# Teaching about Energy Use at the University Level as a Way to Discuss Nuclear Power

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## Abstract

Alberta is considering getting a nuclear power plant. University science departments can play a significant role in educating the public about various aspects of nuclear power, and electricity usage in general. This paper discusses a novel class on energy production, use and distribution. This large lecture course has 100 students who have little to no technical training in energy. By teaching about energy issues, students become more interested nuclear power as part of the energy production portfolio.

## 1. Introduction

The Canadian nuclear industry faces a difficult hurdle to overcome: few people in the public know much about nuclear power. People are suspicious of technology that they don't have direct, personal experience with. The coming nuclear renaissance may very well depend on educating the public about nuclear power. Unfortunately, electricity generation is one of many issues that people don't think about, because it works so smoothly in their lives, which enables an "out of sight, out of mind" attitude. I believe that the solution is to actively engage people to think about where their electricity does come from. I have created a class which gets people thinking about electricity and wondering why isn't more nuclear power being used?

The CNS recently (January 2011) launched a website that shows where electricity is coming from in any given hour in Ontario[1], this website has been tremendously popular. Education can get people beyond thinking that electricity comes "out of a socket in the wall", but some external agent has to break people out of these thought patterns. Power production is a complex issue, especially nuclear power, and these complex ideas are difficult to communicate in the modern day sound byte focused world. The classroom environment keeps students as a captive and receptive audience for months, which allows complex ideas to be developed slowly over time.

Advocates for nuclear power are almost exclusively from within the industry, and advocates against the nuclear industry seldom have extensive knowledge of nuclear power. Having observed this tendency at the anecdotal level, I decided that a course on energy issues might change how people view the nuclear industry. I believe that by teaching people about the electrical grid, and sources of electrical generation, including an introduction to nuclear power, people will ask why nuclear power isn't used even more than it is now. One data point, the first to come from this class: a student in the class commented to me after the first presentation on nuclear power that he thinks the whole solution to our energy difficulties could come from putting up as many nuclear power plants as we possibly can. Preliminary analysis of student opinions seemed to be consistent with this continuing as students learn more. There are a surprising number of misconceptions and lack of opportunities for people to learn about the grid directly from another person as opposed to attempting to sift through the web.

## 2. Introduction to energy

In a classroom atmosphere students are free to learn and change their mind about many issues, including issues related to energy sources. One student commented that he was surprised to learn that cooling towers emit nothing more than water vapor, as opposed to $CO_2$ or other more harmful gasses. I suspect that every time he had seen a picture of a cooling tower for a nuclear power plant he believed that nuclear power contributes a considerable amount to global warming and airborne pollution. Another student is from the area where a nuclear power plant is proposed in Alberta, and as a result of this class has had a chance to learn quite a bit about nuclear power. She privately expressed some frustration that her parents' generation had taken an attitude that is probably best described as: "we're going to decide this for you and not let you participate in the information." At the end of the course several students expressed frustration that there was no course that they could take focusing entirely on nuclear power[2].

My experience teaching this course so far has led me to believe that, unless forced to, people don't associate a fuel or energy source with the electricity coming out of the wall. By actively engaging students in conversation about this process, I believe this awareness can be increased. I'm building up these ideas slowly, and there has been much enthusiasm and curiosity in the course. I have been finding that, until the subject comes in class students don't naturally distinguish between energy, power and electricity, using them interchangeably in conversation. Once again, this can be remedied with instruction. Carefully engaging students using student response systems (often known as clickers) has been shown to increase student retention and student comprehension[3]. I'm using multiple choice and simple numeric questions to make sure the students are attending and participating in class. Students seem to enjoy an almost quiz-show like competition to show that they understand what I'm presenting, or what they read for the homework.

I affectionately refer to my course as "Energy for Everyone", (officially it's "Introduction to Energy"). "Energy for Everyone" fulfills the science requirement for students from non-technical degree programs, but is also taken by some science students. In order to keep the course as accessible as possible, the course uses as little mathematics as possible and uses many lecture demonstrations. The course is currently being taught for the first time and will develop over time. I'm hoping to introduce many teaching technologies to this class, including on-line, videos of me doing related calculations to help students with the homework.

During the normal registration time period only 20 people signed up for the course, and on the first day of class enrollment had grown to 62. As word spread about the course the enrollment reached 100 students a couple weeks later. Many students complained that they had only heard about the course by chance. The department of Physics And Astronomy intends to offer this course again next year with 400 seats available for students. My university hopes for hundreds of students every year in this course; I'm hoping for hundreds of universities offering this course. I believe that this issue should be presented in a format similar to this in every university in Canada.

"Energy for Everyone" starts with how our quality of life depends intimately on energy distribution and specifically electricity generation. Most reasonable measurements of quality of life track quite nicely with per capita energy use and per capita electricity use. A wonderful website, gapminder.org, allows students to look at data for specific countries from a variety of sources. These data include information on quality of life in countries all over the world, and energy use. Students have a chance to play with the data to draw their own conclusions. While most of the students agree coming into the class that energy issues are important, a certain amount of time and effort has to be spent to show students exactly why energy issues are important.

The class moves on to discuss forces, work and energy. A force is defined as the interaction between systems, a push or a pull. Much physics education literature is devoted to students' preconceptions about forces[4], fully addressing these preconceptions take a lot of time, so I make this

as small a part of the course as I reasonably can. In order to do work, a force is exerted for some distance. Work transfers energy between systems and I show a series of simple machines and show how the force times distance winds up being the same no matter what the mechanical advantage of a given simple machine is. Pulleys work particularly well for this concept, although gears and levers are also mentioned. The idea of energy is developed from the idea of work. I discuss energy conservation, and the idea of useful energy and thermal energy. This development of energy makes it quite natural for students to see why energy is needed for every process (industrial, home, etc.) that is done. Many students from the University of Calgary go off to work in some capacity in the energy industry, so I'm hoping that my exploration of energy will give them a good idea of what it is the energy industry sells.

I then move on to common, personal uses of energy, transportation and home use. Much time is spent developing ideas that are often glossed over in physics classes, like air drag and rolling resistance in transportation. Relatively simple models developed in the textbook[5] allow students with high school mathematics to figure out the relative efficiencies of various types of transportation. I introduce heat engines and heat pumps, so students can see how our electricity comes from differences in thermal energy. Home heating and cooling is discussed, with some focus on insulation and efficiency. Some discussion includes fundamental limits of efficiency for heat engines, but also some practical limits for personal energy use conservation. I have heard people claim that we just need to improve the efficiency of our heat engines, or we can cut our energy use by 90% without changing our lifestyle. This course shows why statements like that just aren't true.

One of the touchstone concepts of the course is that just because something is theoretically possible doesn't make it reasonable to attempt it. As the textbook[5] states, when discussing energy options it's important to use numbers, not adjectives. We have 'lots' of solar power available too us and there is a 'limited' amount of uranium on the planet, but these adjectives, while true, can give a very distorted view of what's practical for implementation. This is kept in mind as the course moves on to discuss fossil and nuclear fuels, solar power, wind power and hydro. The course spends a couple days discussing the greenhouse effect and consequences of fossil fuels.

I have a spreadsheet with the past five decades of energy use in the world detailed [6]. I gave the students the spreadsheet and tell them, as an exercise, to come up with an energy plan for the next few decades. The spreadsheet estimates the cost per person of their plan. I've found that having students go through the past century of energy production use and distribution makes them realize it's impossible to meet electricity needs without using nuclear power. This term almost every student increased the amount of nuclear power in use, and usually in much greater proportion to any other source of electricity. When I have used this spreadsheet as part of other courses, most of the students immediately want to know why people aren't dramatically increasing the amount of nuclear power on the grid.

## 3. Conclusion

This is only a preliminary report on the first iteration of the introduction to energy course. I already have plans for improvements for next years' class, which I look forward to implementing. The students discuss energy sources and the related advantages and disadvantages throughout this entire course, and have to rely as much as they can on numbers rather than adjectives. This active discussion among peers creates a neutral forum for student questions to be answered. Students have to explain these questions on an exam and explain the advantages and disadvantages of different energy sources. It's important to show the need for a diverse electricity generation portfolio, based on the demands of the situation. These students have come out of the course wanting to know more about nuclear power as a source of electricity.

## 4. References

[1] http://media.cns-snc.ca/ontarioelectricity/ontarioelectricity.html While the original idea was mine, the real work was done by Elmir Lekovic. At last count this website had been getting thousands of hits a months.

[2] I do teach a course at the University of Calgary on nuclear power, but it requires scientific training beyond this course, including a year of introductory physics. I'm looking into options for these students.

[3] M. Martyn, "Clickers in the Classroom: An Active Learning Approach", Educause Quarterly Nov 2nd, 2007, pp. 71-74.

[4] D. Hestenes, M. Wells and G. Swackhamer, "Force Concept Inventory", Physics Teacher March 1992. There's much excellent literature, but this is one good place to start.

[5] I decided to use the excellent popular science book: "Sustainable Energy: without the hot air" by David MacKay, the book is available for download for free from: http://www.withouthotair.com/

[6] I got this spreadsheet originally from Pat Keefe from Clatsop Community College and Greg Mulder from Linn-Benton Community College and modified it. Please contact me if you'd like to use the spreadsheet.