Innovative

Mock Roof Project for Installation of Demonstration Solar Array by University Students

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Introduction/Need for Project

According to the National Solar Jobs Census published by IREC (2020), between 2014 and 2019 solar employment increased almost five times faster than job growth in the overall U.S. economy. Installation of solar projects makes up 65% of the solar sector (IREC, 2020) with 68% of new hires landing in newly created positions. Over one third of new solar PV capacity installations across the globe are rooftop attachments. The share of rooftop solar peaked in 2018 when 43 percent of all solar panels installed were mounted on residential and commercial buildings (Jaganmohan, 2022). A research estimate of eight billion square meters of suitable roofs in the U.S. if covered with solar modules could produce nearly 1,400 terawatt hours (tWh) annually with two-thirds coming from the residential sector (Johnson, 2018).

Across industry sectors, the highest-demand jobs are concentrated in entry-level technical roles. According to the Bureau of Labor Statistics (2022) installation and construction jobs in the residential rooftop sector are some of the fastest-growing jobs in the country. Students preparing for a career in renewable energy need to assess their skills and interests if considering a pathway in the solar industry. Solar employers prefer candidates with bachelor's degrees and related work experience (Woodruff, 2014). Knowledge and skills of solar installation is part of the Job Task Analysis (JTA) for students preparing for the PV Associate Certification Exam (NABCEP, 2017). The activity of our focus is Domain IV: Installation, Task 3: Identify the elements of racking installation (NABCEP, 2017).

A roof mount method using a rack mount (SEI, 2004) was selected for this project. The solar modules are supported by a metal framework and set at a predetermined angle. The rack-mounted array is placed on the roof with track bolted on the roof's structural members. Manufacturers' mounting systems for pitched roofs tend to follow a top-down rail mounting scheme. Aluminum mounting L-feet are lag-bolted into a rafter, support and aluminum rail at intervals. Two rails support each row of PV modules and are secured to the rail by top-mounted clips. Clips are secured to the rail between modules connecting the sides of two adjacent modules (Hren, 2009). Rail-based racks have been the mainstay of the solar industry for years (Riegel, 2017).

How Does It Work

The roof should be constructed to standard building codes, with some exceptions (Parrish, 2016). The overall roof dimensions were as follows:

- Width: 15-ft Length: 20-ft Depth: 6-ft Pitch: 4:12

A 2-inch angle iron frame was laid out, cut, and welded together using a GMAW process. Nine 8-inch castors with rubber tires were mounted to the steel frame. The roof was composed of 2 x 8 rafters on 16-in centers, sheathed with ¾-inch plywood and 30# roofing felt. A 20-year asphalt composition shingle. Rafter spacing and plywood thickness selected to accommodate weight of multiple students on the roof at same time. All four edges were trimmed with aluminum edging. We outfitted the roof with a safety rail on three sides. To accommodate the

use of a personal safety harness, a reusable roof anchor plate was installed on the top edge of the roof to prevent falls (OSHA, 2022). The solar array will consist of eight solar PV modules, mounted in two rows of four, in portrait-fashion. Each row will be supported by two module rails. Footings for each rail (approximately four) will be permanently affixed to the roof. Rails, modules, cables, micro-inverters, and module clamps will be attached and removed at the completion of each lab or demonstration activity. Example modules are 65" long and 40" wide. The roof has a three-foot spacing around the array to provide room for walking and installation.

Students were introduced to the roof-mount installation activity with a lecture presentation on various solar PV mounting methods including rack-mount roof top used in residential systems. At the beginning of the lab, a presentation and demonstration of various personal protective equipment (PPE) was conducted. A demonstration of the use of personal safety harness for work on pitched roofs was conducted. All students were required to wear a safety bump hat and work gloves were made available. Hand tools used in the attachment of mounting rails and tightening of bolts on clamps were shown and a demonstration on correct use was made. Students were quizzed on the roof mounting components and asked to identify system mounting feet, flashing, lag bolts, rails, end clamps, mid clamps. We finished with the safe handling of large solar PV modules. Two students put on the safety harnesses and attached the safety lines to the roof anchor plates. Students worked in pairs to carry and safely place modules on the rails prior to fastening. At the conclusion of mounting all eight modules in two rows of eight, modules were connected in series to build desired array voltage (Sanchez, 2011) and management of the wires beneath the array was discussed and conducted.

Advice for Others

Assess the solar industry opportunities for students in your region. This project compliments both our building construction skills instructional unit and electrical wiring unit. Students expressing a career interest in renewable energies benefit from this lab activity. As interest in the emerging Agrivoltaics sector grows (incorporating solar PV collection systems into production areas), there will be a growing demand for solar PV installers as well as system designers. Plan for space in your laboratory program for this engaging activity. Funding of $5,000.00 from an institutional sustainability grant secured the materials, tools, and safety materials for this lab teaching activity. Following completion of the Mock Roof, students were very eager to practice on it. There was a lot of positive feedback form our students saying that it was the "last twist of the lightbulb" and they were able to put all their knowledge together. This was the closest that we could get our students to a real world install without all the hazards of being on a building. Students were also surprised at how difficult it was to move among the roof with the fall safety devices on.

Resources

Materials used for this project included: Angle iron (0.125 x 2 x 2), Rafter material (2 x 8 lumber), Framing studs & cripples (2 x 4 lumber), Plywood (3/4 x 48 x 96), 30# Roofing Felt, Safety Rails & Mounts, PV mounting feet, rails, end clamps, mid clamps, 130-Watt solar modules (8 each), safety harness system, and assorted mounting fasteners,

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