BRIGHT SOLAR FUTURES

CURRICULUM TOOLKIT

Introduction to Bright Solar Futures

This curriculum was designed to demonstrate the connection between energy and the everyday lives of students. In it we explore our daily reliance on energy to provide power for the things we love to do with a strong emphasis on understanding where this energy comes from. While we know how to generate and deliver electricity throughout the United States, we now must figure out more sustainable ways of generating and distributing energy in efficient and equitable ways. Solving these problems presents unique challenges. The need to think creatively is critical. This three-year course will push students to not only understand the practical, hands-on aspects of solar energy, but to become the innovators of the solar technology of tomorrow.

The solar industry, along with the interrelated areas of weatherization and home energy efficiency, are growing quickly and will likely continue doing so for the foreseeable future. This highly accessible, hands-on, career-oriented curriculum positions students to capitalize on this growth. Designed for students who have had little or no exposure to this material, this curriculum provides the skills and knowledge required for entry level jobs in the solar industry. The course will help students gain the competencies necessary to obtain industry certifications such as OSHA 10 and the North American Board of Certified Energy Practitioners (NABCEP) Photovoltaic (PV) Associate's credential.

In the solar industry it is widely accepted that the overall energy efficiency of the home is an important part of the overall process. If a building does not contain energy efficient measures, then much of the solar energy produced could be lost through air leakages, resulting in a loss of energy savings. This curriculum recognizes the necessity of understanding energy efficiency and the importance of weatherization. Grounded in the field of building science, this curriculum provides teaching materials which offer an additional complimentary skill set and career path related to weatherization and home energy auditing.

Recognizing the need to support students in their workforce preparations, this program incorporates a robust curricular enhancement

built on existing best practices in workforce development. The program explicitly addresses barriers that may otherwise prevent students from completing the program and securing and retaining jobs in the clean energy industry. The program provides opportunities for students to develop and practice the soft skills sought after by today's employers such as time management and communication. A series of modules included with this curriculum should be integrated on an ongoing basis throughout the school year to allow students sufficient time to strengthen these skills in order for them to become well rounded and competitive job candidates upon the completion of this program of study.

The Solar Energy Technician Curriculum focuses on solar installation, project management, operation & maintenance, and sales while giving a 360° view of all aspects of the solar industry. It provides direct connections to career paths in the industry. It is designed so that students get practical and hands-on experience with solar installation while simultaneously learning the theory and science that enables solar to function. Additionally, students will learn the business side of the solar industry including marketing, sales, and constructing business plans. This program gives students a strong foundation of current practices in the solar industry while looking towards the future (batteries and storage) and encouraging innovation.

Purpose and History of Grant

In 2016, under the leadership of City Council President Darrell Clarke, the Philadelphia Energy Authority launched its primary initiative, the Philadelphia Energy Campaign—a $1 billion investment in clean energy and energy efficiency projects over 10 years to create 10,000 jobs. Solar installer is the fastest growing job in the U.S., and it is currently listed as a High Priority Occupation for Philadelphia County due to high employer demand for solar workers. PEA is committed to preparing Philadelphia's young people to fill these new positions. For over two years, PEA sought to meet employer demand by partnering with the School District of Philadelphia (SDP) to offer solar installation training to high school students and young adults between 18-30 years. In four previous cohorts, PEA provided introductory solar training to 70 students and placed 17 students into internships in the clean energy sector.

In the spring of 2019, PEA received a $1.25 million award from the U.S. Department of Energy to establish one of the nation's first Solar Energy Programs for Career and Technical Education students. This three-year, in-school Program of Study (POS) will help graduates access living wage solar industry jobs that do not require a college degree. The POS will provide 1,080 hours of training to students from 10th to 12th grade. Pending approval of the Solar Energy POS by the Pennsylvania Department of Education, any school district in Pennsylvania will be able to access state funding to offer the curriculum to their own students. PEA will also use the award to start offering intensive solar training to Opportunity Youth in partnership with YouthBuild Philly and PowerCorps PHL.

PEA contracted with the Philadelphia Education Fund for its support with the development of the program proposal to the Department of Energy and with the writing of the curriculum for the new Solar Energy Technology/ Technician Program. Part of this task involved preforming a reconnaissance of existing solar training programs nationwide for high school commercial and technical education.

Summary of Existing Programs

A summary of this research is attached here.

Occupational Advisory Committee/Industry Leadership

Any publicly funded CTE program in the state of Pennsylvania must have an occupational advisory committee composed of industry leaders. Occupational Advisory Committees (OAC) are mandated by **Chapters 4 and 339 of Title 22 of the Pennsylvania Code**. These regulations require the establishment of OACs as a condition for career and technical education program approval by the Pennsylvania Department of Education. As stated in 22 Pa. Code. 4.331(c).l For the Bright Solar Futures Program, PEA sought industry leaders to build this committee. The Committee for the current project meets four times per year. It is composed of members representing a broad cross-section of experts in the Solar and Energy sectors.

Program Evaluation

The Philadelphia Energy Authority (PEA) provides overall leadership for Bright Solar Futures (BSF) program and has chosen Policy Research as the evaluator. The primary objective for the evaluation of the BSF program is to assess how well the program does in achieving its intended outcomes by analyzing data related to program participation, education, and employment. A secondary objective is to examine implementation activities throughout the three-year funded period. Results of Year One and Year Two program outcomes are available in Actus reports which are appended.

Links to evaluation reports:

Year 1 Evaluation Report

Year 2 Evaluation Report

Description of Program of Study

Course Description for *Bright Solar Futures/Solar Power CTE Offering*

Bright Solar Futures is a three-year CTE program that prepares students for career opportunities in the solar energy and weatherization industries. The program gives participants a working understanding of the overall solar energy industry, solar energy system installation, electricity fundamentals, energy efficiency and conservation, work site safety, and job readiness. Career pathways are explored throughout. The course includes in-class learning, lab-based hands-on training, field trips, and instructional visits from subject matter experts. The full program prepares students for opportunities to obtain industry recognized professional credentials including the NABCEP Associates and the OSHA 10 Construction Safety certification. Graduates are supported with internships and job opportunities.

Important Notes About the Program

- Lessons are in the **recommended order** by industry professionals who have had experience teaching the content. The order is flexible and can be restructured by the teaching staff as needed based on personal experience.
- **Field trips** are a very important part of the experience for students. Since local resources, transportation, logistics for class size, insurance and other considerations must be considered, these are not specifically cited in the curriculum but highly endorsed.
- **Guest teachers from the solar industry** play a significant role in bringing the real work to the lab setting when trips are not possible. This is very important in providing for additional perspectives from experienced professionals. Guest teachers in this program provide additional hands-on experiences. The experience and background of the teachers involved also influence the need for professional demonstration and practice.
- Many of the **10th and 11th grade lesson plans** are the same to accommodate new students in a given cohort who have been allowed to join the course in 11th grade for the first time.
- **Lesson plan topics are often linked to the same lesson plan** over the three years . The plans are often meant to provide resources for the teacher on a topic. It is up to the teacher to decide what and how much to teach depending on the background and skill levels of the students.
- Teachers of this curriculum are encouraged to **make this curriculum their own**. They may choose to use other lesson plans to build more knowledge in a specific area of interest. For example, if there is a need to cover additional ground on a topic like renewable vs. finite energy sources, teachers should feel free to do so.
- **Weatherization is presented as a separate quarter.** This is arbitrary. In the original pilot for this course, energy efficiency and weatherization was interspersed with the solar curriculum since many topics overlap in their content. This decision may also be influenced by the availability in the lab of complex equipment such as a blower door and a sample house set up.

- Given that several writers over two years helped to create this curriculum, you will find some **variation in how lessons are formatted** and presented. Every attempt was made to follow the best practices cited later in this introduction.

- **Assessment** should be on-going and tied to hands-on work. While quizzes and exams may find a place in this program, rubrics for demonstrated knowledge has shown to be the most effective for students. Rubrics for demonstrated work with constructive, guided feedback has been successful

- The **North American Board of Certified Energy Practitioners® (NABCEP®) Associate Credential** is the goal for all students in the program. Teachers can find up-to-date information about certification and the NABCEP exam in the NABCEP Associate Handbook and at the NABCEP certifications web site. One of the recommended study prep courses/approaches used in the Philadelphia pilot is the author of one of the solar texts, Sean White. This and other resources, several without cost, are also available, such as the NABCEP PV Associate Practice Exam. In the original pilot, application and fees were covered by the school district. Further reading: Why Get an Associate Credential?

Solar Energy Technology I (10th Grade)

In this first year, students will learn the fundamental aspects of solar energy and weatherization. The course is foundational in the concepts of renewable energy, energy efficiency and construction safety practice. The course also presents an introductory understanding of different types of energy systems, solar installation techniques, solar sales and economics, electricity basics, and building science. Students receive instructor led, lab-based, hands-on experience utilizing solar and energy efficiency components and tools. Their insight into these concepts will be enhanced with field trips to existing solar energy systems and live installation sites in the local area. Students are introduced to the various career choices in the solar/weatherization fields.

Solar Energy Technology II (11th Grade)

Since new students may enroll in 11th grade, students thoroughly review the fundamental skills from solar power I with an emphasis on demonstrating specific skill in performing solar installation. This includes battery-based systems, weatherization, safety and related building work. In year two, the teaching goes deeper. There is in-depth learning to manage and design solar projects and demonstrate use of current computer supported design programs. Additionally, students learn how to conduct quality assurance inspections and site surveys, to maintain and test equipment, and to describe the “House as a System” framework in more depth. During this year, students explore the variety of industry careers that are available in the solar and energy efficiency sectors.

Solar Energy Technology III (12th Grade)

All fundamental skills for solar installation and weatherization introduced in Year I and II are reinforced and connected to direct application of skills. In work groups, students form their own solar company as the platform for presenting their solar and weatherization skills via Capstone projects. Students perform hands-on demonstrations for assembly of photovoltaic system components and conducting effective home energy and weatherproofing audits. They will also demonstrate solar energy system sizing and design principles along with a comprehensive understanding of the overall solar installation process. Students will perform weatherization tasks including installing air sealing, moisture barriers, and insulation application techniques.

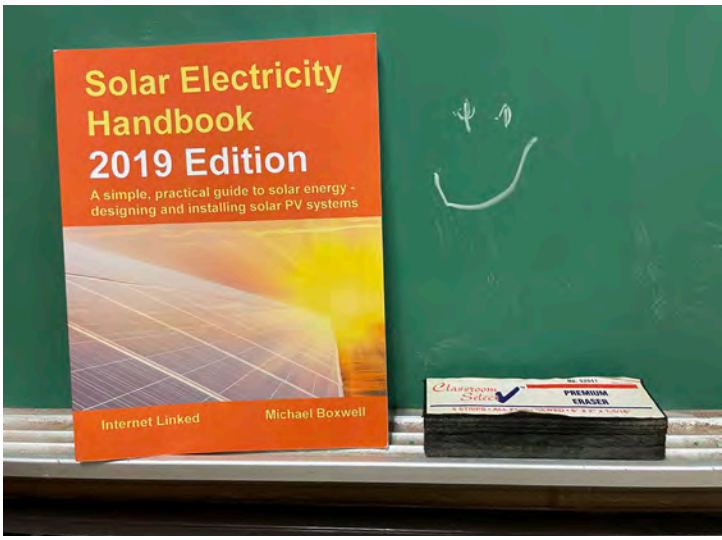
The 4th quarter of Year III is devoted to presentation of work and preparation for the NABCEP PV Associate Exam and Certification. The **North American Board of Certified Energy Practitioners® (NABCEP®)** is the most respected, well-established and widely recognized certification organization for professionals in the field of renewable energy. One of the recommended study prep courses/approaches used in the Philadelphia pilot is the author of one of the solar texts, Sean White. This and other resources, several without cost, are also available, such as the NABCEP PV Associate Practice Exam. In the original pilot, application and fees were covered by the school district.

Curriculum Development

Academic & Industry Standards and Their Use

This curriculum is highly interdisciplinary and as a result is influenced by a combination of education and industry standards. The individual lesson plans feature a variety of educational standards including the Pennsylvania Academic Standards for Career and Work, the Pennsylvania Academic Standards for Science and Technology and Engineering Education, and the nationally recognized Next Generation Science Standards (NGSS).

In addition to the academic standards, the curriculum is also grounded in industry standards. The Occupational Safety and Health Administration's (OSHA) safety standards are a critical feature of the program of study and are integrated throughout the three year course of study. The OSHA10 certification program is compatible with the curriculum; students in the program greatly benefit from adding this certification as a supplemental offering during the second year of the program. This curriculum is also structured so that upon completion of the three-year program students are prepared to take the North American Board of Certified Energy Practitioners' (NABCEP) Photovoltaic (PV) Associate exam. This nationally recognized credential aids in students' marketability in the solar industry workforce.



It is recommended that any school sponsoring this program includes a formal OSHA10 training component that leads to a nationally recognized credential in addition to the safety lessons already included in the curriculum. This training is appropriate at the beginning of the Year 2 during the first quarter. During our pilot phase of the project, the School District of Philadelphia selected an OSHA10 General Industry - Manufacturing online training program offered by https://www.careersafeonline.com/.

Best Practices in Curriculum and Instruction

Best Practice Curriculum Writing: *Using a Constructivist Lens*

Learning takes place in different ways at different levels. The constructivism theory holds that learning is significant when learners construct or create basic knowledge by themselves through inquiry and discovery through active participation: interaction, collaboration and group work.

This approach views students as active creators of their own knowledge. To do this, they must ask questions, explore, and assess what they know, preferably in an interactive process with teachers and peers. This is an active process which is based on the assumption that knowledge is constructed by learners as they attempt to make sense out of their experiences. This point of view maintains that people actively construct new knowledge as they interact with their environment.

LESSON PLANS

Lesson plans in this curriculum encourage the use of social constructivism rather than rote learning through instructional methods such as case studies, research projects, problem based learning, brainstorming, collaborative learning/ group work, guide discovery learning, and simulations, among others. The teacher is encouraged to sometimes divide the class into groups/teams, or pairs, and then guide by prompting, questioning and directing the groups to discover concepts, gather learning experiences, or problem solve according to the intended objectives. Hands-on learning is the target.

LESSON PLAN FORMAT

The lesson plan chosen for this curriculum is the inquiry-based 5E Format: *Engage, Explore, Explain, Extend, and Evaluate*. *Note: Some lesson plans written by industry professionals do not use this format.*

It is highly recommended that teachers use these steps in preparing their lessons. Here is our take on the model:

ENGAGE: The purpose for the ENGAGE stage is to pique student interest and get them personally involved in the lesson, while pre-assessing prior understanding. In Year 2 or 3, it is important to understand what needs review or reteaching.

EXPLORE: The purpose for the EXPLORE stage is to get students involved in the topic, providing them with a chance to build their own understanding, through hands-on, concrete experiences They might be asked to use a scientific format and communicate with peers about observations.

EXPLAIN: The purpose for the EXPLAIN stage is to provide students with an opportunity to communicate what they have learned so far and figure out what it means. This is often a teacher-led part of the lesson. They define the necessary vocabulary and connect their findings to prior knowledge. The teacher should support student discussion and answer student questions.. This is also when teachers utilize video, computer software, live demos, or other aides to boost understanding. This stage is a direct instruction phase and can provide examples and live demos. For example, they may learn how to create a field made solar connector or explain how air typically moves through a house.

EXTEND: Research shows that students need to solidify their understanding by connecting what they have learned to something real. This is where generalizations to a larger context takes place. The purpose for the ELABORATE stage is to allow students to apply what they've learned and continue to explore implications. Students use industry vocabulary and concepts in their project/work completion. Teachers may ask students to create presentations or demonstrate completion of a task using a new skill like using caulk or walking peers through the working of a solar inverter.

EVALUATE: This model allows for both formal and informal assessment. The purpose for the EVALUATION stage is for both students and teachers to determine how much learning and understanding has taken place. It is helpful to note at this point whether students approach problems in a different way based on what they learned. Other elements of this phase include self-assessment, peer-assessment, writing assignments, students demonstrations and exams. NOTE: Formal assessment is left up to the teacher to determine the content, format and frequency of quizzes and tests.

RECOMMENDED TEACHER QUALIFICATIONS

In today's quickly growing field of solar energy technology many companies are recognizing the need to address energy efficiency and weatherization as a critical companion for success. When choosing a teacher it is critical that this individual possess solar installation experience. Additional expertise in weatheriation is desirable. Ideally the teacher selected for the program would also possess PA certification in a related CTE area or in physical science 7-12 and have five or more years of high school teaching experience.

Since it may be difficult to find a teacher who is skilled in both areas, schools might consider bringing in an industry professional(s) for the weatherization lessons. Industry experts play an important role in this program. During the grant period the team scheduled industry experts as guest presenters on a weekly basis.

Scope & Sequence

The Scope and Sequence is linked to the appropriate lessons in the curriculum. The lesson plans are a resource for the teacher experienced in solar technology and can be used to suit the students in a particular group. Lesson plans often differentiate lessons for either 10th, 11th, or 12th grade. However, It is the teacher's knowledge of student background and their needs from year to year that ultimately guides what and how topics are presented initially, in more depth, and for review.

Tools and Materials Lists

An appropriately outfitted lab is required for solar and energy efficiency work. It is recommended that the furnishing of this lab should start a year before the program begins to assure that the needed structures, wiring, ventilation, and tools are in place and ready for students. For the Philadelphia High School CTE program, the building was closed during the first year and the lab outfit was delayed because of precautions and delivery delays due to Covid-19. The program should begin with hands-on experiences with the students from the first day, and a lab that is ready is imperative to achieve full engagement of the students. The following items are recommended by solar and energy efficiency industry professionals:

Solar Tools and Materials

Weatherization Tools and Materials

Task List

The Task List demonstrates the skills that students will be expected to demonstrate by the end of the 3 year program. This represents the overall Scope of what is taught and are considered outcomes of the program. Industry professionals provided this list. Additional skills may be presented within major topics.

Syllabi for Three Years

Each year is divided into 4 quarters of instruction with topics that are linked to lesson plans. These syllabi are the starting place for the suggested sequence in which topics and skills are taught and developed. Districts may want to revise this order to accommodate their own needs. For example, the team chose to place all of the Weatherization lessons in the third quarter although these lessons could be easily implemented during any time period during the school year. In fact, there may be many complimentary topics between the weatherization and solar lessons.

Download the complete 3-year syllabi online here.

Lesson Plans

The complete set of solar energy technology and energy efficiency and weatherization lesson plans will be available in the fall of 2022 from the Philadelphia Energy Authority website.

Pedagogical Support

Student Support: Life and Professional Skill Development

An important part of the Pennsylvania Career & Technical Education (CTE) Solar Technician and Weatherization Technician training program success includes attention to developing and supporting life, personal, and professional skills. In an inner-city high school, tenth graders begin this program with differing needs and skill levels. Personal barriers, as well as academic deficits, must be addressed for this program to be successful. Time is built into the schedule for this component and is shown in the yearly time allotment at the end of each yearly syllabus. Times were carved out for in-class meetings that should take place 3-4 times per month. Individual student and parent coaching is scheduled individually. School Districts can make use of District or private organizations to provide this support.

For the Philadelphia Energy Authority and the School District of Philadelphia demonstration, Tina Pelzer and the Faces And Voices Of Reason (FAVOR) team provide curriculum and teaching to develop these skills. FAVOR assists and supports trainees (personally and professionally) with tools to promote engagement, self-efficacy, focus and communication skills, and help navigate challenges that may arise throughout the course. FAVOR coordinates with the classroom teacher, students and students' families using a case management approach to assist with ongoing support and strategies for trainees to be successful. Highlights of these supports:

- Use of a variety of professional and personal skills including professional etiquette, time management, emotional intelligence, and stress management.
- Development of personal and professional skills including confidence building strategies, trauma informed practices, goal setting, problem solving strategies, effective communication, and team building.
- Planning career path goals and strategies; the ability to describe the top ten skills employers want, job application skill, resume and cover letter preparation, and effective job interview skills.

View a sample FAVOR Life Skills scope and sequence here.

Teacher Support

SUPPORT RESOURCES

- Several resources were available to the CTE teacher chosen to lead the program.
- Solar Training Fellow (PEA) was the primary coordinator and organizer of all aspects of the program including teaching schedules, syllabi, debriefing meetings, monthly partner meetings, gatekeeper, and more. This is a linchpin position.
- School District Support: Teacher coach, principal and CTE Department Liaison, and others
- Curriculum teachers, observation and feedback specialists

- Industry professionals used as demonstration and co-teachers
- Evaluation professional provided feedback for program improvement
- Community college liaison for continuing education opportunities
- Occupational Advisory Committee: composed of energy leaders in the region tasked with supporting complete program development from lab set up, donation of tools and materials, development of the Task List, and more.

PROFESSIONAL DEVELOPMENT (PD)/COMMUNITY OF LEARNING

PD evolved in several ways to provide structured professional learning for teaching practices and learning in order to maximize student outcomes. The Philadelphia Education Fund was tasked with starting the PD process. Teachers started working to design student outcomes, and syllabi for several student cohorts for piloting early versions of the Bright Solar Futures solar training initiative. Existing industry curriculum was used both for Solar and Weatherization. Initial PD focused on working as a team, developing constructivist best practices that included group planning and brainstorming, a development of shared values, and a willingness to share successes and challenges. This phase focused on program development.

As teaching started, PD was conducted at weekly debrief meetings, through observations and feedback, and on-site coaching from industry professionals.

OBSERVATION AND FEEDBACK

Observation/Feedback is a professional development approach that encourages practitioners to analyze, critique, practice, reflect, and revise instructional practices. This involves a series of observations and feedback conferences to be held over an extended period of time targeting teaching best practices for industry profession staff who usually work with post-graduate students. This technique was also used at the beginning of the high school pilot although COVID made this more difficult.

COACHING, DEBRIEFS

Elements of a Coaching and expert support was planned for this program roll out. Remote learning restrictions made this component more difficult. With in-class learning reestablished, solar professionals are critical in establishing the hands-on nature of the program and provide motivating initial sessions around safety measures on the mock roof, solar equipment, tool use, and design projects. Weekly debrief meeting were crucial in analyzing and supporting program issues including curriculum modification for school requirements and student needs, motivating students, case management/counseling for student concerns and barriers, and

CTE SUPPORTS

The School District provided a Career and Technical Liaison to support the final outcomes of the curriculum, teacher resources, clarifying expectation and helping to manage the requirement for the grant.

ACCOMMODATING DIVERSE HIGH SCHOOL LEARNERS

The teacher is responsible for modifying lessons and hands-on work to accommodate background of experience, special needs, and skills levels. Addition of suggestions for such accommodations should come from work with students and adaptation successfully used by the teacher. Results of such work should be included in future editions of the curriculum, if possible.

Links to further resources:

CareerSafe Online OSHA 10 training

Strategies for Solar Workforce Development: A Toolkit for the Solar Industry

Enphase University Training Certification

Solaredge Certification

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