING A COURSE "TECHNOLOGY AND ENERGY AROUND YOU"

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Abstract: An emerging introductory interdisciplinary course, in which students are introduced to the technology and energy needs they experience everyday, is described.

The university community as a small city has been considered for study by students. The cooperation between various university constituents allows students direct access to the facilities to see some of their principles implemented into action facilitating the next step in the process, analyzing the resulting improvements. This cooperative effort creates a mutually beneficial situation where students gain access to the data and knowledge of the facilities personnel; while the facilities personnel gain access to the results, of the course studies, as possible directions for future action in sustainable efforts.

The emerging course focuses on introducing students to the technology and energy use of the university. This includes the space and resource needs of the community through the resource consumption modalities, particularly air conditioning, lighting, fresh air, potable water, non-potable water and safety requirements at all levels in the hierarchical university system. Physico-chemical and biological principles of utilities are explained from the very beginning.

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1. MOTIVATION

Sustainable design and development is not a single topic to be covered as a section in a single lecture course. It is a cross disciplinary mindset that must be developed over a series of courses reinforcing the ideas of lowering the impact of designs from cradle to grave. (Azapagic, 2009; Ray, 2009) Courses are emerging that immerse students in sustainable use and design. The concepts of sustainability are being introduced in these courses through lectures into energy production and consumption and followed by contrived case studies to demonstrate teachable points. (Evans, 2009; Azapagic, 2009) The course being developed uses this framework as a starting point, but rather than contrive cases or use historic cases this course reaches out to the facilities staff at the host institution to develop cases based on current and future efforts that are local to the institution. By developing cases in this manor the students have first hand access to the data sources and can participate in the process from identification through final design installation. Through this interaction of students with facilities personnel on local case studies of energy usage students are introduced to the technology and energy needs they experience every day.

2. PEDAGOGICAL FRAMEWORK

Students come to campus generally never having paid a utility bill, purchased an appliance, or priced a structure repair/remodel. They generally have no experience in where energy and resources are consumed, saved, and wasted. This course begins by opening the student's minds to where energy and resources come from, how they arrive at the university, what they are used for by the university, what by-products are generated by their consumption, and what is done with these by-products. After introducing the resource flow within the university the course focuses on the interaction of these local resource flows within the global resource markets. The course spends some time discussing the effects in disruptions in the interactions between the local and global resource flows and forces students to develop plans for lifestyle sustainment.
Using local resource flow has an advantage in that information and cases can be obtained from within the university. Working closely with the facilities manager we have been able to obtain information on resource usage, broken down by hour in some cases, to tour the facilities spaces in the building, and to have access to the support personnel that maintain the systems. Students benefit by having a direct line of contact to the people that know the answers when questions come up.

The benefit of cooperating with local facilities managers to develop discussion topics and ideas is not a one way aid. The facilities managers have the opportunity to pose problems they are currently tasked with solving to an entire class of engineering students. This leads to a number of different approaches being investigated without requiring time and effort from the facilities department.

This course is structured as a standard lecture course. It will have three 50 minute sessions scheduled each week for 15 weeks. These lectures will be replaced with discussion sessions with the facilities department, field trips to in place infrastructure and project work sessions as necessary throughout the semester.

3. RESOURCES AND TECHNOLOGY WITHIN THE LOCAL UNIVERSITY

Most universities are setup much the same as a small city. They have areas divided into residential, office space, medical, recreational, food service, and retail. Each of these spaces has a different set of resource needs and operational parameters. When generating a sustainable plan of operation for such a diverse collection of spaces there is no overriding norm. The resource utilization, access, and self sustainability all differ widely.

Saint Louis University is not unlike other medium sized universities. It has 128 buildings on 234 acres of land. These buildings have 5.2 million square feet of space divided amongst: Academic, Office, Residential, Retail, Medical, Athletic, Museums, and Theatres. There is an additional 1.5 million square feet of parking. This space is home to 12,000 students and a workforce of 5600 employees. Just like any city these spaces have varying hours of operation and function.
The main focus of this course is not on innovation but on making better use of available technology and resources. This course is targeted at early undergraduates to expose them to sources, transportation, storage, usage and by-product production of resources. The students will be exposed to current and emerging techniques and technology that can be used to stabilize the current system of resource delivery and usage. They will also develop ideas to become more self sufficient in the case of resource disruption.

This course will be project and case based with most of the case material being drawn from interactions with the facilities department of the university. Drawing material from the local facilities department gives the faculty and students direct access to the material being studied. Tours of the facilities being studied can be taken, material can be obtained about the facilities with a phone call, and any innovations developed during the class can be directly implemented under the observation of the students.

3.1 Principles of resource creation, distribution and consumption

This lesson will concentrate on where energy is generated, how energy is delivered and how energy is consumed. The first part of this lesson will concentrate on electricity and natural gas as sources of energy. The campus has a primary transformer that supplies electricity to 30 buildings. This will be treated as the entry point for all electricity in the study. The Physico-chemical and biological principles of energy generation from raw resources will be introduced as a starting point for further discussions on efficiency.

The second part of this lesson will concentrate on potable water. It will discuss where city water is gathered, how it is treated to be potable, how it is delivered, and what happens to it when it leaves the university. This lesson will use one of the public restrooms as the focal point for the study. This has been choose as a place where fresh water is required for hand washing and drinking and non-potable water is required for sanitary reasons. This complex interaction of multiple supply and waste streams forms a nice topic for study.

3.2 Resource Flow Studies

Table 1 shows an initial listing of the resource consumed, the activities these resources support and the by-products produced by these activities at a typical university. A list like this is the starting point for discussions of self sufficiency and sustainability. Once students have an understanding of what resources are required for daily activities and what by-products these activities produce, students can engage in discussions of how to reduce consumption and how to plan for shortages.

Resource	Activity/Use	By-Products
Power	Lighting	Recyclable Trash
Electricity	Heat/Cool	Non-Recyclable Trash
Heating Fuel	Travel	Excess Heat
Automotive Fuel	Cooking	Combustion By-Products
	Powering Technology	Sanitary Waste
Water		
Potable	Lawn Watering	
Non-Potable	Thirst	
	Hunger	
Food	Resource Preservation/Storage	
Perishable	Sanitation	
Non-Perishable		
Cooking Oil		

Table 1: Resource flow for typical university

Once the students have a firm understanding of what resources are used by the university the course will progress to study the effects of shortages in one or more resources. Most students will have experienced brief outages of electricity or short term boil orders for water, but most will have no experience to draw from on planning for prolonged loss of a resource. Even the developed nature of North America does not preclude the chance of losing of one or more resources for a prolonged period of time. Several occurrences in the past five years have shown that loss of electricity for a week or more is a very real possibility, and failure to plan for these occurrences can lead to significant loss of lifestyle.

The course will study how loss of one resource can lead to complete collapse of local sustainability without the proper forethought. During a wide spread loss of electricity, like the North East black out of 2003 and the primary transformer failure at Saint Louis University in the summer of 2006, leads to loss of refrigeration leading to the loss of perishable food. It leads to the closing of stores and an inability to purchase items such as food and gasoline. It leads to an inability to operate most residential heating and air conditioning. It leads to a collapse of communications systems. This lesson is intended to instil in the students ideas of how to be completely self sufficient for at least a week to be able to ride out short term disruption in resource supply.

One plan for being self sufficient is to reduce the resources that are consumed on a regular basis. This lesson discusses that learning to use a smaller amount of resources makes planning for resource interruption easier. It also discusses that reduction in certain resources allows for complete autonomy in that resource. Households that that can reduce their electricity usage below the amount that can be generated through solar and wind sources can not only be completely autonomous but they can trade excess in their electrical power for other resources that cannot be supplied autonomously.

The discussions of resource consumption culminate in a lesson that demonstrates the resource cost of daily activities. In this lesson the students go through a series of brain storming and discussion exercises to develop an approximation of the total resource cost of holding that 50 minute lecture.

3.3 Technology Dependence Studies

The course is planned to have a lesson on why technology is becoming so prevalent in our society and the dangers of relying too heavily on technology. This discussion will start with a demonstration of the students own reliance on their calculators and cell phones as a crutch to daily life and proceed through how too high a reliance on technology can lead to the crashing of localized society during resource outage. One example to be discussed is the failure of the primary computing infrastructure at Saint Louis University in 2004. This collapse was due to primary, backup and secondary electrical failure in the server room and led to the loss of primary computing resource for more than a week.

After introducing this example, the class will analyze those systems on campus that have the potential to collapse resulting in loss of intended use of campus facilities. Part of this study will include the identification of those technologies that are mission critical to the studied facilities and development of plans to maintain those critical technologies in a method that is self contained to resources local to the university.

During the identification of critical technologies the student will be asked to identify why those critical technologies are in use even though their loss would result in the loss of use of the facility. This investigation will walk the students through a learning experience that efficiency gains beyond a certain level are obtained though monitoring and online control of the systems. This monitoring and online control requires a certain level of technology.

3.4 Study of Local Disruption cause by External Interactions

Many times, disruption in local supply of resources is caused by events that are not related to events happening at the university. Studying where resources come from and the forces that can cause disruptions at the source of the resources will give the students an appreciation as to how world events cause ripples in supply chains that may not be seen locally for months or years. This type of interaction is easy to see in gasoline supply and price in the Midwest. When a hurricane approaches the Texas, Louisianan coast and off shore oil platforms are taken off line the price of gasoline in the Midwest climbs even though any actual shortage in oil will not be realized for over a month.

This study will investigate how improving efficiency in supply chains makes those supply chains less able to handle disruptions in resources. A supply chain that is operating under the mantra of just in time delivery is the most efficient due to lack of having capitol tied up in stored resources. However a one day stoppage in the supply chain can cause unexpected resource shortages down stream due to the just in time delivery of raw resources failing. An example of this that can be studied in the course is interruption in local food supply. During breaks the campus closes its restaurants and cafeterias, foreign students that remain on campus have difficulties finding food due to lack of knowledge of additional sources of this resource.

4. FIRST COMPLETED DESIGN CASE

As a first interaction between students in a course and facilities individuals we chose to do an energy audit with suggested upgrades to the Olive Compton Garage on the Saint Louis University Campus. The student involvement in this project was facilitated through a portion of a capstone experience in sustainable energy. As part of their capstone project three students performed an energy audit, suggested upgrades to the lights, and built a system that would allow some of the lights to be turned off during day light hours.

When the Olive-Compton garage at Saint Louis University started, the garage had 550 186-Watt high pressure sodium lights. For security reasons these lights were kept on all the time. The student energy audit used this 2455.2 kWh per day as the starting point in their energy audit. The students experimented with different lights and determined that an 84-Watt compact florescent light would make a suitable replacement. The compact florescent light chosen metered at a lower light output, but due to it being light with a high color temperature people surveyed reported more useful light being present. The students then found components to construct a light harvesting system to enable 150 lights to be turned off for an average of 4 hours per day and an additional 150 lights to be turned off for 2 hours a day. A nice follow on study to the garage project will be to determine how many lights are needed for security during a power failure and to design a backup system for that amount of lighting that is self sufficient for 10 days of operation.

Changing the lights to compact florescent has saved 1346.4 kWh per day and the light harvesting is saving an additional 75.6 kWh per day. This project generated several pieces of knowledge that the participating students and faculty will take forward to other projects. Even security lighting in a garage setting can consume more electricity in a day than the average house does in a month. Designing with the correct color temperature light at the correct level can cut energy usage by more than 50%. The students gained further knowledge by producing installation instructions for their light harvesting and seeing the project installed.

On the success of this initial project we are trying several studies in a sustainable energy course this semester. These projects are all feasible studies that may turn into larger capstone projects in the future. These projects include: a feasibility study to convert used cooking oil into fuel oil for either heating or vehicle use, a study of potential costs and savings of converting a campus building to ground source heat pump for HVAC, a study of using solar heating for the indoor swimming pool, and a benefits study of adding power factor correction to the large inductive loads associated with the HVAC systems on campus. The sustainable power course is currently auditing the electrical usage of the engineering building and suggesting upgrades to become more autonomous and sustainable. These upgrade investigations include replacing architectural lighting with compact florescent or LED lights, adding occupational sensors for lighting control in public areas, and offsetting grid electricity with photovoltaic and wind generated electricity.

5. CONCLUSIONS AND FUTURE ACTIVITIES

In this paper we have outlined the flow of an introductory course which introduces students to their everyday technology and energy needs. Describing the university as a small city and then drawing study examples from this description is mutually beneficial for the students, the instructor, and the facilities managers. Cases drawn from local sources are accessible, relevant, and have results that are immediately implementable.

Future activities for the course include studying the use of energy star appliances, plate exchangers, daylight harvesting sensors, and compact fluorescents. Other possible future activities for the course include investigation of energetic improvement to the University campus through such innovations as solar panels, wind mills, and clean coal stations; and water/energy saving via new technological solutions (e.g. water saving shower heads).

6. REFERENCES

Evans, Geoffrey, Introducing Simple Sustainability Principles to Chemical Engineering Students, 8th World Congress of Chemical Engineering, Montreal, Quebec, 2009.

Azapagic, Adisa, Integrating Sustainable Development into Chemical Engineering Curriculum Enquiry-Based Learning, 8th World Congress of Chemical Engineering, Montreal, Quebec, 2009.

Ray, Ajay K., Green Process Engineer: A New Undergraduate Program at University of Western Ontario, 8th World Congress of Chemical Engineering, Montreal, Quebec, 2009.