Chapter 1
Innovations in Energy-Climate Education: Integrating Engineering and Social Sciences to Strengthen Resilience

Jennie C. Stephens

1.1 Introduction

As the world confronts the challenges of climate change and the multiple negative societal implications of fossil fuel reliance, energy systems are in transition from predominantly fossil fuel-based infrastructures to more renewables-based (Brown et al. 2015; Princen 2015; McKibben 2016). Beyond technological changes, this energy transformation is associated with changing assumptions about energy generation and consumption with the rapid expansion of efficiency, solar, wind, and other renewable energies; these changes involve complex social dynamics which researchers have begun to explore from multiple perspectives (Berkhout et al. 2012; Hess 2013; Turnheim and Geels 2013; Fri and Savitz 2014; Stephens et al. 2015).

The pace of innovation at the energy-climate nexus is accelerating; however, educational priorities have not effectively evolved to prepare students for the rapidly changing energy-climate landscape. Change is occurring with advances in distributed energy resources including innovations in renewable energy and new approaches to managing electricity demand, which are linked to growing awareness of the climate change risks of fossil fuel-reliant energy systems (Brown et al. 2015; Princen et al. 2015).

Adapting education to prepare society for inevitable but unpredictable changes at the energy-climate nexus is a critical aspect of the energy transition that offers huge opportunities for innovation, diversification, and engagement. Many students recognize future job opportunities in the rapidly changing energy sector, but their educational path to prepare for those jobs remains unclear.

J. C. Stephens (✉)
School of Public Policy & Urban Affairs, Northeastern University,
360 Huntington Ave, 360C RP, Boston, MA 02115, USA
e-mail: j.stephens@northeastern.edu
URL: https://jenniecstephens.com

E. Subrahmanian et al. (eds.), *Engineering a Better Future*,
https://doi.org/10.1007/978-3-319-91134-2_1

The “climate-energy-education nexus” is a transdisciplinary space where academic researchers, professional scientists, policymakers, educators, and the general public come together to address real-world social, economic, educational, and environmental problems (Dahlberg 2001; Casillas and Kammen 2010; Dale et al. 2011; Criqui and Mima 2012). Popular journalist Thomas Friedman suggests that we have transitioned to an “Energy-Climate Era” where a positive future depends on renewable energy innovation and committed societal attention toward climate mitigation and disaster reduction (Friedman 2008).

When energy education is broadened beyond engineering—explicitly including social and cultural perspectives of energy system change—a more diverse set of students including women and underrepresented minorities are more likely to be interested in studying energy and entering the energy workforce. A gender imbalance in the energy sector workforce is widely apparent, although it is not well studied or documented (Pearl-Martinez and Stephens 2016). Integrating energy and climate education with engineering as well as social sciences has the potential to recruit a more diverse set of students in both engineering and in energy.

1.2 Advancing Energy and Climate Education in Higher Education

At the university level, students who want to prepare themselves for jobs in the energy sector or at the energy-climate nexus are uncertain what their major should be: should they focus on engineering, economics, policy, government, or environmental studies? To effectively prepare the future energy workforce, universities need to adapt to develop courses, curricula, majors, and minors that prepare students for jobs at the energy-climate nexus. University extension programs also offer the potential to expand awareness and engagement on energy issues between universities and local communities.

The need for interdisciplinary STEM-oriented energy education in higher education is growing as energy systems around the world transition from predominantly fossil fuel-based infrastructures to more sustainable renewables-based configurations. Energy education for sustainability (EEFS) is an emerging interdisciplinary field with growing student interest and strong career opportunities in STEM and beyond, but the field has limited cohesion or community. The National Council for Science and the Environment (NCSE)’s Council of Energy Research and Education Leaders (CEREL) is working to advance energy education in US colleges and universities. Recognizing that problem-based learning is central to STEM education, an emerging network of energy-climate educators are highlighting that the energy-climate nexus provides a particularly salient context to recruit and engage diverse students in active learning. The energy-climate nexus is a metafield that integrates diverse and interdisciplinary technical and nontechnical disciplines.

Expanding energy-climate education has transformative potential for understanding opportunities for empowering individuals, households, communities, and organizations to engage with the challenges and opportunities of energy system change and climate change. Educational institutions are responding slowly to the energy transition and climate change; graduates are insufficiently prepared to address the complex challenges associated with energy and climate change.

1.3 Beyond Conventional Engineering: Engaged Learning at the Climate-Energy Nexus

Conventional engineering education emphasizes the content to be learned and how it might be learned, including the classroom environments and delivery methods. This emphasis has been appropriate as the scope has been the education of engineers to ensure graduates have a solid foundation upon which to build their careers. However, as we broaden the scope of engineering education, we need to consider influences beyond classroom knowledge and skills, and their delivery (Walther and Radcliffe 2015). Increasingly educators are aware that behavioral, cognitive, and affective engagement (and ultimately, achievement) in the engineering major are influenced by the degree to which a student's engineering self-identity is well developed, autonomous (e.g., self-determined), and fits with the realistic features of potential careers they may aspire toward. Further, these constructs (self-identity and career expectations) are shaped by multiple psychosocial factors including individual differences in confidence and self-efficacy, social network factors (including the sense of belonging, connectivity, social support, social strain), motivational factors (e.g., possible selves, grit), and behavior (activity, learning). Student engagement has long been recognized as a critical factor in academic achievement. Engineering educators have studied and validated a wide variety of methods to improve student engagement in the classroom (active learning, inverted classrooms, do-then-learn, etc.). Bridging curricular (structured) and extracurricular (unstructured) engagement offers unique possibilities for making engineering education accessible to a greater diversity and number of students. Such activities create learning atmospheres of joy, trust, courage, openness, and connectedness in a uniquely consistent way.

Integrating the energy-climate nexus as a critical and salient context for expanding engineering education has potential to provide valuable experiences of engagement and a powerful enhanced sense of societal relevance to engineering.

1.4 Advancing K-12 Climate-Energy Education

The interconnected challenges of climate change and energy system change provide a valuable context for improving and advancing STEM education also at the K-12 level in the United States. The *climate-energy nexus* offers STEM teachers a unique opportunity to build students' future adaptive capacity and prepare students for a rapidly changing future in which climate-energy knowledge and experience will be increasingly valuable in the workforce.

STEM researchers and educators have identified a set of grand challenges facing society that have critical connections with the future of energy, food, water, health, and national security (AAAS 2007; Bybee 2010a, b; Nature 2015). Preparing students to address these challenges requires an integrated and transdisciplinary approach that was clearly articulated in a recent special issue of the journal *Nature* on "interdisciplinarity" (Nature 2015). There is growing awareness within the STEM education community that sustainability grand challenges are the most promising context for advancing STEM education and creating a shared vision of STEM education's goals and purposes (Chacko and Jennings 2008; President's Council of Advisors on Science and Technology 2010; U.S. Department of Education 2010; Judson 2014). For this reason, leading science educator Roger Bybee urges STEM educators to place the grand challenges at the center of their work, arguing they are central to STEM education's theory of action (Bybee 2010a, b). This theory of action is clearly evident in the new K-12 Next Generation Science Standards (NGSS) and companion framework (National Research Council 2012), both of which address the grand challenges, including climate change, in substantive ways.

Transforming STEM education around the grand challenges amplifies the convergence between STEM education, sustainability science, education for sustainable development, and environmental education (Clark 2007; Wals 2011; Wals et al. 2014). Research indicates that the majority of teachers are not trained to address sustainability issues and many lack conceptual and practical resources, including high-quality STEM partnerships, required to engage students with these issues (Potter 2009; Anderson 2012a, b). Currently, there is little research on climate change education in general and energy education in particular (Jennings et al. 2000; Jennings and Lund 2001; Thomas et al. 2008; Jennings 2009; Anderson 2010, 2012a, b; Council of Energy Research and Education Leaders 2015), and the STEM education community lacks a coherent framework for integrating the two.

STEM teachers in many parts of the country are also experiencing new opportunities for integrating STEM content and experiences into personalized learning plans (PLPs) for students. To take advantage of these opportunities, teachers will need new professional learning opportunities that integrate the concepts and practices of STEM education, climate-energy education, and personalized learning.

1.5 Energy Democracy for a Changing World

Embracing the potential for educational innovations at the energy-climate nexus is also essential to strengthening democracy. Increasingly over the past decade, renewable energy advocates, climate justice activists, and social and environmental justice activists have joined forces to organize around a call for *energy democracy*

(Burke and Stephens 2017). This call for energy democracy is strategic: democracy implies a broadly appealing agenda for greater inclusivity, equity, and influence among communities involved with a transformation in energy systems. The call is also pragmatic: a massive shift of technologies within the modern energy sector presents innumerable challenges as well as potential benefits. Greater democratic engagement would offer communities around the country and around the world stronger mechanisms to steer energy system changes and shape the development of a more renewable-based energy future.

As energy systems transform to more renewable-based, technologies, infrastructures, institutions, and cultural practices are shifting to accommodate new norms of energy production and consumption with multiple implications for community resilience. The emerging landscape of renewable power provides opportunities for local communities, individual, and households to control, own, participate in, and share benefits from the energy sector; however, renewable deployment does not necessarily result in enhanced community resilience. Energy democracy is a novel concept and emergent social movement that connects energy policy and social policy by rearticulating energy systems as distributed public works that distribute social benefits among local communities. This movement extends the social demands of energy systems beyond access, reliability, and affordability to include a broad suite of environmental, health, and economic benefits. By explicitly connecting policy issues that are generally dealt with independently, energy democracy framing provides a social, political, and cultural framework to assess community and climate resilience in energy system change.

The energy democracy framing is fundamentally political (Burke and Stephens 2018), which raises some challenges for educational institutions. Given the pervasive grip that fossil fuel industries and their financial and political allies command over contemporary political life, energy democracy activists seek to bring out into the public sphere the hidden infrastructures, privatized decisions, and distant consequences of modern energy systems. The instinct to politicize energy transition reflects an implicit understanding that the transition from fossil fuel dominant systems to those based on renewables offers an unprecedented yet potentially unrepeatable opportunity. Energy system changes have potential to reorder dominant corporate-controlled power structures. In more distributed, renewable-based energy systems, different decisions and investments will be made, different groups of actors will be politically repositioned, and material structures as well as enduring social and ecological patterns will be reestablished. The form of politics used to steer the energy transition will greatly influence the possibility for more democratic futures (Mitchell 2013).

In other words, if governed largely to preserve existing power relations, the renewable energy political economy may replicate existing dynamics of power, continuing to strengthen the powerful and weaken the marginalized (Duda 2015). Energy democracy sees in the energy transition an unavoidably political process as well as a key opportunity for advancing renewable energy and democracy together. In this way, energy democracy stands in sharp opposition to the strategy of promoting renewable energy by any means necessary (Sweeney 2014).

This political dimension of educational innovations in the energy-climate nexus provides an even greater justification for the importance of broadening interdisciplinary energy-climate education. When energy and climate change are taught in narrow disciplinary-confined ways, learners miss the opportunity for understanding complex systems and cascading impacts of networked systems.

1.6 Conclusions

Innovations in energy-climate education provide a most valuable and salient context within which to explore integration of engineering and social sciences. The silos that are so effectively maintained in our educational systems are hindering the capacity to prepare students for the rapidly changing energy-climate landscape (Stephens et al. 2008; Stephens and Graham 2010). We need to innovate our educational approach to adapt to the current energy and climate realities of human society (Jorgenson, Stephens et al. in preparation).

The emerging concept of energy democracy provides an innovative lens to explore the transformative social change potential of energy system change in an era of climate change. Social structures and policy processes that reinforce and perpetuate the legacy fossil fuel system are responding to the accelerating momentum moving toward more renewable-based societies. As the connections between energy resilience and climate resilience are becoming increasingly apparent, our educational institutions and systems have multiple opportunities to embrace, adapt, and learn from current and future changes and strengthen innovative integration of engineering and social sciences.

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