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ABSTRACT

This document describes a course designed to acquaint students with the many societal and technological problems facing the United States and the world due to the increasing demand for energy. The course begins with a writing assignment that involves readings on the environmental philosophy of Native Americans and the Chernobyl catastrophe. Emphasizing the many interactions between the energy needs of humanity and the environment is the focus of this course. The introductory lectures are concerned with the nature of energy and its units of measure. A brief summary of past energy crises, a discussion of energy conservation, an examination of the environmental consequences of electric power plants, and an exploration of population growth are also discussed. Other topics examined include renewable and nonrenewable resources, elimination of wastes, and the United States National Energy Policy Plan. (DDR)

ENERGY

by

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July, 1997

1. COURSE TITLE AND CATALOG DESCRIPTION FOR ENVIRONMENTAL STUDIES-33.

ENS-33 "Energy." Designed to acquaint the student with the many societal and technological problems facing the United States and the world due to the ever increasing demand for energy.

2. RESPONSIBLE PROFESSOR

J. Richard Shanebrook

Mechanical Engineering Department

3. PREREQUISITES

This course has no prerequisites and is open to students of any major or year of standing.

4. COURSE DESCRIPTION

The course begins with a writing assignment that is summarized in Appendix A. This assignment also involves a reading on the environmental philosophy of Native Americans (circa 1855) as expressed by Chief Seattle. The second reading, on the Chernobyl catastrophe, presents the current environmental dilemma of how to achieve economic development and, at the same time, preserve the environment. This assignment helps to set the tone for the course which emphasizes the many interactions between the energy needs of humanity and our environment.

The introductory lectures are concerned with the nature of energy as regards its forms (heat, chemical, electric) and units of measure (British thermal unit, quad, calorie, kilowatt hour). The concept of power is introduced and typical units (kilowatt, Btu/hour).

A brief summary of past energy crises is then presented, including how shortages of wood (in England) led to the use of coal and the Industrial Revolution. The predictions of M. King Hubbert (circa 1956) are presented including the energy resources that will be available when our

current fossil fuel economy collapses. The 1973-74 oil crisis is analyzed in the context of the end of an era (oil-fueled economic growth). The next oil crisis (1979 Russian invasion of Afghanistan) presents the Carter Doctrine where President Jimmy Carter warned of our commitment to protect Persian Gulf oil (one implied option was the use of tactical nuclear weapons).

With the above serving as an introduction to energy and its societal implications, the course presents many basics of solar energy processes including the hydrogen fusion process, the Greenhouse effect, photosynthesis, and past inventions for the direct use of solar energy (flat plate collectors, photovoltaic solar cells, passive and active water heating systems, and the design of superinsulated, solar-heated buildings).

The next major topic is energy conservation and how such practices reduce pollution (air and thermal), conserve resources, and save money. The presentation on thermal pollution includes electric power plant efficiencies for fossil and nuclear designs. The discussion on energy economics includes energy conservation measures for the homeowner. Appendix B is a related assignment on saving energy, money, and water with a showerhead flow restrictor. Automobiles are analyzed as regards the benefits of a 55 mile per hour (mph) speed limit compared to 65 mph (e.g., every gallon of gasoline saved reduces CO_2 emissions by 20 pounds). The analysis includes aerodynamic drag forces as well as rolling resistance factors (vehicle weight, tire air pressure, tire deformation).

The environmental consequences of electric power plants is covered with emphasis on coal and nuclear designs. Measures to improve coal plants are presented (gasification, fluidized bed combustion, scrubbers, electrostatic precipitators). The discussion on commercial nuclear

reactors includes pressurized water reactors and breeders. Problems of waste disposal, accidents, and limited supplies of uranium-235 are presented. The writings of Alvin Weinberg on breeder reactors are emphasized with the film, "No Act of God," presented for purposes of balance on this controversial topic.

The above discussion on commercial nuclear power plants leads naturally to a study of nuclear physics, radiation, and nuclear energy as presented in R. Wolfson's book, "Nuclear Choices." This was followed by a class discussion of the nuclear accident at Chernobyl (book by V.K. Savchenko) with emphasis on economic aspects, ecological effects, radiation-induced cancers, the deteriorating sarcophagus, and the lessons learned.

The next major topic covered is the role of population growth in meeting the future demand for energy in the world and the USA. Current statistics coupled with the mathematics of exponential growth are used to predict future trends in population growth and energy demand. An example is the simple formula for doubling time. The role of technology in providing adequate food and energy for the billions of additional people is discussed as is the, "Utterly Dismal Theorem of Economics." Case studies include the Irish Potato famine and the "Green Revolution" (with special emphasis on Mexico). The award-winning book, "Living Within Limits," by G. Hardin supplements much of the lecture material and provides valuable information on T. Malthus, negative feedback, land usage, and population control (China).

The nature of nonrenewable energy resources is discussed as regards the finite supply of fossil fuels and uranium on earth. With world energy demand rising at rates greater than four percent per year, aspects of energy resource planning are covered including the mathematics of exponential expiration time (EET) and the inevitable transition from our present fossil fuel

economy. EET calculations are presented for coal, natural gas, and petroleum. Special emphasis is placed on petroleum as regards its versatile uses as well as USA problems with imports. Hubbert curves are presented for world and USA oil consumption. A case study on the USA military dependence on oil is presented as regards direct uses (fuel for vehicles) and indirect uses (industrial production of military hardware). The total ranks the USA Department of Defense as 12th in the world among all nations (e.g., significantly more energy use than India, the second most populous nation on earth). USA national security is thus seen as very dependent on adequate and reliable supplies of petroleum to fuel the economy and the military.

Renewable energy resources are next presented in the context of alternatives to fossil and nuclear fuels. Biomass energy sources are presented with particular emphasis on wood and the importance of forest preservation (stewardship). Aspects of wind energy are analyzed in terms of its vast potential for the USA (Great Plains, coastal areas) and also associated problems (intermittent, diffuse). Hydroelectric power production is described as regards its technology, current usage, potential, and environmental consequences (dams, flooding, silting). Three forms of ocean energy are discussed (wave, tidal, thermal energy conversion) as well as the more exotic energy from space via satellite power stations. The human body is viewed as a solar-powered engine capable of performing many tasks of human mobility (walking, bicycling) and household chores (thus replacing machines powered by electricity and gasoline). It is noted that this is contrary to the present trend of replacing human labor with machines and leads to a discussion of related social ramifications (robots, computers, corporate downsizing). Current USA corporate survival theory is summarized as having three choices (automate, emigrate, or evaporate). The topic concludes with a discussion of Kurt Vonnegut's novel, "Player Piano," as regards the

dignity of human labor and a current social system where humans have replaced themselves with machines that contain their "ghosts."

The final topic on renewable energy resources concerns the elimination of waste. This involves a fundamental change in our social values from the current consumer society (buy it, use it, throw it away) to a conserver society. The latter minimizes all waste such as energy and materials via design (for efficiency and longevity), recycling, and reducing per capita demand. Specific topics include energy from solid waste (burning trash), recycling (paper, containers, lubricating oil), and methane production (manure, sewage, crop waste). The latter topic includes case studies of dairy farms where cow manure is converted into methane which powers electric generators (diesel engines).

The course concludes with a class discussion and writing assignment on the USA National Energy Policy Plan as published by the US Department of Energy as, "Sustainable Energy Strategy." Appendix C summarizes this assignment, which serves to bring the course material together and to stimulate student thinking on the energy future of our nation. Class discussion focuses on the role of the USA, as the global superpower, whose energy plan for the future may serve as a model for the rest of the world on such issues as population growth, environmental pollution, and future energy sources.

5. REQUIRED READINGS

A. Brother Eagle, Sister Sky, by S. Jeffers, Dial Books, New York, 1991.

B. The Ecology of the Chernobyl Catastrophe, by V.K. Savchenko, UNESCO, Paris, 1995.

C. Energy One, by J.R. Shanebrook, Union College.

D. "To Breed or Not to Breed?", by A.M. Weinberg, Across the Board, The Conference Board Magazine, Vol. 14, Sept. 1977, pp. 5-24.

E Nuclear Choices, by R. Wolfson, MIT Press, Cambridge, MA, 1993.

F. Living Within Limits, by G. Hardin, Oxford University Press, New York, 1993.

G. Sustainable Energy Strategy, National Energy Policy Plan, U.S. Government Printing Office, Washington, D.C., July 1995.

6. INFORMATION ON FILMS/VIDEOS SHOWN IN THIS COURSE

A. "A Conversation with M. King Hubbert," 16 mm film purchased from the National Audiovisual Center, Washington, D.C. (Title No. 007797/RE). Excellent message but sound quality is poor.

B. Two videos, "The Ghost of Chernobyl," and "Three Mile Island Revisited," were rented from Wilmington College, Wilmington, OH. Telephone: (513) 382-5338.

C. "No Act of God", 16 mm film purchased from Bullfrog Films, Inc., Oley, PA. Produced by the National Film Board of Canada, this film explores the question of nuclear power and breeder reactors with emphasis on the problems of waste disposal, terrorists, and plutonium proliferation. Speakers include A. Weinberg, T. Taylor, H. Alfven, and A. Lovins.

D. "Lovins on the Soft Path," 16 mm film purchased from Bullfrog Films, Inc., Oley, PA. This award-winning film features Amory and Hunter Lovins and outlines their analysis of the energy problem.

Appendix A

ENS 33 ASSIGNMENT

I) Read the book, Brother Eagle, Sister Sky, by Susan Jeffers (on Reserve).

II) Read the following from the book, The Ecology of the Chernobyl Catastrophe, by V.K. Savchenko, (on Reserve):

pp. v-vii	(Preface)
pp. xv-xix	(Foreword)
pp. 1-24	(Chapter 1)
pp. 133-154	(Chapter 7)
pp. 181-185	(Conclusion)

III) Write the following:

A) Summarize, in your own words, the environmental philosophy of Chief Seattle.

B) What does Savchenko mean by the following statement:

"At present all our world is faced with the Scylla and Charybdis of the development and the degradation of the environment."

C) What environmental philosophy do you recommend for the future of the earth? Why?

Appendix B

ENS 33 ASSIGNMENT

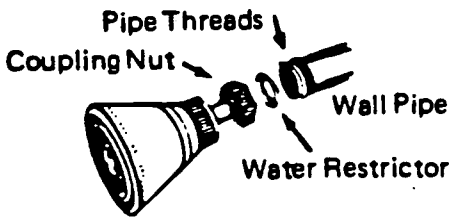
Given the following data, determine the BTUs and dollars saved per year if every shower at Union College were to be equipped with a flow restrictor that reduces the flow rate by 42 per cent:

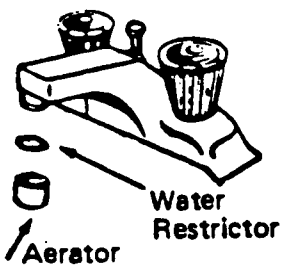
- 400,000 showers per year (2,000 students; 200 showers each).
- 6 gallons per minute is the flow rate without a restrictor.
- Each shower is ten minutes long.
- Electrical energy is used to heat the water by 50 Fahrenheit degrees (from 60 F to 110 F).
- The cost of electrical energy is 6.5 cents per Kwhr.
- One gallon of water weighs 8.36 pounds.

ENERGY CONSERVATION FLOW RESTRICTOR

Installation Instructions: With water shut off, unscrew coupling nut and remove shower head body or remove aerator from faucet. If there is a rubber gasket remove it and insert the flow restrictor with the beveled edge (cone side) facing down. Then replace the gasket and reassemble. Use the same process for shower heads with ball joint attached to the wall pipe.

NOTE: It may be necessary to apply a small amount of sealing compound on pipe threads to assure tight seal.





Appendix C

ENS 33 ASSIGNMENT

I) Read the report, Sustainable Energy Strategy, (USA National Energy Policy Plan), July 1995.

II) Write a critique of this document that includes your suggestions on how to improve the future energy strategy of our nation.

III) One possible form for this critique is a "Letter to the Editor," or letter to your Congressional representative.

IV) There are no length restrictions on this assignment.

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