

WIP: Exploring Electricity Access Education

Susan M. Lord
Integrated Engineering
University of San Diego
San Diego, CA, USA
slord@sandiego.edu

Pritpal Singh
Electrical and Computer Engineering
Villanova, University
Villanova, PA, USA
psingh@villanova.edu

Henry Louie
Electrical and Computer Engineering
Seattle University
Seattle, WA USA
louieh@seattleu.edu

Abstract—This innovative practice work-in-progress shares results from two workshops on promoting energy access education in electrical engineering and discusses next steps. There is a need for a significant increase in US workforce development in the electric energy sector as many people in this field are close to retirement age. The field of humanitarian engineering has 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 engineering major in electrical engineering. 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 700 million people do not have access to electricity. Yet, there is very little coverage of this topic in U.S. universities. Recognizing the importance of this topic, the USA 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 2022, there were 25 participants and in 2023, there were 40. The participants at these successful workshops included engineering educators, students, field practitioners, and non-profit organization representatives. In this work-in-progress, we highlight the results from these workshops, discuss next steps, and focus on the importance of the educational challenges and potential for curricular development in this area.

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

I. MOTIVATION AND WORKSHOPS

Ban Ki Moon, United Nations Secretary General, said “Energy is the golden thread that connects economic growth, increased social equity and a healthy environment. Sustainable development is not possible without sustainable energy” when he launched the Sustainable Energy for All initiative [1, 2]. The global importance of energy was recognized when access to “Affordable and Clean Energy” became one of the United Nations Sustainable Development Goals (SDG) [3]. Over 700 million people worldwide do not have access to electricity. Estimates are even higher, as much as 50% of the world’s population, when considering access to “reasonably reliable” electricity [4]. Yet, there is very little coverage of this topic in US universities. This important topic can motivate students to

pursue engineering studies and inspire engineering students to engage in a variety of activities related to electricity access, making it a pivotal area for educational focus. There is a need for a significant increase in US workforce development in the electric energy sector as many people in this field are close to retirement age. This topic also has the potential to attract a broader representation of students including women and students of color who are eager to make a difference in the world. Research suggests that incorporating humanitarian engineering themes such as electricity access into the undergraduate engineering classroom can improve student recruitment and persistence and is associated with higher enrollment of female students [5, 6]. This could be helpful for diversifying the field of electrical engineering which lags behind other engineering disciplines in participation of women, African American, and Latinx students in the USA [7].

In June 2022, 24 engineering educators, field practitioners, and non-profit organization representatives participated in a USA National Science Foundation (NSF)-sponsored workshop held right before the 2022 ASEE Annual Conference and Exposition [8]. A goal of that workshop was to survey the community about what exists in this field and to consider how to expand electricity access education in the USA. Participants were enthusiastic about the topic of the workshop and eager for more discussion and interaction. In this 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. Following the success of the 2022 workshop, an expanded workshop on this topic was held in October 2023. About 40 attendees, including engineering faculty members, students, and field practitioners participated. The two-day program of sessions included keynote speakers, moderated panels, and themed discussions. Learning from the participants’ feedback from the first workshop about wanting more opportunities for interaction, we incorporated several such activities. For example, we used the Mentimeter audience response system [9] to gather feedback from all attendees to important prompts. We held an informal poster session where each participant prepared a large post-it to introduce themselves

to the entire group including name, location where they do projects, fun fact, something they want to share and something they want to learn. Opportunities to visit these posters were provided several times throughout the workshop. At the end of the workshop, all participants agreed or strongly agreed that they were given opportunities to express their viewpoints and opinions. More details are provided in [10, 11].

Extensive resources were shared among the participants via a OneDrive folder. This included the presentations, participants list, educational resources such as books, sample projects, homework assignments, readings, syllabi, and lectures [12, 13].

In this work-in-progress, we highlight the results from the second workshop and then focus on the challenges of doing this work and the opportunity for curricular interventions to address these challenges.

II. WORKSHOP EVALUATION

At the end of the workshop, participants were invited to complete an electronic survey to evaluate the workshop. Twenty-eight participants responded to at least one question. Overall, the feedback was very positive for the overall organization, sessions, networking, the diverse perspectives of the participants, and logistics.

The participants found the workshop relevant with practical strategies for expanding/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 were enthusiastic in praise of the workshop when asked what they liked best. Interaction and networking were mentioned by most respondents. Since this was an important goal, we were pleased to see that participants thought this was achieved in this version of the workshop. People mentioned the collaborative environment, the Mentimeter system, the mixture of presentations and discussion, and the impressive participants with diverse perspectives. Given the goal of building community, we were particularly pleased that several participants mentioned feeling included.

- *The networking session on the first day (with the sticky notes); structure of the themed discussion (presentations, group discussion, report out); size*
- *I love the fact that it was an open space to express my thoughts, experiences and opinions.*
- *I loved the people and ideas and sharing. Left with more ideas on how to do better!*
- *The interaction with experts and people with different backgrounds and experience. Great discussions and ideas!*
- *So many wonderful people doing wonderful things all in one room. I was overwhelmed by what all is possible in this field*
- *Fantastic group of intelligent, engaging and energized professionals*

- *Fantastic networking opportunity with professionals, practitioners and educators in this important Energy Access research and implementation space –*
- *Dynamic meeting stocked full of stakeholders who bring vastly different perspectives. The cross pollination was invaluable and impactful.*

Some participants praised several aspects of the workshop. *Great focus group discussions, diverse team of stakeholders, precise time management, very educational and eye opening and inclusive.*

As a student, it was an incredible experience to see the collective and brilliant minds that are on the front lines to solve the issues surrounding student involvement towards energy access.

At the end of the survey, participants were invited to share anything else that they would like about the workshop. Fifteen participants provided a response. Seven participants expressed praise and gratitude to the organizers with several being thankful to be included.

- *Pali and Henry were absolutely fantastic in organizing this workshop. They were great to work with before and during the event, and created a respectful and open environment for all.*
- *This was incredible. I am honored to have been invited to come.*

Four participants praised the workshop as excellent, fantastic, or great.

Excellent organization and great opportunities to get engaged, open-ended input solicited from all participants -- extremely inclusive and welcoming to new participants and others who had come before.

Participants said that this topic was important and appreciated that it was “one of the first venues I’ve been at to meet others working in energy access.” Two participants expressed that they would like to participate in future workshops on this topic.

Several participants included suggestions for future work including

- *better publicity for wider reach*
- *More time to work in teams and discuss actionable items would have been nice*
- *I think it would be great to have more perspectives including more industry (any majors orgs with a different perspective?), community partners, potentially someone who does development (\$) for uni[versity]*

III. CHALLENGES AND OPPORTUNITIES

Throughout the workshop, participants identified challenges with education and supported ideas for enhancing the education of undergraduate electrical engineering students in the area of electricity access. 84% of the workshop participants who responded to our survey ($N = 32$) agreed that the quality of undergraduate electricity access education in the US needed improvement. Only 3% felt it was at an appropriate level and 13% had no opinion. Most participants felt that universities in the US are not adequately preparing undergraduate EE students for careers in Global Engineering or graduate study in Global Engineering. 77% thought that the priority for enhancing/expanding electricity access education should be undergraduate students with 13% saying graduate students and 10% 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 energy access, the most common response (13 participants) was curriculum. Time for course development was also mentioned five times. When asked how energy access projects might best be done, there was strong support for being done as a curricular activity with 53% ($N = 32$ total) saying as a curricular activity, 28% saying extra-curricular and 19% not sure. When asked what would improve your teaching of electricity access, 17 respondents said course materials and cited examples of case studies or syllabi.

Mentimeter generates word clouds for responses to questions. Fig. 1 shows the word cloud for the prompt “What are the three most important concepts about energy access that should be taught to students?” Note that participants provided more than one response.

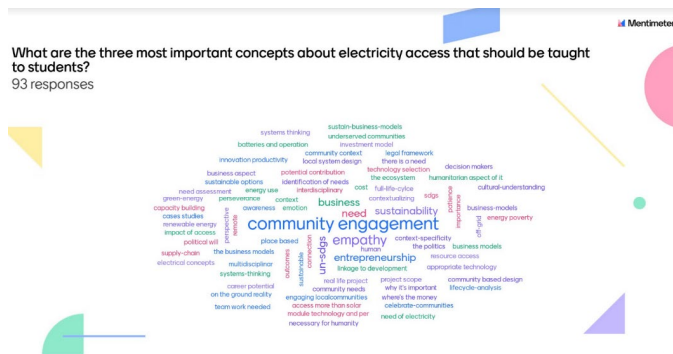


Fig. 1. Mentimeter results from workshop participants about the most important concepts about electricity access that should be taught to students.

It is interesting that community engagement was the most common response (7). Many responses (19) fit into the theme of contextual understanding including empathy, needs assessment, and cultural understanding commonly emerged. Technological aspects were mentioned 13 times including appropriate technology, energy use estimation, renewable energy, and life cycle analysis. Professional skills such as systems thinking, perseverance, patience, and interdisciplinarity were mentioned 12 times. Topics related to human development including the need for electricity access

and humanitarian impact were mentioned 10 times. Business and economic aspects emerged 10 times including business models and project costs. These ideas underscore the importance of this work for meeting the important ABET outcomes related to students' achievement of learning outcomes related to ethical, global, cultural, social, and economic impacts of engineering [14]. Since these outcomes are often challenging for instructors to incorporate into their curricula, energy access could be particularly useful.

IV. NEXT STEPS

At the end of the workshop, participants were asked to briefly describe “a specific idea, best practice, or resource that you intend to implement in the future, if any.” Participants mentioned collaborations with this group and more broadly, curricular efforts, and use of resources from the workshop. Specific comments can be found in Fig. 2. The enthusiasm for further collaboration and curricular development suggests the importance of focusing on curriculum.

Participants were enthusiastic about continuing to participate in efforts such as this. All participants who responded to the survey indicated that they were interested in participating in a similar workshop in the future with 18 participants saying, “very interested” and 7 “somewhat interested.” When participants were asked if they would be interested in participating in something such as a proposal for curriculum development, several expressed such interest.

Six actions for expanding and enhancing electricity access education emerged from the workshops as a roadmap [10]:

- A) Develop electricity access course materials
- B) Connect and articulate electricity access education with program outcomes
- C) Support professional development of faculty
- D) Improve how electricity access projects benefit communities and students
- E) Expand research on electricity access education
- F) Grow the community of electricity access educators and stakeholders.

V. CONCLUSIONS

Energy access is an important area globally where electrical engineers can have a significant impact. However, this topic is not well integrated into the electrical engineering curriculum. Successful workshops about energy access education were held in 2022 and 2023 with participants from academia, industry, and nonprofit sectors. They appreciated the opportunity to gather and discuss this important topic and were eager for future interactions and concrete next steps. The results from this workshop show that the community is interested in curricular materials but that there is a lack of such materials which constitutes a barrier to enhancing education about energy access. These results all point to the community's interest in having curricular materials to support this work. Building on these discussions from these workshops and the roadmap for actions to expand and enhance electricity access education, the organizers are working on next steps including seeking external funding for development of curricular materials.

Collaborations with this Group and more broadly

- *LinkedIn group*
- *create a group and get more people connected to each other*
- *Connecting with colleagues in other institutions for possible partnerships.*
- *Inclusive participation of students, faculty and practitioners*
- *Involved local community in the process, allow students to be part of the doing aspect.*
- *I hope to enlist other EE colleagues at my institution into this arena.*
- *Use of professional practitioners to survey/gatekeep/advise student technical projects abroad*
- *Partnership with universities to have students participate in projects*
- *Mentor agreements for energy access projects!*
- *Involve entrepreneurs from the communities we are developing our projects. Listen to them as we listen [to] the rest of the community.*
- *Talk to stakeholders at project start to tailor the solution, up front.*
- *Undergraduate internship in my company with energy access students.*

Curricular Efforts

- *a course around sustainable off-grid power systems*
- *Implementing case studies with students to expend their view of what they should consider in their design solutions.*
- *Incorporating human aspects into material on renewable energy design more intentionally*
- *Inform students the need of energy access. How to get involved and contribute.*
- *needs assessment and technology mapping*
- *Project ideas, planning*
- *Ways to balance impact and educational goals in community work.*

Use of Resources

- *I intend to review many of the resources shared from the group, particularly the readings on larger trends/research that has been done in this space.*
- *Utilizing resources from the people at the workshop*

Fig. 2 Responses about specific idea, best practice or resource that you intend to implement in the future

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REFERENCES

- [1] UN News, "UN Launches Decade-long Sustainable Energy for All Initiative," Our World, April 10, 2014. <https://ourworld.unu.edu/en/un-launches-decade-long-sustainable-energy-for-all-initiative>
- [2] Yumkella, K., "Sustainable Energy for All," <https://www.un.org/millenniumgoals/pdf/SEFA.pdf>
- [3] United Nations, 2015, Sustainable Development Goals. <https://www.un.org/sustainabledevelopment/sustainable-development-goals/> Accessed May 6, 2024
- [4] Ayaburi, J., M. Bazilian, J. Kincer, and T. Moss, "Measuring 'Reasonably Reliable' access to electricity services," *The Electricity Journal*, Vol. 33, no. 7, 2020, <https://doi.org/10.1016/j.tej.2020.106828>
- [5] Adams, E. A., and M. B. Burgoyne, "Integrating humanitarian engineering design projects to increase retention," *Proceedings of the 2017 American Society for Engineering Education Annual Conference*, Columbus, OH, June 2017.
- [6] Jayakumar, A., and S. Nozaki, "Impact of Humanitarianism on Female Student Participation in Engineering," *Proceedings of the 2020 American Society for Engineering Education Annual Conference*, June 2020.
- [7] Lord, S. M., R. A. Layton, and M. W. Ohland, "A Multi-institution Study of Student Demographics and Outcomes for Electrical and Computer Engineering Students in the U.S.A.," *IEEE Transactions on Education*, vol. 58, no. 3, pp. 141-150, 2015. [10.1109/TE.2014.2344622](https://doi.org/10.1109/TE.2014.2344622)
- [8] Louie, H., P. Singh, J. Urquiza, and M.-L. Tran, "A Workshop for Energy Access Educators," *Proceedings of the 2023 ASEE American Society for Engineering Education Conference*, Baltimore, MD, June 2023.
- [9] Mentimeter, <https://www.mentimeter.com/> Accessed August 9, 2024
- [10] Louie, H., P. Singh, S. Lord, and S. Vasconcelos, "Faculty and Stakeholder Perspectives from a Workshop on Electricity Access Education," *Proceedings of the 2024 ASEE American Society for Engineering Education Conference*, Portland, OR, June 2024.
- [11] Singh, P., H. Louie, S. M. Lord, and S. Vasconcelos, "Electricity Access and Sustainable Business Models Educators Workshop," *Proceedings of the 2024 American Society for Engineering Education Annual Conference*, Portland, OR, June 2024.
- [12] Louie, H., *Off-Grid Electrical Systems in Developing Countries*, Cham, Switzerland: Springer Nature, DOI: 10.1007/978-3-319-91890-7, 2018.
- [13] Grafman, L. and J. Pearce, *To catch the sun*, Humboldt, CA: Humboldt State Press, 2021.
- [14] ABET Accreditation Criteria <https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2022-2023/> Accessed August 9, 2024.