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Energizing the Engineering Pipeline through Agrivoltaics Citizen Science: Curriculum Share

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Energizing the Engineering Pipeline with Agrivoltaics Citizen Science (Pre-College Resource Exchange)

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The Sonoran Photovoltaics Laboratory (hereafter SPV Lab) organizes a regional approach to pursuing photovoltaic (PV) engineering research for 4th-12th grade STEM teachers and students in the Sonoran Desert region of the US. Using community-based engineering and citizen science strategies, teachers lead their students in conducting research on agrivoltaics; coupling the generation of renewable energy via photovoltaic systems with growing food crops as a way to decrease water use, increase crop yield, and find multi-uses for land. Agrivoltaics (agri-PV) is a new area of engineering opportunity being investigated by engineers around the globe; early studies show particularly promising results for arid regions such as the Sonoran Desert. Thus, from an engineering research perspective, the aim of SPV Lab is to contribute to knowledge in this new area of engineering opportunity through community-centered testing of agri-PV.

From a pedagogical perspective, SPV Lab aims to provide opportunities for students to take leadership positions that support their consequential learning and rightful presence in engineering through their participation in real work with real consequences. Individuals from non-dominant communities have frequently been denied opportunities to engage in rich learning opportunities in STEM disciplines, and youth in general are rarely viewed as contributors to engineering endeavors. AgriPV citizen science can foster an equitable and inclusive learning landscape that immerses all learners in authentic engineering inquiry, instilling a sense of rightful presence for youth engineering researchers. Specifically, student-members of SPV Lab help to create scientific knowledge through agrivoltaics engineering research while demonstrating the social value of improving PV performance for their local neighborhoods and region. Over time, this work affords historically minoritized groups the opportunity to leverage their rich experiences and cultural assets in a way that benefits all stakeholders.

The 4th-2th grade Arizona educators who comprise the teacher members of the SPV Lab participate in a six-week summer Research Experience for Teachers (RET) program. Working with university faculty and graduate students from engineering, education, and related fields, teachers learn about PV manufacturing, engage in engineering research projects (e.g., building, programming, and testing a monitoring device that collects data about environmental conditions in school gardens: temperature, humidity, and soil moisture). They also co-develop learning resources, materials, and protocols to engage their students in agri-PV citizen science, in consultation with faculty, students of all ages, and community members with various related expertise (e.g., shading analysts, PV installers).

Returning to their classrooms in the fall, teachers implement agri-PV citizen science with their students. Each school-based SPV Lab research site hosts at least one experimental and one control garden bed (i.e., with and without solar panels). Students make decisions about what

crops to plant, how to care for their growing crops, how to design their PV racking systems, and how to use the power they generate to benefit their community. They also collect, analyze, and share data with researchers and students at other schools, making recommendations for changes in agriPV design and/or protocols based on results. Along the way, students are supported by their teacher and an interdisciplinary team of university researchers and industry partners.

In this session, we share teaching-learning resources that engage students in agri-PV citizen science, co-created by our team members and distributed through the SPV Lab website. Our aim is to help teachers (a) introduce students to agrivoltaics engineering research and the symbiotic relationship between plants and solar panels from a citizen science perspective; (b) develop student-centered strategies to incorporate immersive engineering research experiences into their instruction; (c) support students use the engineering design process (e.g., PV racking, power, and irrigation systems); and (d) incorporate consequential work into their own classrooms so youth can be positioned as experts, leaders, and co-creators in their own communities.

Materials, resources, and lessons from SPV Lab's website will be shared at the session. Discussion will focus on adapting elements for 4th-12th grade agri-PV citizen scientists.

- Understand how PV works at a variety of levels (e.g., how solar cells use wavelengths across the electromagnetic spectrum, how cells are made, the tradeoffs of series vs. parallel circuits, inverters, and battery storage in stand-alone PV power systems.
- Conduct community ethnography in students' local neighborhood, including food and energy equity to guide design decisions. Community-centered engineering needs to be responsive to the values, needs, and strengths of people; thus, SPV Lab develops strategies for community ethnography through spatial mapping, interviews, and surveys.
- Use tools and protocols to collect, analyze, and report agri-PV data: monitoring crop growth and environmental conditions in the garden (i.e., soil humidity; light intensity; temperature of solar panel and top of soil; number and size of leaves, flowers, and fruits).
- Design and build prototypes for agri-PV solar panel racking systems. Panel placement should optimize (a) growing conditions for seasonal crops (e.g., dappled light, optimal temperatures), and (b) efficient power generation (e.g., angle of panels). Students learn mechanical and electrical engineering as they design mobile PV structures.
- Planning fall and spring garden beds in the Sonoran Desert. To collect, analyze, and report on agri-PV data, students must be able to recognize parts of plants. However, they often struggle to differentiate between flowers, flower buds, fruits, and leaves. Students arrange parts of plants collected from native species in the Sonoran Desert, as well as food crops cultivated by Indigenous people and settlers in our region across time.

For the entire set of resources, see the SPV Lab website or email michelle.e.jordan@asu.edu.

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