Chapter 12
Energy Ethics in Science and Engineering Education

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Abstract Substantial global changes in energy production and use are occurring at present and will continue to occur for decades to come, with widespread ramifications for the distribution of wealth and power and humanity's social and environmental future. This raises important ethical considerations that should be addressed in the education of engineers, whose research and practice will assuredly involve energy to some degree. The Energy Ethics in Science and Engineering Education Project, funded by the U.S. National Science Foundation, sought to enhance attention to and projects in energy ethics in graduate research education concerning energy. The partners, the Consortium for Science, Policy and Outcomes (CSPO) at Arizona State University (ASU) and the Center for Engineering, Ethics, and Society (CEES) at the National Academy of Engineering (NAE), conducted a number of research, educational, and outreach activities to develop a foundational intellectual basis for understanding the ethics of energy transitions, to provide opportunities for students to learn about energy ethics, and to disseminate ideas and materials broadly. Evaluation results indicate the project has been successful in engaging students in various formats; additionally the project has illuminated a number of fundamental ideas about the interrelationships among energy, ethics, and society.

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Introduction

Energy production is one of largest industries in the world. Seven of the ten largest transnational corporations are energy companies. At the same time, stimulated especially by concerns with regard to global climate change, the energy sector is undergoing what is often termed an energy transition, the full dimensions of which are not yet clear. Yet in the education of engineers, all of whom have some engagement with energy, the contextual character of this ongoing engineering transition is seldom examined in depth. A collaboration of the Center for Engineering, Ethics, and Society (CEES) at the U.S. National Academy of Engineering and the Consortium for Science, Policy, and Outcomes (CSPO) at Arizona State University set out to address this lacuna with an extended effort to promote the teaching of energy ethics (National Academy of Engineering 2013). The goals of the energy ethics (EE) project have been threefold:

- To develop a strong intellectual basis for understanding ethical challenges posed by large-scale transitions in energy systems, as well as criteria and approaches for evaluating the ethical desirability of future energy options;
- To provide a variety of robust opportunities for students to learn about energy ethics and how it applies to energy research and development; and
- To disseminate ideas and materials broadly for use in science and engineering education.

The project examined the technological and socio-political plausibility of energy systems as well as issues of research ethics in energy-related disciplines, using a problem-oriented approach to ethics that required identification, assessment, and integration of diverse ethical traditions, responsiveness to real-world situations, and educational strategies in interdisciplinary settings. Ethical perspectives employed in the project ranged from traditional ethics (which considers whether actions are required, recommended, permitted, or forbidden) to issues of individual (microethical) and collective (macroethical) responsibility.

Global changes in energy production and use are occurring at present and will continue to occur for decades to come, with widespread ramifications for the distribution of wealth and power and humanity's social and environmental future. As yet unclear is the path this transition will take and the ultimate energy system that will result. One possibility is a high carbon path involving abundant new sources of fossil fuels, while another is a low carbon path involving a high proportion of renewable energy resources. In either case, the ways that energy is produced and consumed will change dramatically, based on technologies that we are beginning to see come

into use. Both paths have enormous implications for how human beings will live on earth in the future (Miller et al. 2013; Kostyk and Herkert 2012).

Now is the critical time to evaluate these alternative pathways, using ethical, social and environmental as well as economic criteria. The framework for understanding energy justice must be significantly broadened (Miller 2014; Mitcham and Rolston 2013) and include attention to gender, race, class, disability, and other forms of social power in relationship to it. While traditional measures of energy justice, rooted in differential access and availability of energy among and across groups, remain important, they are inadequate. We must also consider the degree to which specific energy systems contribute to or detract from human thriving; the just and unjust distributions of benefits, costs, and risks associated with energy systems; and the role of diverse individuals, groups, and organizations in making decisions about energy futures (Bhadra 2013; Moore 2013).

We briefly summarize this project in the belief that the process it involved provides a useful model for the enhancement of engineering education. But the outcome is what is most important: six general conclusions about energy and its ethical implications. We also think the results are generally applicable; that is, that it would be beneficial for all engineering programs to introduce energy ethics into the curriculum.

Enacting the Goals

Project activities included intellectual research, pilot curriculum development, and outreach. Early in the project an interdisciplinary group of 19 scientists, engineers, social scientists and philosophers gathered in a research workshop. An engineer, a social scientist, and a philosopher made presentations about the ethical, institutional, and educational dimensions concerning energy ethics, complemented by a CSPO student's presentation on her graduate research.

Workshop findings included the following: Thinking about energy transitions from an ethical and social vantage point raises issues concerning system complexity and composition, and their effects on organization of patterns of human activity. These effects can include difficulties in how democracies engage their publics in determining energy futures. Questions of distributive and procedural justice, including social and environmental justice, arise, as do questions about professional and organizational ethics. For instance, one student participant argued that an adequate examination of siting practices requires looking outside of the NIMBY ("not in my backyard") lens and thinking about how the public relates to place, as imbued with meaning by various actors, rather than merely space. Another pointed to the ways in which aid agencies become invested in a particular "technological fix" for a particular problem which may be low in priority for communities to which they are providing assistance. In some communities, the benefits or risks of energy transitions, as well as voice, influence, or power in energy decisions, may flow disproportionately

to different groups, such as men or women, different racial or ethnic groups, or groups of different abilities. Energy systems are often designed for those with specific abilities, limiting access or increasing risks to those with different ability sets (Wolbring 2011).

Historically, people have thought about questions of morality or ethics in terms of right or wrong personal action. Now, both scholarly and public talk about ethics echoes the structural differentiation characteristic of other modern discourse – for instance, biology now differentiates as ecology, genetics, etc. Energy ethics as a particular applied or practical field now raises questions about whether energy should be perceived as an unqualified good, which allows a critique that can define desirable ideals for the relationship of humanity and nature with energy, and use those ideals to direct policy and progress at critical decision moments.

Implicit institutional and ethical assumptions for energy can be identified by distinguishing between intended and non-intended purposes. Intended purposes are those at which energy aims, while non-intended are those that come along with reaching the goal. For example, coal-fired power plants have an intended goal of generating electricity with a non-intended consequence of creating smog and greenhouse gas emissions. Historically, energy policies have two intended goals: efficiency and security. But where do externalities such as environmental risks and costs fall in this equation? In energy ethics education, considerations of sustainability and development can introduce students to these issues. Class discussions can compare efficiency versus sufficiency as human development goals, and examine scores in the human development index as a function of per capita energy use. Considering the steps required to lower per capita consumption of carbon dioxide equivalents to that necessary for climate sustainability further requires students to think about the structural changes that would be needed to reach this ideal, what the costs of those changes would be, who should pay and who should say who should pay.

Overlapping with this intellectual research were various curriculum development and outreach activities: (1) a faculty and graduate student seminar on energy ethics, society and policy; (2) a set of energy ethics case studies; (3) a workshop on the social dimensions of energy transitions; (4) collaboration in two outreach and engagement events in order to incorporate ethical and social considerations into public and policy deliberations about energy futures; (5) two pilot workshops for Arizona State University (ASU) graduate students on social and ethical considerations of energy; (6) a week-long National Institute on Energy, Ethics and Society; and (7) a student-made video contest on energy ethics.

Participants in the seminar included faculty and students from science and technology policy, engineering ethics, social studies of science and technology, bioethics, applied ethics, energy, history, geography, business, chemistry, biological design, solar energy engineering and commercialization, and law. The seminar involved three major activities: (a) discussion of how humanistic and social science perspectives can be fruitfully brought to bear on discussions of energy transitions; (b) presentations of faculty and student research; and (c) presentations by outside speakers involved in Arizona's energy science, engineering, business, or policy

communities. Seminar speakers included experts in electricity grid engineering and stability, state and local energy policy, the oil industry, the science and business of algae-based fuels production, utility regulation, energy consumption in the information technology sector, microgrids, and other relevant topics. The seminar also included a series of focused discussions with energy leaders about the background report (Miller and Moore 2011) and results of an Arizona Town Hall outreach exercise on "Arizona's Energy Future" which discussed key ethical, social, and policy challenges confronting the energy sector, including modules on climate change, the future of utilities, sustainability and resilience, and governance of energy systems.

The three-day Arizona Town Hall consensus conference included two days of discussions by four working groups of a series of key questions. Together the working groups involved approximately 100 individuals, representing both a geographic and demographic balance of the state's citizens, as well as key economic and policy organizations involved in the energy sector. The focus of these questions examined: the values, goals, and vision that should underlie planning for Arizona's energy future, the importance of energy for the state's economic future, the potential roles of both energy efficiency and renewable energy in creating the state's energy future, and the specific policies and strategies that the state should pursue to achieve its energy goals. The working groups developed draft reports that were synthesized by a writing team from Arizona Town Hall after each session. Finally, on the last day, the entire conference met in plenary session to negotiate on a word-by-word basis a final document of recommendations. The recommendations were subsequently circulated to state policy and business leaders and citizens through approximately 30–40 diverse events organized by Arizona Town Hall.

A second three-day workshop developed humanistic, narrative-based scenarios of Arizona's energy future, for the purposes of informing ongoing ASU energy research activities. Following traditional scenario planning methods, reconfigured to emphasize narrative story-telling among participants as the principal engagement tool, participants developed four potential future scenarios in response to the question: "How will Arizonans produce and consume energy in 2050?" The scenarios were anchored by two axes: degree of energy investment (high vs. low) and degree of centralization of energy development (centralized vs. decentralized). The resulting scenarios, and associated narratives, were intriguing, especially regarding their ethical implications, since they offered markedly different visions of Arizona society in 2050, highlighting the centrality of energy paths to future social, political, and economic organization. Key ethical considerations, such as the distribution of benefits, costs, and risks of energy production and consumption or the justness of decision-making procedures, emerged in distinct ways and required distinct forms of analysis across the four scenarios, highlighting both the significance and the path dependence of ethical analysis surrounding energy transitions (Miller et al. 2015).

CSPO also hosted one-day workshops to train graduate science and engineering students conducting energy-related research to think about the social and ethical dimensions of their own work and in energy systems more broadly. Each workshop focused on a particular energy technology (one on biofuels and another solar energy) so as to assure that the problems being considered would be relevant to the students

who participated. The educational framework employed for the workshops included: (1) energy systems as complex socio-technological systems; (2) ethical theories, frameworks, principles, and codes for grappling with ethical questions and challenges; (3) energy transitions and ethical questions and challenges they raise; and (4) case studies of contemporary and historical energy transitions that illuminate key ethical challenges. The cases differed depending on the workshop audience. In the biofuels workshop, students were asked to identify ethical issues and potential solutions involving a hypothetical algal biofuels demonstration facility sited in a desert environment while the solar energy workshop held a fictionalized role-play based on controversies around the actual siting of a solar electric generating system in the California desert.

In another combination education and outreach activity, the EE project organized a National Institute on Energy, Ethics, and Society, a week-long educational seminar for ten graduate students doing energy-related research. Students were recruited by contacting over 250 faculty in energy centers and engineering departments at universities across the country and internationally. In total, there were seven participants from schools other than ASU (one international) along with three ASU students. Student topics included: ethics of cybersecurity for the energy grid, ethical issues with the development of nanoparticles for solar panels and batteries, stakeholder engagement in uncertain decisions, ethical issues with village energy development, and the implications of carbon centric discussions of climate change. All of these topics raise social justice issues for energy engineering, where the ability of different groups to influence the outcomes will be affected by status differentials that must be kept in mind for them to be overcome. In advance of the institute, students were provided with copies of recommended readings chosen to provide an orientation to the content of the workshop and to reflect the students' research interests in the broad thematic areas of energy systems and energy policy, energy ethics and social justice, fossil fuels extraction, nuclear safety, and tradeoffs involving renewable energy.

The workshop itself was organized in three phases. Phase one focused on foundational discussions of energy systems as socio-technical systems and energy ethics, with emphasis on the interrelationship of energy, ethics, and social factors. Phase two emphasized specific energy systems, in particular solar energy, fuels (both conventional and biofuels), and electric utilities. The final phase dealt with education and included presentations by the student participants of their research and take-home projects. Activities included invited talks by industry experts, scholars, and doctoral students in ASU's Human and Social Dimensions of science and technology program, a showing of the film *Gasland*, and field trips to ASU's Solar Power Lab and Biofuels Research Lab. Throughout the week students were given the opportunity to discuss their projects with the group and with individual mentors.

At the end of the week the NIEES students made presentations on their research, what they learned from NIEES that they will be applying to their research, and their follow-up plans. The students described a wide range of follow-up activities including: campus group discussions and lectures, summer high school education

programs, writing articles, organizing conference sessions, building a network of advisors on ethics issues in energy development, developing ethic standards for village energy development, and writing a case study for the NAE Online Ethics Center for Engineering and Research (OEC) website (www.onlineethics.org).

Using participant observation at the student workshops and NIESS and web-based online surveys before and after the activities, an external evaluator assessed the educational activities. Overall for the biofuels workshop, close-ended questions assessing confidence in knowledge and abilities regarding issues related to energy from biofuels indicate stronger confidence after attending the workshop even for students that overwhelmingly felt confident before the workshop. After the workshop, participants also tended to be more able to provide examples of issues with energy from biofuels in most of the assessment measures. A content analysis of the workshop yielded evidence that the topics were presented in a clear, engaging manner to facilitate learning and interest. For the Solar Energy Workshop, the closed-ended questions assessing confidence in understanding issues related to solar energy and ethics indicated slightly stronger confidence after attending the workshop even for groups that felt confident before the workshop. The qualitative assessment for both workshops of ability to accurately provide examples to questions about the workshop topics indicates primarily positive, but mixed results. The evaluator recommended that examples of key workshop concepts be made more clearly and specifically so that participants could demonstrate a stronger working knowledge of the areas of concern. NIEES planning took these results into account, and the survey data indicate overwhelmingly that more participants felt confident in their understanding of a broad range of ethical concerns related to energy and ethics and in their understanding of ethics research issues after attending.

A final dual education-outreach activity consisted of a Video Challenge on the ethics of energy choices and energy research. Teams of three to four students from seven US academic institutions across the country submitted 18 videos. The videos focused on topics from fracking to wind farms, from nuclear waste disposal to smart grids, from use of public transportation to the energy costs of the meat industry.

Of the 18 videos three were determined to be gold-level quality, meaning they (a) successfully identified and depicted an ethically significant problem regarding energy, (b) clearly explained or showed the different views or sides of the issue, and (c) made a compelling argument or case for what should be done or how to handle the situation. The winning videos are available on the OEC and will be supplemented with some commentary from either judges or members of the Advisory Group from the CEES. The videos will serve as a continuing resource to faculty and students that can help spur discussion in classrooms about ethical issues in energy research and energy choices.

A final outreach activity consisted of a workshop in Washington, D.C. for a broad audience interested in energy ethics, particularly people in policy oriented positions, those involved in science and engineering education, and representatives from energy industries and professional societies. The workshop highlighted ethical, educational, and policy issues that come with various energy choices, and spurred educators and policy makers to think beyond the traditional technical

aspects of energy discussions. Speakers and panelists presented alternative positions on energy ethics and policies and highlighted the project's educational activities and curriculum; discussion considered how these activities might provide a useful model for expanding energy ethics education to other universities across the country. The role of professional societies' leadership in encouraging graduate education on energy ethics was also discussed. The presenters and audience recognized that there was a strong link between the ethics and public policy activities of societies and that this linkage needs to be better addressed in professional societies' structures and policies and in their activities for members.

Summary and Conclusions

The EE project engaged substantively with numerous undergraduate and graduate students and postdoctoral fellows in engineering and other energy related fields. It involved diversified formats, from semester-long seminars to week-long short courses, from one-day research workshops to community engagement exercises. Conclusions may be summarized under six headings.

1. Energy is best understood as a complex network of socio-technological systems that integrate engineered technologies with social values, behaviors, relationships, and institutions, on the one hand, and natural resources and ecological systems, on the other. This interweaving of nature, society, and technology takes place on scales that range from the local to the global and from the individual to the organizational.
2. Energy choices involve technological and social components, embedded in a number of socio-technological systems. Energy transitions can disrupt both. Hence, current approaches to energy transition assessment, management, and policy that focus narrowly on issues of technology choice and/or energy prices are inadequate to capture either the full meaning of energy systems or the full ramifications of energy transitions for individuals and communities.
3. Energy systems are wrapped in non-obvious as well as obvious ways in modern socio-political-economic orders, and vice-versa. Thus deliberations on the ethics of energy transitions are not simply a matter of science and engineering ethics but more fully a matter of the ethics of diverse forms of individual and collective life and organization. Energy transitions are inevitably social, economic, and political transitions demanding broad assessments of ethics and justice.
4. Decisions made by scientists and engineers about designing and implementing energy research and engineered energy technologies not only incorporate notions of value, responsibility, liability, and more throughout the energy system; they also have the potential to significantly shape the human and social outcomes of energy transitions. This is also the case in public and private sector decision making that includes scientific and technical expertise.

5. Key normative and ethical questions associated with energy include: (a) the distributive justice of the costs, benefits, and risks of energy systems and of the wealth and power associated with them; (b) the procedural justice of energy governance rules, practices, and policies that determine who will have a voice in energy decisions, over what questions, and at what stage in the process; (c) the professional and organizational ethics that guide and shape resource allocations, decision-making, and standard setting by professional and organizational leaders; (d) the ethics and politics of behavior modification strategies by both private and public sector entities within the energy sector; and (e) the geopolitics and political economy of energy development, production, and consumption and their relations to patterns of energy exploitation, energy insecurity, and energy violence. These five normative issues should be incorporated into any stand-alone energy ethics course or other educational materials.
6. Publics are increasingly aware of and attendant to the social and ethical dimensions of energy system change and are in many parts of the world increasingly active in social mobilization around issues of energy policy. The forms of this activism are varied, as is the effectiveness of publics in asserting influence over energy policy choices.

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