Energy Awareness Efforts at Baylor University

Abstract

Understanding energy, where it comes from, and how it is used, will become increasingly important in the future. At Baylor University, the authors have undertaken two efforts to help the public and students become more energy literate.

The authors received a grant in 2007 to develop an "Energy Room" at the Mayborn Museum on the Baylor campus. The Mayborn Museum is a facility that "provides a wide spectrum of learning opportunities to engage all types of visitors." A grid-tie solar photovoltaic system and a small wind turbine were installed by seniors on the roof of the museum in the spring of 2007. Controls for these components, along with a demonstration wind turbine, exterior wall and window displays, and instrumentation will be part of the public exhibit. The paper details these elements and the student involvement in their construction.

A second effort is the creation of an energy literacy class for incoming freshmen. This class was created as part of Baylor University's Quality Enhancement Plan (QEP) presented to the Southern Association of Colleges and Schools (SACS). Faculty were given the opportunity to develop residential learning communities for incoming freshmen that revolve around a theme. The topic of energy, and its associated societal, political, environmental and economic threads, was submitted by the authors and eventually selected for development into a course that is being offered for the first time last fall. A total of 28 freshmen from a wide diversity of disciplines voluntarily signed up for the course and will remain in it for up to four consecutive semesters. The paper examines the structure of this course and our assessment goals.

The Case for Energy Education

People often assume that energy will always exist in forms and quantities inexpensive enough to satisfy personal uses. Today, it seems there is enough gas at the pumps so cars can have full tanks, electricity is almost always there to power lights and computers, and thermostats can be set to just about any comfortable temperature. Therefore, little thought is given to the abundance of these resources or the likelihood of these resources being available in the years to come. Industrialized society takes energy for granted.[1,2,3,4,5] However, just under the surface lies a great need for people to be informed about energy and its uses, from politicians who govern our energy industry to the average consumer[6].

Desperately needed are educational initiatives with a balance of technical and social content. This need for energy education is the fundamental motivation for the energy awareness efforts at Baylor University. According to the National Energy Policy[7], the U. S. must have between 1,300 and 1,900 new electricity generation plants in place to meet the projected 45% increase in electrical demand by the year 2020. Economic and political policies often reflect the unspoken assumption that the United States will be able to continually increase its reliance on natural resources and more importantly, energy resources. On May 2, 2007, a local newspaper editor took time to remind the public of the energy history of the United States in the past few decades[8].

He remembered the 1973 Arab oil embargo and how gasoline prices skyrocketed. He pointed out that every president from Nixon onward has used the government to attempt to regulate energy or to deregulate energy. Goals for energy independence have continually slipped since the term first appeared in 1980. With plentiful supplies, efficiency standards for cars have been often relaxed or postponed. By avoiding the topic of energy and delaying discussion until the future, the public does not perceive the impending problem of dwindling energy supplies. The problem may actually get worse[6]. The editor has no solution to the energy supply problem other than, "We have to do more." The public often has the impression that more technology is the answer and that technology will always provide the solution[9]. Again, this is why energy education is so necessary today. The U.S., which is the number one consumer of energy in the world, is often looked to for leadership. If the United States can't identify, acknowledge, and then educate its people about the problems of energy, then it may be unrealistic to expect China's emerging economy to have any consideration for energy usage and the impact of irresponsible energy usage on the global environment.

There is a need to gather information and assess the facts concerning energy; however, much of what the public sees from mainstream media is terribly difficult to sort out. For example, sensationalized headlines appear almost daily on the effects of global warming. USA Today posted an article in January, 2007, that illustrates the uncertainties in what media outlets report[10]. The article addressed the possible consequences of global warming and its impact on the melting of polar ice. The U.N. Panel on Climate Change warned that by 2100 the sea level could rise from 5 to 23 inches, while an article in Science predicted a rise of 20 to 55 inches in the same time period. James Hansen, a NASA climate expert predicts even larger sea level rises. Michael McCarthy, an environmental editor for TerraNature published a web article in February 2007 which predicted a 6.4^{o}C rise in average global temperature by the end of the century[11]. Mark Lynas, of the same online journal, published an article warning that this rise in temperature will bring about the extinction of most life as we know it including man[12]. More recently there is speculation that green house gasses are not to blame for global warming – the sun and sunspot intensities might be causing the effect[13].

Needless to say, there are many issues surrounding global warming that are not resolved. Global warming, though, is just one energy-related area where people find themselves ill-quipped to know what to believe. A survey conducted by the National Environmental Education and Training Foundation (NEETF) finds that people are often bewildered, or worse yet, may choose to ignore information because it is deemed "too complex" to understand[6]. Certainly, we should expect college graduates to be able to ask the right questions and then evaluate the answers they receive, but in the area of energy usage, Americans are clearly at a disadvantage. According to the NEETF survey, only 12 % of Americans correctly answered seven or more questions on a basic energy knowledge test[6]. Questions about trends in electrical energy generation, gas mileage for cars, and which sector of the economy uses the most energy were often answered incorrectly. Ironically, however, the survey finds that people often overestimate their energy knowledge. Clearly, this is an inconsistency that must be remedied through intensified educational efforts.

Successive generations will have to ask tough questions regarding energy[9,14] and then have the knowledge base with which to make wise decisions. The authors are advocating a concept termed *energy literacy* and are proposing to address a national need by developing energy literate students from all disciplines on the Baylor campus. But how is energy education best accomplished?

Several organizations are also advocating energy literacy; including the Energy Literacy Project, the organization for National Energy Education Development, the Energy Information Administration, the National Energy Foundation and the NEETF. The general consensus of these organizations is that energy education is much needed. Unfortunately, while these organizations provide some resources, they do not seem to have a large impact on the problem. An individual must be motivated to seek them out, implying that that person's interest has already been captured.

At the university level, the problem of energy literacy is being addressed in several areas. The first area addresses materials and teaching expertise for K-12 teachers[15,16,17]. Another idea is to include energy topics in courses that are already being conducted, such as thermodynamics, heat transfer and fluid mechanics[18,19,20,21]. Other courses have been specifically developed as electives to address specialized topic areas[22,23]. Still other courses emphasize service learning[24,25,26]. Nevertheless, the state of energy education in higher education is dismal. For example, in 2001, one study found only 10 four-year colleges or universities regularly offering a solar energy course[27]. The energy education picture is likely somewhat better today, though we do not know how much better.

While all of these curricula address energy, most only deal with one aspect of energy, presenting either advanced technical engineering material (e.g. how electricity is generated) or purely social content (e.g. policy regarding energy usage). The same study[27] found a pressing need for energy courses that are accessible and available to non-technical majors, observing, "Bankers and other professionals are very important in achieving increased use of [alternative energy]; however, they are perhaps the least familiar with energy systems." The authors are attempting to integrate both: to teach basic technical knowledge about energy and simultaneously to examine the social, political, and economic impact of energy-related decisions. Not only do engineers and scientists need to be smart concerning energy, but so do politicians, business professionals, journalists and homemakers. Everyone will eventually engage energy issues on several levels – in personal financial decisions, as part of a local workforce consuming energy to provide a good or service to society, and as one member of the global population bearing the impact of energy on world environments and economies.

One additional interesting reason to promote holistic energy education was found in a recent interview with Arizona State University president Michael Crow of ASU's new School of Sustainability,

> One of our reasons for doing this is we are failing in finding ways to teach science – and one of the reasons is that we are teaching science the way scientists think about science, and nine-tenths of the population can't get it. When you ask how to get them more interested, they always say, give them a context[28].

While a study of whether students learn science better with context is beyond the scope of this paper, Dr. Crow was clearly inferring that sustainability – and by association, energy – is a relevant topic that can spark interest in the study of rather dry but important topics in science and engineering. And where better to generate interest than at the very beginning, when freshman are still forming their view of the academic process, the relevance of their professors and coursework, and their potential career paths? This is the context of the two projects described in this paper.

The Museum Project

The Museum Project began as an idea to build and install a laboratory exhibit in the Mayborn Museum focusing on alternative and renewable energy. The museum is a great place where children of all ages can come and learn in a warm, friendly environment.[29] The Discovery Center, a part of the museum, has 16 hands-on discovery rooms for interactive education. One of these rooms, the Energy Room, will house the permanent exhibit described in this paper. A proposal was made to a local foundation, the Baylor/Waco Foundation, which adopted and funded the project. The concept behind the final project was to target three distinct demographics to help them learn more about energy in unique ways. For young children, there will be interactive hands-on elements that illustrate principals of alternative energy sources in action: photovoltaic (i.e. solar electricity), thermal (i.e. solar air and water heating), and wind. This exhibit will also appeal to junior and senior high students, an audience the museum wants to build, by revealing and explaining certain technical details of the exhibit. Lastly, the exhibit will serve as a laboratory for engineering students studying alternative and renewable energy at both the high school and college level. The exhibit will have a small photovoltaic system which was installed on the roof of Museum, powering a grid-tied DC-to-AC inverter that will feed electricity into the Museum's electrical system. Details of this installation will be visible to Museum patrons. Student branches of engineering service organizations including the American Society of Mechanical Engineers (ASME) and the Institute for Electrical and Electronics Engineers (IEEE) will assume responsibility for docent training and occasional demonstrations and lectures for visitors.

The National Energy Policy explains that the present geopolitical climate, combined with the dwindling discovery of new petroleum resources, will gradually force America to build and use renewable energy facilities in a widespread manner. Energy usage and costs touch all of us, and people can become quite excited about alternative and renewable energy when they can see and understand how it can be harnessed in their homes, farms and businesses (as well as by large power companies). Unfortunately, in our region there are virtually no working residential renewable energy installations, and only a handful of commercial installations. This sharply contrasts with neighboring cities to the north and south, in which a cadre of small businesses install thousands of solar pool, water, photovoltaic and wind systems each year.

Additionally, public education and awareness of other energy-related issues can immediately help people to make better decisions about energy usage and efficiency. The exhibit will feature a "mock house," allowing illustration of the energy impact of lighting, heating, air-conditioning, and appliances as well as the true costs and value of energy. The proposed project represents the first step in a larger vision for comprehensive energy education at the Mayborn Museum, eventually including alternative fuels, fuel cells, large-scale power generation, and transportation. As a functional laboratory, new technologies can be adapted and tested with the results becoming part of the exhibit. The Mayborn Museum provides an outstanding venue to stage the results.

Construction of the Wind and Solar Exhibits for the Mayborn Museum

The wind and solar exhibits for the museum were constructed as part of the senior capstone design class. "Senior Engineering Design II" is divided into sections of between 10 and 30 engineers of all disciplines. Each section is organized into a "company," with a project manager, departments and department heads, a budget and a project client. In this case, the Museum served as the client. The company was tasked to design and install, if possible, (1) a 1.1 kW (peak) photovoltaic (PV) array on the Museum roof, including a mounting structure to withstand 80mph straight-line winds, (2) a mounting structure for a small Sevonious-type wind turbine, (3) a grid-tie DC/AC inverter system with NEC-compliant disconnects and power meter, and (4) two embedded Ethernet controllers to report PV and turbine power statistics across the web and visually, in the exhibit area.

The class successfully met these requirements. Figures 1 through 3 illustrate several components. At present, various parts of the public exhibit are still under construction, so the rooftop PV and turbine have not been commissioned yet.

Figure 1. Students pose for a picture after installing six BP7185 185W (peak) PV modules and a powder-coated steel mounting structure on the Museum's standing-seam roof.

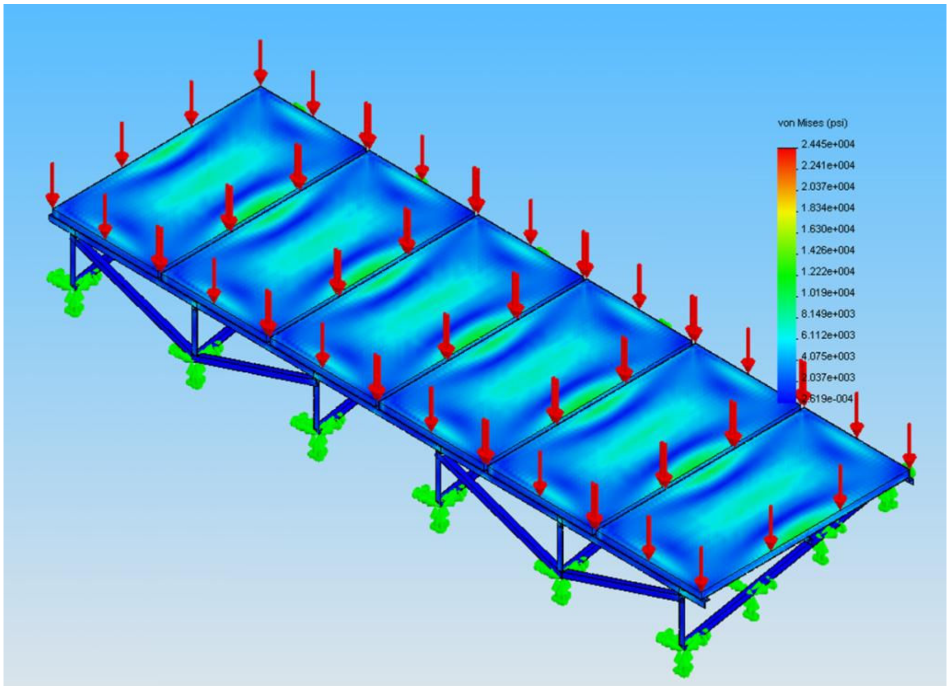

Figure 2. The PV rack system in SolidWorks, illustrating stresses from wind loading.

Figure 3. Two embedded Ethernet controllers with Power-Over-Ethernet (POE) capability, for reporting power statistics for the roof-top PV and turbine.

Construction of Energy Exhibits for the "Mock House"

The energy displays for the "mock house" were constructed as part of the senior mechanical engineering laboratory course, working closely with the Museum staff. Two separate projects were undertaken by two teams consisting of three students each. The first team had the responsibility of developing an interactive wind turbine demonstrator that would be displayed on the floor of the Energy Room. This demonstrator has an operational wind turbine that would enable young children to visually observe that an increase in power correlates with an increase in wind speed. The concept was to develop a vertically mounted wind turbine in a Plexiglas case. The Plexiglas case was constructed on top of a base supplied by the museum staff. Housed in the base is a three speed squirrel cage blower that pulls air in from below the base. Because of the size of the case, air is directed from the blower to the wind turbine through a Plexiglas duct inside the case. On the front of the case are three buttons; a green, yellow and red. Each button corresponds to one of the three fan speeds with green being the lowest and red being the highest speed. As the buttons are pushed, the operator is able to visually see the speed of the wind turbine increase. Corresponding to the increase in speed is an increase in power output of the wind turbine. A small microcontroller measures the power output of the turbine, and operates an LED array to visually indicate the output power. Incorporated into the activation of the blower is a timer circuit so the fan does not operate continuously. Airflow exits out the top of the unit into the room. A screen covers the top of the unit so that unwanted objects cannot be thrown in the interior of the unit.

Figure 4. Wind Turbine Demonstrator

The second group developed and tested the demonstrations that will be a part of the Energy Room. Specifically, they designed a comparison experiment for different types of wall insulation. Small sample walls were constructed and filled with insulation materials. These wall units were instrumented with thermocouples to measure the temperature change across the

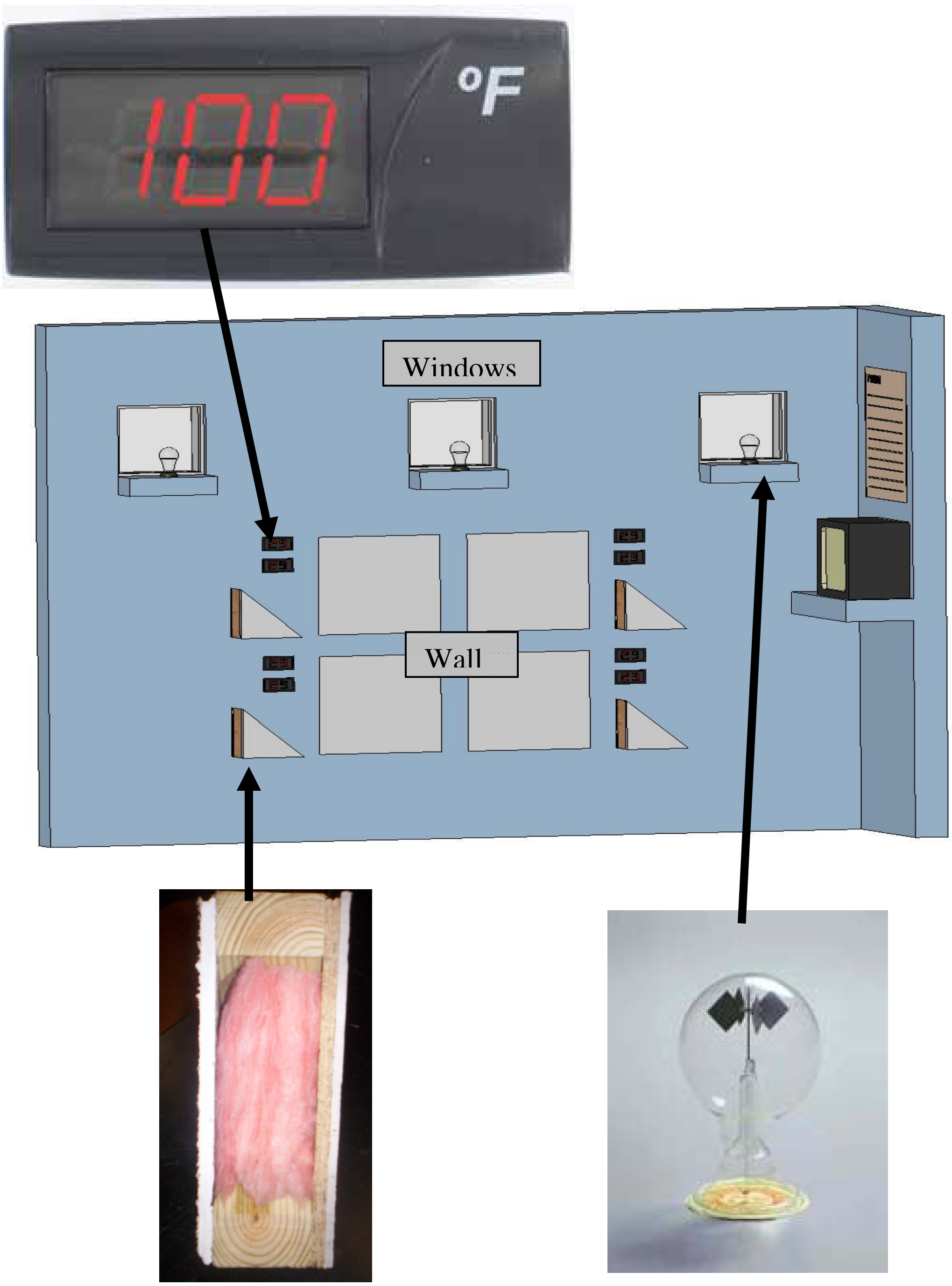

Figure 5. Wall with Displays for Energy Room

insulations. Fiberglass, foam, cellulose and an uninsulated control wall were tested. Digital displays were purchased so that a temperature difference across each wall will be visible for visitors to compare. A heat lamp was used to irradiate one side of the wall. It was also desired to compare different types of windows. Small windows were also purchased and instrumented with thermocouples. One window is double pane, another is double pane with a Low-E coating, and third is a single pane window. Again, each window is irradiated and temperatures are measured. A visual display for the amount of energy transmitted through the windows is found by using a radiometer, a device that spins faster when more energy is incident on its paddles. Both the wall samples and windows will be incorporated into a sample wall that is being constructed in the Energy Room (see Figures 4 through 7). At this point in time, the sample wall is still under construction.

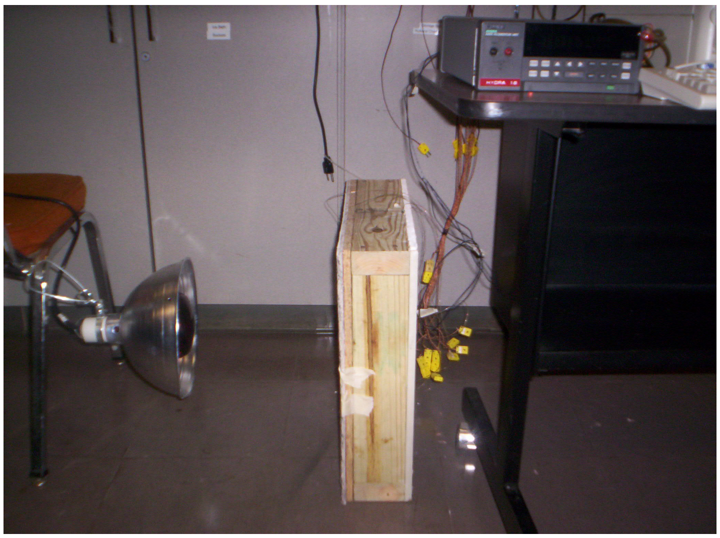

Figure 6. Experimental Wall Setup

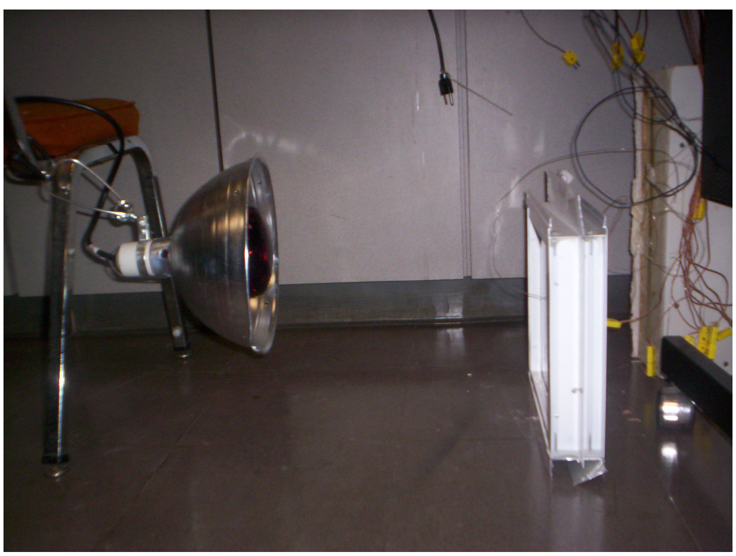

Figure 7. Experimental Window Setup

The Energy and Society Engaged Learning Group

The concept of the *Engaged Learning Group* (ELG) is the novel result of a process tied to Baylor University's re-accreditation under the Southern Association of Colleges and Schools (SACS). The present accreditation guidelines require every SACS school to submit a Quality Enhancement Plan (QEP). Baylor's plan consists of two components, the ELG structure, aimed at freshman and sophomores, and the Undergraduate Research and Scholarly Achievement concept aimed primarily at juniors and seniors.

Three new ELG's commenced in fall 2007. In each, the students initially begin as freshmen and take one semester hour per semester for four semesters. If students complete the required number of semesters, they will receive credit for a course in their major (typically a laboratory science, in the case of the "Energy ELG.") The four semesters roughly adhere to the following topics:

> **Energy Literacy –** This semester began by connecting energy production and consumption with societal and environmental effects. As a foundation, students learned basic unit conversions, calculations for energy values, and the concepts of energy conservation (i.e. the first law of thermodynamics) and efficiency. This seminar also addressed the topics for transition from high school to college. Students wrote a report about some aspect of energy usage, production, etc. that interests them.
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> **Energy Production –** This semester will expose students to energy conversion from fossil fuel, nuclear, solar, thermal, photovoltaic, fuel cell, hydro, alternative fuel, and wind sources. Students will explore how energy is used in sectors such as transportation, housing/HVAC, electronics, agriculture, and industry. Students will also write and research an energy-related scientific hypothesis, e.g. fuel derived from a given source will create net-positive revenue after X years and Y dollars invested; building Z will reduce its electrical consumption by so much if the following phantom loads are controlled, etc.
>
> **Energy and Society –** In this semester, stewardship and worldview will be the thread that is woven throughout the topics concerning energy, environment and society. This leads to questions concerning energy production and usage, in particular, which energy sources are appropriate for the future. Energy and the environment, politics, economics, and culture will be addressed. The concepts of sustainable and renewable energy will be explored. Teams of students will write formal research proposals based on promising hypotheses from the previous semester
>
> **Energy Research –** This seminar allows the student research teams to investigate a thesis/hypothesis that was developed throughout the previous three seminars. The desire for these seminars is to examine the Baylor University campus as an energy laboratory. They will research topics that could be of significant impact to energy consumption/production and energy economics on campus.

The purpose of the proposed Energy ELG is to give Baylor University students a foundation upon which to build an informed understanding of complex energy issues. With understanding comes the ability to begin answering the questions confronting society. Specifically, the four overarching learning objectives are:

1.) To develop scientific energy literacy;
2.) To closely examine the production and consumption of energy in both developed and developing countries;
3.) To examine the social, political, environmental and ethical problems of an energy-dependent civilization.
4.) Understand, hypothesize, propose and execute a research project in the theme, “The campus as an energy-efficiency and alternative-energy laboratory.”

The burgeoning term “energy literacy” suggests that people exhibit varying degrees of energy knowledge. Many may not fully understand the differences between a BTU and a Calorie, a Watt and a VA, what a KWh is on their electric bill, why there are different grades of gasoline (and what “octane” means), and the foundational place in industrialized civilization of the heat engine. Thus, the central – but not sole – aim of the Energy ELG is to teach the science of energy and therefore to promote energy literacy. The majority of the class time will be spent on objectives 1 and 2, encompassing the science of energy. However, it is objective 3 that makes the science relevant and interesting, and gives it context.

The 4th overarching learning objective concerns undergraduate research. The research theme will be woven throughout the ELG. Its four components – understand, hypothesize, propose and execute – correspond to the four ELG semesters. At the end of semester 1, students will write about an energy-themed topic related to the Baylor Campus, doing “paper” research to back it up. At the end of semester 2, they will defend a hypothesis relating their theme topic to some aspect of energy usage, production, public education, etc., at Baylor. Concluding semester 3, teams will form to write formal proposals to investigate the most viable hypotheses. A $10,000 budget has been set aside to seed the team projects, with the proposed research occurring in the 4th semester. In the section on Assessment, we outline some of the ways in which the student research can be disseminated.

The research theme will support an exciting and independent extracurricular activity. Students will be able to work on topics of their choosing with any professor on campus, with theme writing, proposal writing, speaking and presenting, and independent research all tied together. Topics will vary widely, but example subject areas might be:

- Feasibility of converting campus waste streams into biodiesel, ethanol or methane
- Design of active daylighting systems for campus building
- Passive and active solar designs for new academic buildings
- Energy usage behavior modification studies
- Surveys to estimate student energy literacy
- Cost/benefit business analysis for using alternative energy on campus
- Energy audits for campus sectors such as dormitories, athletic facilities or computing equipment

- Development of curriculum to educate local stakeholders about insulation
- Estimating economic consequences of providing campus hot water via renewable resources

ELG Outcomes and Assessment

In addition to the engagement and participation assessment, the investigators will undertake a learning outcome assessment as part of the proposed project. An outline of the proposed outcomes and assessment methods follows.

Outcome 1: Students will exhibit increased energy literacy. Specifically, students will

- Understand the science behind the principal kinds of energy that drive modern civilizations, e.g. fuels, electricity, heat, wind and solar;
- Be capable of manipulating the basic mathematical expressions that model these energy sources;
- Be capable of manipulating and converting between the numerous units for energy, work and power. Develop a feel for the magnitude of each unit system.

Assessment instruments will be somewhat traditional, consisting of one exam and one comprehensive final per semester and a weekly short quiz. Brief quizzes will be administered at the end of class using a wireless CPS (Classroom Performance System). CPS units permit students to key multiple-choice responses into their personal CPS transmitter, and to view the aggregate responses instantaneously on a projector. Exams will involve handwritten responses.

It is also planned to use an assessment instrument developed by the National Energy Education and Training Foundation (NEETF)[6]. On the subject of "Energy IQ," it asks 10 simple questions, and shows that only 12% of Americans can answer seven or more correctly. NEETF questions will be included in the assessment.

Outcome 2: Students will understand the principal ways in which energy is produced and consumed. To support this outcome, approximately 1/3 of the classroom lecture time, small group discussion and assignments will focus on

- Energy production technologies, including coal, nuclear, hydro and wind generation, fossil and alternative fuels, and advanced topics like photovoltaics and geothermal technologies;
- Energy consumption, including HVAC and buildings, transportation, real and phantom electrical loads, manufacturing, and agriculture.

The majority of field trips (two per semester, one required for each student) will also focus on energy production. To assess this outcome, we will use occasional examination or quiz questions, but we will rely most heavily on writing assignments. The syllabus calls for at least one short paper on some aspect of energy production or consumption every semester.

It is proposed to use "extrinsic information" criterion as our measurement tool. Extrinsic information consists of inferences, observations, or arguments citing knowledge that does not come directly from class lectures and homework. Such knowledge will instead come from group discussion, readings, student research, field trips, extracurricular film screenings, laboratory exercises and other ELG activities.

Outcome 3: Students will understand some of the social, political, environmental and ethical problems associated with modern energy-dependent societies. Leveraging the two previous outcomes (energy literacy and extrinsic information), students will be prepared to articulate and defend an informed position related to the social dimensions of the production and consumption of energy. Students will be able to examine the sustainability of a given energy-related decision or event, estimate its environmental and economic consequences, and participate knowledgeably in America's political process when it relates to the subject of energy. They will be prepared to digest and understand what they see or read about energy in the media, and make informed and beneficial decisions about energy in their own lives. It is proposed to use "value-added assessment" as the principal method to asses whether students are advancing in their understanding of these non-technical issues.

Outcome 4: Students will understand and practice the scientific method through experience with a research project. To reiterate, in each of the four semesters, respectively, students will: research and write about an interesting topic within the broad research theme; develop a hypothesis that links two or more variables in their topic; propose a research plan (including a small budget) to examine the hypothesis; and execute the research plan under faculty guidance. The theme will be "The campus as an energy-efficiency and alternative energy laboratory." There are three principal mechanisms to assess progress.

- Written deliverables, described in the preceding paragraph;
- Final oral report at end of 4th semester;
- Survey of faculty research advisors.

Assessment will be designed to illuminate four corresponding questions: can the students understand a problem (develop a well-formed inquiry), hypothesize an answer or outcome, prepare a plan to discover that answer or outcome, and execute the plan? It is difficult to quantify how well students have learned the inquiry-discovery process because sometimes research fails or produces mundane results. However, that does not imply the student has failed. Therefore, we will score this outcome on a somewhat courser scale of 1 (poor) to 5 (excellent) assigning a score to each of the four areas – inquiry, hypothesis, planning, execution.

Conclusions and Long Term Goals

Thus far, only one of the four ELG semesters has been completed and the data for this semester has not been compiled. Overall, the first semester was a success according to student comments. Since this was the first offering of the ELG, much was learned and much is still to be learned concerning the administration of such a course. The course is seen as a very positive step in beginning to address the problem of Energy Literacy. The Energy and Society ELG took 28 incoming freshman from across the campus, housed them together, sponsored co- and extracurricular activities built community and engagement with faculty, and will keep the group (faculty and students) together for 2 years while studying an interdisciplinary academic subject. Students will study energy, how it is produced and used, and its societal impact. A full spectrum of academic and social activities will transpire, culminating with 4th semester sponsored research projects within the ELG theme, "The campus as an energy-efficiency and alternative-energy laboratory."

The project will also support a rigorous and in-depth assessment of four specified learning outcomes related to energy and to student aptitude with the inquiry-discovery process. Opportunity exists to improve, as the first ELG will conclude in spring 2009. ELG teams that show good assessment efforts will be encouraged to restart their ELG, which is the intention for the Energy and Society ELG. The second Energy and Society ELG will conclude in spring 2011, giving a complete and thorough assessment-improvement picture. If successful, this novel learning structure will be adaptable to almost any residential campus.

In the long run, energy and sustainability are bound only to increase in importance. Many researchers and authors feel that world energy usage is not only unsustainable, but that industrial economies will experience continuing volatility as non-renewable resources dwindle. Solutions must come not only from technical innovation, but also through changes in business practices, legislation, and personal choices. Individuals in all walks of life will be affected by the changing world energy situation. This project has the potential to elevate students' comprehension of the complete energy picture, and to give them tools that will remain relevant and useful throughout their lives and careers.

Bibliography

1. Deffeyes, Kenneth S., *Beyond Oil: A View from Hubbert's Peak* (paperback ed.), Hill and Wang, 2006.
2. Hayden, Howard C., *The Solar Fraud: Why Solar Energy Won't Run the World* (2nd ed.), Vales Lake Publishing, 2004
3. Kraushaar, Jack J., Ristinen, Robert A., *Energy and Problems of a Technical Society* (2nd ed.), John Wiley, 1993
4. Smil, Vaclav, *Energy at the Crossroads: Global Perspectives and Uncertainties* (paperback ed.), MIT Press, 2005
5. Tertzakian, Peter, *A Thousand Barrels a Second*, McGraw Hill, 2006
6. RoperASW and NEETF, "Americans' Low 'Energy IQ:' A Risk to Our Energy Future," 10th Annual National Report Card: Energy Knowledge, Attitudes and Behavior, Aug 2002
7. U. S. Government Printing Office, Washington, D.C., "National Energy Policy: Reliable, Affordable, and Environmentally Sound Energy for America's Future," 2001
8. Nethaway, Roland, "If the spigots turn back off: Energy portfolio puts U. S. in a vulnerable position," Waco Tribune-Herald, May 2, 2007
9. Goldblatt, David L., *Sustainable Energy Consumption and Society: Personal, Technological or Social Change?* Springer, 2005
10. USA Today, "Melting ice means global warming report all wet, say some experts," Jan. 28, 2007
11. McCarthy, Michael, "UN Delivers definitive warning on dangers of climate change," TerraNature, available: www.terranature.org/IPCCwarning2007.htm, Feb 3, 2007
12. Lynas, Mark, "Global warming: the final warning," TerraNature, available: www.terranature.org/IPCCwarning2007.htm, Feb 3, 2007
13. Investor's Business Daily, "Solar Eclipse of the Facts," March 23, 2007
14. Black, Edwin, *Internal Combustion: How Corporations and Governments Addicted the World to Oil and Derailed the Alternatives*, St. Martins Press, 2006
15. DeWaters, J., and Powers, S., "Improving Science Literacy Through Project-Based K-12 Outreach Efforts that Use Energy and Environmental Themes," Proceedings of the American Society of Engineering Education Annual Conference and Exposition, 2006
16. Johnson, T. G., "A New Engineering Degree Program for Secondary School Teachers," Proceedings of the American Society of Engineering Education Annual Conference and Exposition, 2004

17. Krohn, J. L., and Apple, S. C., "Energy and the Environment: An Energy Education Course for High School Teachers," Proceedings of the American Society of Engineering Education Annual Conference and Exposition, 2003
18. Blekhman, D., and Mohammadzadeh, A., "Do Fuel Cell Topics Belong in a Combustion Course?" Proceedings of the American Society of Engineering Education Annual Conference and Exposition, 2006
19. Idowu, P., "Energy Systems and Conversion – Course and Content," Proceedings of the American Society of Engineering Education Annual Conference and Exposition, 2003
20. Johnson, T. G., "A New Engineering Degree Program for Secondary School Teachers," Proceedings of the American Society of Engineering Education Annual Conference and Exposition, 2004
21. Schumack, M., "Incorporation of an Energy Conversion Theme into Thermal Science Courses," Proceedings of the American Society of Engineering Education Annual Conference and Exposition, 2002
22. Hodge, B. K., "Alternate Energy Systems – A New Elective?," Proceedings of the American Society of Engineering Education Annual Conference and Exposition, 2002
23. Rosa, A. J., Predecki, P. K., and Edwards, G., "Technology 21 – A Course on Technology for Non-Technologists," Proceedings of the American Society of Engineering Education Annual Conference and Exposition, 2004
24. Jansson. P. M., Stewart, J., Heston, W., Molner, R., Murphy, J., and Tomkiewicz, P., "Undergraduate Service Learning: Campus Photovoltaic System Siting, Design, and Permitting," Proceedings of the American Society of Engineering Education Annual Conference and Exposition, 2005
25. Wies, R., and Aspnes, J. D., "Design of an Energy-Efficient Hybrid Power Source for Remote Locations as a Student Project," Proceedings of the American Society of Engineering Education Annual Conference and Exposition, 2002
26. Weissbach, R. S., and Kephart, L. A., "Hybrid Renewable Energy System Analysis for Off-Grid Great Lakes Residental Housing," Proceedings of the American Society of Engineering Education Annual Conference and Exposition, 2005
27. Goswami, D.Y., "Present Status of Solar Energy Education," Proc. ASEE Annual Conf. and Exp., 2001, paper 2001-1433
28. Scherer, Ron, "Sustainability gains status on U.S. campuses," reprinted in USA Today, (copyright Christian Science Monitor), Dec 19, 2006.
29. http://www.baylor.edu/mayborn/index.php?id=15383 accessed on January 16, 2008.