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Energy Education: Easy, Difficult, or Both?

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Abstract: Energy services undergird all modern, industrial societies, yet economies based on fossil fuels are not sustainable. Insecurity of supply, particularly of oil, has sparked major geopolitical tensions and warfare. Pollution from use of fossil fuels and other energy sources has damaged local, regional, and global health. Greenhouse gases from fossil fuels have triggered concerns about the earth's climate. Educational institutions are responding only slowly to these existential threats. This paper addresses the challenges facing students, faculty, and administrators as institutions move from simply providing technical education on the respective components of the energy industries to a more comprehensive program that also addresses the environmental, political, economic, cultural, and ethical contexts of energy literacy. Students at most institutions lack courses and programs outside of engineering and physical science. Only 8 percent of 1638 institutions have systematic, broad-based energy studies. The U.S. Department of Energy has supported initial efforts to develop this field. Development includes helping students move from energy studies to employment. Nevertheless, student interest is high. Faculty teaching sustainable energy have generally self-taught, and faculty employment opportunities in energy studies seldom exist. A faulty member delivering energy studies generally lacks a community of supporting peers. Those in this interdisciplinary field may fear the effort will not be rewarded by the institution. Nevertheless the intellectual rewards from developing energy studies are significant and motivating. Administrators face questions of balancing competing claims for institutional resources and face criticism from internal and external constituencies. In addition, they must guide the institution to promoting, enabling, and rewarding interdisciplinary work. Development of energy studies, however, positions the institution for better internal operations and for meeting critical societal needs. We conclude that energy education is both easy and hard, but it can and must be done.

Keywords: Energy, energy education, higher education, students, faculty, administrators

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A serious gap in the curriculum

Energy services undergird all modern, industrial societies. Despite the fundamental importance of energy, problems of sustainability afflict the energy industries. Since the 1930s, three major factors have steadily impinged on the reliability and safety of energy flows worldwide. First, insecurity of supply, particularly of oil, has sparked major geopolitical tensions and warfare. Second, pollution from use of fossil fuels and other energy sources has damaged local, regional, and global health. Third, especially since the 1990s, greenhouse gases from fossil fuels have triggered concerns about the destabilization of the earth's climate. Taken together, these factors threaten the long-term prospects for humankind.

Educational institutions are responding only slowly to the existential threats raised by an energy economy based largely on fossil fuels. This paper speaks to that gap in higher education and concludes that addressing the needs for energy literacy of students, faculty, and administrators involves many issues, some easy to resolve but others hard.

The need for a new brand of energy studies

First, consider the good news. Colleges and universities have an excellent track record of educating and training the engineers and technicians with the technical information needed to run the energy industries that power the world. Similarly the natural sciences (e.g., physics, chemistry, geoscience, atmospheric and oceanic science, and biology) have increasingly included the concept of energy as an organizing framework.

The not-so-good news is that education relevant to the energy industries has been "siloed" within the natural sciences and engineering, usually within the domain of a particular means of generating energy, such as nuclear, wind, or fossil fuel combustion. Specialized knowledge lies within a discipline, with its own concepts and methods, and specialists in one area seldom venture into another arena.

For example, a petroleum engineer is unlikely ever to have a serious discussion with a nuclear engineer or a materials scientist working on solar cells let alone with an architect designing energy-efficient buildings. Furthermore, engineers and technicians generally learn about the supply of energy but little about demand for it. This imbalance tilts energy engineering toward more energy supply, even though demand management has become a key concept to minimize energy use and maximize the potential of alternative and renewable energy.

In other words, the practical study of energy in academia today is really the study of *components* of the energy industries. A graduate knows how to make the machines of his or her specialty work, and he or she may know the basics of production costs and sales prices of the energy produced by their particular industry. They are less likely to know about the environmental, political, economic and ethical contexts surrounding their industries. Many have never considered questions of equity and social justice that connect to decisions about new energy

technologies. Similarly they probably have little experience analyzing alternative energy choices.

Graduates of energy policy programs may have concepts and methods for comparative analysis and for deploying demand management. If so, however, their education likely focused on economic and legal issues without significant inquiry into the ethical, social, and environmental dimensions of energy. Rarely do students in supply-side fields interact with those who study demand. Those who learned about demand management may come from policy programs or from urban planning, architecture, or civil engineering. Similar to the preparation of energy engineers, however, the use of both policy tools and demand management may also be "siloed" and focus on just one fuel or one sector for energy services.

The important links among technical energy topics and other issues have begun to appear in other areas. For example, climate change and the imperative to reduce carbon emissions from fossil fuels are topics that appear in sustainability, environmental studies, and environmental science curricula. Students learn the nature of greenhouse gases, their sources, and their connections to climate disruption (see, for example, Wolfson, 2008; Bloom, 2010; Kitchen, 2014).

Links to energy, however, are yet to be forged. As students learn about climate change, do they also learn the concept of energy from the physical and biological sciences? Do they learn about the industries that marshal immense amounts of fuel, heat, and electricity to power industrial civilization? Do they learn the comparative strengths and weaknesses of different fuels? Do they learn about the comparative geopolitical impacts? Do they learn about specific energy services and their comparative magnitudes of energy use? If they learn about cap-and-trade or carbon-tax policies, do students go the next step and discuss what should replace the energy lost when—as intended—higher prices depress demand for fossil fuels? Do they ask questions about who should decide? What relative consequences follow from different decision processes?

To questions such as these, the answer most likely is "no." Survey data indicate that most institutions of higher education in the United States have few (if any) programs that address these issues (Vincent, *et al.*, 2013). Most schools, colleges, and departments have not embraced the challenges of energy education, either in environmental and sustainability studies and sciences or in separate degree programs.

To change "no" to "yes," we argue for a new academic field that we designate as "energy studies" (Perkins, *et al*., 2014). This broadly-defined, interdisciplinary field would include elements of science, technology, political economy, history, ethics, environmental, and cultural studies.

Students in all areas of the curriculum—science, engineering, business, and other fields—must have access to this new curriculum. As an example, consider business students whose impact on the energy economy may be disproportionately large. Energy is a key component of construction, production, operating, and maintenance costs for all businesses. Increasingly, however, business students need a more complete knowledge of energy systems. For example, a manufacturer whose factories burn large amounts of fossil fuels may have customers who prefer

products with a lower carbon footprint. A manufacturer may also have regulators or financers who push for reductions of energy inputs, demand management, or a switch to renewable energy. To cope, leaders in business and industry will be much better prepared to face challenges if their energy literacy is high. At the very least, this will allow them to better understand new technologies and new regulatory climates. Yet most business students learn little about either energy supply or demand.

Similarly, students in the humanities or social sciences can benefit from higher energy literacy. They may have concerns about the environment and know that carbon dioxide from fossil fuels plays a key role in climate change. They also may know that pollution from energy sources can damage their health. However, they probably have learned little about energy, either as a concept or as a set of industries. As a result, they may have little capacity to think about the deeper implications of the links between energy, climate change, their personal health, and the health of their community.

Filling this gap in the curriculum will involve challenges, some easy and some really hard. Students, faculty, and administrators each have their own concerns and each will face unique obstacles. We start by discussing the challenges that our students face.

Our Students

The good news—drawn from our personal experience—is that many students have an interest in energy, including an interest in the links between energy and climate change. The bad news is that most institutions of higher education are poorly positioned to respond to this interest.

If students want to engage in learning about energy, they face the challenge of identifying areas of study that connect to energy. Unfortunately, "energy studies" seldom appears in the list of majors, minors, and certificates. A census of all four-year U.S. colleges and universities found (a) fewer than 40 interdisciplinary degree programs on energy and (b) slightly more than 300 energy minors, concentrations, and certificates at 132 (8%) of the 1638 US Colleges and Universities. This leaves over 1500 institutions with no easy way for students to identify ways to study energy (Vincent, *et al*., 2013).

Even if undergraduates find an energy-related course of study, it may not be at an appropriate level to match to their interests. For example, pathways through the physical sciences and engineering must include in-depth study in physics and mathematics, but this pathway meets the needs of only a small proportion of students. Instead, many students need an alternative pathway to learn about the sources of energy, energy units and their inter-conversion, how energy supply and demand shape modern life, options for changing and shaping energy budgets, and methods to make energy economies sustainable for the indefinite future. Students who select this alternative pathway should learn the importance of choices to maintain energy services in ways that cause the least harm, provide equity, and function reliably.

Most important ideas in energy don't require advanced mathematical skills, but learning about energy requires a strong grasp of basic algebra. Proportions, percentages, the ability to convert a multitude of energy units (some metric, some British), and simple inferential statistics must

become second nature to students of energy. For some students, this level of mathematics is perceived as a barrier. Accordingly, pathways into the study of energy should meet students where they are and progressively build their mathematical skills to the desired level.

Even if students can easily find "energy studies" in the curriculum, they may still face challenges in gaining a broad perspective of the area. Students in engineering and the physical sciences may face the most severe difficulties. Although they have access to excellent technical instruction, they may lack opportunities to learn broadly about energy and its wider context. These students, with their heavy load of required courses, may have few opportunities to fit in additional courses that add breadth. Furthermore, they even may resist learning "soft" content, in spite of the fact that the energy industry seeks leaders with broad contextual and communication skills (Cohen, 2013). Faculty and administrators must work to ensure that students can find room in established majors to broaden their understandings of energy.

The U.S. Department of Energy led an effort to develop *Principles of Energy Literacy* (U.S. Department of Energy, 2013) and then supported development of an "Energy 101" course based on *Principles* (U.S. Department of Energy, 2014). The University of Maryland, Harford Community College, and Caroline Community College piloted the model Energy 101 course in 2013 – 2014. Taken early, a course such as this may serve as a gateway to majors and careers in energy. Energy 101 also may well position students to seek an academic advisor who can help them find courses in the field of energy studies.

The National Science Foundation recently awarded a grant to the National Council for Science and the Environment (NCSE) to pilot the use of the book *Earth The Operators' Manual* (Alley, 2011) as required reading for all first year students at selected institutions. This book, which accompanies a three part PBS series of the same name, introduces climate change and the clean energy economy.

Finally, students and their parents must be able to see pathways from energy studies to employment. Energy literacy should enhance the prospects of students in a variety of fields, including business, law, agriculture, and others that deal with the built- and human-manipulated environment. Understanding the context of energy use also should enhance the skills of energy technicians and engineers. Strong, high quality internships on energy, well supported by faculty and employers, amplify the curriculum in ways that link a new type of interdisciplinary study with employment. Internships can occur in private companies, government, and non-profit organizations. Universities such as the University of Illinois at Urbana-Champaign have developed professional science masters programs to connect students with careers in renewable energy.

In the next section, we turn to the faculty members who deliver energy education. They face severe challenges that undermine the capacity of institutions to deliver broad and interdisciplinary energy education.

Our Faculty

For many instructors, the heart of the problem lies in their education. Faculty members in the natural sciences or engineering who received their doctoral degrees a decade or more ago are unlikely to have learned how their field can address today's energy challenges. Furthermore, their graduate mentors were more likely to have valued depth in a particular field than breadth.

As a result, pioneering faculty moved into the area of energy studies *via* self-instruction. To avoid over-stretching, they needed to establish boundaries for the field commensurate with their own skills and education. They may have become discouraged by the prospect of being a novice or beginner. Their doctoral degree may have turned into a trap that hinders them from venturing beyond the areas of their scholarship.

Whether self-taught or not, faculty who want to teach energy studies may lack a community of peers with whom to collaborate. The National Council for Science and the Environment in 2006 organized the Council of Energy Research and Education Leaders (CEREL), which now has over 30 affiliated institutions. One of CEREL's missions is to build community for energy scholars with broad perspectives. To this end CEREL has organized an inaugural National Energy Education Summit, in January 2015 (www.energyeducationsummit.org).

The structures of employment in colleges and universities also work against preparing faculty who can deliver courses on a broadly conceived topic such as energy studies. With few exceptions, "energy" is not the name of any department in which graduate students study, and new graduate-degree holders are unlikely to have received a degree in "energy studies." Once on the job market, new graduates do not find employment to teach "energy studies."

In addition to the intellectual challenges, practical barriers may smite the otherwise intrepid new scholar of energy studies. At many institutions, the number of faculty in a department is barely large enough to cover the required courses for majors. Adding a new course in "energy studies" may overtax the resources of the instructional staff. In addition to this shortage of resources, the department chair may (for a number of good reasons) be unsupportive of new curriculum on energy. Untenured instructors may well fear that branching out to energy will endanger the tenure decision; those tenured may have a different set of worries, such as promotions and salary increases.

Despite these obstacles, a teacher-researcher who plows ahead will find powerful rewards from delving into energy. For example, at some institutions, funds may be available for emerging fields, thus providing stipends for course development. Perhaps the strongest incentive is the intellectual challenge of defining energy studies amenable to personal interests and skills. Energy offers excitement for learning and research. Moreover, the subject matter can return a sense of satisfaction from contributing to the solution of one of humanity's most pressing problems. Keeping the intellectual fires burning brightly makes energy studies a stunning motivational resource.

Administrators

This final section considers administrators, the people who face the unenviable task of keeping institutions afloat and running, despite entropic, centrifugal forces battering at the walls. They,

too, have key roles to play. Energy studies cannot thrive without active administrative support, including those at the highest rungs of the institutional ladder

The most severe difficulties arise from the simple fact that a new energy education course or program involves the expenditure of dollars, faculty time, or both. Even well-endowed institutions operate at the limits of their resources, so a decision to allocate new resources to energy education inevitably generates debate: "Is this really the best way to spend scarce resources?" Other departments and programs with ideas for expansion and improvement will probably argue that the resources would be better utilized in their programs, not some new venture in energy studies.

Specific problems may emerge from engineering and physics departments, traditionally the home for courses on energy. Members of these departments may not respond positively to other academic units wishing to teach about energy, especially when the request comes from environmental and sustainability programs. Engineering students, however, often seek context for their technical studies and can benefit from energy courses organized from a different perspective.

No matter which new venture is under discussion, administrators have the job of balancing competing interests. Those in administration need to justify any decision about resources to a new energy education venture. The best defenses will likely center on (a) enhanced student enrollments, and (b) the tuition revenues generated.

Other challenges lie beyond that of justifying expenditures. The curriculum for broad energy education must rest on a foundation of interdisciplinary teaching and learning. Can the administrator guide the institution to embrace interdisciplinary work, in which both students and faculty are rewarded for their exertions? Will faculty members with the appropriate expertise be available for the needed instruction and mentoring? Can faculty development enable an interested teacher to make the leap into energy? For research universities, questions will arise about research grants from agencies and foundations more accustomed to disciplinary-based projects. Will students find employment after studying energy? These are not trivial problems, but they have solutions. Administrators must anticipate them.

Administrators and their institutions must also have sensitivity to outside constituencies, especially if their institution receives state support. Energy industries are large and exercise political clout with state legislatures. Will energy education put the administrator venturing into this field at cross purposes with powerful companies and with the state legislature? What, for example, will executives from a large fossil fuel industry in a state think about a new venture at the state university touting the replacement of fossil fuels with efficiency and renewable energy? Again, these are not trivial problems for some administrators, and they must anticipate them. And the administrator may be called upon to vigorously defend academic freedom.

Administrators have already faced decisions on various energy issues. Most prominently, more than 700 presidents in the United States have signed the American College and University Presidents' Climate Commitment (ACUPCC), which involves changes in curricula as well as

management of the physical plant to reduce the institution's carbon emissions. Energy education offers an opportunity to help meet these commitments.

More recently, student pressure has led many colleges and universities to consider divestment from fossil fuel companies in their institutional portfolios. This offers a wonderful "teachable moment." Western Washington University, for example, is greatly expanding its offerings in energy education while it continues a lively discussion about divestiture. The University recently decided not to divest, but it acknowledged that student activism required serious rethinking of policies long considered non-controversial (WWU Foundation, 2014). An excellent video based at New York University shows students at several universities learning about social change and discussing divestment with administration (http://gofossilfree.org/diary-of-an-activist/).

On the positive side, energy education can be coupled with changes in institutional practices that result in saving money as well as energy (Cohen and Lovell 2013; Thomashow 2014). Energy touches all people, so properly structured energy education offers excellent opportunities for developing highly diverse student clienteles. Thus energy education can be a win-win proposition for institutions on a number of levels. Skillful administrators can turn the need for energy education into an achievement that will well serve the institution and the administrator's career.

Conclusions

Energy education: is it easy, hard, or both? We've made the case for both. It is easy in the sense that it is timely, essential, and popular. Hundreds of educators have participated in webinars on "Energy 101" organized by the U.S. Department of Energy. As more and more faculty and their institutions embrace the imperative for energy education, many of the barriers of "activation energy" will fall by the wayside.

Nevertheless energy education poses significant challenges for students, faculty, and administrators. It is hard for students, because it is often lacking or difficult to find. In addition it requires at least some quantitative understanding that makes many students uncomfortable. Conversely, technically-oriented students will need the broad contextual understanding of energy in their work to supplement quantitative skills, and courses addressing these needs may not exist. In general, energy courses and academic programs are still too few and far between.

Energy education is difficult for faculty, because it is a new field with heavy demands for cross-disciplinary understanding. Instructors must self-educate, worry about tenure and other rewards for their work, and seek out a new intellectual community. And it is difficult for administrators, because they must balance resources among new and existing programs and because they may face opposition from internal and outside constituencies.

Energy education may be difficult, but it is possible. Colleges of engineering and community colleges will continue to produce needed expertise about the design and operation of energy infrastructure, but sustainability and environmental studies and other fields must supplement the knowledge of engineers and technicians. Existing programs in environmental and sustainability

studies already have achieved success in delivering interdisciplinary education. We urge our colleagues in these programs to embrace the challenges of providing broad, interdisciplinary teaching and learning about energy, which is the prime cause of climate disruption, the largest threat outside of nuclear war to the quest for sustainability. Climate change is one of the fundamental challenges of our times, and investment in energy education is fundamental to meeting that challenge.

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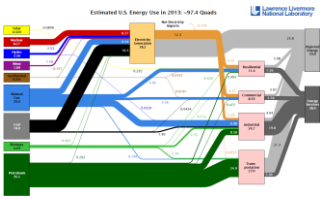

Image for article:
Energy out of the siloes: Energy flow chart, U.S., 2013
(Lawrence Livermore National Laboratory)

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