The Importance of Energy in the Undergraduate Curriculum

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Abstract
Billions of dollars are spent every year by the United States and other OECD countries protecting the supply lines coming from oil rich areas. In the early 70s, even the threat of a slight cutback in oil imports from OPEC countries caused huge lines and gas stations and a disruption of the American economy. Energy literacy is an important component of an informed citizenry. Yet most citizens know little.
From global warming to toxic waste to resource depletion, energy is central. This paper describes two courses the author has developed and teaches, Energy and Sustainability and Renewable Energy. They not only teach the fundamentals of energy, such as the laws of thermodynamics, which are essential to understanding its role, but also the social and political context of energy extraction and use. Enthusiasm for these courses is high among students, and pre- and post-tests show that students have a much greater understanding and appreciation of energy in our society. The paper will also present some of the basic data covered in the courses concerning energy use and availability worldwide, which among other things, shows the great disparities that exist around the world.

1. Introduction
In any consideration of environmental, social justice, economic, political or foreign policy issues, energy plays a key role. Yet many students receive a baccalaureate degree without having any sense of what energy means to our economy and society, or how energy flows affect our lives. Energy literacy is an important component of an informed citizenry. From global warming to toxic waste to resource depletion to military spending, energy is central. This paper discusses the importance of energy to our economy, and describes two courses the author has developed and teaches, *Energy and Sustainability* and *Renewable Energy*.

2. The Issues
2.1 Energy and the Economy
"In the year 1973 the term 'energy' became common in households throughout the United States." [1] Why? Because that year everyone in the United States became aware of the crucial role energy played in our society and economy, all because the Organization of Oil Exporting Countries (OPEC) decided to withhold, for political reasons, some of the oil exported to the United States. Gasoline lines formed around the block in most American cities; cities and states adopted various schemes to ration the gasoline, such as allowing cars with even numbered license plates to fill up on one day, odd numbered plates on another day, and so forth.
The annual use of energy in the United States went from about 5 QBtus in 1850 to 100 QBtus in 2000, during which time the population increased from 23 to 281 million. Energy use, therefore, grew almost 10 times as fast as population. Other developed nations showed a similar growth. It allowed many lives to improve. It stimulated many inventions, not the least of which was the automobile, which liberated many and let families picnic in open spaces, men and women travel to work more easily, and allowed for more expansive use of leisure time. Although it took struggles, it also allowed the working day to be shorter.

2.2 The Problems with Energy

But along with the benefits have come problems. Among the most important, although by no means the only one, is global climate change. Despite the existence of well known and well funded climate change deniers, most of the population in our countries accepts the existence of an increase in global average temperature. [3, 4] It is beginning to have results that affect us all; rising sea levels, extreme weather patterns, crop failures, and more.

Of course, these are not the only problems presented by our profligate use of fossil fuels for our energy supply. Consider, for one, the military might that is necessary to guard the sea lanes through which the oil from the Middle East and elsewhere travels to its ultimate destination. [9] Also, consider the military conflicts that have arisen as a result of competing claims for oil and other resources. [10, 11] There is not space in this paper to thoroughly examine these issues, but they all speak of the importance of eliminating or at least reducing our reliance on fossil fuels. And to do this we need a population more "literate" in energy issues.

Another group of issues is raised by nuclear power, including the connection between nuclear power and the nuclear weapons enterprise. I have made the case that nuclear power must be considered in the face of certain global climate change. [15] One must remember, however, that the same process used to "enrich" the uranium, necessary to make sure the uranium can sustain a chain reaction in a reactor, can also be used to further enrich it so that it can be used in a bomb. It is also true that in the "spent" fuel rods from a reactor used to produce electricity is contained small amounts of plutonium, which after being separated chemically - much easier than the process using centrifuges to enrich the uranium with the proper amount of the proper isotope - and also produce a bomb. Wherever one has nuclear power, one has the possibility of the proliferation of atomic weapons.

Most experts agree that our urban centers, home of over 50% of the world's population, are key to solving the world's energy problems, by making themselves more energy efficient. [16, 17] In many cases, this will imply significant changes in the ways in which cities are laid out.

3. The Courses

The courses described here are not meant to be blueprints, but merely examples of what can be done. There are many different ways of explaining energy to a lay population; these are just some. Although some of the students in these courses are environmental studies majors, many are not, but are drawn to the courses because of their inherent interest in energy and environmental issues. Although there is a good deal of science in the courses, the school in which I teach has very few science majors, although it is known for its innovative teaching and pedagogical advances. [18-24]

3.1 Energy and Sustainability

This is a course developed by the Department of Natural Sciences, of which I once was chair. I taught it for six years, and have written about it elsewhere. [25] Although it is required for the science major, many of the students in the course are not science majors. In surveys, most non-science majors said that they took the course to learn something about sustainability.

The sustainability portion of the course starts with a fairly comprehensive look at the history of the discovery of climate change. [26] Using an historical approach allows one more easily to understand the nuanced nature of changes in the climate. It also allows for a discussion of the epistemology of science, very important for an understanding of this particular issue. With current talk of the lack of reproducibility in many scientific experiments, [27] it is important that students understand the nature of scientific discovery. Otherwise, students as well as the general public are mystified by seeming great differences of opinion on scientific issues of public import. Nowhere is this more true than in the case of climate change.

The course then quickly turns to the discussion of energy, including the basic science. There are several basic “facts” that students (and the general population) need to know. The first is alluded to above, namely that the laws of thermodynamics tell us that there is no such thing as 100% efficiency, and that in particular, reciprocating engines, the kind that use fossil fuel to propel our automobiles, trucks, airplanes and the like, suffer from “Carnot efficiency” laws, and cannot gain efficiencies above about 38%. This is hard to understand, and even harder to swallow, so a considerable time is spent on it.

3.2 Renewable Energy

An advanced course, it relies on student initiative; it runs much like a graduate school group of students preparing for an exam. It also has been written about elsewhere. [28] A unique feature of the class is that as a whole, with each student taking on one aspect, the class researches and writes a paper showing how the United States can be fossil fuel free by 2030, a date chosen because it is the date by which many say CO_2 in the atmosphere, without significant change, will reach dangerous levels.

Each semester in which the class is given, it builds on the work of a previous semester. They check the previous work done for its accuracy and for any updates on the technology and its cost, and add a technology that was unable to be examined previously. Everything is posted on a Google Drive, so that everyone can edit and add sections. At the end of the class, a presentation is made to an audience of interested students and faculty.

4. Conclusion

As stated before, these are not blueprints, but simply examples of what can be done. Experience has shown that teachers are much more excited about courses which they design than those that are simply taken over from someone else. And the need is there.

References

[1] Ristinen, R.A. and J.J. Kraushaar, *Energy and the environment*. 2nd ed. 2006, Hoboken, N.J.: John Wiley. xvii, 365 p.

[2] Temple, R.K.G. and J. Needham, *The genius of China : 3,000 years of science, discovery, and invention*. 1986, New York: Simon and Schuster. 254 p.

[3] Leiserowitz, A.A. *Yale Project on Climate Change Communication*. 2014 [cited 2014 February 11]; Available from: http://environment.yale.edu/climate-communication/.

[4] Leiserowitz, A.A., N. Smith, and J.R. Marlon, *Americans' Knowledge of Climate Change*. 2010, Yale U, New Haven, CT:niversity Yale Project on Climate Change Communication: New Haven.

[5] Braun, L., *Race, Ethnicity, and Health: can genetics explain disparities.* Perspectives in Biology and Medicine, 2002. **45**(2 (Spring 2002): p. 159-74.

[6] Delucchi, M.A. and M.Z. Jacobson, *Providing all global energy with wind, water, and solar power, Part II: Reliability, system and transmission costs, and policies.* Energy Policy, 2011. **39**: p. 1170-1190.

[7] Jacobson, M.Z. and M.A. Delucchi, *Providing all global energy with wind, water, and solar power, Part I: Technologies, energy resources, quantities and areas of infrastructure, and materials.* Energy Policy, 2011. **39**: p. 1154-1169.

[8] Jacobson, M.Z. and M.A. Delucchi, *A Path to Sustainable Energy by 2030*, in *Scientific American*. 2009. p. 58-65.

[9] Liska, A.J. and R.K. Perrin, *Securing Foreign Oil: A Case for Including Military Operations in the Climate Change Impact of Fuels*, in *Environment*. 2010, Taylor & Francis: Philadelphia.

[10] Klare, M.T., *Resource wars: the new landscape of global conflict*. 1st ed. 2001, New York: Metropolitan Books. 289 p.

[11] Meadows, D., *Basic Facts About Energy and the Middle East*. 2012, Sustainability Institute: Hartland, VT.
[12] Rhodes, R., *The making of the atomic bomb*. 1986, New York: Simon & Schuster. 886 p., [42] p. of plates.
[13] Wills, G., *Bomb power : the modern presidency and the national security state*. 2010, New York: Penguin Press. 278 p.
[14] McGowan, A.H., *The Science and Politics of the Atomic Bomb*. 2012, ICERI. p. 5766-5771.
[15] McGowan, A., *The Case for Nuclear Power*, in *Jewish Currents*. 2013: New York. p. 4-7.
[16] Anonymous. *The City Next Door*. Pictures of the Future 2013 [cited 2014 February 15]; Available from: http://www.siemens.com/innovation/apps/pof_microsite/_pof-fall-2013/_html_en/urban-energy-efficiency.html.
[17] Soule, J., *Key Role of Urban Planning in Energy Efficiency*. American Planning Association.
[18] Chamany, K., *Ninos Desaparecidos.* Journal of College Science Teaching, 2001. **31**(1): p. 61-65.
[19] Chamany, K., *Science and Social Justice: Making the Case for Case Studies.* Journal of College Science Teaching, 2006. **36**(2).
[20] Venkataraman, B., *Chemistry of Life: Chemical Evolution as a Theme for Teaching Undergraduate Chemistry*, in *Chemical Evolution: Chemical Change Across Space and Time*. 2007, Oxford University Press: American Chemical Society.
[22] McGowan, A., *Teaching Science and Ethics to Undergraduates: A Multidisciplinary Approach.* Science and Engineering Ethics, 2012.
[23] McGowan, A.H., *Genes and Race in the Classroom.* Journal of College Science Teaching, 2005. 34(6).
[24] McGowan, A.H., *Innovation in Science Education: Combining Science with Ethics and Politics*. 2011, ICERI. p. 4815-4821.
[25] McGowan, A.H., *Energy and Sustainability: An Undergraduate Course.* Environmental Studies and Sciences, 2011. **1**(1).
[26] Weart, S.R., *The discovery of global warming*. Rev. and expanded ed. New histories of science, technology, and medicine. 2008, Cambridge, Mass.: Harvard University Press. x, 230 p.
[27] McNutt, M., *Reproducibility.* 2014. 343(17 January): p. 229.
[28] McGowan, A.H., *Renewable Energy: An Interdisciplinary Problem Solving Course.* Journal of Systematics, Cybernetics and Informatics, 2013. 11(1): p. 51-54.