PVMaT 5: PowerGuard® Advanced Manufacturing

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Abstract

PowerLight™ was awarded a PVMaT contract in 1998 to advance its manufacture of PowerGuard®, a world-class photovoltaic (PV) roof tile for low-slope commercial buildings. As a result, manufacturing improvements have increased annual production capacity from 5 MW/yr to 16MW/yr, reduced production labor requirements by 75%, and reduced overall tile production costs by 57% — while also improving both product safety and quality. In addition, the introduction of Integrated Design Software and Standardized Package Systems, as well as UL and international certifications, have further reduced PowerGuard system costs, while increasing consumer acceptance and confidence.

1. Introduction

PowerLight is a manufacturer and systems integrator of PowerGuard, a leading photovoltaic (PV) roof tile system for low-slope commercial buildings.

The PowerGuard system consists of PowerGuard tiles along with ancillary building and electrical components. The PowerGuard tile consists of a flat plate PV laminate mounted onto a flat, rigid, extruded polystyrene (XPS) board. Two edges of the XPS board are routed into a tongue profile, and the other two edges are given a groove profile, allowing PowerGuard tiles to be assembled adjacent to each other in an interlocking fashion. Adjacent tiles are connected electrically through module electrical connectors, thus creating a string of PV modules. One or more strings are tied together electrically at a remote location creating a solar electric PowerGuard array system. The resulting DC currents from the PV array are passed through a DC/AC inverter and transformer, before being tied into the building's electric service.

The goal of PowerLight's PVMaT project has been to improve the manufacturing process of PowerGuard in order to reduce costs, improve quality, and increase manufacturing capacity. In addition, certain product features have been advanced: special wiring harnesses have been created for use with thin film PV modules; a sloped PowerGuard tile was developed; manuals were created for specifying and installing PowerGuard systems; and special software was created to aid in the layout and the component specification of PowerGuard systems. All assemblies making up commercial PowerGuard systems have been UL listed, and various international certification efforts have been undertaken to extend PowerGuard into foreign markets.

All of these efforts have helped to bring down the costs of PowerGuard manufacturing, thereby increasing the demand for PV. At the same time, PVMaT improvements have enabled PowerLight to meet its growing co\nsumer demand.

2. Cost Reduction

At the start of this PVMaT contract, PowerGuard was hand assembled, one tile at a time. Under PVMaT, PowerLight has worked with subcontractors to design and build a custom PowerGuard assembly line. The assembly line was installed in PowerLight's manufacturing facility in Berkeley, California.

Previous XPS board production required six workers and close management oversight to ensure quality compliance. With the implementation of the new XPS prep line, labor was cut by 75%, and first-time quality was improved by 80%.

The original pre-1998 coating process required 3 minutes per tile. The current process requires less than 30 seconds per tile. At the same time, the coating material has gone from a batch mixing process to a continuous, consistent process, thereby reducing costs by 57%. Only the minimum amount of material is required at any one time, minimizing material waste. At the same time, the coating formula has been substantially improved, resulting in a forecasted 50-year product life.

Standardizing and streamlining various parts of the system design process have significantly reduced the cost of PowerGuard system delivery. Similarly, by obtaining various certifications, the process of site permitting has been greatly simplified, creating system cost reductions.

3. Quality Improvements

In an on-going effort to become a world-class leader of PV commercial mounting technologies, PowerLight aggressively pursued and succeeded in minimizing statistical special cause variation and reducing standard deviations of normal random variation. PowerLight increased consumer value by achieving the following:

a) Transitioning from hand-fabrication and hand-assembly to a continuous streamlined process, cutting geometry variation between PowerGuard tiles by more than 50%. The new manufacturing line uses a CNC router for cutting the tongue and groove profiles in the XPS boards. This process creates boards with dimensional tolerances of

±.002", thereby providing secure interlocking and aesthetically pleasing installations.

b) Hand mixing of cementitious coatings has been replaced with automated mixing and application processes. The cementitious mixing process provides viscosity improvements of 65%, thereby generating uniform product application.

c) Spacer positioning equipment has been incorporated to improve the consistency of spacer placement. This enhancement has eliminated first-time quality rejects as compared to the previous process.

d) Ergonomically-enhanced hand tools were added to the manufacturing process to trim the edges of the protective coating. This advancement allows the tongue and groove profiles to mate perfectly during installation and insures proper UV protection. This improvement also eliminates operator fatigue, thereby improving safety and quality expectations.

4. Capacity Improvements

PowerLight's on-going commitment to provide unique commercial PV mounting technology is exemplified by increasing capacity from 5MW/yr to 16MW/yr. This advancement was produced via cycle time reductions, elimination of non-value added processes, quick changeovers, and error-proofing processes. These improvements pave the way for capacity enhancements to 50 MW/yr

5. New complementary and improved products

PowerLight has made significant improvements to its PowerGuard tile and system integration process.

PowerLight identified new materials and processes for the PowerGuard cementitious coating. These changes reduced costes while increasing freeze/thaw resistance, compressive and tensile strength, and application consistency.

PowerLight also developed several product advancements:

a) A sloped PowerGuard tile was designed, refined and wind tunnel tested. This product increases energy capture in northern latitudes by up to 10%, and improves shipping density by 20%.

b) Modular systems for source circuit combining circuitry were developed to reduce non-value added components, reduce costs and improve reliability.

c) Inverter advancements reduced inverter components, improved statistical Failure Mean Time, and incorporated data acquisition.

d) An Integrated Design Software package was created to streamline PowerGuard system designs, generate product bill of materials, create drawing references, and support permitting.

e) New wiring harnesses were created for use with thin-film PV modules. These wiring harnesses allow several PV strings to be connected in parallel, greatly reducing the number of wires and fuses necessary to provide safe and reliable service.

6. Testing and Certification

PowerLight has conducted an extensive testing and certification program to support rapid growth in the PV industry. Three phases of wind tunnel testing have been used to certify the PowerGuard design while enhancing PowerGuard robustness under a wide range of local wind conditions. PowerLight has obtained UL listings of eleven different PowerGuard tiles and system components. UL listings are vital to the process of customer acceptance and system permitting.

PowerLight has also applied for PowerGuard certification through the International Conference of Building Officials (ICBO), along with international agencies. This process has created significant technical credibility with code authorities, and has facilitated international installations in Japan and Europe.

PowerLight aggressively made worker safety and elimination of environmental hazards a high priority in the design and manufacturing process. PowerLight undertook extensive surveys of all applicable federal and state regulations concerned with equipment design, operations, and worker safety. OSHA representatives and environmental consultants provided key input on exceeding government compliance. Key findings were incorporated into PowerLight Installation Manuals, Operations and Maintenance (O&M) Manuals, and training programs. Recyclables and waste elimination were also implemented in the manufacturing process to reduce environmental impact while reducing costs to the end user.

7. Conclusion

PowerLight is proud to be a PVMaT success story. The results of this three-year contract clearly demonstrate the manifold benefits of federal funding through PVMaT. Significant advancements in technology, quality standards, manufacturing processes, novel product improvements, and ultimately lower costs, have and will continue to stimulate the renewable energy market. As a direct correlation of improvements brought about through PVMaT, PowerLight's business has dramatically expanded to meet the needs of PV commerce. Naturally, the expansion of the photovoltaics market leads to immense economic and social benefits to our world and provides clean renewable energy technology for generations to come.