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A Free Online Resource for Teaching University Courses on Climate Change and Energy

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Abstract

The University of Calgary energy education team is developing a free web resource that covers climate change and its relationship to the entire energy sector. In the short-term, this resource can be treated as an encyclopedia, but the long-term hope is that it can be used as an online textbook as well. This website helps university students (or the general public) learn about issues surrounding energy using interactive data visualization tools and simulations. This website will supplement university courses or free online courses on climate change and energy.

Keywords: energy education, climate change education

Résumé

Si l'article est en français, le résumé français sera le premier.

Mots clés : conférence, article, modèle, dix mots maximum

1. Introduction

Conversations about climate change often fail to take into account the energy needs of society. On the energy side of the discussion, many conversations about energy resources and use fail to take into account the impact of these on the world's climate. Real conversations about ways to minimize both climate change and energy poverty require people to have a broad understanding of energy and climate, which traditional academic disciplines fail to provide. Both energy and climate issues involve topics from many traditional fields of study including chemistry, physics, economics, environmental science, and biology. This creates a need for a treatment of energy that encompasses many academic disciplines. Universities exist, in part, to educate the adult public; therefore, a university-based resource that serves as both a textbook for courses and an open access resource for public use would advance this objective. Universities have the advantage of being positioned at arms-length from energy corporations, but also at arms-length from politically-driven non-governmental organizations and activist groups. This paper discusses the ongoing process of developing a free online resource at the University of Calgary.

The energy education team at the University of Calgary has spent the past two years developing a resource that will cover the entire energy sector: primary energy sources, the extraction of primary energy from nature, its processing, distribution, and use, ultimately to the environmental consequences of these practices. The environmental consequence of most

immediate concern is how carbon dioxide emitted from fossil fuels is warming our planet and creating a dangerously changing climate.

The energy education team was formed in the summer of 2013 to create this system *de novo*. We investigated operating platforms, came up with a set of guidelines for creating content, and defined the scope and goals of the project. We now have a preliminary public website with over 300 pages of content on the science behind the energy sector. Our team hopes to have 1000 pages of content by 2017 so that the website can be used to teach university courses on energy. The website can be found at energyeducation.ca. Notably, our resource includes several data visualization interfaces to help people better understand where their energy comes from; some examples of these will be discussed below.

2. The encyclopedia

2.1 The platform

We've chosen to develop this resource on the Wikimedia platform [1]; this platform also provides some of the images that are used, as Wikimedia's images are creative commons licensed. This wiki platform has made linking different pages quite easy for the various writers. This software also keeps track of what pages still need to be written, so we can see where next to devote our development efforts.

Two separate versions of the wiki are operational. The public version (energyeducation.ca) has our final product. This version still gets updated, for example, as information changes or as we have better ideas of how to express what we wish to say. We only upload content to the public platform once we are confident that it is of high quality. We also have a password-protected version on a hidden platform to make sure that incomplete draft versions are available to all editors. This staged process allows us the freedom to flesh out creative ideas privately before posting them to the world at large.

2.2 Data and concept visualizations

The biggest advantage of an online platform is having it freely available to anyone with internet access. The next great advantage is the ability to include interactive visualizations. We have made extensive use of the PhET visualizations, created by the Physics Education Research Group at the University of Colorado [2]; and Chronozoom, developed by a consortium of collaborators (a complete list is available on their website) [3]. These ready-made visualizations are popular with students and research has shown that when students use these visualizations in other contexts (like classrooms), the result is a dramatic improvement in understanding these science concepts [4]. These computer simulations allow the users to follow their own interests and interpret information in their own ways. This ownership of the learning process inspires students to pursue individualized inquiry with the information and take ownership of what they learn. The downside is that people rarely challenge deeply held beliefs without guidance. Thus, guidance provided along with these simulations will be able to do what the simulations alone cannot [4]. This is why having a teacher use this resource in a class will provide more help than this resource alone.

Some examples of how the PhET simulations have been used in our project:

- Our explanation of how potential energy becomes kinetic energy and vice versa: http://energyeducation.ca/encyclopedia/Potential_energy

- Our explanation of how friction turns energy that we can see (moving objects) into energy that we can't see (moving molecules):
  http://energyeducation.ca/encyclopedia/Friction

- Our explanation of how a nucleus forms and holds energy:
  http://energyeducation.ca/encyclopedia/Nucleus

And our use of Chronozoom [3] can be seen here:

- An explanation showing how long the universe has been around and how little time humans have been on the planet:
  http://energyeducation.ca/encyclopedia/Timescale_of_the_universe

The team has also used Google's graphing tools to create a way of visualizing data about population, energy, and fuels. We have taken data from British Petroleum (BP) [5], the Organization for Economic Cooperation and Development (OECD) [6], and the United States Energy Information Agency (EIA) [7] about energy use. Examples of how we allow the user to interact with graphical representations of these data can be found at the bottom of each of the following pages:

- For BP [5] data showing natural gas use in different regions of the world as a function of time:
  http://energyeducation.ca/encyclopedia/Natural_gas

- For OECD [6] data showing how much more energy per person is used in rich countries than in poor countries:
  http://energyeducation.ca/encyclopedia/OECD

- For EIA [7] data showing where every single country in the world gets its electricity:
  http://energyeducation.ca/encyclopedia/Electricity_generation

These resources will be further developed in the coming years.

3. Discussion

Energy issues are important to Canada today. Climate change is being caused largely by the CO_2 we release when using fossil fuels to generate our energy. The Canadian economy is powered by these fossil fuels. Many people seem to understand that there's a relationship between the CO_2 and the energy we make use of in our everyday lives, but many people simply 'don't think about' what that connection is. While people often understand that fossil fuels contain carbon, there seems to be a mental disconnect between the act of using an electronic device and the likely source of its electricity - a power plant emitting CO_2. The energy story is complicated. Different electricity grids produce different amounts of carbon dioxide per kilowatt hour. Most people don't understand what a kilowatt is, what a kilowatt hour is, or where they come from, how they are measured, or even why it might matter. In short, people often don't trace the origins of the electricity they use any further than a plug in the wall.

An even deeper issue is that most people don't realize how almost all transportation energy comes (indirectly) from oil through energy products like gasoline, diesel, and jet fuel. While switching to efficient light-bulbs is nice, and one of the most commonly talked-about solutions

for climate change, driving fewer kilometers would have a far larger *per capita* impact. In many regions of Canada, improving insulation in houses would have a greater impact still. The most visible solutions are not necessarily those that produce the most significant effects.

We have found that, in terms of facilitating energy literacy, simply making information available via energyeducation.ca is insufficient. People often seem to seek out particular facts rather than an overarching understanding of energy. When people use the resource on their own time, people confirm their preconceptions. What is needed is a comprehensive view of the energy sector as a whole; literacy must involve a deep understanding of the interplays between all of the parts of an energy system.

Trivial treatment of energy topics (as found in free online quizzes and the like) obfuscates the deep and complex issues surrounding energy. Without a proper treatment of the topic, no solution to today's issues will be found. Furthermore, people have a strong tendency to focus on the part of the energy sector that's most visible, like the part that they work in, but a holistic approach dealing with the entire energy system must be undertaken in order to establish context. The conversation must grow beyond carefully selected facts to offer a picture of the whole industry.

Current impetus for policy change is often based on a 'feel good' approach. This creates pressure for companies to greenwash (make a change that looks good but has no significant positive impact) rather than to green our energy mix (make change with significant consequences). With the public failing to hold these companies accountable for their energy choices, companies need only to appear to care about climate and environmental issues. An energy literate public can create an environment that pressures companies to take meaningful action. When people are energy literate they are capable of understanding the subtle nuances to why we need energy, what energy does for us, and what our options are moving forward. All energy sources have environmental consequences; a real conversation about energy must discuss the trade-offs of issues such as pipelines and solar panels.

True energy literacy is not simply a key to obtaining social license. Many companies seem to approach the idea of energy literacy from the following point of view: 'if you understand enough about my part of the energy sector you should see that I'm trustworthy and therefore my company will continue to be allowed to make large sums of money.' Energy literacy initiatives often start with energy companies. Environmental groups are not interested in people understanding why energy is needed, but focus instead on why caring for our environment is needed, and this incomplete picture prevents real conversations from taking place. Industry-driven energy literacy projects are often spoken of as being 'fact based', but their authors cherry-pick their facts in such a way as to massage the listener into believing, for example, that the bitumen projects in Alberta won't have negative impacts on the way that people live today.

Climate change is a difficult problem, and it is made considerably more difficult by the misinformation about climate, scientific consensus, and energy with which people are constantly bombarded. We cannot have a real conversation about climate if the subject is in any way divorced from how we're changing the climate in the first place. Vilifying natural gas, coal, and oil without understanding why we are chained to these fossil fuels in the first place prevents the public from coming to any sort of understanding about what realistic options are available to us.

In order to combat energy illiteracy, efforts must go deeper than creating a passively available website. We can neither expect people to independently read enough of our website to make a

difference, nor can we expect them to confront their preconceptions on their own [4]. Teachers are important, classwork is important, and both must be provided to ensure a deeper understanding. This website is a resource for teaching people about the energy sector, starting with educating people on which gaps they have in their existing knowledge. The pervasiveness of incomplete information (and misinformation) in the public sphere and opinions about energy means that people have just enough knowledge to believe themselves well-informed without having a complete picture of the issues involved. Energy is an issue about which people don't know what they don't know. Metacognitive processing is necessary to get people to develop a subtle and sophisticated way of approaching these topics. One of the ways that people do that is with blogs. We are hoping that this resource will provide fodder for blogs, data, information, and explanation of what terms actually mean and don't mean.

The main strength of the project is that it is a tool to help people develop their own sophistication by being guided through material. Guides must be both expert and aware their own prejudices and accommodate them properly. It's impossible to avoid having opinions about energy issues; the issues are far too deeply entrenched in our personal and political identities. It is possible, however, to get people sufficiently informed to appreciate the complete picture and thoughtfully consider the complexities of the issues involved.

This resource will allow university professors to teach an 'energy overview' course for non-science majors at institutions across Canada [8]. Our project will hopefully eventually grow to include other opportunities for teaching as well, such as energy issues training for k-12 teachers. It is also hoped that eventually the website could support one or more free online courses covering the entire energy sector. A course-based approach will allow people to spend sufficient time with the material to move beyond their preconceptions and obtain a deep understanding of the interplay between modern society's need for energy and its consequences on climate.

One big advantage of an online format is that rather than being read in a traditional linear fashion like a textbook, the resource can be approached at any point and can lead people through the connections of their interests. Much like Wikipedia, the resource is densely interlinked, making this sort of exploratory work quite easy to do. Unlike Wikipedia, the resource has clear authors with clear and credible expertise. The online nature makes it quite possible for other content creators such as bloggers to link in to the material. This has already happened with Forbes magazine [9]. We have deliberately not pursued much in the way of publicity yet, as we feel quite strongly that until we have 1000 pages of content, our resource won't be complete enough to warrant extensive self-promotion.

4. Conclusion

We are in the ongoing process of developing a web-based resource that will grow to cover the entire energy sector and climate science. This means that the resource will explain how all primary sources of energy work. The resource will also explain benefits and drawbacks of each of these sources. The methods for turning these primary energy sources into energy products and energy currencies will be discussed, as will the distribution methods of these products (e.g., pipelines and electricity grid). The use of these products will also be discussed, both in terms of quantity and also how this energy is used to deliver various energy services.

Future work will involve incorporating this website into university based and online courses on energy.

5. References

[1] The Wikimedia foundation's resources: http://commons.wikimedia.org/wiki/Main_Page

[2] http://phet.colorado.edu/ These cross platform simulations have been used extensively in recent years in a variety of educational forums. The PhET Interactive Simulations Project initially focused on development of physics simulations, where PhET was an acronym for Physics Education Technologies. However, the project has since evolved to include a breadth of science education content from chemistry, math, biology, and earth sciences, while the branding has remained constant. The term PhET is now understood to refer to the project as a whole, rather than being used as a specific acronym, and the simulations are referred to broadly as PhET sims.

[3] Chronozoom is an open source project teaching about big history and can be found at http://chronozoom.com/

[4] "High-Tech Tools for Teaching Physics: the Physics Education Technology Project" by Noah Finkelstein, Wendy Adams, Christopher Keller, Katherine Perkins, Carl Wieman and the Physics Education Technology Project Team, MERLOT Journal of Online learning and teaching Vol 2, No 3. September 2006. Available: http://jolt.merlot.org/vol2no3/finkelstein.htm, accessed 1/13/2015.

[5] BP produces an annual statistical review of energy production and use, we use their data with permission and the data and information about the data can be found here: http://www.bp.com/en/global/corporate/about-bp/energy-economics/statistical-review-of-world-energy.html

[6] Data taken from OECD, copyright 20014, www.oecd-ilibrary.org

[7] Energy Information Agency publishes electricity generation data for all of the countries in the world, and can be found here: http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=2&pid=2&aid=12

[8] J.M.K.C. Donev and Y. Carpenter "Teaching Energy Issues At a University" conference proceedings from Climate Change Technology Conference 2013, Montreal Canada, May 27-29th, 2013. available: http://www.cctc2013.ca/English/TechSessions.html.

[9] Jim Conca's Forbes article for October 2014 "So You Think We're Reducing The Use Of Coal? -- Think Again" (accessed January 13th, 2015): http://www.forbes.com/sites/jamesconca/2014/10/23/so-you-think-were-reducing-the-use-of-coal-think-again/

6. Acknowledgements

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7. Biography

Jason Donev is an award winning senior instructor at the University of Calgary where he teaches about energy issues and physics. He leads the energyeducation.ca team of enthusiastic energy educators.