Panel Session: Bringing Humanitarian Engineering into ECE Programs through Electricity Access Education

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***Abstract*— This paper describes a panel session on electricity access education. Electricity access refers to the provision of electricity to populations that do not have access to the electrical grid, usually in under-resourced settings. Around the world, over 600 million people do not have access to electricity. Yet, there is little coverage of this topic in U.S. universities. There is also a need for a significant increase in U.S. workforce development in the electric energy sector as many people in this field are close to retirement age and the transition from fossil fuels may require a significant increase in energy engineers. Topics related to humanitarian engineering have been found to attract a diverse range of students and motivate students to engage in and persist through their engineering education. Yet, few students who are involved in humanitarian projects major in electrical engineering. Recognizing the importance of this topic, the U.S. National Science Foundation sponsored two workshops in 2022 and 2023 with the goal of identifying approaches to enhance and expand electricity access education at the undergraduate engineering level in the U.S., primarily within electrical engineering. In this panel session, we discuss electricity access, highlight the results from these workshops, discuss approaches to incorporating electricity access into the electrical engineering curriculum, survey the attendees on their interest in and expertise regarding electricity access, and brainstorm next steps for curricular development in this area. Thus, we aim to increase awareness of engineering educators about opportunities to incorporate electricity access learning in their courses and continue to build a community of engineering educators interested in electricity access education.**

Keywords—electricity access, engineering education, humanitarian engineering, educators

I. Background

A. Electricity Access

Electricity access refers to the provision of electricity to populations that do not have access to the electrical grid, usually in under-resourced settings. Over 600 million people across the world do not have access to electricity including people in the U.S., primarily on indigenous lands [1, 2, 3]. Estimates are even higher when considering access to "reasonably reliable" electricity [4]. Access to electricity is associated with several positive developmental outcomes, including health, education, gender equality, and income [5]-[11]. The global importance of energy is recognized with "Affordable and Clean Energy" being one of the United Nations Sustainable Development Goals (SDG) [12]. Yet, there is very little coverage of this topic in U.S. universities.

There is also a need for a significant increase in U.S. workforce development in the electric energy sector as an increasing number of people in this field are close to retirement age. In addition, an estimated 800,000 additional jobs in the solar and energy storage industry will be needed in the transition from fossil fuels [13]. The field of humanitarian engineering has been found to attract a diverse range of students and motivate students to both engage in and persist through their engineering education [14, 15]. Yet, most of the students who are involved in humanitarian engineering projects tend to be students outside electrical engineering. Incorporating themes related to humanitarian engineering may help diversify the field of electrical engineering which lags behind other engineering disciplines in participation of women, African American, and Latinx students in the U.S. [16]. In addition, discussion of electricity access provides an opportunity to address some of the ABET student outcomes that instructors find challenging such as those related to global, social, and economic concerns [17].

B. NSF-Sponsored Electricity Access Workshops

In 2022 and 2023, the National Science Foundation (NSF) sponsored two, two-day workshops with the goal of identifying approaches to enhance and expand electricity access education at the undergraduate engineering level in the U.S., primarily within the electrical engineering discipline [18, 19, 20]. Participants came from a broad range of backgrounds including faculty members, students, non-profit organization representatives, and field practitioners. In 2022, there were 25 participants and in 2023, there were 40.

Participants were enthusiastic about the topic of the workshop and eager for more discussion. In the first workshop, participants identified three areas for future exploration: enhancing the classroom experience, implementing sustainable, ethical, and beneficial projects, and barriers and opportunities. These themes were used to develop the agenda for the second workshop. Learning from the participants' feedback from the first workshop about wanting more opportunities for

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interaction, more such activities were included. For example, the Mentimeter audience response system [21] was used to gather feedback from all attendees to key prompts throughout the workshop. At the end of the workshop, all participants agreed or strongly agreed that they had opportunities to interact.

The participants found the workshop relevant with practical strategies for expanding and enhancing electricity and sustainable business education. Most participants said that the workshop improved their understanding of skills and experiences that students need to pursue careers in electricity access.

Participants identified challenges with education and supported ideas for enhancing the education of undergraduate electrical engineering students in electricity access. Of the 32 participants who responded to the survey, 84% agreed that the quality of undergraduate electricity access education in the US needed improvement while only 3% reported that it was at an appropriate level and 13% had no opinion. Most participants felt that universities in the U.S. are not adequately preparing undergraduate EE students for careers in Global Engineering (an alternative term for "humanitarian engineering") or graduate study in Global Engineering. 77% of respondents recommended focusing on undergraduate education as the priority for enhancing/expanding electricity access education. 13% said graduate students should be the priority and 10% were unsure. 52% of the respondents said the highest priority should be on courses rather than extra-curricular projects or research.

When asked about the biggest barrier to teaching electricity access, 13 participants indicated curriculum with an additional five participants citing time for course development. There was strong support for being done as a curricular activity with 53% of participants saying electricity access projects best done as a curricular activity, 28% as extra-curricular and 19% not sure. 17 respondents said having course materials would improve their teaching of electricity access and were particularly interested in examples of case studies or syllabi.

The surveys and discussions at the workshops led to a roadmap for expanding and enhancing electricity access education at the undergraduate level. The six actions of the roadmap are:

1. Develop electricity access course materials
2. Connect and articulate electricity access education with program outcomes
3. Support professional development of faculty
4. Improve how electricity access projects benefit communities and students
5. Expand research on electricity access education
6. Grow the community of electricity access educators and stakeholders

This strong focus on the importance of curricular items (action 1) and growing the community of educators involved in electricity access (action 6) are part of the motivation for this panel. In this panel session, leaders of the NSF-sponsored workshops will share information about both workshops, highlight key findings, and engage in discussion with the audience about how to expand the incorporation of electricity access into electrical engineering programs throughout the U.S.

II. Goals of the Panel Session

The goals of the panel session are to:

1) Increase awareness of electrical engineering educators about opportunities and approaches to incorporate electricity access learning in their courses including traditional power system topics, off-grid renewable energy system deployment considerations, and sociotechnical factors.
2) Build a community of electrical engineering educators interested in electricity access education.
3) Bring together like-minded educators to brainstorm next steps towards developing educational material content (such as case study examples) to support educators interested in incorporating electricity access education in their curricula.

III. Panel Description and Agenda

A. Intended Audience

The intended audience for the panel is primarily electrical engineering instructors, including faculty and graduate students, that are interested in electricity access education. Anyone interested in broadening participation in electrical engineering or incorporating more relevant topics in electrical engineering courses might find this panel helpful. This panel would be particularly useful for educators who are interested in starting initiatives in their electrical engineering programs but do not know how to begin. They will benefit from the experiences of faculty members who have been doing this work for many years. Engineering instructors outside of the electrical engineering discipline will also find value in learning about energy access more broadly, and possible ways electricity access intersects with their discipline. The connections and networks that the audience can learn about, and join will be of great benefit if they are planning to work in this area.

B. Tentative Agenda

The session will include brief talks by the panelists along with small group discussions and online responses to prompts to promote interaction. The planned agenda for the 80-minute session is:

1) *Introduction and Objectives (10 min)*
   The session will begin with a brief introduction of the panelists and description of the session format and objectives.

2) *Overview of Electricity Access (10 min)*
   Panelists will introduce the context of energy poverty and the concept of electricity access including the impact on human development, supporting statistics of global electrification, and the role of electrical engineers in solutions.

3) *Electricity Access Workshops (10 min)*

Panelists will share highlights from the 2022 and 2023 NSF-sponsored Electricity Access Workshops. Feedback from workshop participants will be included.

4) *Activity: Interest in and Experience with Electricity Access (10 min)*

Panelists will use the Mentimeter audience response system to gather feedback from attendees to prompt their interest in and experience with electricity access. This online platform facilitates engagement from the entire audience using their internet-connected smartphone or mobile device. Responses to the prompts can be shared real time. The panelists have experience using Mentimeter from the 2023 workshop.

5) *Incorporating Electricity Access Education in Electrical Engineering Curricula (10 min)*

Panelists will provide an overview of the need for, opportunities, and challenges with incorporating electricity access education in electrical engineering curricula. Examples of available materials and instructor resources and curricular student projects will be discussed.

6) *Small Group Activity: Electricity Access Education in Electrical Engineering (10 min)*

Panelists and the audience will brainstorm in small groups about next steps towards developing educational material content to support educators interested in incorporating electricity access education in their curricula.

7) *Report Out (10 min)*

The facilitator will collect main takeaways from small groups. Mentimeter may be used to gauge interest of entire group in suggestions.

8) *Wrap-up and next steps (10 min)*

The facilitator will summarize main takeaways and describe reasonable next steps to achieving panel session goals.

IV. Expected Outcomes

One anticipated outcome from this panel session will be an enlarged community of electrical engineering educators and network of practitioners who will continue to share information about electricity access education. A second, and equally important outcome, will be that this panel will contribute to the further development of the electrical engineering power and energy workforce of the future, particularly under-represented students, by focusing on the topic of electricity access education.

V. Panel Participants

Panelists include organizers of the NSF-Sponsored Electricity Access workshops. One of the panelists will also serve as the facilitator.

Dr. Susan Lord, Professor and Chair of Integrated Engineering, University of San Diego

Dr. Lord has been working with students on the integration of sociotechnical considerations, social justice, and ethics in engineering curricula for years [22]-[26]. She has worked with a USD alumnus from South Sudan on developing modules for her USD students on solar energy in South Sudan [27]. She will help the audience see how to connect some of the social justice considerations of electricity access to curriculum. Given her extensive experience with facilitating workshops including the National Effective Teaching Institute (NETI) [28], she will serve as the moderator for the panel.

Dr. Pritpal ("Pali") Singh, Professor of Electrical Engineering, Villanova University

Dr. Singh has been engaged with electricity access projects in underserved communities for almost 40 years. He has worked in a number of countries all over the world including India, the Galapagos Islands, Guatemala, Kenya, and Mexico. He has incorporated electricity access projects into senior design projects as well as a renewable energy systems course. Dr. Singh's efforts in these areas have been recognized by the International Federation of Engineering Education Societies (IFEES) 2022 Duncan Fraser Award for Excellence in Engineering Education [31].

Dr. Henry Louie, Professor of Electrical Engineering, Seattle University

Dr. Louie has been teaching about electricity access for over 20 years. He teaches a senior level course in off-grid solar electric system design and has written a textbook in this area [29]. He established a non-governmental organization, Kilowatts for Humanity, that he uses to bring electricity access to communities, primarily in Africa [30]. He has been offering short courses in the Power Africa conference on Off-Grid Electrical System design for the past 5 years.

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