

# Developing Photovoltaic Online Training for Code Officials (PVOT)<sup>1</sup>

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## ABSTRACT

Photovoltaic Online Training for Code Officials (PVOT) has been developed from mid-2011 through mid-2012 and includes seven online training modules. Six of the learning modules use traditional linear online training approaches presenting a series of pages with onscreen content, 2D media and video with narration, followed by an assessment quiz. The seventh module is an immersive capstone lesson imbedded in a game-based framework, with its own assessment. All seven learning modules are presented in WebGL<sup>2</sup> via the NTER platform, with KUDA also utilized for the immersive lesson.

The National Training & Education Resource (NTER) is an online platform intended to revolutionize how online training and education is developed, accessed, and delivered, and includes a sub-internet and search engine for education and training.<sup>3</sup> Kuda is an advanced JavaScript library and related World Editor that together enable web developers to rapidly build 3D interactive web products.<sup>4</sup> In future phases of PVOT, some of the 3D interactive KUDA resources used in the capstone module may be incorporated into all of the learning modules.

With new advances in the field of online graphic libraries that allow for 3D intensive simulation environments, the web based learning module has taken on a new power in its ability to convey and impress information upon the user. This project capitalizes on the emerging technology and uses it to the fullest extent available.

The primary intended audience is practicing code officials. Secondary audiences include PV installers, homeowners, and students. The six basic learning modules encompass the major topics of concern for field inspection and expedited permitting, including: Roof Mounted Arrays and Wire Management, Electrical for Roof and Ground Mounted Arrays, Specifics of Ground Mounted Arrays, Appropriate Signage, Equipment Ratings, and Expedited Permitting. All modules developed have been reviewed and vetted by currently serving code officials and field inspectors, and representative members of the solar industry.

## Introduction – Description of the Project

The Photovoltaic Online Training (PVOT) Program was initiated by the Interstate Renewable Energy Council as a method of instructing code officials nationwide in the key issues involved in granting permits and performing field inspections for small scale PV installations. The Institute for Sustainable Performance of Buildings (SuPerB) was contracted to develop

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<sup>1</sup> The sponsor for this project is the Office of Energy Efficiency and Renewable Energy (EERE), U.S. Department of Energy (DOE), via the Interstate Renewable Energy Council (IREC)

<sup>2</sup>For example see <http://en.wikipedia.org/wiki/WebGL>.

<sup>3</sup> Michelle Fox and Alex Cohen of DOE were instrumental in the development of NTER. For further information on NTER see <https://www.nterlearning.org/home>.

<sup>4</sup> SRI international and others have developed and applied Kuda, with funding support from DOE. For example see <http://code.google.com/p/kuda/>

Sharable Content Object Reference Model (SCORM)<sup>5</sup> compliant training modules to distribute standardized information to jurisdictions across the country, many of which have observed an increase in the number of PV permit applications requiring processing. Many small-scale residential PV installations can be permitted through an expedited process, followed by a field inspection upon completion of the installation. The intent of the PVOT training is to

- encourage an efficient permit processes
- eliminate structural review when not required
- instruct the code official in reliable field inspection practices

This paper describes the development process and provides an overview of the online modules, including the underlying images, 3D models, videos, interactive game-based frameworks, immersive test procedures, and other resources.

## **Mission and Intent**

The mission of this project is to develop and substantially increase the reach and scale of training available to code officials throughout the US. To achieve this goal SuPerB and our team have produced SCORM compliant online training for code officials conducting review and inspection of PV (Photovoltaic) systems for code compliance and safety. This online training should allow effective training to quickly and cost-effectively reach a far greater number of code officials than has been possible using live workshops and seminars.

## **Audiences**

The primary audience for PVOT is the practicing code official. The PVOT project was conceived by the Interstate Renewable Energy Council (IREC) to assemble the most relevant material and distribute it to a nationwide audience of code officials tasked with reviewing, permitting, and field inspecting small scale photovoltaic applications. The objective was to distribute standardized learning nationwide. A cost-benefit analysis determined that traditional workshops led by subject matter experts were unlikely to reach all jurisdictions in need of providing training to their inspectors. Costs of travel is prohibitive for many officials who could benefit from instruction, creating gaps in knowledge, a loss of efficiency, and unnecessary delays in permitting and inspecting PV installations.

### **Likely secondary audiences include:**

- PV designers and installers intending to prepare themselves for pending inspections
- Owners of small scale structures concerned with code compliance and safety issues of PV systems
- Students of the photovoltaic industry

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<sup>5</sup> For an explanation of SCORM see <http://scorm.com/scorm-explained/>

## Approach

The project is intended for use in a variety of settings. Most importantly, it will be made available to code officials and could provide continuing education credits for those who complete the course and all assessment quizzes with a score of 80% or better. Assessment will be an optional aspect of the training. The training will be available online to anyone who wishes to view the content. It will also be used to augment and enhance existing photovoltaic curricula and workshops provided by Subject Matter Experts (SMEs). The content will be directly accessible to the student learner, or may be used in a classroom setting as an introduction to further instruction and discussion.

The development team began by classifying the lessons under six basic training modules, and a seventh “Capstone” module. SuPerB used three reference documents written by Bill Brooks, P.E. to create lesson content (see references). The first six learning modules function within a GUI (Graphical User Interface) that contains onscreen text, video and voice-over narration. For each learning module an “i-button” (information button) links the user to relevant National Electrical Code (NEC) references.

### Page-Turner Modules

These include six traditional online learning modules that contain sequential materials with photos and videos. Interactivity is provided only in the assessment portion of each lesson, where the user answers and is scored on multiple-choice questions. See figures 1-6 for examples of images used in these lessons.

### Game-Based Module

One learning module is Game-Based. This is an immersive learning module of a virtual house that includes the increased learning potential of gaming features, problem based challenges, and scoring. This learning module uses a Kuda-based interactive framework (IAF). See figure 7 for an example of a 3D model used in the interactive lesson.

**Table 1. PVOT Learning Modules Produced**

| Lesson Title                                | Page-Turner | Assessment | Game-Based |
|---|-------------|------------|------------|
| 1. Roof Mounted Arrays & Wire Management    | •           | •          |            |
| 2. Electrical: Roof & Ground Mounted Arrays | •           | •          |            |
| 3. Ground Mounted Arrays                    | •           | •          |            |
| 4. Appropriate Signs                        | •           | •          |            |
| 5. Equipment Ratings                        | •           | •          |            |
| 6. Expedited Permitting                     | •           | •          |            |
| 7. Capstone (Immersive Lesson)              |             | •          | •          |

**Example Images from Each Learning Module:**

**Figure 1. Roof Mounted Arrays and Wire Management**



Source: Photovoltaic Online Training for Code Officials

**Figure 2. Electrical for Roof and Ground Mounted Arrays**



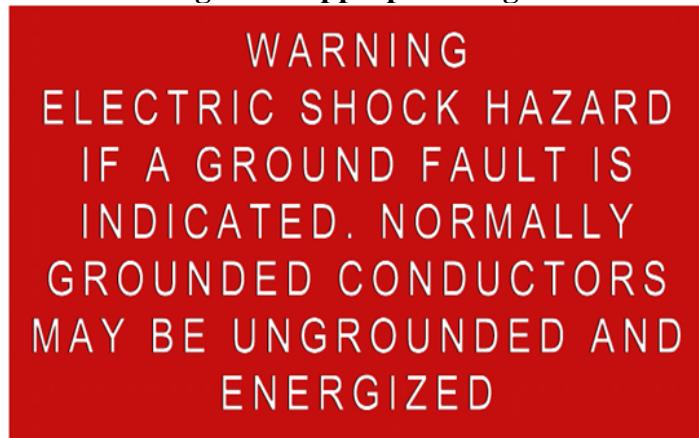
Source: Photovoltaic Online Training for Code Officials

**Figure 3. Specifics of Ground Mounted Arrays**



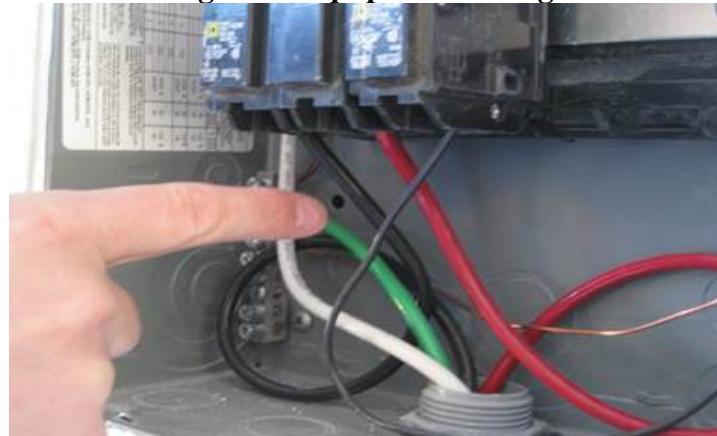
Source: Photovoltaic Online Training for Code Officials

**Figure 4. Appropriate Signs**



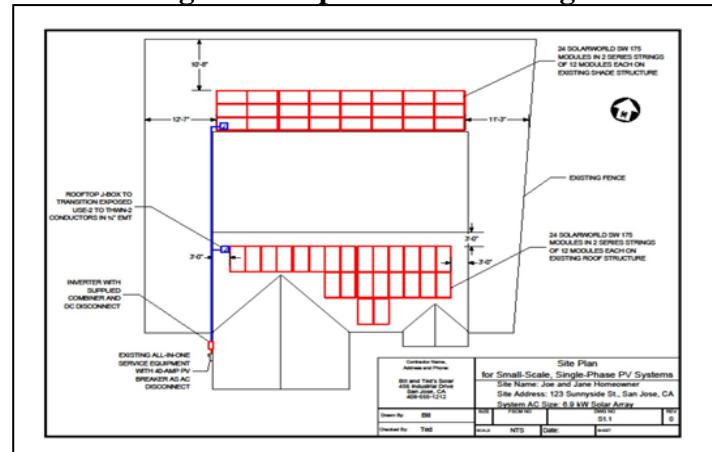
Source: Photovoltaic Online Training for Code Officials

**Figure 5. Equipment Ratings**



Source: Photovoltaic Online Training for Code Officials

**Figure 6. Expedited Permitting**



Source: Photovoltaic Online Training for Code Officials

**Figure 7. Example 3D Model Image from Immersive Lesson**



Source: Photovoltaic Online Training for Code Officials

The 7th learning module, the “capstone,” is intended to fully engage the learner in a 3D environment, navigated via the computer keyboard and mouse. This capstone lesson will provide an interactive form of learning and assessment for users:

- Who benefit from a “learn by doing” or a “hands-on” approach to the educational process
- Are experienced workers with 30 many years of on the job experience with little formal education in PV installation

The capstone learning module was conceived as an immersive 3D environment in which the user will be able to engage with a virtual house and roof-mounted PV installation. The capstone has three different sequential simulation options: Guided Instruction, Exploration, and Assessment. Each of these options provides separate but equally useful experiences within the learning module.

- The Guided Instruction option provides the user with layover text screens that provide the necessary information for the selected object within in the environment, e.g. selecting the inverter provides a close up of the inverter a description of its purpose.
- The Exploration option provides the user with the ability to discover correctly or incorrectly installed PV components without being tested or graded.
- The Assessment (or testing) option mirrors the Exploration option but includes a quiz at the end of each lesson, testing the ability of the student to identify correctly or incorrectly installed PV components.

The main objective of the capstone learning module is to provide an immersive and interactive environment in which the user can assess and improve her ability to identify correctly and/or incorrectly installed components of the PV Array. Once the user identifies a problem by selecting whether it is correctly or incorrectly installed, she will be asked for reasoning to support her assertions, e.g. if the user claims to have found an issue with the mounting brackets she will then be prompted by a second question designed to test her knowledge of why the component is correctly or incorrectly installed.

All media and text within the six page-turner learning modules and within the capstone lesson strives to be 508-code-compliant. However, 508-code-compliance is not a strict requirement for this project.

Mobile applications for field use also will be available for PVOT, and the page-turner modules are being tested for use on the iPad.

## **Chapter-Level Assessment**

In addition to the assessment contained within the capstone learning module, of the first six lessons contain a multiple-choice assessment at the end. These questions are presented as standard multiple choice and true/false questions that pertain to the knowledge garnered from each lesson. The user must score 80% or better to achieve a passing score.

## **The Team**

The PVOT team was fortunate to be under the direction of Chris Nichols, Project Manager for DOE, and Ms. Jane Weissman, Executive Director IREC. Joe Sarubbi, National Administrator for IREC, contributed to the management of the project. IREC is a non-profit organization accelerating the use of renewable energy since 1982. IREC's programs and policies lead to easier, more affordable connection to the utility grid; fair credit for renewable energy produced; best practices for states, municipalities, utilities, and industry; and quality assessment for the growing clean energy workforce through the credentialing of trainers and training programs.

## **Team Roles and Responsibilities**

- Management Focus
  - DOE – project management
  - Interstate Renewable Energy Council (IREC) - project management
  - The Institute for the Sustainable Performance of Building (SuPerB) - management, direction, integration, instructional design, 3D model development support.
- Subject Matter Expertise Focus
  - Brooks Engineering, Brooks Solar – subject matter expertise and content development, and photography
  - Building Media Inc. (BMI) – subject matter expertise and content development, video media development, and instructional design.
  - County of Santa Clara, California – subject matter expertise and content development, and photography
  - City of Palo Alto, California – subject matter expertise and content development, and photography
  - National Renewable Energy Laboratory (NREL) – subject matter expertise and content development, and photography
- Instructional Design Focus
  - Jon Scoresby, PhD - instructional design including educational game expertise
- Media, simulation, and modeling focus

- JHT Inc.– media development, simulation and animation
- Studio Strong - web interface design

## **The Program Advisory Committee (PAC)**

In consideration of the vast amount of expertise among PV designers, installers, code officials and educators nationwide, we developed a short list of nine program advisors to review the alpha version of each learning module. Their comments were extremely valuable and we were able to incorporate many of their suggestions into our content. It was generally agreed among the PAC members that code officials would be interested to know which building and electrical codes applied to each topic. Because codes are regularly updated and revised, it was decided by the project managers that this content should be served via an “i-button”, a clickable icon on the screen that will allow the user to view relevant code information in a pop-up format during each lesson. From a programming perspective, this simplifies our ability to keep the content current, by allowing the building and electrical codes to be updated as needed, independently of the main content.

## **Development Process and Schedule**

The project schedule was extremely tight due to budgetary constraints. Thus, it was important to track the development of the seven learning modules, or lessons, and to remove barriers to the speedy production of high quality products.

### **Communication**

The team employed a variety of electronic management tools to keep team members and PAC members informed of project developments:

- WebEx meetings: routine web meetings.
- DropBox: For storage of PowerPoint storyboards, photos, and video
- Google Sites: For project description, lists of team and PAC members, contact information, and publication of resources utilized in content development
- Google Docs: For project schedules and real-time sharing of Capstone development documents.

## **Developing the Graphical User Interface (GUI)**

Using text and color guidelines provided by the DOE/ Energy Efficiency and Renewable Energy (EERE) a draft of the graphical user interface (Figure 8) was developed by SuPerB, and was later refined by Laura Strong, of Studio Strong. The SunShot Initiative logo was used on each page of the GUI, as the PVOT project shares its intent with the SunShot Initiative, a program sponsored by DOE/EERE to reduce administrative barriers to residential and small commercial PV solar installations.

## Sequence of Development Steps

The first six learning modules, or lessons, underwent the following development process:

1. SuPerB creates a course outline using content provided by Bill Brooks, P.E.
2. SuPerB holds meeting with Program Advisory Committee (PAC) to discuss learning objectives, goals and approach to presenting content
3. SuPerB develops a video shot-list which is recorded in the field by the media producer
4. SuPerB develops a PowerPoint storyboard with embedded photos and video
5. SuPerB develop assessment questions for each learning module
6. SuPerB orchestrates QA of content and assessment with subject matter experts

**Figure 8. Example of Graphical User Interface for PVOT**

The screenshot shows a web-based training interface. At the top, there's a navigation bar with icons for help, Creative Commons, search, and other functions. The main title is 'Roof Mounted Arrays & Wire Management'. Below the title, it says 'Lesson 1: Introduction'. On the right side, it indicates 'Page 1 of 8'. In the center, there's a large image of a house with solar panels installed on its roof. To the right of the image, under 'Key Points:', there's a bulleted list: 'Verify that the plan and the installed array are in agreement.', 'Number of modules should agree with the plans.', 'Part numbers should agree with the plans.', and 'Inspect the overall quality and installation of array before doing a detailed inspection.' Below this, under 'Common Installation Mistakes:', there's another bulleted list: 'Changing the array wiring layout without changing the submitted electrical diagram.', 'Changing the module or equipment type or manufacturer as a result of supply issues.', 'Exceeding the inverter or module voltage due to improper array design.', and 'Putting too few modules in series for proper operation of the inverter during high summer array temperatures.' At the bottom of the page, there's a footer with the text 'Photovoltaic Online Training' and the 'SunShot' logo, which includes the text 'U.S. Department of Energy'.

Source: Photovoltaic Online Training for Code Officials

7. SuPerB edits PowerPoint storyboards to incorporate SME input and additional media
8. SuPerB delivers storyboards to media producer to produce a professionally narrated alpha version
9. Program advisors reviews alpha versions of lessons
10. SuPerB revises learning module based upon PAC input
11. SuPerB deliver revisions to media producer
12. SuPerB orchestrates a final QA and review with subject matter experts
13. Product packaged in SCORM compliant format
14. Product published on NTER's public site

## Project Uses Recently Emerging Resources

An important project objective was to utilize emerging 3D browser-based interactivity, especially game-based learning. The NTER and Kuda platforms, the game-based Interactive Framework (IAF), WebGL have all undergone continuing development during the course of previous and concurrent projects. These resources have been developed by others as the result of

the commitment of considerable talent and funds. The PVOT project has been an early adopter of these emerging resources. Examples include:

- The NTER platform
- Kuda 2.0 was fully realized during the course of this project and has been an invaluable tool to provide the virtual 3D environment that is required for the realization of the Capstone learning module.
- Interactive Framework (IAF) for the Capstone learning module: media producer JHT, Inc. used their expertise in creating engaging 3D environments that employ the emerging Kuda platform. They utilized JavaScript functions to produce a game-like environment, in an interactive framework (IAF).
- WebGL: Emerging WebGL browser capabilities have made it possible for users of the program to inhabit and manipulate a fully immersive 3D simulation environment, without need of downloading plugins or using graphic libraries stored on CDs.

## Conclusion

The content used to develop this software has been previously delivered at a number of workshops and lectures around the United States, and will be familiar to many code officials who plan-check and field-inspect photovoltaic systems. The value of this project is in improving the ability to reach and instruct a wide audience of code officials and to provide a foundation of knowledge that can be built-upon during live workshops. The game-based approach to instruction will engage the learner and increase retention of the material. Photovoltaic Online Training will be made available to the public via the National Training and Education Resource (NTER) in May 2012.

Future plans may include further development of the game-based instruction modules, to include a sequential walk-through of a PV field inspection, and a simulation of the expedited permitting process for PV systems.

## References

- (IREC 2010) for [IREC] Interstate Renewable Energy Council. 2010.
- Brooks, Bill, PE. 2011. "Expedited Permit Process for PV Systems, a Standardized Process for the Review of Small Scale PV Systems." *SolarABC's*, June 2011. Accessed May 15, 2012. <http://www.solarabcs.org/about/publications/reports/expedited-permit/>
- Brooks, Bill, PE. 2010. "Field Inspection Guidelines for PV Systems." *IREC*, July 2010. Accessed May 15, 2012. <http://irecusa.org/wp-content/uploads/2010/07/PV-Field-Inspection-Guide-June-2010-F-1.pdf>
- Brooks, Bill, PE. 2010. "Permitting and Inspecting PV Systems." Presented at workshops for code officials and photovoltaic installers, led by Bill Brooks, P.E. 2010-2012.