AC 2008-1900: INCORPORATING AND ASSESSING ABET "SOFT SKILLS" IN THE TECHNICAL CURRICULUM

Timothy Skvarenina, Purdue University

Tim Skvarenina was born in Chicago, Illinois. He received the BSEE and MSEE degrees from the Illinois Institute of Technology and the Ph.D. in electrical engineering from Purdue University. During his college career he worked four summers at U.S. Steel as an assistant electrician, rewinding motors and installing electrical equipment. He served 21 years in the U.S. Air Force, including six years designing, constructing, and inspecting electric power distribution projects for a variety of facilities. He spent five years teaching and researching pulsed power systems including railgun systems, high power switches, and magnetocumulative generator modeling. He also has four years experience in operations research, having conducted large-scale systems analysis studies for the Strategic Defense Initiative. He has authored or coauthored over 30 papers in the areas of power systems, pulsed power systems, and engineering education. He is the primary author of a textbook, now in its second edition, and is Editor-in-Chief of a Power Electronics Handbook. In 1991, he joined the faculty of the College of Technology at Purdue University where he primarily teaches undergraduate courses in electrical machines and power systems. He is a senior member of the IEEE; a member of the American Society for Engineering Education (ASEE), Tau Beta Pi, and Eta Kappa Nu; and a registered professional engineer in the state of Colorado. He has served as Chair of the Central Indiana Chapter of the IEEE Power Engineering Society, Chair of the ASEE Energy Conversion & Conservation Division, and as a Vice President, and member of the board of directors, of ASEE. He was Chair of the Purdue University Senate in 2005-06, and is currently a member of the Purdue Athletic Affairs Committee.

Incorporating and Assessing ABET "Soft Skills" in the Technical Curriculum

Abstract
TAC-ABET accreditation requires that each program develop program outcomes that embrace ABET criteria 2a to k. Several of those, such as diversity, internationalization, and ethics, are often referred to as the soft skills. Generally students exposure to these items is through their elective (or required) courses in the humanities and social sciences. However, ABET accreditation also requires that the achievement of the outcomes be assessed and evaluated. Obtaining direct evidence of achievement of the outcomes by the students can be problematical as the other departments may not be doing assessment. Even if they are, the technology students in a humanities course are probably just a small fraction of the course enrollment, so it may be difficult to obtain information about their performance. While we rely on other departments to provide the bulk of the students' exposure to the soft skills, we have tried to incorporate soft - skill material into the technical curriculum. This allows us to obtain some direct assessment of their attitudes and performance. This paper describes the incorporation of internationalization material into an electric power course, which is required in our EET curriculum. The students were required to read a case study related to global warming and the Kyoto protocol and to answer questions concerning these topics. The answers were brought to class for discussion along with other international considerations. Student attitudes toward internationalization were surveyed before and after the discussion and results are presented in the paper.

Introduction

The Technology Accreditation Commission (TAC) of ABET has moved to outcomes-based accreditation of engineering technology programs, via the so-called TC2K criteria. TC2K requires that every accredited program develop a set of program outcomes, which must insure that students have demonstrated the achievement of eleven outcomes, the so-called "a" to "k" lists. Table 1 shows a listing of the "a" to "k" outcomes for TC2K. With the change from previous accreditation criteria, ABET has gone away from the so-called "bean counting" that required certain numbers of credit hours in various categories, such as mathematics, sciences, social sciences, and humanities. Instead each program must evaluate and assess its curriculum on a continuous basis to show that graduates are demonstrating the required outcomes.

Looking at the ABET required outcomes, it is clear that a number of them not technical and they are sometimes referred to as "soft skills." Among these soft skills are ethics (outcome "i"), teamwork ("e"), global perspectives ("j"), diversity ("j"), communications ("g"), and life-long learning ("h"). These skills are, in many cases, learned by the students in their non-engineering technology courses; however, it is the responsibility of the engineering technology faculty to assess and evaluate the student learning in those areas. At large schools, there are a vast number of courses that students may take to fill their humanities and social science electives. One alternative would be to require students to take certain courses that cover the desired materials, but that defeats some of the advantages of attending a large school, specifically the ability to tailor a program to one's interests. In addition, there is the problem of getting classroom

assessment from faculty who are not in the engineering technology department that is being accredited. In view of these problems, I believe that the technical courses in the curriculum should contribute to the teaching and assessment of the soft-skills. In particular, some of these topics can be taught using material that is germane to the technical course.

Table 1: TC2K Outcomes "a" to "k"

a.	an appropriate mastery of the knowledge, techniques, skills and modern tools of their disciplines,
b.	an ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering and technology,
c.	an ability to conduct, analyze and interpret experiments and apply experimental results to improve processes,
d.	an ability to apply creativity in the design of systems, components or processes appropriate to program objectives,
e.	an ability to function effectively on teams,
f.	an ability to identify, analyze and solve technical problems,
g.	an ability to communicate effectively,
h.	a recognition of the need for, and an ability to engage in lifelong learning,
i.	an ability to understand professional, ethical and social responsibilities,
j.	a respect for diversity and a knowledge of contemporary professional, societal and global issues,
k.	a commitment to quality, timeliness, and continuous improvement.

I teach a course titled, "Electrical Power and Controls," in our Electrical Engineering Technology Program. It is a fourth-semester course and is required for all students in the program. This course has been described previously[1], but, briefly, it includes topics such as single and three-phase power, power quality, basic magnetics, transformers, induction motors, relay controls, motor protection and feeders, and programmable logic controllers. In looking to find a way to contribute to the department's assessment process I wanted to find something related to the course topics. One of the first areas that came to mind was that of global perspectives. People usually think of their electrical utility as a local company with operations confined to perhaps a portion of their state. However, with deregulation and globalization, many utilities have split into regulated and non-regulated subsidiaries of larger companies that are active in the international markets. This lead me to believe that something in this area would fit into my course. Since global warming has been in the news quite a bit during the past few years (especially in 2007) and is largely blamed on electrical generation, it seemed like a good topic to use as the basis for a discussion of the international implications of technology and the global economy. To provide background information for the students, I developed a case study that could form the basis for class discussion of the issues. Appendix A to this paper contains the Kyoto Protocol/Global Warming case study. About one and a half 50-minute class periods were devoted to the topic, which meant that something had to be taken out. Time was made available by deleting the first lecture of the course, which was a review of basic mechanics concepts (energy, force, work, etc.) and by deleting a single lecture on power system grounding. In the remainder of the paper, I will describe how the case study was used in class, and some of the results over the past two years.

Global Perspectives

The global perspectives discussion was done during the 10th week of the semester, after many of the major course topics, such as energy-efficient motors and variable-speed drives, had been covered. This allowed the students to relate course topics to the case study.

At the end of the class session prior to the global perspectives class, I conducted a pre-survey of the class. The pre-survey had 19 questions of which eight were surveyed again after the discussion. The remaining 11 questions were from a Time Magazine article[2], which will be discussed later. The eight questions that were used in the pre- and post-survey are shown in Table 2, along with results from the Fall 2006 and 2006 classes. The responses to the questions all of the questions, except 4 and 5, were: Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree, which were assigned values of 1 to 5 points, respectively. Questions 4 and 5 only had four responses: Very Unfamiliar, Unfamiliar, Familiar, Very Familiar, which were assigned values of 1 to 4 points, respectively.

Table 2: Pre- and Post-Survey Questions Relating to International Awareness

Questions	Fall 2006		Fall 2007	
	Pre	Post	Pre	Post
1. As an ET professional, I will need to communicate with colleagues from other countries.	4.07	4.3	3.95	4.15
2. I believe that having an understanding of other countries and cultures will be essential to my future success in the workplace	3.77	3.84	3.89	4.05
3. I expect that my job as an ET professional will be impacted in one way or another by outsourcing.	3.87	3.9	3.79	3.86
4. I am _____ with global warming	3.13	3.44	3.32	3.43
5. I am _____ with the Kyoto Protocol	1.77	3.0	1.9	3.1
6. During my career, international treaties or agreements will likely affect how products are designed, constructed, and used in the US.	3.74	4.27	4.33	4.6
7. I believe that developing more energy-efficient products will be an important aspect of my career.	4.19	4.45	4.5	4.5
8. Global warming will be a significant problem for the world to deal with during the next 50 years.	3.35	3.53	3.43	3.75

I began using the case study in the Fall of 2004. Until the Fall of 2006, I started the discussion with an automotive example–the Chrysler PT Cruiser. At that time, the parent company was in

Germany and the car was built in Mexico for primarily the United States market. With the divestiture of Chrysler by Daimler in 2007, I dropped that example. In the fall of 2007, I began with a brief discussion related to electronics–the Reduction of Hazard Substances law that restricts the amount of lead in electronics in Europe. This is an example of an international standard that affects the way we do business in the United States. Since it went into effect in 2006, some of the students were familiar with it, particularly in the 2007 class. This is shown by the increase in the average response to question six in Table 2. The 2006 class had yet to deal with RoHS when ordering parts, while many of the fall 2007 class had. When students asked why the RoHS was passed, I showed them a graphic[3] that indicated that 4% of Europe's waste is discarded electronics, but it results in 40% of the lead in landfills.

Following the introduction, I moved on to a discussion of the nature of large companies. In another survey question 72% of the 2007 class indicated they would probably work for a Fortune 500 company. I showed them websites from local electric utilities that indicated the parent companies had divisions with overseas assets and trading and I indicated that engineering is being practiced around the world by many large companies. One of the reasons is indicated by the data in Tables 3 and 4, namely it is cheaper.

Table 3: Annual EE Salary, Five years Experience[4]

City	**Salary**
San Jose	$106,400
Hong Kong	~$ 38,000
Shanghai	~$ 11,000
Mexico	~$ 9,000
Bombay (Mumbai)	~$ 7,000

Table 4: Engineer Hourly Wage[5]

Country	**Rate/Hr**	**Country**	**Rate/Hr**
Poland	$4.32	Bulgaria	$ 1.43
Czech Rep.	$5.38	China	$ 3.50
Hungary	$5.09	India	$ 2.40
Slovakia	$4.15	Germany	$38.90
Romania	$2.58		

Students actually already had a pretty good understanding that they will be dealing with people from other countries, as indicated by the responses to questions 1, 2, and 3 in Table 2, but many were surprised at the large discrepancies in pay rates around the globe. I concluded the discussion of outsourcing with the JibJab cartoon, "Big Box Mart."

After the introduction, we moved into the global warming case study and discussed the questions at the end of the case study. The students were instructed to type their responses and bring them to class for the discussion. That way, they could turn them in after class and I would be sure they hadn't written their answers during class. We began with a discussion of what greenhouse gases are and where they came from and then moved into a discussion of what impact global warming might have on decisions the students would make when designing products or selecting equipment for a plant. Most students indicated they would be more conscious of energy efficiency.

Figures 1 to 7 shows a comparison of the students' response to a Time Magazine survey. These were shown to the students, during the discussion. There is some rounding in the student numbers, so they may not add to 100%. The results shown for students are from the fall 2007 class. The results for the fall 2006 class were similar but are not shown here for brevity.

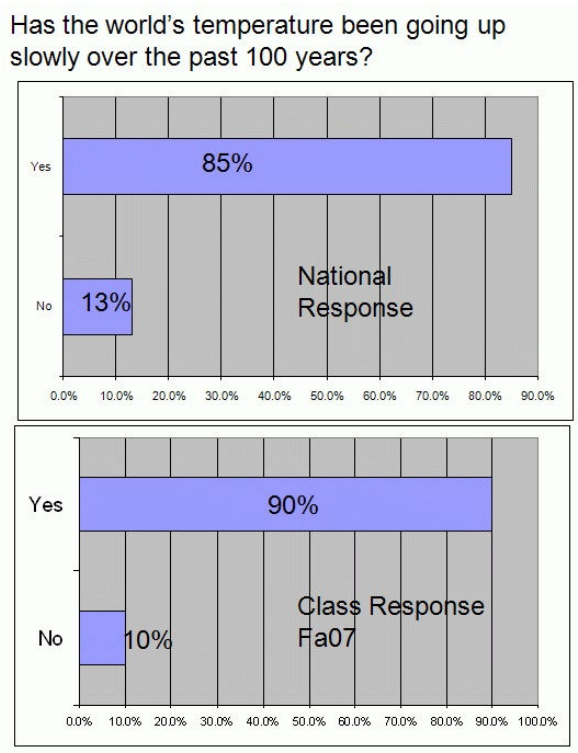

Figure 1: Comparisons of students' opinion to national sample

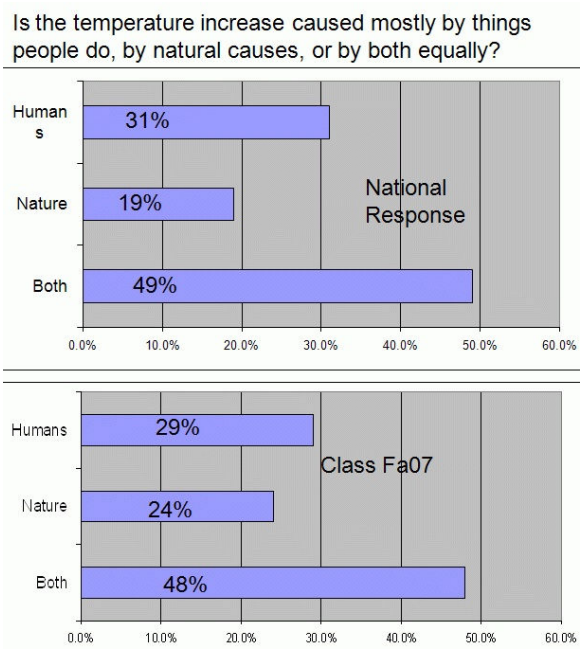

Figure 2: Question 2 of the Time survey

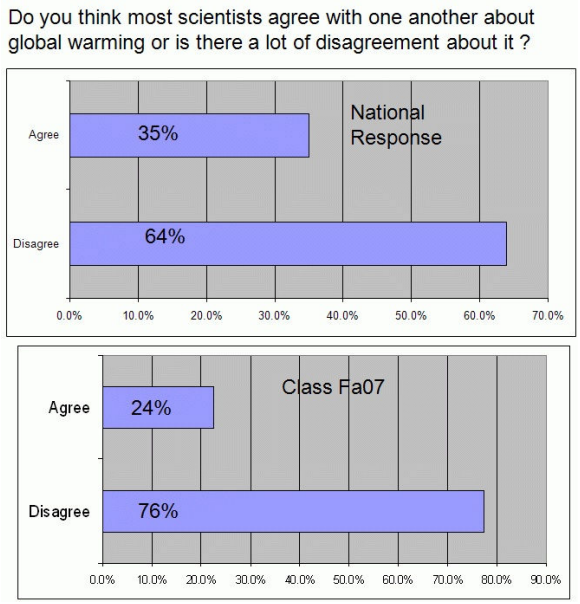

Figure 3: Question 3 of the Time Survey

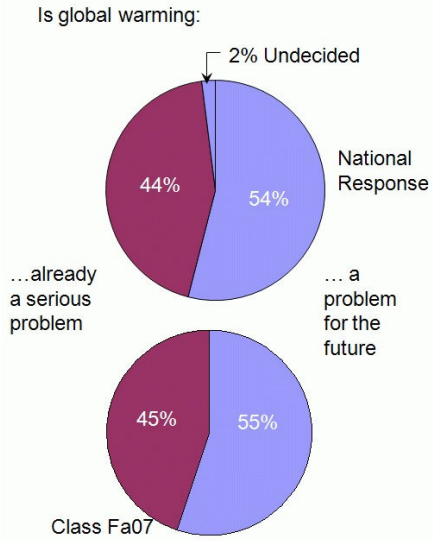

Figure 4: Question 4 of the Time Survey

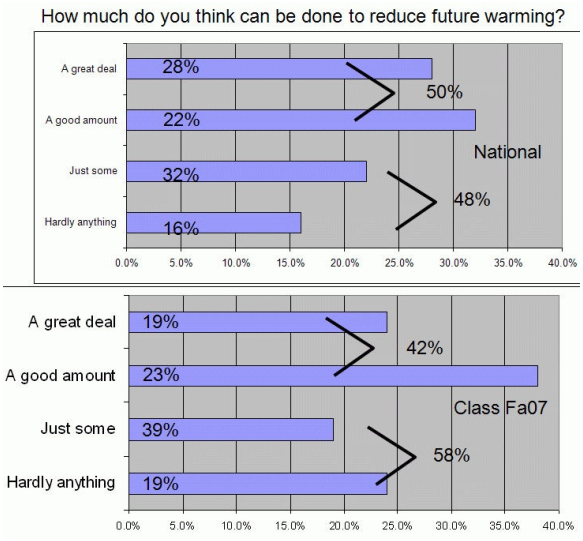

Figure 5: Question 5 of the Time Survey

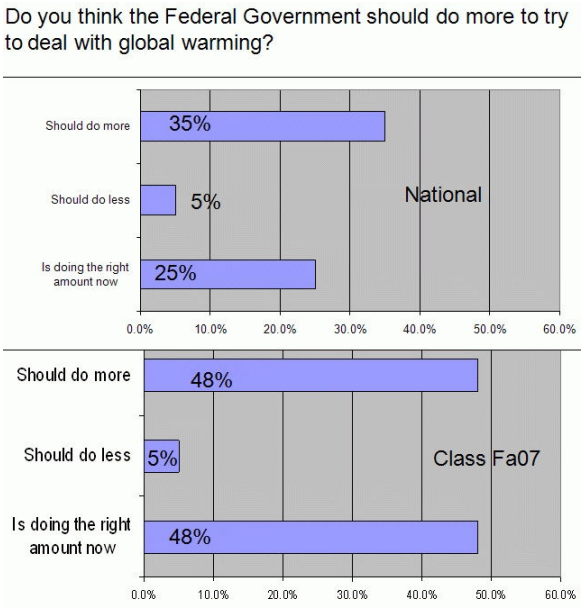

Figure 6: Question 6 of the Time Survey

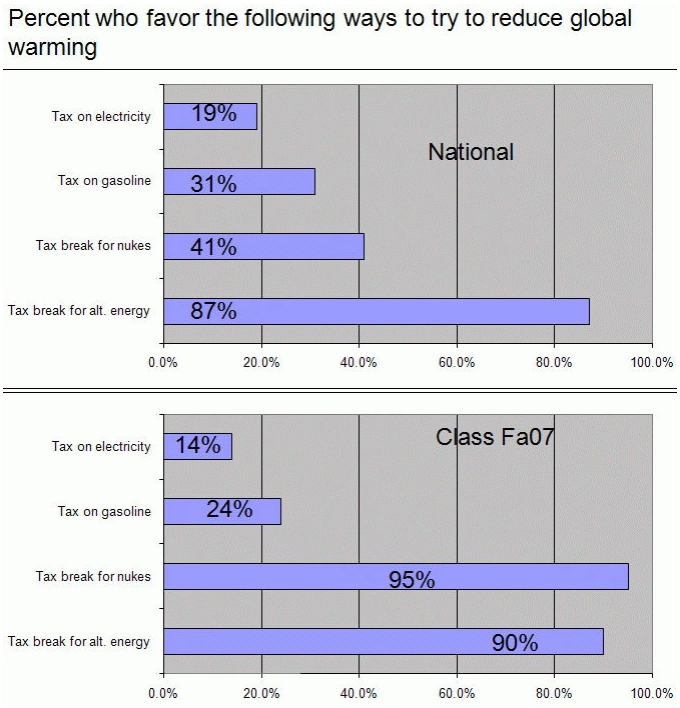

Figure 7: Question 7 of the Time Survey

The students were very interested in seeing how their responses compared to the national survey. In some cases, such as the questions in Figures 1, 2, and 4, the students responses were very similar or almost exactly the same as the survey. Figure 3 indicates that students seemed to believe more strongly that there is disagreement among scientists about global warming. Figure 5 indicates the students were slightly more pessimistic concerning our ability to reduce future global warming. The results shown in Figure 6 were somewhat different because I didn't give

the option of no opinion, which apparently the Time survey did. Finally, the results from Figure 7 were very interesting. Students were far more accepting of nuclear power than the general population. This might be because Three Mile Island and Chernobyl are just historical to them, while many in the general population remember and fear the possibility of a recurrence. On the other hand, students were less supportive of tax increases on gasoline and electricity, which would hit them directly in the pocketbook.

During the discussion, I presented the students with data from a variety of sources. Examples included projections of rising sea levels, melting of the polar ice caps, and changing climates. Having learned about the Kyoto Protocol, they wondered how the world is doing. Unfortunately, the news is not good in terms of reducing CO_2 emissions. Figure 8 shows the amount of global emissions from 1990 to 2005.

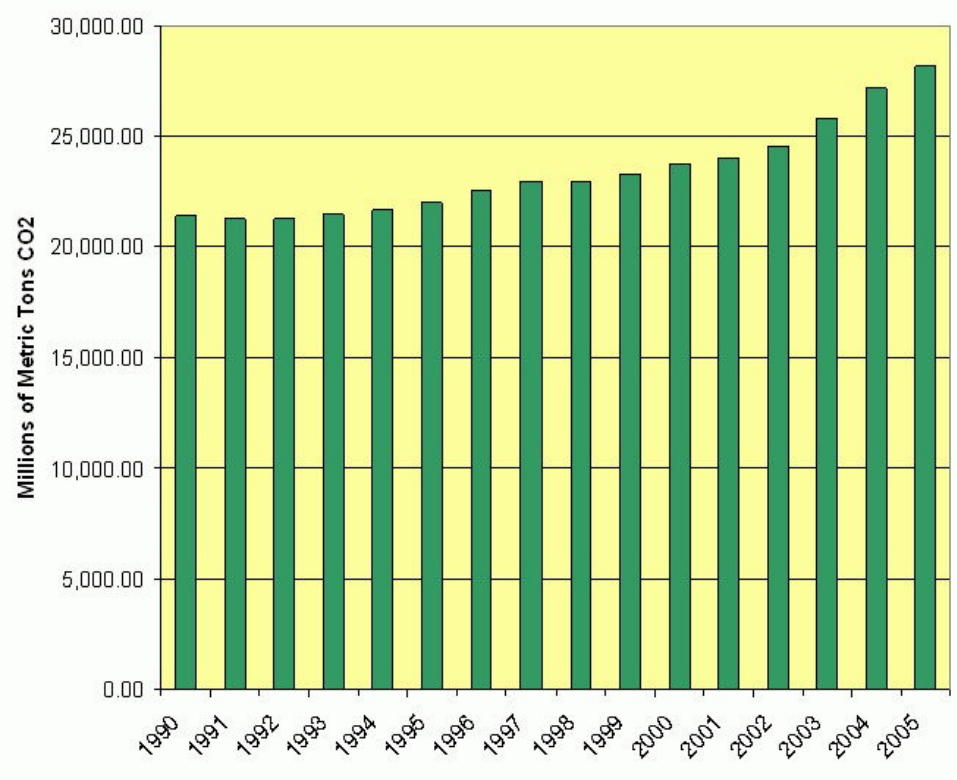

Figure 8: Global CO_2 Emissions (Source: US Energy Information Agency)

The chart in Figure 8 shows that CO_2 emissions increased by about 35% during the 15 year period. The students were also interested to learn that the United States is probably no longer the largest emitter of CO_2. Figure 9 shows the emissions from the United States and China during the same period (1990 – 2005), with an estimate for the US in 2006. Projecting the trend line for China, it is quite likely that it has become the largest emitter of CO_2. Of course, on a per-capita basis, the United States is still far and away the largest emitter.

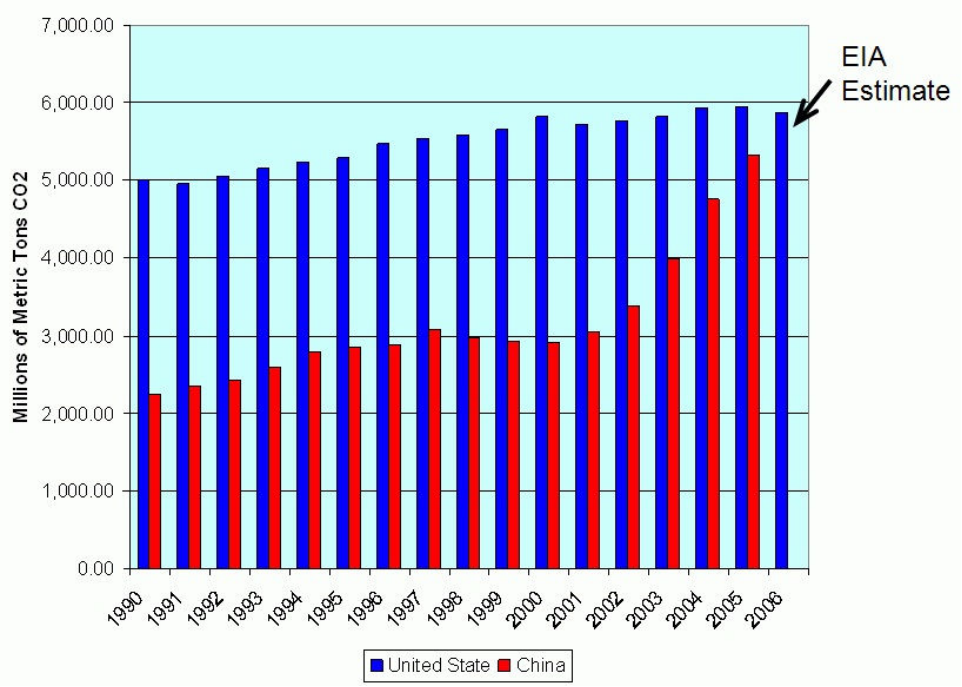

Figure 9: US and China emissions (Source: US Energy Information Agency)

The class concluded with discussions of methods that will help to reduce greenhouse gas emissions. Among the methods briefly discussed were carbon-dioxide sequestration (there are currently several demonstration projects for coal-gasification and eventual sequestration), wind energy (a rapidly growing source of electricity in the US and Europe), conservation, energy storage, and greener vehicles (hybrid, all-electric, and hydrogen-powered). It was evident the students were concerned about the future of the planet and gained an understanding of some of the international considerations involved in reducing greenhouse gas emissions.

Assessment

Criterion "i" requires, "knowledge of contemporary societal and global issues," and I believe that in the process of completing the assignment and class, the students demonstrated achievement of the outcome. Assessment techniques include both direct and indirect methods. By utilizing the pre- and post-class survey, indirect evidence of student learning was obtained. In particular, with the exception of question 7 (which scored very high on the pre-class survey) the students scored their agreement or knowledge level higher on the post-class survey for all of the questions in Table 2.

Questions 1 to 3 in Table 2 dealt with student attitudes towards globalization. Question 1 indicates that students agree they will need to communicate with colleagues from other countries and the scores were somewhat higher on the post-class survey. There agreement was slightly less on question 2, which dealt with the necessity of understanding other cultures and on question 3, which asked them whether outsourcing would affect their careers.

In the case of question 5, it was particularly evident that the students were not familiar with the Kyoto Protocol before the class and homework (scores of 1.77 and 1.9 out of 4). Following the assignment and class, they indicated they were familiar with Kyoto (scores of 3.0 and 3.1 out of 4). Question 5 showed that the students were somewhat familiar with global warming prior to the class. This 2007 class was even more familiar with global warming. I attributed that to the fact that the class occurred right after the award of the Nobel Peace Prize jointly to the United Nations Panel on Climate Change and former U.S. Vice President Al Gore. Question 8 shows that the students somewhat weakly agreed that global warming will be a problem during their working lifetimes.

The students were required to type answers to the case study questions and bring them to class for the discussion. At the end of the class, the assignments were turned in for grading. These assignments were graded and constitute a direct assessment of the students' knowledge of the issues associated with global warming. In addition, the midterm exam following the class contained an essay question, which asked the students to describe how internationalization might affect their careers and how international standards might affect the products they design or build. The results of this question could also be used for direct assessment of the students' achievement of criterion "i."

Conclusion

A course module (about 1.5 lecture periods) was developed to expose students to international and societal concerns as they relate to the use of electrical energy. A case study about global warming and the Kyoto protocol was written as used as the basis for the homework assignment and class discussions. The case study has been used for four years, but during the last two years a pre-class and post-class survey was introduced in an effort to determine if student attitudes and knowledge were changing as a result of the course module. Our program was reviewed by ABET in the fall of 2005 and some of the materials from this evaluation were included in the displays. Specifically, student responses to the homework questions and end of class quiz were included. In addition the assessment materials included indirect measurements from survey results[6]. The evaluators did not make any specific comments with respect to these results, although they were generally very complimentary about the thoroughness of our display material.

In general the students seem to enjoy the class discussions and are very interested in what can be done to reduce CO_2 emissions. The material that is presented in class each year during the discussions has been updated, but the case study hasn't. Thus, the next task is to revise the case study to account for recent developments, such as discussions for a post-Kyoto agreement. Regardless of who is elected as President of the United States in 2008, the change of administration is likely to bring about a new position for the United States with respect to emission controls.

References

1. Skvarenina, T.L.* & DeWitt, W. (1998). Development of an EET Electrical Power and Controls Course [CD-ROM]. 1998 Annual Conference Proceedings, ASEE, six pages.
2. TIME Poll. Time Magazine. April 2, 2006. Available online at http://www.time.com/time/magazine/article/0,9171,1176975,00.html
3. Europe Says: Let's Get The Lead Out. Business Week. February 7, 2005. Available online at

http://www.businessweek.com/magazine/content/05_06/c3919015_mz003.htm#ZZZU9TJ1H4E
4. The Big Picture: Engineering on the Cheap. Business Week. October 6, 2003. page 13
5. How Central Europe's Workers Stand Up. Business Week. December 12, 2005
6. Skvarenina, T. 2006. Triangulating TC2K Assessment Results by Using Student Surveys, ASEE 2006 AnnualConference (CDROM). 23 pages

Appendix A
Case Study: Greenhouse Gases and Global Warming

It is often said that the economies of the world have become a global economy, and many corporations have become multinational in their operations. One might not think of the electric utility industry in the global economy context; however, a number of United States utilities have operations in other parts of the world. One problem that the utilities are a part of, and which has a major global impact, is global warming. This case study will present some of the basics of the issue of global warming and the Kyoto Protocol, which was a treaty designed to reduce the amount of greenhouse gas emissions by the industrialized countries of the world.

Definitions:

Global Warming:	Increase in the average temperature of the earth beyond the normal year to year variations
Green house effect:	Trapping of heat in the lower atmosphere by clouds and greenhouse gases
Greenhouse gas:	A gas that appears in trace amounts in the atmosphere and causes warming of the lower atmosphere by the absorption of thermal radiation from the earth. The six that are covered by the Kyoto Protocol are: carbon-dioxide (CO_2), methane (CH_4), nitrous oxide (NO_2), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur-hexafluoride (SF_6)

Introduction:

During the past century, the average global temperature has increased by about 1°F according the U.S. Environmental Protection Agency (EPA) and many other scientific or governmental organizations around the world. The 10 warmest years in that timeframe have all occurred since 1983 and seven of them occurred during the 1990s. By examining historical evidence such as tree rings, pollen records, and air locked inside ancient ice, some scientists have concluded that the 20th century was the warmest century, the 1990s the warmest decade, and 1998 the warmest year of the last millennium. These results have led many to conclude that the earth is becoming warmer and that the rate of increase is accelerating.

The earth's atmosphere is composed of 78.1% nitrogen, 20.9% oxygen, and 1% other gases. Over nine-tenths of the 1% of other gases is argon, leaving less than 0.1% for a variety of other gases, which occur only in very small, or trace, amounts. Among the trace gases are the greenhouse gases, which serve the important role of trapping heat in the earth's atmosphere, making the planet inhabitable. Without them, the average temperature on the earth would be several degrees below 0°F. However, as is often the case, too much of a good thing can be bad.

Increasing the amount of greenhouse gases causes the earth to warm up. While a one degree

increase doesn't seem like much, consider that the temperature only decreased by about 9°F during the last ice age. An increase of six or seven degrees would cause melting of some glaciers and portions of the polar ice caps resulting in massive flooding of coastal areas. In addition, the entire climate of the world would shift, with heat waves in some places, colder temperatures in others, excessive rainfall in some regions, drought in other. The results of the climatic changes will cause more air pollution, damage to crops, increased disease, and significant loss of human life.

Evidence points to humans as the reason for the increase in the earth's temperature. Since the start of the industrial age, the amount of CO_2 in the atmosphere has increased by 30%, from 280 to 367 parts per million by volume. Over 200 billion tons of CO_2 are released by the oceans and plant life each year, but a similar amount is absorbed by them as well. Since these actions are balanced, they do not increase the amount of greenhouse gas in the atmosphere. Mankind apparently has upset that balance, however. Carbon dioxide is, of course, a by product of the combustion of carbon-based fuels, including coal, gas, and oil, so the generation of electricity by burning fossil fuels, wood, or biomass creates huge amounts of CO_2. Similarly, automobiles and many manufacturing processes contribute additional CO_2 to the atmosphere. Methane, which also contributes to the greenhouse effect, is produced by solid-waste landfills and sewage treatment. Nitrous oxide is produced as a result of agricultural processes, such as fertilization of fields. Deforestation for the land development reduces the amount of carbon that can be absorbed from the atmosphere.

All together, human activities are adding some seven billion tons of carbon equivalent to the atmosphere each year. Bear in mind that carbon has an atomic mass of 12 and oxygen 16. Thus, CO_2 has a mass of 44, so the carbon is about 27% of the weight of the CO_2 molecule. Thus, there is about 25.6 billion tons of CO_2 being put into the atmosphere each year. About half of the human emissions may be absorbed by the oceans and plants, but the remainder stays in the atmosphere for many years, increasing the greenhouse effect. With the earth's human population approaching 6.5 billion, we are currently emitting a little over a ton of carbon per person per year. Of course, this is an average and the numbers vary dramatically between the industrialized and developing nations. Figure 1 shows the annual per-capita emissions of greenhouse gases in tons of carbon for a number of industrialized countries, as reported by the U.S. EPA. As most would expect, the United States leads the list with 6.6 metric tons (1000 kg or 2200 lbs) per person due to the tremendous usage of electricity and gasoline. In fact, the U.S. accounts for approximately 25% of the world's greenhouse gas emissions. Not shown on the list are the Russian Federation and the developing countries. Russia is second to the U.S., contributing about 15% of the greenhouse gas emissions. While the developing countries contribute smaller amounts on a per-capita basis, several of them (China, India, Mexico, and Brazil) have rapidly growing economies and are significant emitters of greenhouse gases.

Reducing the rate at which greenhouse gases are added to the atmosphere can be done using a number of methods, such as restricting the amount of emissions or removing them at the source, replacing of fossil fuels by other sources, and reducing deforestation or planting of new forests.

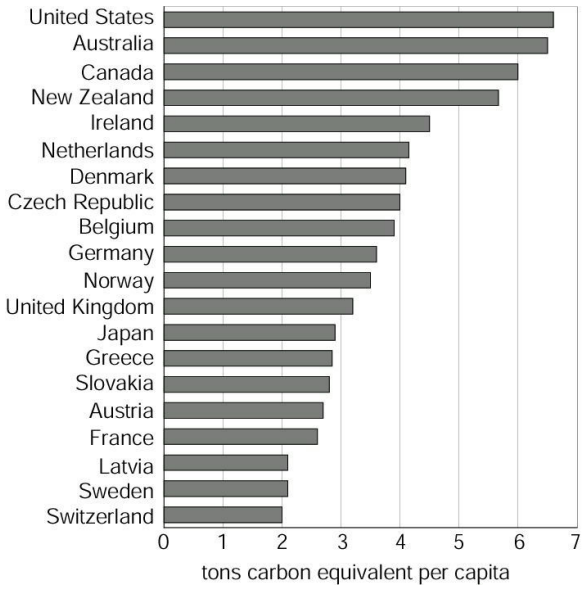

Figure 1: Annual, per-capita greenhouse gas emissions for a number of industrialized nations

World Actions to Address Climate Change

In 1990 the Intergovernmental Panel on Climate Change (IPCC) issued its first assessment of climate change research, which confirmed that climate change was a threat and calling for a global treaty to address the issue. The United Nations (UN) General Assembly passed a resolution to begin negotiations for such a treaty in December 1990, and in May 1992, the United Nations Framework Convention on Climate Change (UNFCCC) was made available to the nations of the world for signature and ratification. Some 186 nations, including the United States and the European Union, have ratified it and are bound by its provisions. The treaty took effect on March 21,1994. The Convention is a broad framework document that began the process of reducing mankind's impact on the global climate. Specifically, it recognized that there is a problem and that the ultimate objective should be to stabilize the composition of the atmosphere so as to prevent dangerous climatic changes. Finally, it directed that the stabilized level should be achieved in sufficient time to insure the production of food and to allow sustainable economic development.

The Convention was essentially a beginning, because it was not possible to get all the nations to agree to a specific course of action in 1992. Creating the framework allowed discussions of the problem to proceed and created peer pressure throughout the international community. The countries that ratified the Convention agreed to take climatic change into account in a variety of areas and to create programs to slow the rate at which the climate is being changed. Recognizing that the developed countries (Europe, North America, Japan, and others) were largely responsible for the problem, the Convention makes them responsible for cleaning up the problem and paying for it. The developed countries are, for the most part, members of the Organization for Economic Cooperation and Development (OECD).

Forty-one nations including members of the OECD and 14 so-called "economies in

transition" (countries in Central and Eastern Europe and the former Soviet Union) were listed in Annex I of the convention. The so-called Annex I countries pledged to reduce greenhouse gas emissions so that emissions in the year 2000 would be no higher than they were in 1990. According to the United Nations (UN), they succeeded as a group; however, that was largely due to significant drops (>40%) in the transition countries. Many of the OECD members had increases from 1990 to 2000, including the United States. Figure 2 shows the change in gross domestic product, population, emissions per capita, and emissions per dollar of GDP for the United States from 1990 to 2000. While the per-capita emissions increased only slighty, the population grew by about 14%, resulting in a 16% increase in the total emissions.

The Convention recognized that developing countries have a right to aspire to better living conditions through economic development, which will require an increase in their share of the global emissions. In 1995 the Intergovernmental Panel on Climate Change (IPCC) issued its second assessment of climate change research and concluded that the process of climate change had probably already started as a result of previous emissions. Pressure was building for additional action that would require specific actions by the developed countries to reduce greenhouse gas emissions. In March 1995, new negotiations were undertaken to define more substantive commitments.

In December 1997, the international community adopted the Kyoto Protocol. According to the UN, "A protocol is an international agreement that stands on its own but is linked to an existing treaty." In this case, the Protocol was linked to the 1992 Convention. Only countries that ratified the Convention could ratify the Protocol; however, countries that chose not to ratify the Protocol would not be bound by it, even though they had ratified the Convention.

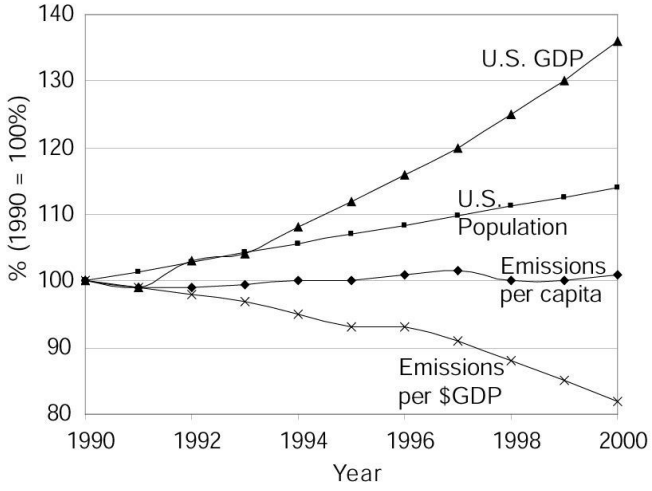

Figure 2: Change of population, per-capita emissions, GDP, and emissions per dollar of GDP from 1990-2000

The Protocol set legally binding targets for the reduction of emissions in the Annex I countries. Specifically, these countries would reduce their greenhouse gas emissions during the

five year period 2008-2012 by 5% from the levels of 1990 for CO_2, N_2O, and CH_4. For the remaining greenhouse gases (HFCs, PFCs, and SF_6), the reduction could be from a baseline of 1995, if desired. The reason for the later base year was to compensate for the large increase in the use of these materials as a result of the banning of chlorofluorocarbons (freon) under a 1987 UN Convention. Those materials were banned because they were destroying the ozone layer that protects the earth from UV radiation. Although, the average decrease for greenhouse gas emission was set at 5%, different requirements were established for each of the Annex I countries. These targets were listed for 38 countries in Annex B of the Protocol and are shown in Table 1. The European Union consists of 15 countries and they allocated their targeted savings in a non-uniform manner among the member countries.

Table 1: Kyoto Protocol required greenhouse gas emission reduction for the Annex I countries

Country(ies)	**Target for change from 1990 to 2008-12**
European Union, Bulgaria, Czech Republic, Estonia, Latvia, Liechtenstein, Lithuania, Monaco, Romania, Slovakia, Slovenia, Switzerland	-8%
United States of America	-7%
Canada, Hungary, Japan, Poland	-6%
Croatia	-5%
New Zealand, Russian Federation, Ukraine	no change
Norway	0.01
Australia	0.08
Iceland	0.1

While CO_2 is by far the most prevalent of the greenhouse gases, the others can actually have a worse effect for a similar quantity. For example, on a molecule for molecule basis, SF_6 has 23,900 times the global warming potential than CO_2. Thus, the emissions are converted to carbon equivalent using weighting factors, and the targeted reduction is applied to the entire group of six gases. The Protocol allows a number of ways for a country to meet its reduction. For example, part of the goal could be met by reforestation that creates carbon sinks to remove CO_2 from the atmosphere. Other possibilities allow a developed country to pay for a reduction in a developing country and apply the savings to its quota, or for one country to save more than its target and sell credits to another country that is short of its target. The Protocol also allows a country that saves more than is required to "bank" the savings for use in subsequent monitoring periods. Although the average reduction of 5% sounds small, you should recall from Figure 2, that the United States was already about 16% over the 1990 levels by 2000. Considering additional population and GDP growth from 2000 to 2008, the reductions would be well over 20% from business as usual and would impact many industries

For the Kyoto Protocol to take effect, two things were required. First, 55 nations must ratify the treaty and second, nations that account for at least 55% of the emissions from the Annex I

countries must ratify it. As of May 2003, 109 countries had ratified the document, but that only included 31 Annex I nations that account for about 44% of the emissions. Thus, the treaty has not gone into effect. The United States and Russia have not ratified the agreement

In the summer of 1997, the United States Senate by a vote of 95-0 passed the Byrd-Hagel resolution, which advised then President Clinton that the Senate would not support any global warming treaty that did not require growing developing economies, such as India, China, Brazil, and Mexico, to participate or that endangered the U.S. economy. Negotiations in Kyoto were seriously bogged down until then Vice President Gore went to Kyoto and instructed the U.S. negotiators to be more flexible. The Protocol was completed in December 1997 and was signed by the United States. However, faced with hostile comments from the Senate, President Clinton never submitted it for ratification, which would have required a two-thirds vote in favor for ratification.

In 2001, several months after taking office, President Bush announced that the U.S. would not ratify the Kyoto Protocol. He indicated that the treaty would cost the U.S. economy millions of jobs and billions of dollars as producers moved to countries that did not have to comply with the Protocol. Instead he proposed that the United States achieve a voluntary 18% reduction by 2012 in the amount of greenhouse gases emitted per dollar of GDP from a baseline in 2002. In 2002, there were 183 metric tons of CO_2 per million dollars of GDP, and under the proposal that would be reduced to 151 metric tons by 2012. Critics of this plan included environmental groups and many European allies, because the total emissions would continue to increase albeit at a slower rate. Some allies, however, applauded President Bush for recognizing that CO_2 emissions should be reduced and taking action rather than just ignoring the Protocol.

Faced with withdrawal from the United States, in July 2001 representatives of over 170 nations negotiated a revised version of the Kyoto Protocol that would proceed without U.S. participation, but which also would lower the target reduction from 5% to 1.8%. In August 2001, the Foreign Relations Committee of the U.S. Senate unanimously approved (19 to 0) a resolution that asked President Bush to negotiate a global warming treaty that would protect the economic interests of the U.S. and include developing countries. Some executives from large power companies, such as American Electric Power, Cinergy, and Wisconsin Electric Power, have joined in the call for control of CO_2 emissions. These individuals have stated their belief that such controls are inevitable and they would rather include them now while they add pollution controls for other gases rather than having to add them later.

A number of individual states have joined in the battle against greenhouse gases by requiring that certain percentages of electricity be obtained from renewable sources by certain dates. Although renewable sources include methane gas from landfills, the largest source of renewable power is wind power. As a result, in 2002 some 410 MW of wind generation was added in the U.S., bringing the total to 4,685 MW in 27 states. California (1822 MW), Texas (1095 MW), and Iowa (423 MW) were the three leading states for wind generation at the end of 2002. With the large increase in wind generation, its cost has become competitive with coal-fired generation. Wind power has also proven popular in Europe as a result of the Kyoto Protocol, with a total capacity of about 20,500 MW during 2002. Fifty-percent of that is located in Germany, which added some 2000 MW in 2002 alone, and Denmark derives 18% of its electricity from wind power. Predictions by the European Wind Energy Association (EWEA) indicate that world wind generation could reach 200,000 MW by 2010.

References

1. Global Warming and Our Changing Climate, Answers to Frequently Asked Questions. U.S. Environmental Protection Agency, document EPA 430-F-00-011, April 2000
2. A Guide to the Climate Change Convention and Its Kyoto Protocol. United Nations Framework Convention on Climate Change (UNFCCC). Preliminary Version. 2002. Bonn
3. Understanding Climate Change: A Beginner's Guide to the UN Framework Convention and Its Kyoto Protocol. UNFCCC. July, 2002. Bonn.
4. E. Pianin. Emissions Treaty Softens Kyoto Targets. Washington Post. July 29, 2001
5. E. Pianin. Bush Urged to Negotiate Global Warming Treaty. Washington Post. August 2, 2001
7. The U.S. Environmental Protection Agency has information concerning global warming on its website. As this case study was being written, the URL was:
   http://epa.gov/climatechange/index.html

Discussion Questions

1. Assume you are a practicing engineer or technologist. What impact will global warming and the efforts to reverse it have on the decisions you might make in designing products or selecting equipment for a plant? Consider how the requirements of other countries might affect your decisions.

2. What role should the United States play in the efforts to reduce greenhouse gas emissions? Can any nation "go it alone" in the world economy of today?

3. Do you think it is necessary to reduce the standard of living in developed countries to reduce greenhouse gas emissions? What can a country do to combat global warming?

4. Do you, as an individual, believe there is anything you can do to help reduce greenhouse gas emissions? Have we studied anything that can help?