

module frame(s) or support structure. A grounding electrode conductor shall be sized according to 250.66. A support structure for a ground-mounted PV array shall be permitted to be considered a grounding electrode if it meets the requirements of 250.52. PV arrays mounted to buildings shall be permitted to use the metal structural frame of the building if the requirements of 250.68(C)(2) are met.

Part VI. Source Connections

690.56 Identification of Power Sources. Plaques or directories shall be installed in accordance with 705.10.

690.59 Connection to Other Sources. PV systems connected to other sources shall be installed in accordance with Parts I and II of Article 705.

The requirements for inverters in 705.40 prevent energizing of otherwise de-energized system conductors or output conductors of other off-site sources (such as an electrical utility) and are intended to prevent electric shock. The ability to automatically de-energize output upon loss of voltage is normally a feature of the interactive inverter.

690.72 Self-Regulated PV Charge Control. The PV source circuit shall be considered to comply with the requirements for charge control of a battery without the use of separate charge control equipment if the circuit meets both of the following:

- (1) The PV source circuit is matched to the voltage rating and charge current requirements of the interconnected battery cells.
- (2) The maximum charging current multiplied by 1 hour is less than 3 percent of the rated battery capacity expressed in ampere-hours or as recommended by the battery manufacturer.

ARTICLE 691

Large-Scale Photovoltaic (PV) Electric Supply Stations

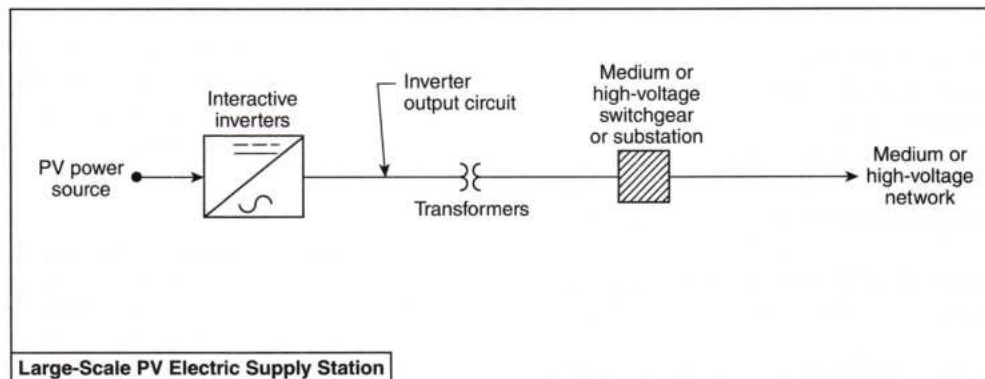
Δ 691.1 Scope. This article covers the installation of large-scale PV electric supply stations not under exclusive utility control.

Informational Note No. 1: Facilities covered by this article have specific design and safety features unique to large-scale PV facilities outlined in 691.4 and are operated for the sole purpose of providing electric supply to a system operated by a regulated utility for the transfer of electric energy.

Informational Note No. 2: See 90.2(B)(5) for additional information about utility-owned properties not covered under this Code. See ANSI/IEEE C2-2017, *National Electrical Safety Code*, for additional information on electric supply stations.

Informational Note No. 3: See Informational Note Figure 691.1.

The systems covered by this article are a minimum size of 5000 kilowatts (kW), or 5 megawatts (MW). Based on their immense size, these large-scale photovoltaic (PV) installations are often referenced as "solar farms." As of 2021, the largest solar farm in the United States, and 13th largest in the world, was the Copper Mountain Solar Facility in Boulder City, Nevada, sized at 802 megawatts. In the same year, the largest solar farm in the world, Bhadla Solar Park in India, nearly tripled the size of Copper Mountain, having a capacity of roughly 2245 megawatts. Exhibit 691.1 shows the Nyngan Solar Farm in Australia, a large-scale PV installation generating 102 megawatts of power through roughly 1.35 million solar PV modules. Because installations of this magnitude are much too large to be installed on buildings, the installation requirements for Article 691 differ from those of Article 690, which is primarily aimed at installation on buildings.



Notes:

- (1) The diagram is for informational purposes only and is not representative of all potential configurations.
- (2) Custom designs occur in each configuration, and some components are optional.

Δ INFORMATIONAL NOTE FIGURE 691.1 Identification of Large-Scale PV Electric Supply Station Components.



EXHIBIT 691.1 The Nyngan Solar Farm, Australia. (Getty Images)

Δ 691.4 Special Requirements for Large-Scale PV Electric Supply Stations. Large-scale PV electric supply stations shall be accessible only to authorized personnel and comply with the following:

- (1) Electrical circuits and equipment shall be maintained and operated only by qualified persons.

Informational Note No. 1: See NFPA 70E-2021, *Standard for Electrical Safety in the Workplace*, for electrical safety requirements.

- (2) Access to PV electric supply stations shall be restricted in accordance with 110.31. Field-applied hazard markings shall be applied in accordance with 110.21(B).
- (3) The connection between the PV electric supply station and the system operated by a utility for the transfer of electrical energy shall be through medium- or high-voltage switch gear, substation, switch yard, or similar methods whose sole purpose shall be to interconnect the two systems.
- (4) The electrical loads within the PV electric supply station shall only be used to power auxiliary equipment for the generation of the PV power.
- (5) Large-scale PV electric supply stations shall not be installed on buildings.
- (6) The station shall be monitored from a central command center.
- (7) The station shall have an inverter generating capacity of at least 5000 kW.

Informational Note No. 2: Some individual sites with capacities less than 5000 kW are operated as part of a group of facilities with a total generating capacity exceeding 5000 kW.

Large-scale PV systems are required to be accessible to qualified personnel only. Section 691.9 requires an engineered design installation to have documented procedures and means of isolation of equipment.

691.5 Equipment. All electrical equipment shall be approved for installation by one of the following:

- (1) Listing and labeling
- (2) Be evaluated for the application and have a field label applied
- (3) Where products complying with 691.5(1) or (2) are not available, by engineering review validating that the electrical equipment is evaluated and tested to relevant standards or industry practice

691.6 Engineered Design. Documentation of the electrical portion of the engineered design of the electric supply station shall be stamped and provided upon request of the AHJ. Additional stamped independent engineering reports detailing compliance of the design with applicable electrical standards and industry practice shall be provided upon request of the AHJ. The independent engineer shall be a licensed professional electrical engineer retained by the system owner or installer. This documentation shall include details of conformance of the design with Article 690, and any alternative methods to Article 690, or other articles of this *Code*.

691.7 Conformance of Construction to Engineered Design. Documentation that the construction of the electric supply station conforms to the electrical engineered design shall be provided upon request of the AHJ. Additional stamped independent engineering reports detailing the construction conforms with this *Code*, applicable standards and industry practice shall be provided upon request of the AHJ. The independent engineer shall be a licensed professional electrical engineer retained by the system owner or installer. This documentation, where requested, shall be available prior to commercial operation of the station.

691.8 Direct Current Operating Voltage. For large-scale PV electric supply stations, calculations shall be included in the documentation required in 691.6.

Δ 691.9 Disconnecting Means for Isolating Photovoltaic Equipment. Disconnecting means for equipment shall not be required within sight of equipment and shall be permitted to be located remotely from equipment. The engineered design required by 691.6 shall document disconnection procedures and means of isolating equipment.

Informational Note: See NFPA 70B-2019, *Recommended Practice for Electrical Equipment Maintenance*, for information on electrical system maintenance. See NFPA 70E-2021, *Standard for Electrical Safety in the Workplace*, for information on written procedures and conditions of maintenance, including lockout/tagout procedures.

Buildings whose sole purpose is to house and protect supply station equipment shall not be required to comply with 690.12. Written standard operating procedures shall be available at the site detailing necessary shutdown procedures in the event of an emergency.