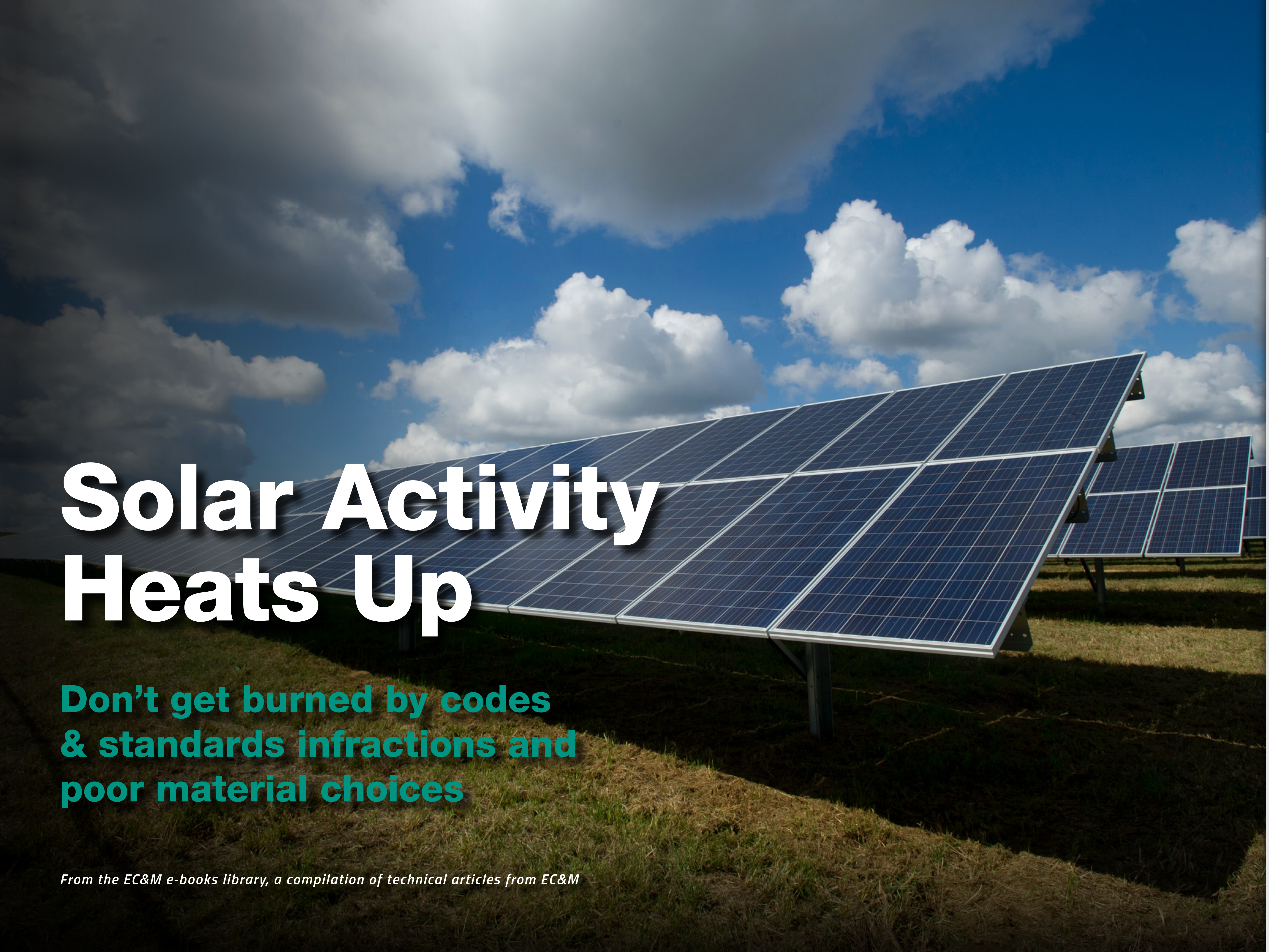

Solar Activity Heats Up

Don't get burned by codes & standards infractions and poor material choices

From the EC&M e-books library, a compilation of technical articles from EC&M

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THE SOLAR MARKET IS BOOMING. ARE YOU READY?

Even with tight supply chains and trade disruptions, 2022 was another banner year for the U.S. solar market. In Q3 alone, another 4.6GW of capacity was installed, bringing the total to 135.7GW, according to the most recent "Wood Mackenzie/ SEIA U.S. solar market insight®" report.

Many of those new installations were commercial (340MW) and utility-scale (2.5GW) projects, which bodes well for electrical contractors targeting those sectors. Although 2023 is shaping up to be just as busy, the next several years look even brighter, thanks to supply chain expansion, Inflation Reduction Act incentives, and utilities and businesses using solar to meet their ESG goals.

"Beginning in 2024, annual installations of solar will consistently reach 30-40GW," the Wood Mackenzie/SEIA report predicts, adding that annual solar market growth will average 21% between 2023 and 2027.

And when they're not drawing solar-powered electricity from a local utility, consumers are getting it from their rooftops: "The fundamentals for residential solar are strong — customers crave energy independence and savings from a solar system, particularly as retail power prices increase," the Wood Mackenzie/ SEIA report predicts.

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CODE PLUS FOR SAFETY AND RELIABILITY

These numbers highlight the importance of ensuring that installations are safe and reliable. In fact, solar is already the U.S. grid's No. 1 source of new generating capacity, which means the percentage of homes, businesses and schools that depend on solar will continue to skyrocket.

The booming solar market also means even more electricians will be installing and maintaining those systems. As "PV Installation Safety Standards Beyond NEC Art. 690" on p. 7 notes, "with utility-scale installations now typically reaching 1,000V or 1,500V, protecting workers against ground faults and arc flash incidents is critical."

Learning and applying Art. 690 goes a long way toward protecting workers and the customers who rely on solar — especially when it's augmented with standards from UL and other organizations. That's because when it comes to grounding and bonding, internationally recognized standards such as those from IEC and IEEE are often stricter than U.S. standards, which helps boost safety and reliability.

For example, UL 467, *Safety for Safety Bonding & Grounding Equipment*, provides basic requirements for grounding and bonding equipment, including direct-burial installations. IEEE 837-2014, Standard for *Qualifying Permanent Connections Used in Substation Grounding*, provides additional tests to ensure installations can meet demanding utility-scale requirements and withstand harsh environmental conditions. Check out "Considerations for Direct Burial Conduit" on p. 12 for insights into standards such as UL94, the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, and how they determine whether conduit labeled for above-ground applications can be installed underground.

BESS BECOMES A MUST-HAVE

Over the past several years, battery storage has become an increasingly important component in residential, commercial, and utility-scale solar installations. This trend could see a hockey stick uptick as the cost of battery energy storage system (BESS) hardware declines, making it something that even more solar projects can afford.

Solar also isn't the only renewable energy source that uses BESS, thus increasing sales volumes that help drive the technology down the cost curve. "The Inflation Reduction Act provides incentives that cut the cost of solar, wind, and storage equipment by anywhere from 20% to 60%," Wood Mackenzie predicts in a January 2023 report.

Safety and reliability are key for BESS. But as "Navigating Codes for Solar and Solar-Plus-Storage" on p. 4 explains, "In many cases, jurisdictions do not have much, if any, experience with these systems, [so they] often rely on solar-plus-storage system installers for help understanding the proper Code requirements that apply to a given system."

SPEED INSTALLATION WITH THE RIGHT PRODUCTS

The electrical industry has a chronic shortage of employees, with roughly 11% of all positions unfilled through 2031, according to the U.S. Department of Labor. That makes it difficult for electrical contractors to meet demand for solar installations.

Hence the importance of selecting products designed to streamline installation. AES did exactly that for its new solar farm in Charles City, Virginia. The case study on p. 10 — "Maximum Temperature Range and Streamlined Underground Burial Benefit Skipjack Solar Center" — outlines a host of challenges, including five 35kV circuits requiring 4 to 5 miles of cable to a new substation, much of which had to go underground to meet landowner agreements.

PVC conduit wasn't an option due to pandemic product shortages and limited temperature range. Instead, AES went with medium-wall (MW) and heavy-wall (HW) fiberglass, which were strong enough to be buried directly — thus eliminating the time and expense of pouring concrete. It's one more example of how the industry is working smart to keep up with the demand for solar power.

NAVIGATING CODES FOR SOLAR AND SOLAR-PLUS-STORAGE

What codes and standards should PV and ESS installers be familiar with?

Electricians and solar installers are required to navigate several codes and standards when installing solar photovoltaic (PV) and energy storage systems (ESSs). Solar and energy storage equipment manufacturers introduce new equipment at seemingly lightning speed; therefore it can be difficult to stay on top of all the requirements. This article highlights the key codes and requirements contractors working with solar PV and battery storage systems should be familiar with.

NATIONAL ELECTRICAL CODE

The most common code that system designers, installers, and inspectors refer to for PV and ESS installation is NFPA 70, *National Electrical Code* (NEC). PV systems have requirements that span multiple Articles in the NEC. Technicians need to navigate these requirements to install Code-compliant PV and ESS installations.

Article 690 [Solar Photovoltaic (PV) Systems] is the primary Article to reference when designing and installing PV systems. This Article supplements — and, in some cases, modifies — the general requirements located in Chapters 1 through 4 of the NEC. Article 690 has seen substantial changes over the last several Code cycles. These changes are not surprising given the rapidly advancing nature of the solar-plus-storage industry. Admittedly, the Code is often playing catch-up with advancements in solar technology and system components.

Everything in Art. 690 is important for technicians to understand, but here are a few of the key Sections that should be well understood and often lead to the most confusion.

IDENTIFICATION OF PV SYSTEM COMPONENTS IN COMMON CONFIGURATIONS

There are five different images in Fig. 90.1(b) of the NEC, which was updated in the

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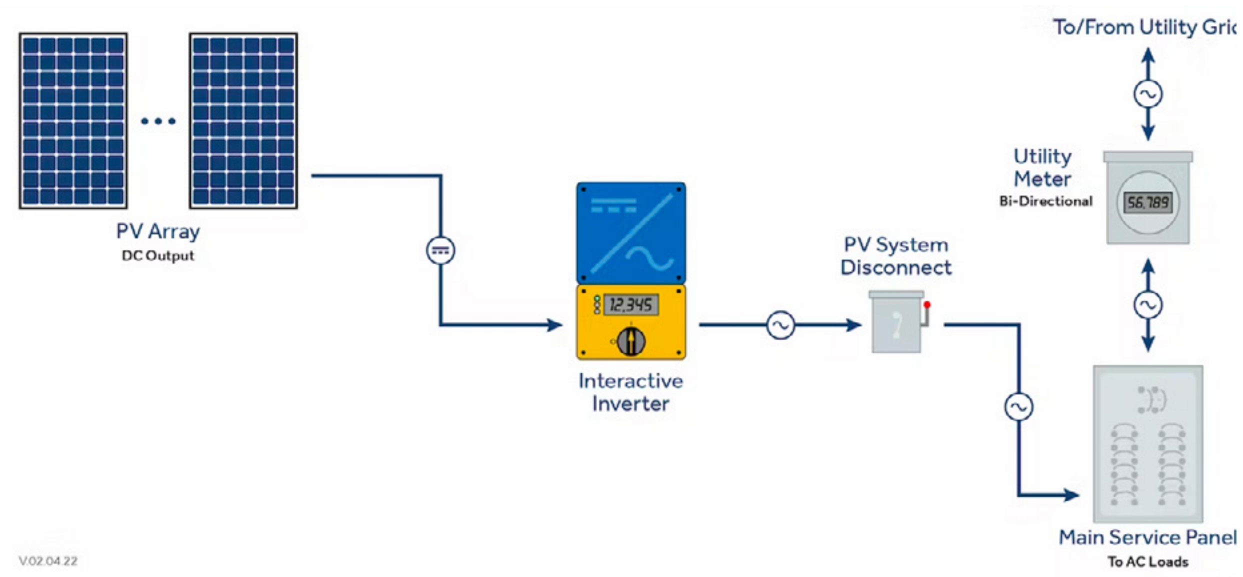
2017 Code cycle. These images are important to examine because they visually help installers understand how to apply Code requirements to different solar PV components and circuits. For example, the **Figure** shown below — based on NEC Fig. 90.1(b) — shows a direct grid-tie system that does not incorporate storage. A direct grid-tie or "batteryless" PV system is the most common system type solar companies install across the country today. The image is helpful because it defines the PV system disconnect, a point of demarcation for the PV system.



The PV system disconnect does not necessarily need to be a knife switch. It can also be a breaker that interconnects the inverter to the electric utility supply. Additionally, it is important to note that this image may not represent all required system components.

The PV system disconnect does not necessarily need to be a knife switch. It can also be a breaker that interconnects the inverter to the electric utility supply. Additionally, it is important to note that this image may not represent all required system components.

SECTION 690.12

Rapid shutdown requirements were added to the NEC during the 2014 Code cycle. The intention of rapid shutdown is to protect firefighters from the shock hazards they may encounter when interacting with a rooftop PV array while doing fire-suppression activities. When installed to Code with good attention to installation details, solar PV systems are inherently as safe as any other electrical system installed per Code. Note that these rapid shutdown systems are not meant to be used during routine system-maintenance activities.

Rooftop solar PV array circuits must be controlled to reduce potential shock hazards to firefighters. To meet this requirement, the rapid shutdown section of the NEC provides multiple ways to meet the requirements based on the location of the circuit in relation to the PV array.

Many PV installers use module-level power electronics (MLPE) to meet these rapid shutdown requirements. MLPE devices are typically mounted directly to the same racking system that supports the PV modules and are wired directly to the modules. These devices may be DC-to-DC converters or DC-to-AC inverters. MLPE can control the voltage on their respective circuits through a rapid shutdown initiation. The most common initiation is the loss of AC power that sends a signal to the MLPE devices to reduce the circuit voltage to an acceptable level per Code requirements. Other initiation devices that are properly labeled and accessible are acceptable as well.

A recently released UL standard, "UL 3741 Photovoltaic Hazard Control," is being employed by some manufacturers. This standard provides testing mechanisms for equipment manufacturers to prove their equipment provides effective and compliant shock protection for firefighters. This new standard and its application on the rooftop lead to new array configurations, inverter location strategies, and reducing (or possibly eliminating) the need for MLPE devices within the array while still meeting Sec. 690.12 requirements.

ARTICLE 705 [INTERCONNECTED ELECTRIC POWER PRODUCTION SOURCES]

This Article covers the requirements for interconnecting all power production sources, so it isn't unique to solar. Most installed PV systems are interconnected with the electric utility grid; therefore, Art. 705 is an integral part of installations.

The most often-cited section of Art. 705 are Sec. 705.11 [Supply-Side Source Connections] and Sec. 705.12 [Load-Side Source Connections]. The reference to "side" is the main service-disconnecting means. Article 705 allows for the connection of power-production sources to either side of the main service-disconnecting means. This is an important consideration, as the associated requirements can be dramatically different depending on where the connection is located in relation to the main service disconnect.

Additional Articles that impact PV installations include: Art. 691 [Large-Scale Photovoltaic (PV) Electric Supply Stations]; Art. 706 [Energy Storage Systems]; Art. 480 [Storage Batteries]; and the entirety of Chapters 1 through 4 — with Art. 250 and Art. 300 being commonly referenced.

The addition of battery storage to existing or new PV systems is growing rapidly across the U.S. In many cases, jurisdictions do not have much, if any, experience with these systems. Authorities Having Jurisdiction (AHJs) often rely on solar-plus-storage system installers for help understanding the proper Code requirements that apply to a given system. This information-sharing partnership is similar to general PV systems 20 years ago, when the learning curve for Code officials was also steep. It is important for installers to recognize the codes and standards that apply to solar and energy storage systems. Be prepared to help educate your local code officials, especially in regions where solar PV is less common or when manufacturers release new equipment and technologies.

FIRE CODES

Outside of the NEC, technicians need to be cognizant of the fire codes their jurisdictions enforce and how PV systems are regulated within those codes. The most common fire codes are NFPA 1, Fire Code and ICC's International Fire Code (IFC). These codes typically impact the physical layout of PV modules on the roof of a building. The intent is to provide safe access around the equipment in the case of a first responder suppressing a structure fire from a building's rooftop.

The rules typically vary based on the type of structure — residential versus commercial, the roof pitch, and the overall area of the array. Pathways around the perimeter of the array are a general requirement per IFC 605.11.3.2.1. Residential requirements start with 3-ft pathways for firefighter access. For larger commercial rooftops, it is common to require pathways across the roof at least every 150 ft.

Fire codes also regulate the use and location of ESSs. Chapter 15 of NFPA 855, Standard for the Installation of Stationary Energy Storage Systems, provides requirements for residential systems. ESS spacing, unit capacity limitations, and maximum allowable quantities (MAQ) depending on location.

STRUCTURAL CODES

PV systems also have structural requirements and codes associated with them. Many jurisdictions use ICC's International Building Code (IBC) and ASCE 7 to guide the structural components of a PV installation. The IBC addresses the installation methods of roof attachments in Sec. 1503, fire classifications for PV systems in relation to the roofing material in Sec. 1509, and structural loading considerations in Sec. 3403. This aspect of PV installations can vary widely between jurisdictions, so it is best to familiarize yourself with the local requirements prior to system design and installation.

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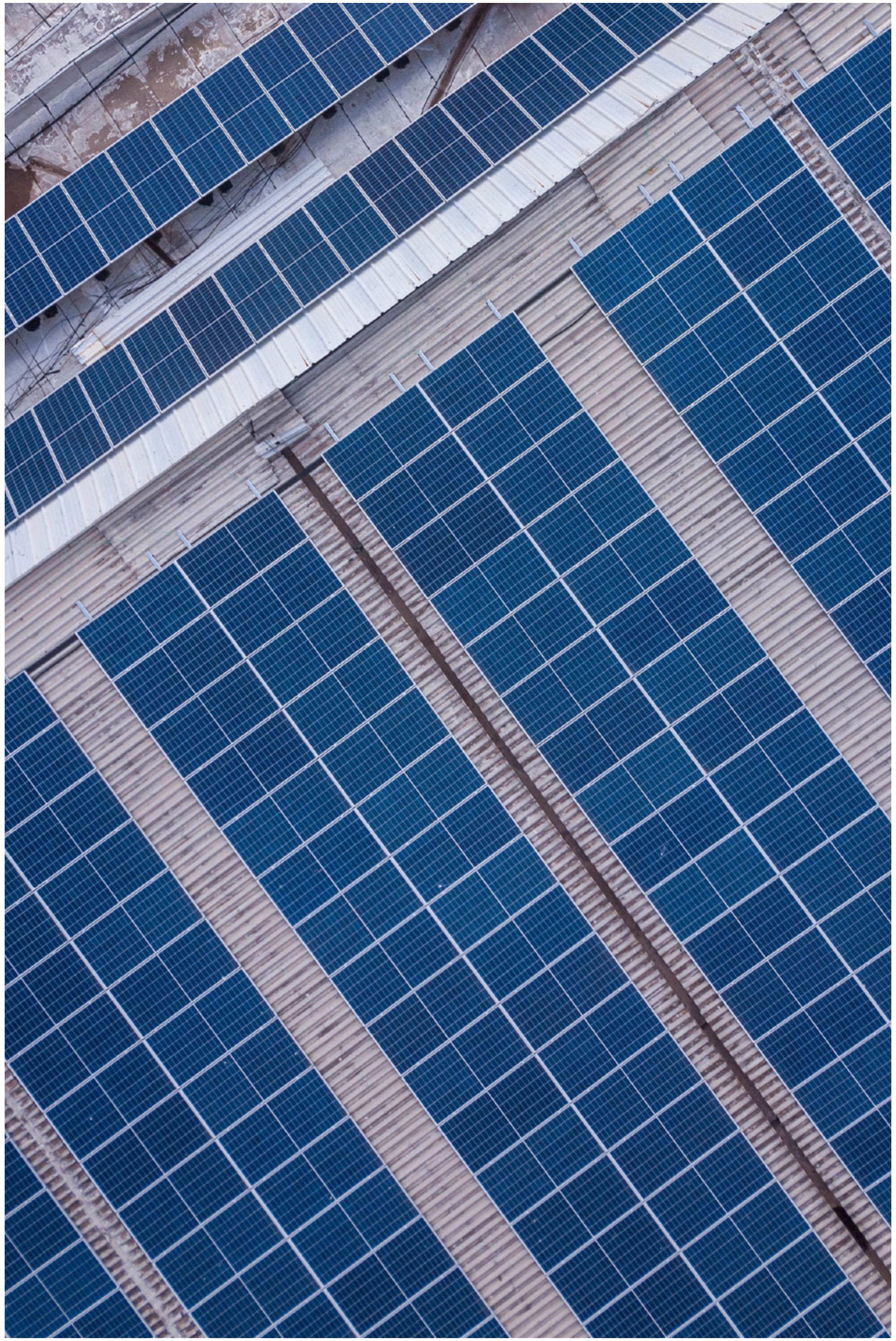

PV INSTALLATION SAFETY STANDARDS BEYOND NEC ART. 690

Complementing Art. 690 with IEC, UL, and IEEE standards can help further mitigate the dark side of solar installs.

As commercial and utility-scale solar projects become more widespread, fires and failures should not. Unfortunately, the number of rooftop solar installation fires in the United States increased 69% between 2016 and 2018, according to U.S. Fire Administration data. Unprotected, improperly connected, or incompatible connectors are some of the most common causes of photovoltaic (PV) panel failure and fires.

Meanwhile, with utility-scale installations now typically reaching 1,000V or 1,500V, protecting workers against ground faults and arc flash incidents is critical. Although no solar-specific data is available, OSHA statistics show the utility and construction industries experience the highest rates of both fatal and nonfatal electrical injuries.

One fact is certain: Fires, faults, and electrocutions are a real risk with PV installation. The good news is that safety hazards can be mitigated with the right knowledge and practices, and by expanding their familiarity beyond what's covered by the requirements of NEC Art. 690.

Article 690 [Solar Photovoltaic Systems] outlines many safety and performance requirements but isn't comprehensive enough on its own to prevent all possible injuries (nor should it be). Often, Art. 690 and UL standards work together, such as with arc-fault circuit interrupters (AFCIs). Nevertheless, there are gaps, such as ensuring cables remain secured in place during a short circuit event.

This is where international standards such as IEC and IEEE can provide guidance because in areas such as grounding and bonding, internationally recognized standards are often stricter than U.S. standards. That's not to say NEC and UL standards are at odds with international standards. In fact, UL and IEC have worked together to align codes on things like general cable management as well as more specific PV safety requirements. This growing move toward standards harmonization will help the industry by streamlining requirements and improving safety across the board.

This article provides an overview of a few UL, IEC, and IEEE standards that can work with NEC guidelines to improve the safety of commercial and utility-scale solar installations.

ART. 690 UPDATE: CONNECTORS AND INTERMATING

Manufacturers have been warning against intermating connectors for years. Despite these cautions, the practice of combining different kinds of connectors has become commonplace due to the increased availability of cheaper, generic connectors, MLPE devices, and prewired components. Although different brands of connectors may appear to be compatible and are UL-certified, no single standard exists for connector size, tolerances, or materials. The contacts inside might be copper or they could be steel, bronze, or aluminum alloy. They may connect without any noticeable issues upon installation but, over months or years, small design differences will lead to wear, contact resistance, and — at worst — catastrophic failure.

Article 690 was revised in 2020 to prohibit intermating, with Sec. 690.33 of Part 4 now stating, "Where mating connectors are not of the identical type and brand, they shall be listed and identified for intermatability, as described in the manufacturer's instructions." Oftentimes, however, major manufacturers' warranties prohibit mating of their connectors with products from other suppliers rather than allow it, as is suggested in the updated NEC language.

GROUND-FAULT AND ARC-FAULT CIRCUIT PROTECTION

Article 690 requires arc and ground-fault detection and interruption as well as rapid shutdown capabilities on rooftop PV installations in case of fire (Secs. 690.5, 690.11, and 690.12, respectively). Although Art. 690 requires the installation of devices such as arc-fault circuit interrupters (AFCIs) and shutoff switches, it does not outline performance requirements for these devices. Instead, it requires them to be tested and listed to UL1699B, *Standard for Photovoltaic (PV) DC Arc-Fault Circuit Protection*, which was developed specifically for Art. 690. The difficulty of measuring arc faults initially led to some issues with 1699B testing.

After its introduction, several AFCIs listed under it were found to be sensitive to unwanted tripping or unable to detect arc-fault events. This is because the standard tested devices for performance under an instantaneous arc fault instead of the gradual buildup of deteriorating conditions that often lead to faults in the real world. Updates in 2016 and 2018 addressed this issue. The updates also included better-defined testing parameters and testing to ensure performance when the PV array is a further distance from the inverter or arc detection circuit.

The general standard governing AFCIs, UL 1699B, was used as the basis for IEC's international standard (62606:2013), but the two are not identical. Although not yet approved, IEC 63027 will fill a similar role as UL 1699B, covering AFCIs for PV systems.

WIRING METHODS AND MATERIALS

Wiring methods and materials are covered in Part 4 of NEC Art. 690. It allows for cable trays in outdoor PV installations but classifies cable trays as support systems, not raceways. Compared to a raceway, exposed cables in a cable tray are at greater risk of damage and present greater risk in a fire situation. This makes properly securing cables especially important. Article 690 states that cables in a cable tray must be supported at intervals of 300 mm (12 in.) and secured at least every 1.4 m (4.5 ft) but does not specify how they are to be secured.

A short circuit event can release a considerable amount of force before fault protection devices have time to react, and with electromagnetic force ranging upwards of 10,000 pounds, the damage can be significant. IEC 61914:2015 sets standards for resistance to electromechanical forces and outlines testing requirements for temperature rating, corrosion, UV resistance, and more to ensure that cable cleats can withstand harsh construction site conditions. Cable cleats that meet IEC 61914:2015 exceed the NEC's safety requirements and should be used whenever possible.

GROUNDING AND BONDING

UL 467, the general safety standard for grounding and bonding equipment required by the NEC, includes requirements for tensile force strength, short time current, and corrosion-resistance testing, as well as direct burial rating and markings. To mitigate hazards, UL 467 should be considered a baseline rather than the finish line.

A more stringent standard is IEEE 837-2014, *Standard for Qualifying Permanent Connections Used in Substation Grounding*, which addresses the connections used in the grid system to join ground leads to the grid system, equipment, and structures. Like UL 467, IEEE 837 is a general grounding and bonding standard not specific to PV systems. In fact, compliance with the IEEE standard requires an acceptable pull-out test rating under UL 467. Unlike the UL standard, compliance is self-proclaimed by the manufacturer, but manufacturers should be able to provide test data to back up their claim.

The IEEE 837 short time current test requirements are stricter than UL 467 and designed to mimic a utility-scale fault. It also requires additional sequence testing designed to emulate harsh and heavy environmental conditions.

STANDARDS HARMONIZATION

Joint certifications, such as those between UL and IEC, are becoming more common. For manufacturers, having to comply with multiple standards can be costly — especially where conflicting standards require the design of different product models. Harmonization eliminates that redundancy and reduces the amount of testing required. For engineers, installers, and EPCs, it helps simplify product selection.

The joint IEC/UL 62275 standard for cable management systems, which has been in place since 2016, specifies requirements for cable ties and associated fixing devices used in electrical installations. IEC/UL 62109 was also published in 2016, which aligned UL 1741 (Inverters, Converters, Controllers, and Interconnection System Equipment for Use with Distributed Energy Resources) with IEC 61209, resulting in a unified standard that defines the minimum requirements for the design and manufacture of power conversion equipment and inverters for protection against electric shock, energy, fire, mechanical, and other hazards.

Most recent is the development of IEC/UL 61730 (*Standard for Photovoltaic Module Safety Qualification*), which harmonizes UL 1703 (Flat-Plate Photovoltaic Modules and Panels) with IEC 61730. In effect since December 2019, this unified standard encompasses construction and the testing requirements relating to solar panel electrical, mechanical, thermal, and fire safety.

Even if standards aren't harmonized, building installations to stricter international standards is beneficial because it helps future-proof projects against future standards harmonization. While harmonization is moving in the right direction, it's important to note that there are also standards gaps, such as with connectors. And even though Art. 690 now prohibits intermating, the development of an industry standard for PV connectors would resolve the problem entirely.

WRAPPING IT UP

Ultimately, there's no magic wand that can be waved or single standard that can be applied to remove all risk from the PV installation process. However, the inclusion of standards to complement Art. 690 is one way to keep engineers and installerssafe is both viable and practical.

Amit Mehta is a senior product manager with Panduit.

MAXIMUM TEMPERATURE RANGE AND STREAMLINED UNDERGROUND BURIAL BENEFIT SKIPJACK SOLAR CENTER

AES Corporation, a clean energy company, was planning a new solar farm in Charles City, Virginia. Called the Skipjack Solar Center, the facility is built on former working timber land.

This project consisted of the installation of five 35 kV circuits in a single 3.2 mile corridor. Each circuit has the capacity of transmitting 44 MW of solar generation (a total of 220 MW) to the grid. Construction included underground burial of conduit encased wire (0.75 mile in one continuous pull), as well as pole risers. The project involved significant trenching and the navigation of material shortages due to COVID-19.

Phase two of the project included a 230kV underground transmission gentie (generator tie line), capable of transmitting 320 MW of solar generation to the grid. Installation involved a 4,500 foot duct bank with a continuous run (long pull) of 230 kV underground transmission cables through cultivated fields between two new H-frame riser structures. Contractor Booth & Associates and their subsidiaries provided full engineering, equipment procurement, management and construction.

CHALLENGE

This solar project presented a number of challenges. First, there were multiple circuits coming through the project. An interconnection facility was designed and installed bringing the solar facility to the grid. This involved five 35 kV circuits along 4 to 5 miles of cable to a new substation where voltage stepped up to 230 kV to connect underground to the grid.

Additionally, there were special requirements for long segment installation due to landowner agreements forcing overhead lines underground. Buried installation posed a challenge as concrete encased duct banks can be a bit more complex than other types of installation. The engineers and project managers desired to eliminate as much cable, conduit and equipment as possible.

The last challenge was procurement due to COVID-19 product delays. Lead times and costs of some products such as PVC conduit were long.

SOLUTION

The engineers and project managers developed a scenario running cable underground in a straight line pull. Fiberglass conduit was ideal for the job due to its broader temperature range, up to 250°F (121°C), so it tolerates more heat. PVC conduit was not seriously considered due to its limited temperature range. Fiberglass conduit allowed for the maximum cable rating of105°C for this project. The more capacity a conduit can hold, the more heat is generated, so temperature range was a key factor in conduit selection.

Use of fiberglass conduit allowed project managers to consider a more straight forward burial type. Durable, corrosion-resistant medium wall (MW) and heavy wall (HW) conduit provided mechanical protection so the conduit and cable could be buried directly without the need to pour concrete.

Champion Fiberglass® conduit (55,000 feet) was procured within a faster time frame, 6 to 8 weeks, half the time of other conduit types that were experiencing supply chain issues.

Installation was easy. Trenches, 60 to 80 feet, were buried, conduit was laid and connected with a slip fit connection that was hammered into place. There was no need for epoxy, so fewer materials were needed and installation took less time.

RESULTS

- Optimized design included durable, corrosion-resistant fiberglass conduit capable of handling a significant cable load due to its wide temperature range.
- Product secured in half the time of competing conduit. Low material costs were easy on project budgets.
- A complex project with significant underground burial in tight corridors was streamlined with an installation that shaved weeks off the timeline, enabling the contractor to meet important deadlines.
- Excellent customer service helped the project reach a successful conclusion.

QUICK FACTS

PROJECT NAME
Skipjack Solar Center

APPLICATION
Solar/Utilities

CHAMPION FIBERGLASS PRODUCT(S)
Champion Duct®

> Solar farm project included buried conduit installation and pole risers.

> Broad conduit temperature range was able to handle heat generated by the cables.

> Streamlined installation beat deadlines.

> Conduit procured with short lead times.

FIND A REP

CONSIDERATIONS FOR DIRECT BURIAL CONDUIT

Installation type plays a key role in the type of conduit selected for electrical systems in industrial construction projects.

Installation type plays a key role in the type of conduit selected for electrical systems in industrial construction projects. Above ground, below ground, direct buried, encased buried and whether installation is simple or complex — all depend on the project type and environment.

WHAT IS THE DIFFERENCE BETWEEN ABOVE GROUND AND BELOW GROUND CONDUIT?

The main difference is fire resistance. Above ground conduit has fire resistance per UL2515 and CSA C22.2 No. 2515 standards, meaning that the conduit will self-extinguish within 15 seconds after each of five successive flame applications per the UL 2515 flame test standard.

Below ground conduit meets UL94 HB (horizontal burn) requirements, which aren't as stringent as vertical burn requirements. This also means that conduit manufactured and labeled for "above ground" applications can be used for "below ground" applications.

DIGGING DEEPER INTO DIRECT BURIAL CONDUIT

Direct buried conduit is a type of conduit used in below ground installations of electrical systems in commercial and industrial construction projects. Typically, direct burial conduit is used in applications where there will be minimal digging after installation, as digging has the potential to disrupt and damage conduit (and the cable) buried beneath.

Direct burial serves to protect electrical systems from environmental factors such as trees, branches, wind, and fire plus it can also be an aesthetic solution that hides overhead power lines. Additionally, direct burial conduit is often a solution when electrical systems must cross roadways because it offers less disruption to traffic patterns. Specifically, direct burial is often used in applications such as data centers, waste water treatment facilities and utilities.

Direct buried (DB) conduit must have mechanical strength to withstand the load of the soil that is packed over it. DB quality applications should utilize UL Listed conduit. We typically recommend using our Standard Wall for 3/4"– 4" diameter, and Medium Wall for 5" and 6" (UL designates Champion Fiberglass MW for 5" and 6" as SW). For very deep trenches, special soil conditions or where high rate of compacting can be expected, an even heavier wall should be selected.

KEY CONSIDERATIONS FOR DIRECT BURIAL CABLE AND CONDUIT IN INDUSTRIAL CONSTRUCTION PROJECTS

Electrical conduit provides additional protection for cables in industrial construction projects.

When determining whether your below ground conduit installation requires direct burial quality, there are several factors to consider:

1. **Volatility of the environment.** Soil types and load as well as the mechanical strength of the conduit must be considered here. Frost and settlement can impact the stability of direct burial conduit. Corrosion from soil can compromise the conduit as well.
2. **Compacting of soil.** This is an important factor in direct burial conduit. For very deep trenches, special soil conditions or where a high rate of compacting can be expected, a heavier wall conduit should be selected. **Contact Champion Fiberglass to answer any questions about the level of compacting in a project.**
3. **Ease of access for later service.**
   Using conduit will allow you to more easily locate and repair cables down the road with less risk of damage to the conduit. Consider a conduit's coefficient of friction to evaluate for ease of pulling as well as cable fault resistance, which allows a cable to be easily pulled through for repair and replacement.
4. **Project complexity.** Challenging installations can benefit from the efficiency that carefully planned conduit use can provide for cable runs.
5. **Local regulations.** While the NEC (National Electrical Code) may approve a conduit (also referred to as "duct" or "pipe") use for direct burial, local regulations may call for more stringent installation techniques such as dictating how deep the conduit must be buried.
6. **Future landscaping.** It is important to consider whether future landscaping projects may disrupt direct buried conduit and put the conduit at risk for damage.

SELECTING A CONDUIT TYPE

For projects requiring direct burial conduit, selecting the best underground conduit for the job is important. You'll want to also consider the costs associated with each type of conduit's raw materials as well as installation, the long-term financial impacts of a conduit's durability, as well as availability for your substrate of choice. Commonly used conduits for underground applications include traditional metal conduits such as RMC (rigid metal conduit) or EMT (electrical metallic tubing), fiberglass (RTRC) conduit and PVC conduit.

For help selecting electrical conduit, reach out to an Electrical Sales Rep to learn more.

RESOURCES

- Champion Duct® — Lightweight fiberglass conduit with unmatched versatility and strength.
  championfiberglass.com/products/champion-duct/
- Champion Fiberglass Elbows — Delivering labor-saving, no-burn-through fiberglass elbows, fast.
  championfiberglass.com/products/champion-fiberglass-elbows/
- Visit the website for a full list of resources.
  championfiberglass.com/resources/

ABOUT CHAMPION FIBERGLASS

Headquartered in Spring, Texas, Champion Fiberglass Inc. is the leading supplier of fiberglass conduit and strut to the industrial, electrical, and mechanical markets. Ours is the most advanced production facility for manufacturing rigid fiberglass conduit in North America, where the company's proprietary high-speed winding process and high-temperature curing ovens are key to the consistency and quality of these versatile products.