Energy and the Environment: An Energy Education Course for High School Teachers

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Introduction

During the summers of 1999, 2000 and 2001, the Department of Engineering at Arkansas Tech University conducted a two-week workshop for junior and senior high school science teachers entitled "Energy and the Environment". Participants received three hours of graduate credit for the course in either secondary education or physical science. The goals of the course were to introduce the participants to the various sources of energy available and utilized in our society, to give them a balanced view of the advantages, disadvantages and potential for each of these sources, and to provide them with the equipment and training to be able to conduct some simple energy related experiments in their classes.

The Arkansas Center for Energy, Natural Resources and Environmental Studies (ACENRES) and the Arkansas Math and Science Institute (both located at Arkansas Tech), along with the Arkansas Department of Higher Education (through the Eisenhower Grant program) and the Arkansas Section of ASME provided grant funds to cover some of the participant's costs and to purchase equipment. Each participant who was currently employed as a public school teacher received an experiment kit with approximately $450 of equipment to take to their school at the end of the course.

Motivation

The "Energy and the Environment" course grew out of a desire of the engineering faculty involved to promote discussion and knowledge of energy supplies, both now and in the future, for our nation and the world. On a global level, energy use is growing, and will grow at a more rapid pace, as more nations aspire to the standard of living of the more developed nations. What sources will mankind choose to utilize to produce this energy while also balancing the effect of this energy production and usage on the environment?

One of the greatest challenges facing our nation in the intermediate future (20-40 years hence) is the development of a reliable and sufficient supply of energy, especially electricity, when faced with the inevitable decline in the present primary sources (coal, oil and gas). While securing a stable and available supply of petroleum has long been a matter of U.S. national security, the general public has only a modest level of knowledge of, or concern for, our energy sources.

Most members of the general public have a vague idea that the utility companies "make" electricity and deliver it to their homes, but very few of the details of this process are known outside of industry employees and university teachers/researchers. In short, the public's "energy IQ" is rather low which may be a large contributing factor to the inability to arrive at a comprehensive energy policy for the nation. One of the aims of the course was to increase this "energy IQ" among the secondary science teachers who would then be able to reach a much larger audience in their classrooms.

Structure

The course was taught in the summer over a two week period. A typical day's schedule included a morning lecture session lasting from 9:00 to 10:20 a.m., a ten minute break, and then a laboratory exercise or demonstration from 10:30 to noon. After the lunch break, there was another lecture session, or a guest lecture by a representative from the electric industry, or a field trip to a local facility. One hour of computer lab time to allow the students to work on lab reports and portfolios concluded the afternoon. Typical destinations for field trips included a local hydroelectric plant, a local nuclear power plant, the Arkansas Energy Office and a solar power company, both in Little Rock, and a large coal-fired generation station in Gentry, Arkansas. The latter two destinations involved one-day trips for which we were able to secure sponsors to provide lunch for the group. During the two week course period, participants were involved in approximately 24 hours of classroom lecture, 15 hours of laboratory experiments/demonstrations, and 8 hours of facility tours.

Grading for the course was based on laboratory reports, class participation, development of two classroom activity/lesson plans, and a class portfolio which included a daily journal of activities, impressions and reflections on lessons learned.

While the primary instructors for the course came from the mechanical engineering faculty, every effort was made to keep the course at a level appropriate for the students, most of whom had taken college algebra (sometimes several years ago!) as their highest level mathematics course. The class lectures were kept as informal as possible with lots of encouragement for questions and discussions during the class.

Content

A copy of the course syllabus/schedule for the 2001 offering is included as Appendix I. The text book used was "Energy and the Environment", by R. Ristinen and J. Kraushaar (J. Wiley publishers) and the course content closely followed the text. Whenever possible, however, news articles dealing with recent developments related to the text material were included in the classroom discussions. For example, there have been a number of new wind turbine installations in the last few years, and the latest numbers/statistics from such areas was brought in to supplement the information contained in the text.
The first day of class was comprised of orientation activities, a campus tour, and covering the

first two chapters of the text on the importance of energy supplies in the development of our modern style of living. Over the next four days, lectures were given on a number of different energy sources including fossil fuels, hydroelectric generation, solar energy, wind energy and geothermal energy sources. In each case, a description of the method of generating electricity from that source was given along with a summary of the current level of usage and the prospects and impediments to further use of that source in the future. Lab exercises normally carried out during this week included a water power design exercise in which the students used a small water turbine to raise a weight, and a demonstration of the department's parabolic solar collector. Field trips to a local hydroelectric station, nuclear power plant, or to a solar power company in Little Rock rounded out the week's activities. In addition to the pictures included in this paper, a number of pictures of lab exercises, tours, etc. may be found on the web sites listed in the bibliography.

The second week of class included lectures on nuclear electric generation and remaining alternative sources such as biomass, municipal waste, etc. and some related topics such as energy storage, energy needs for transportation, and environmental effects of the major current electricity suppliers (fossil fuels, especially coal, and nuclear were emphasized). A guest speaker involved in some aspect of the electric power industry typically presented a lecture. Lab experiments during this second week included a fuel cell demonstration, simple radiation detection and counting, and determining the heating value of coal. During this week a field trip was taken to the Flint Creek coal-fired generation station in Gentry, AR (approximately 150 miles away). Figures 1 & 2 below are from two of the field trip locations visited during the course.

Figure 1 - Hydroelectric turbine

Figure 2 - Steam turbine

The majority of the final day of class was devoted to tying up any loose ends and allowing time in the computer lab for the students to complete any remaining lab reports and work on their lesson plans. At the end of the day the students turned in their portfolios, exchanged lesson plans/activities, and were given their equipment kit to take home.

The majority of the lab experiments performed during the course utilized the same equipment as was provided to the students in the experiment kit at the end of the course. The kit included the following items: a water turbine, a cloud chamber, an aluminium/air fuel cell, a solar cell demonstration kit, two gas lantern mantles (one containing Thorium, one without), a flashlight, and a Radalert 50 Geiger counter. A picture of an experiment kit is included below as Figure 3.

Figure 3 - Experiment Kit

As stated above, typical lab experiments conducted by the students during the week included a hydro-power demonstration using the small water turbine from the kit to raise a small weight, a radiation detection and counting experiment utilizing the Geiger counter and the department's radiation detection lab, a demonstration of the cloud chamber, a demonstration of the department's parabolic solar collector, a determination of the heating value of coal using a bomb calorimeter, and a demonstration experiment using the aluminum/air fuel cells. The fuel cell experiment as an example, compared the voltage and current outputs of the small fuel cells using salt water or potassium hydroxide as the electrolyte. When 1-M KOH is used as the electrolyte, each cell produces approximately 400 mA at 1.8 V. The lab also investigated methods to produce higher voltages and currents by connecting a number of the fuel cells in series and then in parallel. Figure 4 below shows the first class of students conducting the fuel cell experiment.

Figure 4 - Fuel Cell Experiment

Results

The Energy and the Environment course was offered for the three summers with a total of 16 students. Of this number, all but two were classroom teachers. Feedback from the participants has been positive. All of the classroom teachers contacted since taking the course have reported using some of the lab activities in their classrooms and several have indicated plans to include other portions of the course, such as some of the field trips, in their classes if arrangements can be made. While the total number of participants was less than originally envisioned, the smaller class sizes had the benefit of improved communication between the instructors and the students. All participants reflected positively on their experiences in the course in their course journals and in classroom evaluations completed at the end of each session.

The Department of Mechanical Engineering, in conjunction with the ACENRES and the Math and Science Institute, plans to again offer "Energy and the Environment" during the summer of 2003. It is hoped that this course will continue to be offered on a regular basis in the future. While the upcoming offering will most likely result in the issuance of the last of the previously purchased equipment kits, the departments involved plan to pursue further funding support for future offerings.

Conclusion

From the viewpoint of the engineering programs, the creation and offering of "Energy and the Environment" has been very successful. It has served as an initial foray into graduate offerings, has fulfilled portions of the summer course load for two faculty members, and has served to further advertise the engineering programs to potential students through their high school science teachers.

More important, however, we believe the course has fulfilled its goals of providing classroom science teachers at the secondary level with knowledge and tools to address an issue of vital importance to the future of our country. While the level and amount of knowledge taken to junior and senior high schools by these teachers is not extremely high, they will present to their students a greater awareness of the need for secure and reliable energy supplies and some of the problems facing us in the future. The authors feel they are influencing tomorrow's consumers, researchers and citizens to have a greater concern for these issues. Hopefully, this course, and similar efforts by others, will lead to a more informed citizenry, better equipped to participate in the development of a sound, secure and safe energy policy for the United States in the future.

Acknowledgments

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many people who have helped in delivering portions of this course including fellow TECH faculty members and representatives from the various facilities visited.

Bibliography

Energy and the Environment, R. Ristinen and J. Kraushaar, J. Wiley & Sons, 1996.

http://www.atu.edu/msi/MSI_Photo_Album/PIX.htm

http://ces.atu.edu/seed_phsc.htm

Biographies

Dr. John L. Krohn currently serves as the Chair of the Department of Mechanical Engineering at Arkansas Tech University. Dr. Krohn holds the rank of Associate Professor in Engineering and is currently in his 12th year at TECH. Dr. Krohn received his doctoral degree from Texas A&M University in 1992 where he majored in nuclear engineering. He was previously employed as Assistant Director at the Texas A&M Nuclear Science Center.

Mr. Stan Apple currently serves as Instructor in the Department of Mechanical Engineering at Arkansas Tech University. Mr. Apple is in his 14th year at TECH. He also serves as the campus Radiation Safety Officer and operates the department's scanning electron microscope and neutron generator. Mr. Apple received his BSME degree from the University of Arkansas in 1989 and was previously employed by Brown & Root Construction.

APPENDIX I

SEED 6883 - Workshop

Energy and the Environment

1998 - 2000 Catalog Data	Prerequisite: Permission of instructor. The workshop will require the equivalency of fifteen clock hours of instruction per credit hour.
Textbook:	Energy and the Environment; R. A Ristinen and J. J. Kraushaar, J. Wiley and Sons Publishing Co., 1999.
References:	N/A
Coordinator:	Dr. John L. Krohn, Associate Professor of Engineering
Goals:	This course is designed to provide the K - 12 science teacher an introduction to the use of the earth's resources to meet current and future energy demands. The course will cover the major sources of electric power production: fossil fuels, nuclear fuels, and hydroelectric. In addition, the course will look at alternate energy sources and the effects of energy production on the environment.
Prerequisites by Topic:	College Algebra
Topics:	1. Energy Fundamentals 2. Fossil Fuels 3. Heat Engines 4. Renewable Energy Sources 5. Nuclear Energy 6. Energy Conservation 7. Transportation 8. Air Pollution 9. Global Effects
Computer Usage:	The computer is utilized as a tool in the performance of some lab experiments and in the preparation of lab reports and lesson plans.
Laboratory Projects:	1. Hydro Laboratory Experiment 2. Solar Energy Laboratory Experiment 3. Fossil Fuels Laboratory Experiment - Determination of the higher heating value for coal 4. Fuel Cells Laboratory Experiment 5. Radiation Detection Laboratory Experiment

General Course Information

SEED 6883 - Workshop

Energy and the Environment

Instructors:	Mr. Stanton C. Apple, Instructor of Engineering Dr. Randy Culp, Professor of Engineering Dr. Wayne Helmer, Associate Professor of Engineering Dr. John L. Krohn, Associate Professor of Engineering Dr. Bob Allen, Professor of Chemistry Dr. Robert Maruca, Associate Professor of Chemistry		
Textbook:	Energy and the Environment; R. A Ristinen and J. J. Kraushaar, J. Wiley and Sons Publishing Co., 1999.		
References:	N/A		
Supplies:	Calculator, Paper, Pencil, Eraser		
Grading:	Lesson Plans	100	points
	Lab Reports	50	points each
	Notebook	50	points
Grades:	90% - 100%	A	
	80% - 89%	B	
	70% - 70%	C	
	60% - 69%	D	
	0% - 59%	F	
Course Objectives:	This course is designed to provide the K - 12 science teacher an introduction to the use of the earth's resources to meet current and future energy demands. The course will cover the major sources of electric power production: fossil fuels, nuclear fuels, and hydroelectric. In addition, the course will look at alternate energy sources and the effects of energy production on the environment.		

SYLLABUS
SEED 6883 - Workshop
Energy and the Environment

Date	Period	Assigned Text Reading	Instructor	Laboratory Exercise	Snacks
Week One					
July 17	1a. 1b. 1c.	Registration and Welcome (8:00 - 9:40) Question and Answer Lesson Plan Review (10:00 - 12:00)	Krohn and Zimmer Krohn Morgan	N/A	A.M.
	2a. 2b. 2c.	Tour Campus Question and Answer Chapter 1	Apple Apple Krohn	N/A	
July 18	1a. 1b. 1c.	Chapter 5 Question and Answer Chapter 5	Krohn Krohn Krohn	N/A	A.M.
	2.	**Dardanelle Dam Tour** **Contact: Ken Storm xxx-xxxx**	Apple	N/A	
July 19	1a. 1b. 1c.	Hydro Lab Introduction Question and Answer Student Lab Preparation	Helmer Helmer N/A	N/A	A.M.
	2.	Lab	Helmer	Hydro Experiment	P.M.
July 20	1a. 1b. 1c.	Chapter 4 Question and Answer Travel	Krohn Krohn Apple/Krohn	N/A	
	2.	Tour the Arkansas Energy Office Photo-voltaic Experiment **Guest Speaker** - Arkansas Energy Office			Lunch
July 21	1a. 1b.	**Guest Speaker - ANO** - Garry Young - License Renewal of Nuclear Reactors Question and Answer			A.M.
	1c.	Chapters 2 and 3	Apple	N/A	
	2a. 2b. 2c.	Lab Question and Answer Preparation of lab reports	Allen Allen N/A	Fossil Fuels Experiment	

Period 1a - Morning Session: 9:00 - 10:20
Period 1b - Morning Session: 10:20 - 10:40
Period 1c - Morning Session: 10:40 - 12:00

Period 2a - Afternoon session: 1:00 - 2:20
Period 2b - Afternoon session: 2:20 - 2:40
Period 2c - Afternoon session: 2:40 - 4:00

SYLLABUS
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Date	Period	Assigned Text Reading	Instructor	Laboratory Exercise	Snacks
Week Two					
July 24	1. and 2.	**Tour - Flint Creek Power Plant, Gentry, Arkansas (Apple)** **Flint Creek Contact: Claude Gregory (xxx)-xxx-xxxx**			Lunch
July 25	1a. 1b. 1c.	Chapter 8 Question and Answer Lab	Krohn Krohn Apple	N/A Fuel Cell	A.M.
	2a 2b 2c	Chapter 6 Question and Answer Lab	Apple Apple Apple	 Radiation Detection	P.M.
July 26	1a. 1b. 1c.	Chapter 7 Question and Answer Preparation of lab reports	Helmer Helmer Apple	N/A	A.M.
	2a. 2b. 2c.	Chapters 9 Question and Answer Chapter 10	Allen Allen Allen	N/A	P.M.
July 27	1a. 1b. 1c.	Preparation of lab reports Question and Answer Chapter 6 (Revisited)	N/A Apple	N/A	A.M.
	2a. 2b. 2c.	Lab Question and Answer Lab	Apple Apple Apple	Radiation Detection	P.M.
July 28	1. 2.	Finish the preparation of lab reports and lesson plans Turn in Notebook			A.M.

Period 1a - Morning Session: 9:00 - 10:20
Period 1b - Morning Session: 10:20 - 10:40
Period 1c - Morning Session: 10:40 - 12:00

Period 2a - Afternoon session: 1:00 - 2:20
Period 2b - Afternoon session: 2:20 - 2:40
Period 2c - Afternoon session: 2:40 - 4:00