SOLAR AND ENERGY STORAGE SYSTEM

PERMITTING & INSPECTION GUIDELINES

FOR PERMITTING AND INSPECTING ENERGY STORAGE OR COMBINED SOLAR AND ENERGY STORAGE SYSTEMS (ESS) IN MULTIFAMILY & OFFICE BUILDINGS

2017 NATIONAL ELECTRICAL CODE (NEC), THE 2018 INTERNATIONAL BUILDING CODE (IBC) AND THE 2018 INTERNATIONAL FIRE CODE (IFC)

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ACKNOWLEDGEMENTS

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ACKNOWLEDGMENT AND DISCLAIMER

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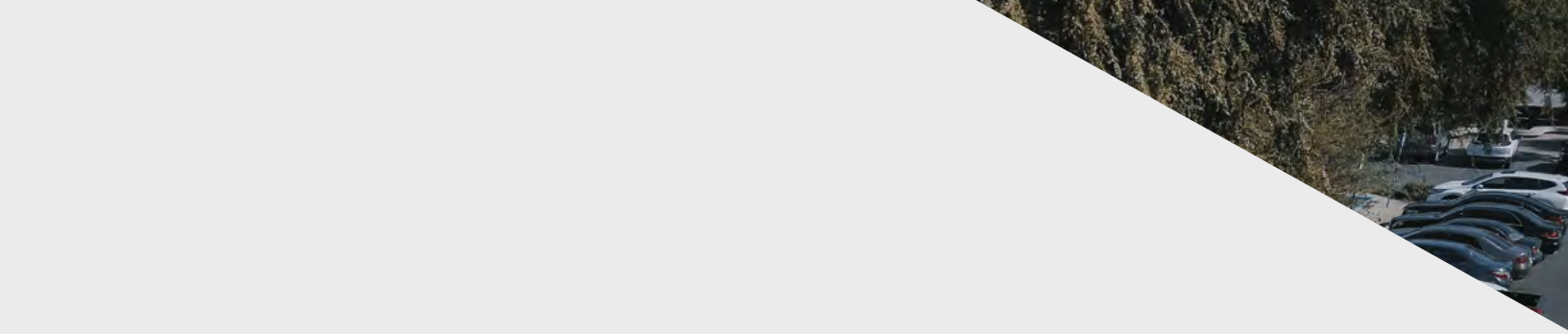
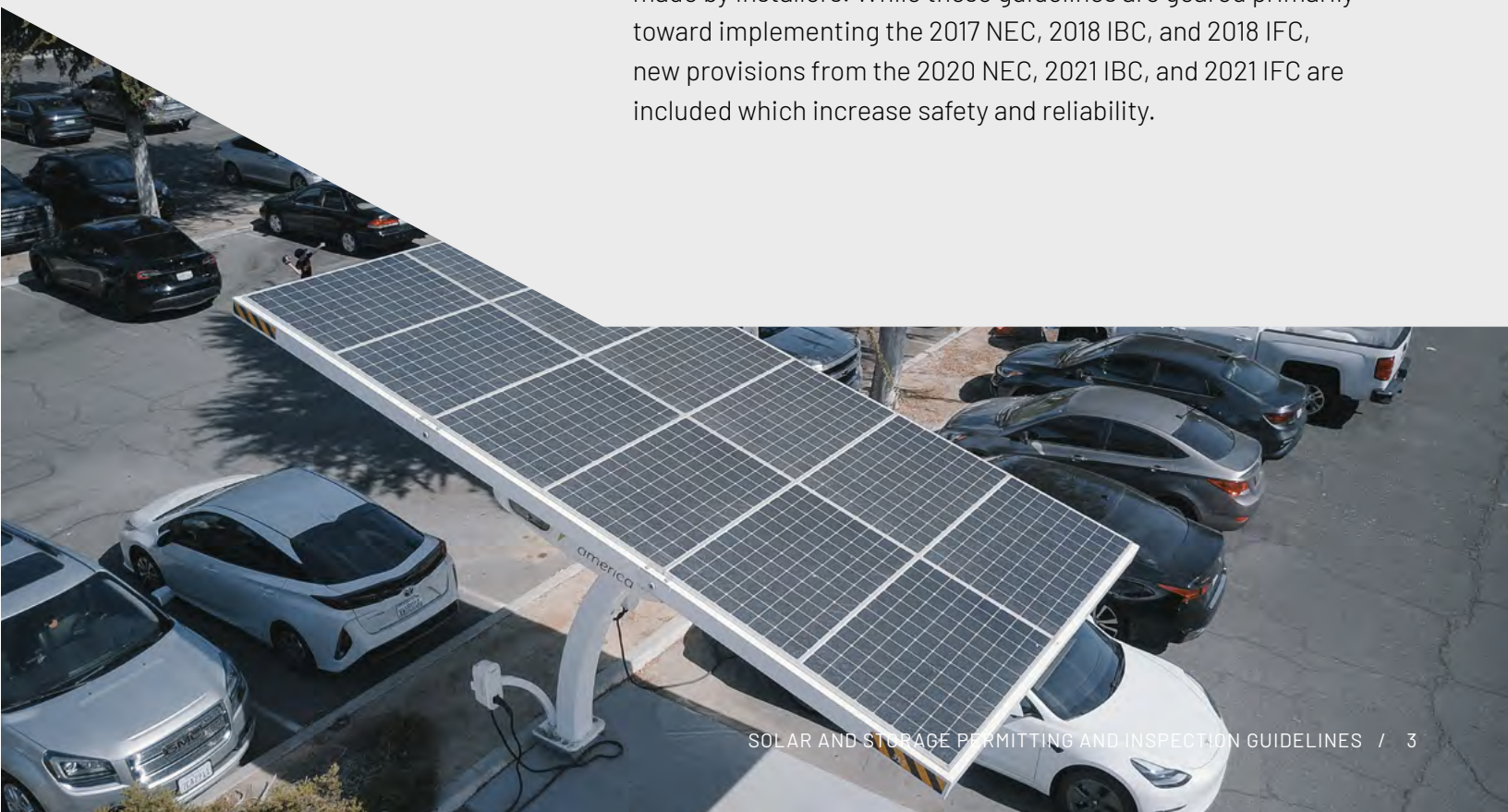
A portion of the solar criteria in this guideline is based off of SolSmart's National Simplified Residential PV and Energy Storage Permit and Inspection Guidelines. For more information about SolSmart, a program intended to provide no cost technical assistance to jurisdictions who want to make it faster, easier and more affordable for their communities to go solar visit: www.solsmart.org. The SolSmart guide is supported by the Department of Energy and Office of Energy Efficiency and Renewable Energy (EERE), under Award Number DEEE0007155.



INTRODUCTION

More and more, buildings are incorporating energy storage systems with photovoltaic systems to both provide a backup power source to a building and reduce utility bills. This is a new aspect of building operations that a growing number of jurisdictions will need to address. This guide provides an overview of code requirements for the installation of energy storage systems (ESS), and combined solar and energy storage system installations. By providing specific and replicable list of permitting and inspection requirements, local jurisdictions can reduce informational barriers and help ensure the design and installation of solar and energy storage are consistent and code compliant. This guide references the most applicable requirements for 2017 National Electrical Code (NEC), the 2018 International Building Code (IBC) and 2018 International Fire Code (IFC). Not all requirements are covered by these checklists but they do include the most important life and safety aspects of the installation and can be used to highlight "common mistakes" made by installers. While these guidelines are geared primarily toward implementing the 2017 NEC, 2018 IBC, and 2018 IFC, new provisions from the 2020 NEC, 2021 IBC, and 2021 IFC are included which increase safety and reliability.

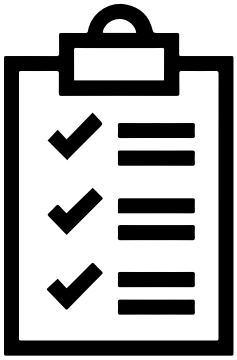


PERMIT APPROVAL REQUIREMENTS

- [x] This permitting and inspection guide is only applicable to the installation of the following applications:
    - Lithium-ion energy storage systems
    - Energy storage systems with total maximum energy capacity on site of 600kWh
    - Energy storage systems installed with simple solar systems meeting SolSmart criteria that are less than 15kW consisting of no more than 2 series strings per inverter and no more than 4 source circuits in total per inverter.
- [x] Standard electrical diagrams are provided in Appendix B and can be used to accurately represent the ESS or combined ESS and PV installations. If the electrical system is more complex than the standard electrical diagram can effectively communicate, the project does not meet the requirements for a simplified permit application and additional information may be necessary for the jurisdiction to process the permit application.
- [x] This permitting and inspection guide does not include any service upgrades or other electrical work. If the load calculations demonstrate a service upgrade is needed, this permitting and inspection guide cannot be used to determine compliance with code requirements for a service upgrade.

"National Simplified Residential PV and Energy Storage Permit Guidelines." SolSmart, https://solsmart.org/resources/national-simplified-residential-pv-and-energy-storage-permit-guidelines/

PERMIT SUBMISSION REQUIREMENTS



TO APPLY FOR A PERMIT
SUBMIT THE FOLLOWING:

1] Permit application [1] (See Appendix A) which include basic information about the project, location and installer.

2] Site plan (see Appendix B) drawn to scale showing:

i) Location of PV array and ESS components on the property,
ii) Primary use of the space or area where the ESS will be installed,
iii) ESS spacing,
iv) PV and ESS setback and access pathways,
v) Fire detection, and fire suppression systems if applicable.

3] A standard electrical line diagram (see Appendix B) that accurately indicates:

i. PV array configuration (if applicable),
ii. Mounting details,
iii. ESS components,
iv. Conductors, cables, and conduit types, sizes, and markings,
v. Type and size rating of overcurrent protection and disconnects
vi. Inverters,
vii. Required signs,
viii. Connection to the premises wiring system, and
ix. Location of additional meters, main electrical service panel, distribution panels or subpanels.

4] Specification sheets and installation manuals for all major system components including: ESS and PV components, inverters, and mounting systems. PV modules, DC-to-DC converters.

5] Structural Load Calculation

6] Electrical Load Calculation

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[1] Jurisdiction can fill this text box with link to their own permit application. A sample permit application is shown as an Appendix A to this guide.

GENERAL INSTALLATION GUIDE

FIGURE 1:
TWO STORAGE UNITS COMPLYING WITH 3 FOOT SEPARATION

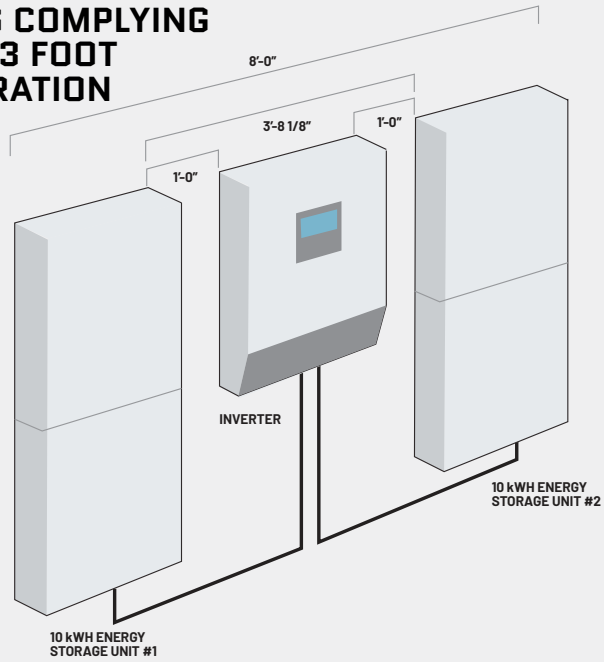
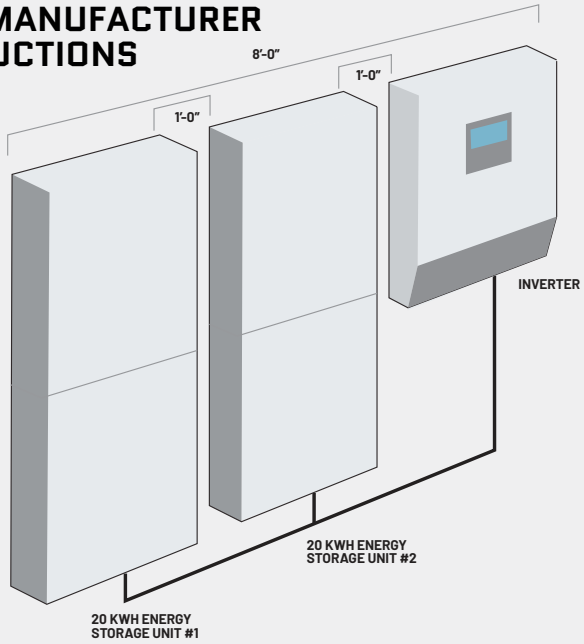


FIGURE 2: TWO UL9540A STORAGE UNITS COMPLYING WITH MANUFACTURER INSTRUCTIONS



ENERGY STORAGE SYSTEM REQUIREMENTS

1. ESS is listed to UL9540 or UL9540a by a Nationally Recognized Testing Laboratory (NRTL). (IFC 1206.2.10.1)
2. ESS is listed to UL1973. (NEC 706.5)
3. Inverters are certified to UL1741. (NEC 690.4(B))

ENERGY STORAGE SYSTEM INSTALLATION REQUIREMENTS

4. ESS is installed according to manufacturer installation instructions. (NEC 110.3(B))
5. All work is done in a neat and workmanlike manner. (NEC 110.12)
6. Access and working space for ESS equipment such as ESS units, battery units, inverters, disconnecting means, and panelboards is adequate. Working space is at least 30 inches in width, 6.5 feet in height and 4 feet in depth or the width, height and depth of the equipment, whichever is greater. (NEC 110.26)
7. Grounding/bonding of ESS units, battery units, inverters, conduit and other electrical equipment according to the NEC and manufacturer's instructions. (NEC 110.14. 250.148(A), NEC 110.3(B))

UL9540

8. In rooms, areas or walk-in units with ESS, explosion control is installed which provides either explosion venting, explosion prevention systems or barricades which comply with NFPA 69 or NFPA 495. (IFC 1206.2.3.2)
9. ESS units either are separated by 3 feet and in groups no larger than 50kWh (IFC 1207.5.1)

UL9540A

10. Energy Storage Systems are grouped and separated according to manufacturer instructions. (IFC 1207.5.1, NEC 110.3(B))

FIGURE 3: LARGE SCALE FIRE TESTED LABEL

ENERGY STORAGE SYSTEM SIZE LOCATION REQUIREMENTS

11 ESS is located: (IFC 1206.2.8.1, 2021 IFC 1207.7.3)
- a. In a space that is not a dwelling unit or sleeping unit,
- b. 75 feet or below the lowest level of fire department vehicle access, and
- c. At or above the lowest level of exit discharge.

12 ESS installed on exterior walls meets the following:
- a. ESS is separated from doors, windows, operable openings into buildings or HVAC inlets by at least 5 feet. (2021 IFC 1207.8.4)
- b. Within 10 feet of outdoor ESS, area is cleared of combustible vegetation. (2021 IFC 1207.5.7)
- c. Located 10 feet away (or 3 feet away if ESS is enclosed in a weatherproof encloser of noncombustible materials) from: (2021 IFC 1207.5.8, 2021 IFC 1207.8.3
  - a. Any means of egress under fire conditions
  - b. Other buildings
  - c. Lot lines,
  - d. Public ways,
  - e. Stored combustible or hazardous materials, and
  - f. Parking spaces.

13 For ESS installed indoors: (2021 IFC 1207)
- a. ESS is separated from other areas of the building with a 2-hour fire barrier and 2-hour horizontal assembly. (2021 IFC 1207.7.4, IBC 707, IBC 710)
- b. A smoke detection or radiant energy-sensing fire detection system is installed. (IFC 1206.2.11.2, IFC 907.2)
- c. The room or area with an ESS is protected by one of the following fire suppression systems: (IFC 1206.2.11.1, 2021 IFC 1207.5.5, IFC 903.3.1.1, IFC 904)
  - a. An automatic sprinkler system that meets the requirements of Section 2021 IFC 1207.5.5 and IFC Section 903.3.1.1
  - b. One of the following alternative automatic fire protection system: carbon dioxide extinguishing system, water spray fixed systems, water mist fire protection systems, clean agent fire-extinguishing systems, or fixed aerosol fire-extinguishing systems that meets the requirements of Section 2021 IFC 1207.5.5 and IFC Section 904.

14 ESS installed in a garage must meet the following requirements: (2021 IFC 1207.9.6)
- a. If in an open parking garage, ESS is located 10 feet away or 3 feet away if ESS is enclosed in a weatherproof enclosure of noncombustible materials from:
  - a. Other buildings
  - b. Lot lines
  - c. Public ways
  - d. Stored combustible or hazardous materials, and
  - e. Parking spaces. (2021 IFC 1207.9.3)
- b. ESS is installed within a locked gate, fence or other barrier that prevents the public from standing within 5 feet of the ESS.
- c. ESS is located 50 feet or more from air inlets of building HVAC systems unless a fire alarm system can shut off ventilation system upon detection of fire.
- d. ESS is located 25 feet away from exits from the attached building if on a covered level of the parking structure.
- e. ESS is protected by an approved radiant energy-sensing fire detection system. (2021 IFC 1207.5.4)
- f. ESS is protected from vehicular impact by one of the following: (2021 IFC 1207.4.5, IFC 312)
  - a. Installed in a location not subject to vehicular impact such as 4' or more above floor level,
  - b. Protected by guard posts constructed of steel not less than 4" in diameter and concrete filled, spaced not more than 4 feet apart, set not less than 3 feet deep in concrete footing, with top posts not less than 3 feet above the ground, and located 3 feet or more away from the ESS,
  - c. Protected by wheel barriers anchored in place located 4.5 feet or more away from the ESS, or
  - d. Protected by other barriers where approved.

15 ESS installed on the rooftop is: (2021 IFC 1207.9.5)
- a. Located at least 5 feet away from the edge of the roof if the height of the system is 5 feet or less.
- b. Located at least the height of the system away from the edge of the roof if the height of the system is greater than 5 feet.
- c. Located within 10 feet of the fire service access point.
- d. Accessible via a stairway through a bulkhead from the building interior or exterior stairway.

16 Rooftops with an ESS must have: (2021 IFC 1207.9.5)
- a. Service walkways at least 5 feet in width from the access point to the ESS.
- b. Roofing materials under and within 5 feet of the ESS that are noncombustible or have a Class A ASTM E108 or UL790 rating.
- c. A Class I standpipe outlet installed on the roof level of the building or in the stairway bulkhead at the top level.
- d. An approved radiant energy-sensing fire detection system. (2021 IFC 1207.5.4)

The following figure illustrates the effect that the location limitations have on an ESS. The highlighted area depicts zones that meet the location limitations for outside walls in this guideline

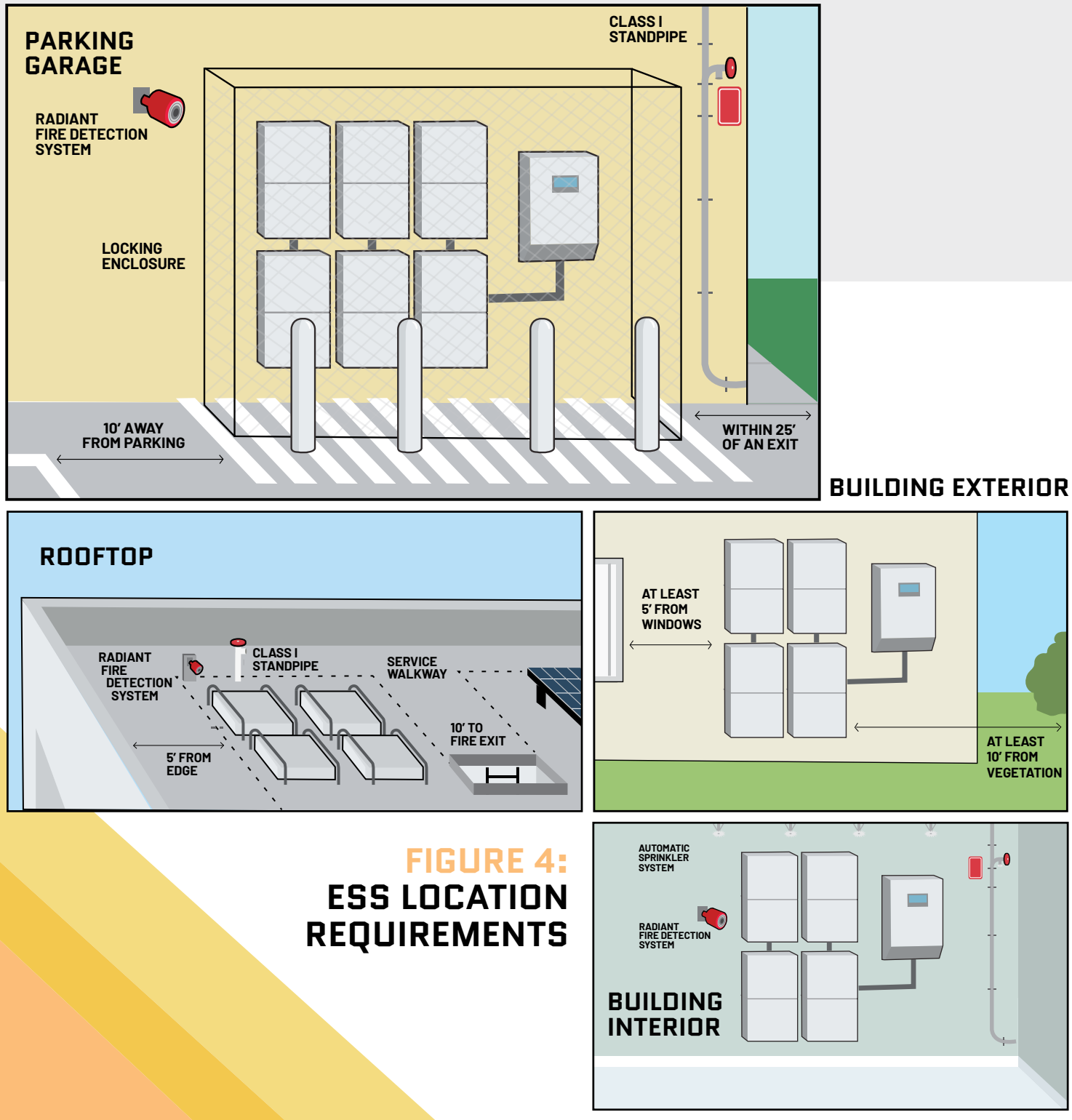


FIGURE 4: ESS LOCATION REQUIREMENTS

PHOTOVOLTAIC AND ENERGY STORAGE SYSTEM INTERCONNECTION REQUIREMENTS

17 The inverter installation meets the requirements of one of the items below: (NEC 705)

a. Supply-side connection complies with the following: (2020 NEC 705.11)
   a. The sum of the power source continuous current output rating on a service does not exceed the capacity of the service conductors. (2020 NEC 705.11(A))
   b. The power source output circuit conductors to the first OCPD device are no smaller than 6AWG copper and sized at 125% of maximum current or maximum current with adjustment and correction factors. (2020 NEC 705.11(B), 2020 NEC 705.28)
   c. Power source output circuit conductors are protected by an OCPD. (2020 NEC 705.11(C), 2020 NEC 705.30)
   d. When power source output circuit conductors make connection to service outside the building, OCPD are located in a readily accessible location outside the building or where the power source conductors enter the building. (2020 NEC 705.11(C))
   e. When power source output circuit conductors make their connection to the service inside a building, OCPD are either within 10 feet of conductor length in dwelling units and 16.5 feet in other than dwelling units from the point of connection to the service or located within 71 feet of conductor length from the point of connection to service. (2020 NEC 705.11(C))

b. Load-side connection complies with the following:
   a. Each source interconnection is made at a dedicated circuit breaker or fusible disconnecting means. (NEC 705.12(B))
   b. The bus amp meet the 120% busbar rating allowance in a building. Table 2: AC Interconnection Options below displays several AC Interconnection options. (NEC 705.12(B))
   c. Equipment containing OCPD are marked to indicate the presence of all sources (NEC 705.12(B))
   d. Fused disconnects are suitable for backfeed. Circuit breakers must either not be marked "line" or "load" or be specifically rated for backfeed. (NEC 705.12(B))
   e. Circuit breakers backfed from power sources that are interactive do not need a fastener. (NEC 705.12(B))

c. Load-side Power Control Systems which use controls to prevent overcurrent of equipment are listed to UL1741 CRD comply with the following:
   a. The PCS controller must monitor all currents within the PCS. Any busbar or conducts not monitored must comply with the load-side requirements listed above. (2020 NEC 705.13(A))
   b. The sum of all PCS controlled currents do not exceed the ampacity of any busbar or conductor and set within the range of the OCPD. (2020 NEC 705.13(B))
   c. The PCS provides overcurrent protection. (2020 NEC 705.13(C))
   d. The rating of the PCS does not exceed the rating of the busbar or conductors. (2020 NEC 705.13(D))
   e. The access to the settings of the PCS are restricted to qualified personnel. (2020 NEC 705.13(E))

d. Load-side distribution equipment listed to combine sources and supply loads.

Maximum Inverter Current	Required Inverter OCPD Size	Minimum Conductor Size (Copper) in Conduit	Minimum Busbar/ Main Breaker Combinations Busbar Amps/Main Amps
64 Amps	80 Amps	4 AWG	400/400; 200/150
56 Amps	70 Amps	4 AWG	225/200; 250/225
48 Amps	60 Amps	6 AWG	300/300; 200/175
40 Amps	50 Amps	8 AWG	125/100; 150/125
32 Amps	40 Amps	8 AWG	225/225; 200/200; 150/125
24 Amps	30 Amps	10 AWG	150/150
16 Amps	20 Amps	12 AWG	100/100; 70/60
12 Amps	15 Amps	12 AWG	80/80

TABLE 1: AC INTERCONNECTION OPTIONS

PV SYSTEM ELECTRICAL CODE INSTALLATION REQUIREMENTS

18 All work done in a neat and workmanlike manner. (NEC 110.12)

19 Access and working space is provided for PV equipment such as inverters, disconnecting means, and panelboards (not required for PV modules). (NEC 110.26)

20 Exposed cables are properly secured, supported, and routed to prevent physical damage.

21 Grounding/bonding of rack, modules, inverter(s), and other electrical equipment according to the manufacturer's instructions. (NEC 110.3(B))

22 PV system markings, labels, and signs according to the NEC. (NEC 690.13(B), 690.53, 690.54, 690.56)

23 Major electrical components including PV modules, DC-to-DC converters, and inverters, are identified for use in PV systems.

24 Inverters are listed as utility interactive in accordance with UL 1741.

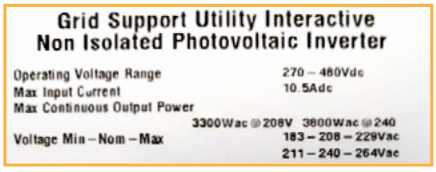


FIGURE 7: UTILITY INTERACTIVE INVERTER LISTING

25 PV Modules are listed as UL 1703, UL 61730-1, or UL 61730-2. (NEC 690.4(B)

26 PV panel systems and array mounting system are listed and identified with a fire classification in accordance with UL 2703. (NEC 690.43(A), IBC 1505.9)

FIGURE 8: UL2703 LISTED GROUNDING DEVICE

27 The PV array consists of no more than 2 series strings per inverter input and no more than 4 source circuits strings in total per inverter.

28 All exposed PV source circuit wiring is a minimum 10 AWG copper PV wire. (NEC 690.31)

29 The maximum PV DC system voltage for a multifamily or office building is limited to 600Vdc. Use either the checklist shown below or methods described in 690.7(A)(1) or 690.7(A)(3) to ensure the system is designed and connected so that 600Vdc is not exceeded on the average coldest day of the year. (NEC 690.7)

a. ASHRAE Extreme Annual Mean Minimum Design Dry Bulb Temperature (one source is https://energyresearch.ucf.edu/solar-certification/solar-reference-map/) = _____; Table 690.7(A) (NEC) value _____

b. Max module Voc (adjusted at minimum temperature):
Rated Voc _____ V x Table 690.7(A) value= _____ V

c. DC-to-DC converter(s) or microinverter rated maximum input voltage: _____ V (must be greater than Max module Voc in (b.))

d. Maximum number of DC-to-DC converters allowed in series (up to 600Vdc*): _____

e. Maximum number of DC-to-DC converters allowed in series (up to 600Vdc*): _____

f. Inverter(s) rated maximum input voltage: _____ V (must be greater than g. below)

g. Inverter input max V: Max module Voc (b.) _____ V x max # in series= _____ V

30 PV system circuits on buildings meet requirements for controlled conductors.

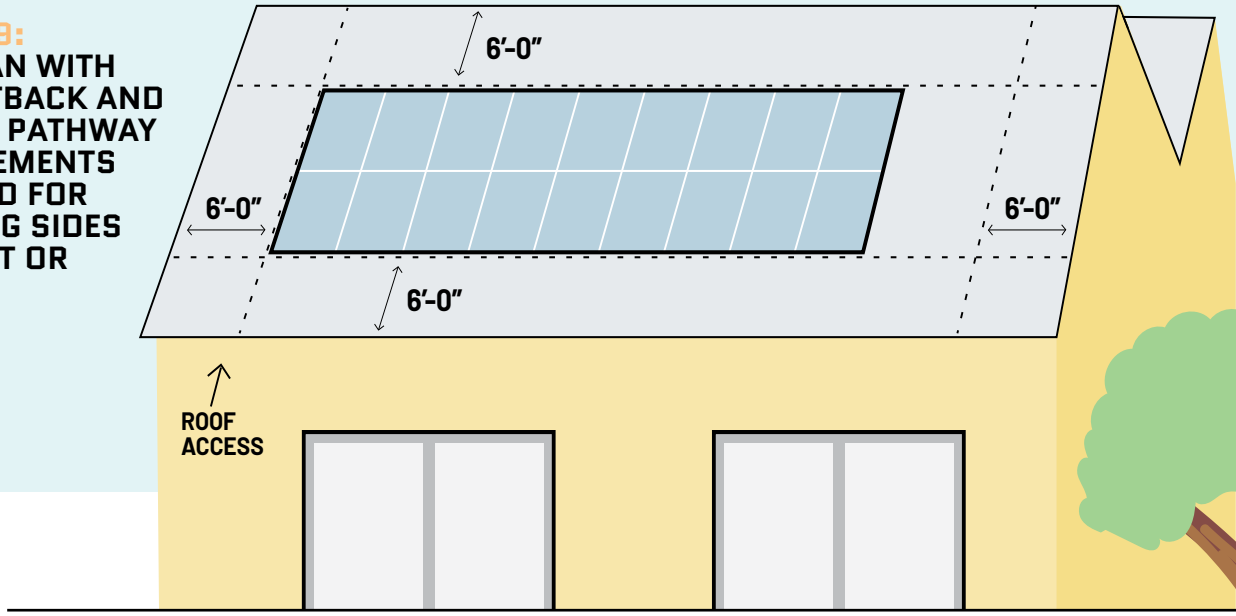
a. Controlled conductors more than one foot from the array are capable of being shutdown to below 30 volts within 30 seconds

b. PV array wiring within the array are either listed to the PV Hazard Control product safety standard (UL3741) or limited to not more than 80 volts within 30 seconds of rapid shutdown initiation. (NEC 690.12)

31 The PV System disconnecting means is sized for the maximum short circuit current and voltage and installed in a readily accessible location. (NEC 690.13(A))

STRUCTURAL PV ARRAY MOUNTING AND INSTALLATION LOCATION REQUIREMENTS

FIGURE 9:
SITE PLAN WITH FIRE SETBACK AND ACCESS PATHWAY REQUIREMENTS DETAILED FOR BUILDING SIDES 250 FEET OR LARGER



32 PV arrays are located to meet the fire setback and access pathway requirements: (IFC 1204.3.1 IFC 1204.3.2)

a. There is a 4-foot wide clear perimeter around the edges of the roof for building sides less than 250 feet. For building sides equal to or larger than 250 feet, 6-foot wide clear perimeter pathways are required.
b. Interior pathways are provided at intervals not greater than 150 feet throughout the length and width of the roof.
c. A pathway at least 4 feet wide is provided in a straight line to roof standpipes or ventilation hatches.
d. A pathway at least 4 feet wide is provided around roof access hatches, with at least one pathway to a parapet or roof edge.

33 Roof structures are designed to resist the applicable uniform concentrated roof live loads with PV panel dead loads and with PV panels present. Roof live loads do not need to be applied if the space between the panels and the roof surface is 2 feet or less. (IBC 1607.13.5.1)

34 The roof structure is designed to accommodate PV panels or modules and ballast dead load, including concentrated loads from support frames, roof live loads, snow drift loads created by PV panels and modules if applicable, and other applicable loads. (IBC 1607.13.5.2)

35 Roof penetrations flashed/sealed according to manufacturers' instructions. (NEC 110.3(B))

PLAN REVIEW CHECKLIST

ENERGY STORAGE SYSTEM REQUIREMENTS

- [ ] **1** ESS is listed to UL9540 or UL9540a by a Nationally Recognized Testing Laboratory (NRTL).
- [ ] **2** ESS is listed to UL1973.
- [ ] **3** Inverters are certified to UL1741.

ENERGY STORAGE SYSTEM INSTALLATION REQUIREMENTS

- [ ] **4** In rooms, areas or walk-in units with UL9540 listed ESS, explosion control is installed which provides either explosion venting, explosion prevention systems or barricades which comply with NFPA 69 or NFPA 495.
- [ ] **5** UL9540 listed ESS units either are separated by 3 feet and in groups no larger than 50kWh.
- [ ] **6** UL9540a listed ESS are grouped and separated according to manufacturer instructions.

ENERGY STORAGE SYSTEM LOCATION REQUIREMENTS

7 ESS is located:

- [ ] a. In a space that is not a dwelling unit or sleeping unit,
- [ ] b. 75 feet or below the lowest level of fire department vehicle access, and
- [ ] c. At or above the lowest level of exit discharge.

8 ESS installed on exterior walls meets the following:

- [ ] a. ESS is separated from doors, windows, operable openings into buildings or HVAC inlets by at least 5 feet.
- [ ] b. Within 10 feet of outdoor ESS, area is cleared of combustible vegetation .
- [ ] c. Located 5 feet away (10 feet away 2021 IFC 1207.5.8) (or 3 feet away if ESS is enclosed in a weatherproof encloser of noncombustible materials) from:
  - a. Any means of egress under fire conditions
  - b. Other buildings
  - c. Lot lines,
  - d. Public ways,
  - e. Stored combustible or hazardous materials, and
  - f. Parking spaces. (2021 IFC 1207.9.3)

9 For ESS installed indoors:

- [ ] a. ESS is separated from other areas of the building with a 2-hour fire barrier and 2-hour horizontal assembly.
- [ ] b. A smoke detection or radiant energy-sensing fire detection system is installed
- [ ] c. The room or area with an ESS is protected by one of the following fire suppression systems:
  - a. An automatic sprinkler system that meets the requirements of 2021 IFC 1207.5.5 and Section 903.3.1.1
  - b. One of the following alternative automatic fire protection system: carbon dioxide extinguishing system, water spray fixed systems, water mist fire protection systems, clean agent fire-extinguishing systems, or fixed aerosol fire-extinguishing systems that meets the requirements of 2021 IFC 1207.5.5 and Section 904.

10 ESS installed in a garage must meet the following requirements:

- [ ] a. If in an open parking garage, ESS is located 5 feet away (10 feet away 2021 IFC 1207.5.8) or 3 feet away if ESS is enclosed in a weatherproof enclosure of noncombustible materials from:
  - a. Other buildings
  - b. Lot lines
  - c. Public ways
  - d. Stored combustible or hazardous materials, and
  - e. Parking spaces. (2021 IFC 1207.9.3).
- [ ] b. ESS is installed within a locked gate, fence or other barrier that prevents the public from standing within 5 feet of the ESS.
- [ ] c. ESS is located 50 feet or more from air inlets of building HVAC systems unless a fire alarm system can shut off ventilation system upon detection of fire.
- [ ] d. ESS is located 25 feet away from exits from the attached building if on a covered level of the parking structure.
- [ ] e. ESS is protected by an approved radiant energy-sensing fire detection system.
- [ ] f. ESS is protected from vehicular impact by one of the following:
  - a. Installed in a location not subject to vehicular impact such as 4' or more above floor level,

or

- ☐ b. Protected by guard posts constructed of steel not less than 4" in diameter and concrete filled, spaced not more than 4 feet apart, set not less than 3 feet deep in concrete footing, with top posts not less than 3 feet above the ground, and located 3 feet or more away from the ESS,
- ☐ c. Protected by wheel barriers anchored in place located 4.5 feet or more away from the ESS, or
- ☐ d. Protected by other barriers where approved.

11 ESS installed on the rooftop is:

- ☐ a. Located at least 5 feet away from the edge of the roof if the height of the system is 5 feet or less.
- ☐ b. Located at least the height of the system away from the edge of the roof if the height of the system is greater than 5 feet.
- ☐ c. Located within 10 feet of the fire service access point.
- ☐ d. Accessible via a stairway through a bulkhead from the building interior or exterior stairway.

12 Rooftops with an ESS must have:

- ☐ a. Service walkways at least 5 feet in width from the access point to the ESS.
- ☐ b. Roofing materials under and within 5 feet of the ESS that are noncombustible or have a Class A ASTM E108 or UL790 rating.
- ☐ c. A Class I standpipe outlet installed on the roof level of the building or in the stairway bulkhead at the top level.
- ☐ d. An approved radiant energy-sensing fire detection system.

PHOTOVOLTAIC AND ENERGY STORAGE SYSTEM INTERCONNECTION REQUIREMENTS

☐ **13** The inverter installation meets the requirements of one of the items below:

- a. Supply-side connection complies with power source continuous output rating, conductor size, over current protection, connection, and ground fault requirements in 2020 NEC 705.11.
- b. Load-side connection complies with 705.12 and can meet the 120% busbar rating allowance in a residence.
- c. Load-side Power Control Systems which use controls to prevent overcurrent of equipment are listed to UL1741 CRD and comply with monitoring, setting, overcurrent protection, single power source ratings, and access requirements in 2020 NEC 705.13.
- d. Load-side distribution equipment listed to combine sources and supply loads.

PV SYSTEM ELECTRICAL CODE INSTALLATION REQUIREMENTS

☐ **14** Major electrical components including PV modules, DC-to-DC converters, and inverters, are identified for use in PV systems.

☐ **15** Inverters are listed as utility interactive in accordance with UL 1741.

☐ **16** PV Modules are listed as UL 1703, UL 61730-1, or UL 61730-2.

☐ **17** PV panel systems and array mounting system are listed and identified with a fire classification in accordance with UL 2703.

☐ **18** The PV array consists of no more than 2 series strings per inverter input and no more than 4 source circuits strings in total per inverter.

☐ **19** All exposed PV source circuit wiring is a minimum 10 AWG copper PV wire.

☐ **20** The maximum PV DC system voltage for a multifamily or office building is limited to 600Vdc. Use either the checklist shown the general installation guide or methods described in 690.7(A)(1) or 690.7(A)(3) to ensure the system is designed and connected so that 600Vdc is not exceeded on the average coldest day of the year.

☐ **21** PV system circuits on buildings meet requirements for controlled conductors.

- a. Controlled conductors more than one foot from the array are capable of being shutdown to below 30 volts within 30 seconds
- b. PV array wiring within the array is either listed to the PV Hazard Control product safety standard (UL3741) or limited to not more than 80 volts within 30 seconds of rapid shutdown initiation.

☐ **22** The PV System disconnecting means is sized for the maximum short circuit current and voltage and installed in a readily accessible location.

STRUCTURAL PV ARRAY MOUNTING AND INSTALLATION LOCATION REQUIREMENTS

- [ ] **23** PV arrays are located to meet the fire setback and access pathway requirements:
  a. There is a 4-foot wide clear perimeter around the edges of the roof for building sides less than 250 feet. For building sides equal to or larger than 250 feet, 6-foot wide clear perimeter pathways are required.
  b. Interior pathways is provided at intervals not greater than 150 feet throughout the length and width of the roof.
  c. A pathway at least 4 feet wide is provided in a straight line to roof standpipes or ventilation hatches.
  d. A pathway at least 4 feet wide is provided around roof access hatches, with at least one pathway to a parapet or roof edge.

- [ ] **24** Roof structures are designed to resist the applicable uniform concentrated roof live loads with PV panel dead loads and with PV panels present. Roof live loads do not need to be applied if the space between the panels and the roof surface is 2 feet or less.

- [ ] **25** The roof structure are designed to accommodate PV panels or modules and ballast dead load, including concentrated loads from support frames, roof live loads, snow drift loads created by PV panels and modules if applicable, and other applicable loads.

FIELD INSPECTION CHECKLIST

HELPFUL TIP

Numbers that correspond to the requirement in the permitting checklist are provided next to the same requirement in the field inspection checklist.

ENERGY STORAGE SYSTEM REQUIREMENTS

Make sure all ESS disconnects and circuit breakers are in the open position and verify the following:

- ☐ **1** All work done in a neat and workmanlike manner (NEC 110.12).
- ☐ **2** Equipment installed, listed, and labeled according to the approved plan and manufacturers' instructions (e.g., ESS units, battery units, inverters, disconnects). (1- 3)
- ☐ **3** ESS equipment model numbers, quantity, and location according to the approved plan. (see PV+ESS permitting general installation guide for additional information)
  - a. ESS units have either 3 foot spacing between units or ESS unit is UL9540a listed and manufacturer spacing requirements are followed. (4-7)
- ☐ **4** Access and working space for ESS equipment such as ESS units, battery units, inverters, disconnecting means, and panelboards is adequate. Working space is at least 30 inches in width, 6.5 feet in height and 4 feet in depth or the width, height and depth of the equipment, whichever is greater.
- ☐ **5** For ESS installed on exterior walls: (8)
  - a. ESS is separated from doors, operable openings or HVAC inlets by 5 feet.
  - b. ESS is located 10 feet away (or 3 feet away of enclosed in a weatherproof encloser of noncombustible material) from combustible vegetation, egress under fire conditions, other buildings, lot lines public ways, stored combustible or hazardous materials, and parking spaces.
- ☐ **6** For ESS installed in indoor areas, fire barrier, smoke detection, and fire suppression systems is installed. (9)
- ☐ **7** For ESS installed in a parking garage: (10)
  - a. ESS has an approved radiant energy sensing fire detection system,
  - b. ESS is installed within a locked gate, fence or other barrier that prevents the public from standing within 5 feet of the ESS, and
  - c. ESS is either installed in a location not subject to vehicular impact or protected from vehicle impact with guard posts, wheel barriers or other approved barrier.
- ☐ **8** For ESS installed on the rooftop, ESS is located at least 5 feet away from the edge of the roof in a location that is is accessible via stairway from building interior or exterior stairway and a 5 feet wide service walkway. (11)
- ☐ **9** PV system electrical interconnection point (supply-side or load-side connection, load-side power control systems, and load-side distribution equipment) complies with approved plan.
- ☐ **10** Grounding/bonding of ESS units, battery units, inverters, conduit and other electrical equipment according to the NEC and manufacturer's instructions.
- ☐ **11** Conduit and other wiring methods installation according to the NEC and the approved plan. (13)
- ☐ **12** Conductors, cables, and conduit types, sizes, and markings according to the approved plan. (13)
- ☐ **13** Overcurrent devices are the type and size according to the approved plan. (13)
- ☐ **14** Disconnects according to the approved plan and properly located as required by the NEC. (13)
- ☐ **15** PV system electrical interconnection point (supply-side or load-side connection, load-side power control systems, and load-side distribution equipment) complies with approved plan. (13)

PHOTOVOLTAIC ELECTRICAL AND STRUCTURAL REQUIREMENTS

Make sure all PV disconnects and circuit breakers are in the open position and verify the following:

- ☐ **16** All work done in a neat and workmanlike manner.
- ☐ **17** PV module model number, quantity, and location according to the approved plan.
- ☐ **18** Array mounting system and structural connections according to the approved plan and manufacturers' instructions. (17)
- ☐ **19** Roof penetrations flashed/sealed according to the approved plan and manufacturers' instructions.
- ☐ **20** Exposed cables are properly secured, supported, and routed to prevent physical damage.
- ☐ **21** Conduit installation according to NEC 690.31 and the approved plan. (19)
- ☐ **22** Firefighter access according to IFC 1204.3.1-2 and the approved plan. (23)
- ☐ **23** Roof-mounted PV mounting system and modules have sufficient fire classification (17)
- ☐ **24** Grounding/bonding of rack, modules, inverter(s), and other electrical equipment according to the manufacturer's instructions.
- ☐ **25** Equipment installed, listed, and labeled according to the approved plan and manufacturers' instructions (e.g., PV modules, inverters, dc-to-dc converters, rapid shutdown equipment). (14, 15, 16)
- ☐ **26** For grid-connected systems, inverter is marked "interactive," or documentation is provided to show that inverter meets utility interconnection requirements. (15)
- ☐ **27** Conductors, cables, and conduit types, sizes, and markings according to the approved plan. (18, 19, 21)
- ☐ **28** Overcurrent devices are the type and size according to the approved plan.
- ☐ **29** Disconnects according to the approved plan and properly located as required by the NEC. (22)
- ☐ **30** PV system electrical interconnection point (supply-side or load-side connection, load-side power control systems, and load-side distribution equipment) complies with approved plan. (13)
- ☐ **31** PV system markings, labels, and signs according to the approved plan.
- ☐ **32** PV system equipment grounding conductors installed according to the approved plan.
- ☐ **33** Access and working space is provided for PV equipment such as inverters, disconnecting means, and panelboards (not required for PV modules).
- ☐ **34** The rapid shutdown system is installed and operational according to the approved plan and manufacturers' instructions. (21)

SUPPORTING RESOURCES

International Code Council "2018 International Fire Code", Aug. 2017, https://codes.iccsafe.org/content/IFC2018P6

International Code Council "2018 International Building Code", Aug. 2017, https://codes.iccsafe.org/content/IBC2018P6

National Fire Protection Association. "NFPA 70®." NFPA 70®: National Electrical Code®, Delmar Cengage Learning, 2017, https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=70&access=open.

International Code Council "2021 International Fire Code", Oct. 2020, https://codes.iccsafe.org/content/IFC2021P1

International Code Council "2021 International Building Code", Oct. 2020, https://codes.iccsafe.org/content/IBC2021P1.

National Fire Protection Association. "NFPA 70®." NFPA 70®: National Electrical Code®, Delmar Cengage Learning, 18 Sept. 2019, https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=70&access=open.

"National Simplified Residential PV and Energy Storage Permit Guidelines." SolSmart, https://solsmart.org/resources/national-simplified-residential-pv-and-energy-storage-permit-guidelines/.

APPENDIX A: SOLAR AND/OR ESS PERMIT APPLICATION

FOR OFFICE USE ONLY

Application Number:

Permit Number:

Issued By:

Date Applied:

Date Issued:

SECTION 1 - GENERAL INFO

PROJECT ADDRESS

PROPERTY OWNER'S NAME PHONE NUMBER EMAIL

PROPERTY OWNER'S MAILING ADDRESS (IF DIFFERENT FROM PROJECT ADDRESS)

SECTION 2 - PROJECT DETAILS

BUILDING TYPE/EXISTING USE

☐ SINGLE FAMILY ☐ DUPLEX ☐ MULTI-FAMILY

☐ COMMERCIAL/ INDUSTRIAL ☐ NEW CONSTRUCTION ☐ OTHER: _____

NEW OR EXISTING PV SYSTEM

☐ NEW SYSTEM

☐ ADDITIONAL SYSTEM

☐ SYSTEM REPLACEMENT

PV SYSTEM TYPE

☐ ROOF MOUNT

☐ GROUND MOUNT

☐ BUILDING INTEGRATED/ OTHER

INVERTER CONFIGURATION

☐ STRING INVERTER

☐ STRING INVERTER W/ DC CONVERTERS

☐ MICROINVERTERS OR AC MODULES

TOTAL PV SYSTEM SIZE _____ kW DC

TOTAL SQ. FT. OF PV SYSTEM _____ SQ FT

PROJECT VALUATION $ _____

INCLUDES ENERGY STORAGE SYSTEM ☐ YES ☐ NO

TOTAL SYSTEM CAPACITY RATING _____ kWh

POWER RATING _____ kW

☐ AC ☐ DC

PROJECT DESCRIPTION:

SECTION 3 - CONTRACTOR INFORMATION

CONTRACTOR BUSINESS NAME | CONTRACTOR LICENSE NUMBER

BUSINESS ADDRESS

CONTRACTOR CONTACT NAME | PHONE NUMBER | EMAIL

SECTION 4 - PERMIT FEE

[Include fee schedule/options and/or instructions for calculating fee, directions on how and when to submit the permit fee.]

SECTION 5 - IMPORTANT NOTICE

A permit must be obtained for all installations or alterations of electrical equipment BEFORE WORK STARTS. Refer to EVSE Permitting Checklist for additional documents required. Failure to provide all required documents, including **(1) Site Plan, (2) Electrical Diagram, and (3) Specification Sheets** and Installation Manuals will delay permit approval. All permits expire six (6) months after date of issuance. Failure to start the work authorized by a permit within this six-month period renders the permit invalid and a new permit must be obtained. Once work begins, noticeable progress must continue until completion. All work must be complete within eighteen (18) months of a permit issue date.

Please Submit the following additional documents with the EVSE Permit Application

- **Site Plan**
- **Electrical Diagram**
- **EVSE Specification Sheets and Installation Manuals**
- **Structural Load Calculation**
- **Additional Document - edit or delete as necessary**

Submit Permit Application

[Describe the submission process, how should the permits be submitted? In-person, on-line, e-mail, fax, etc.]

SECTION 6 - APPLICANT SIGNATURE

I, the undersigned, certify that I have proper authority to apply for this permit, that the Contractor has obtained a signed contract from the Property Owner for the specified work, that all contractors have consented to being listed, and that all the information contained on this application is true and accurate to the best of my knowledge.

NAME | TITLE

SIGNATURE | DATE

APPENDIX B: SOLAR AND/OR ESS PERMIT APPLICATION

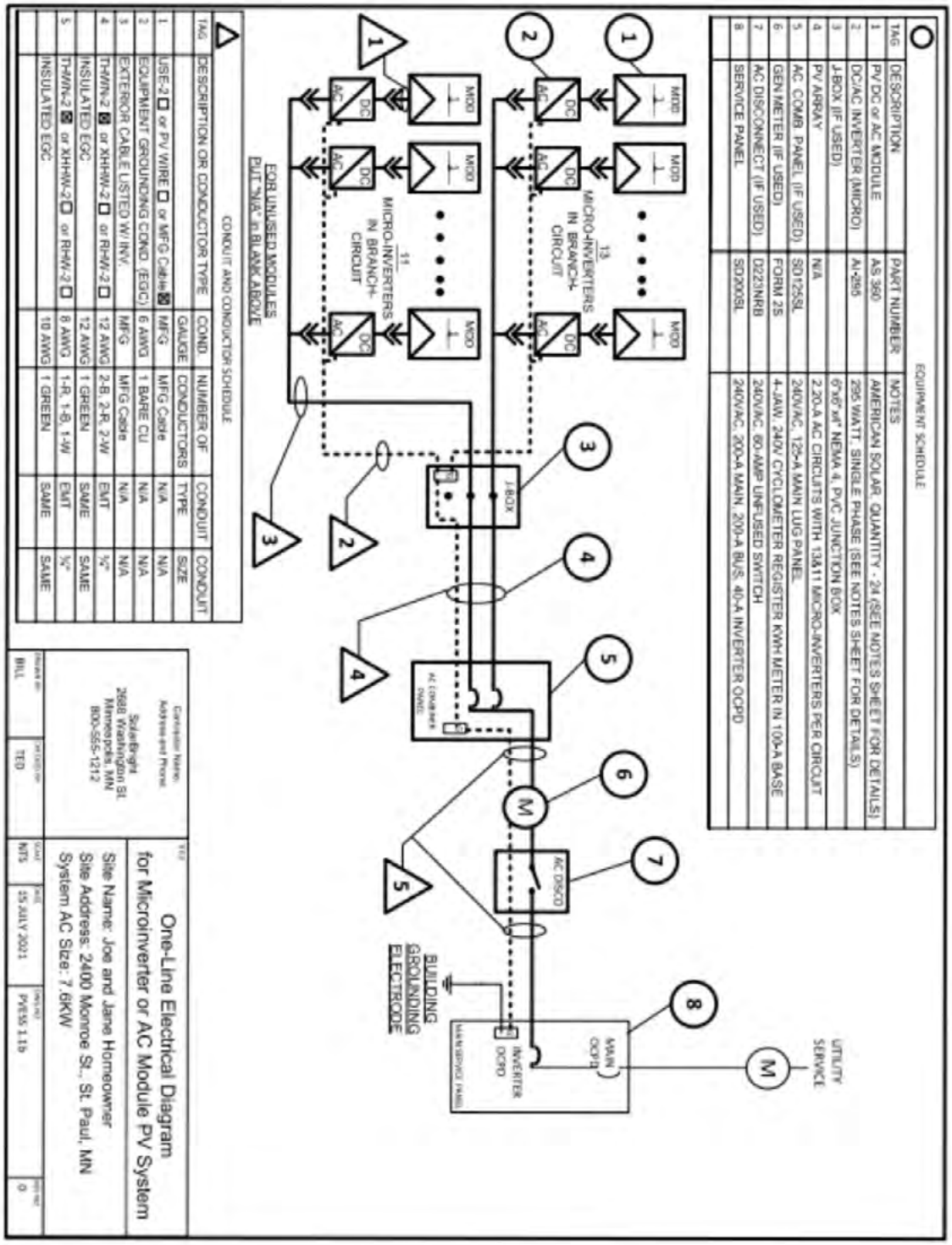


FIGURE 9: ONE LINE PV ONLY WITH MICROINVERTERS

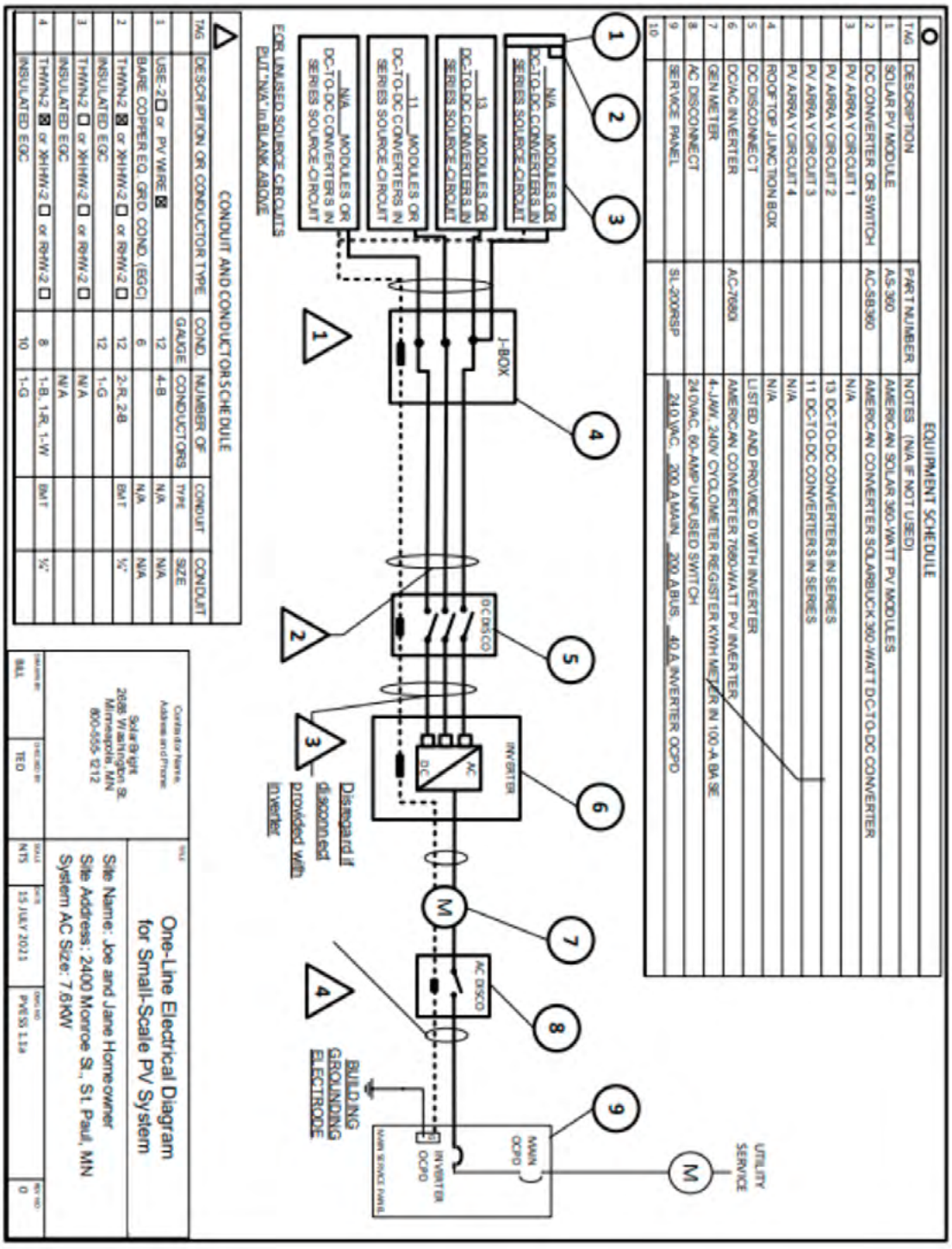


FIGURE 10: ONE LINE PV ONLY WITH DC CONVERTERS

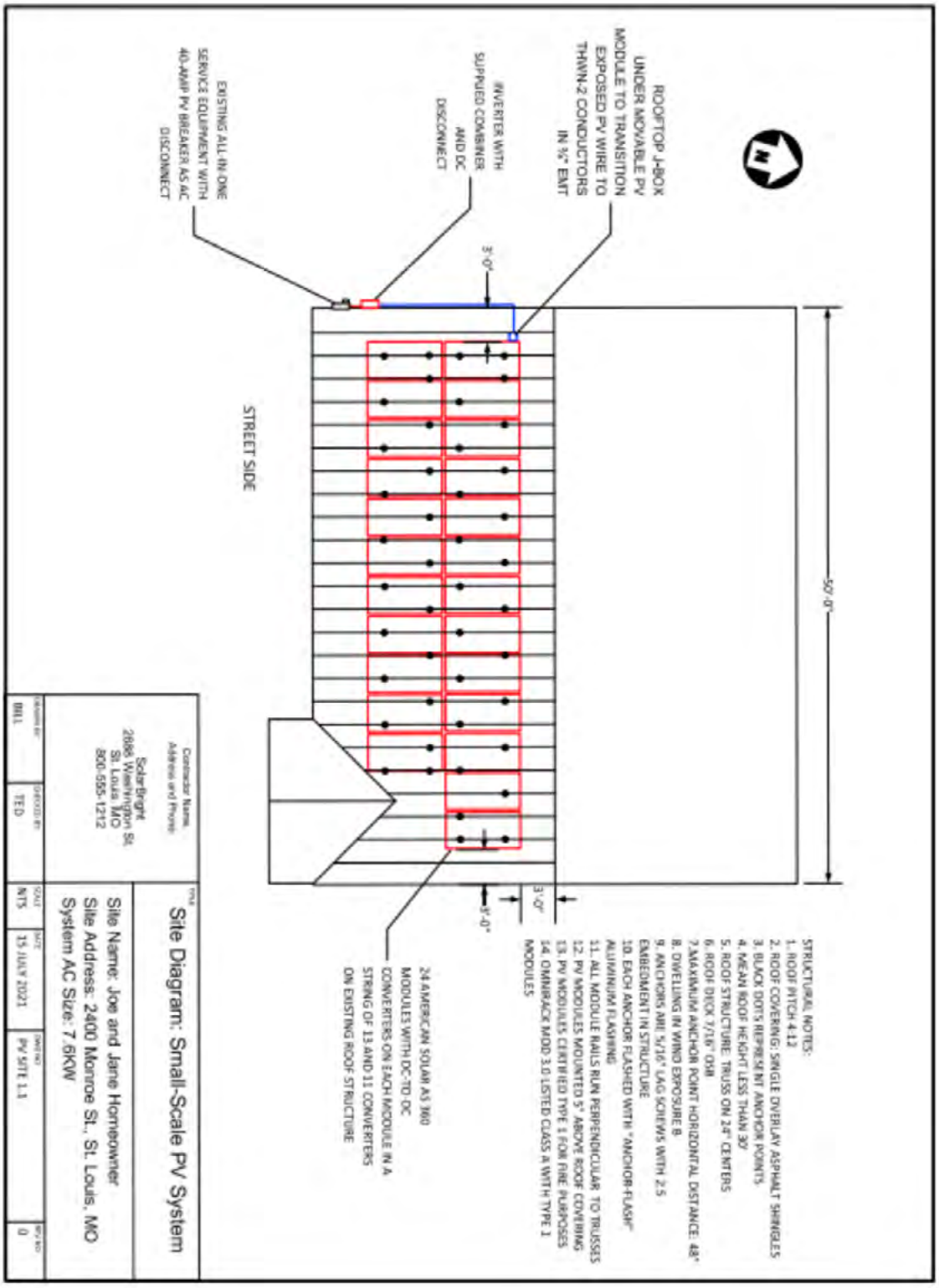


FIGURE 11: SITE DIAGRAM PV ONLY WITH DC CONVERTERS

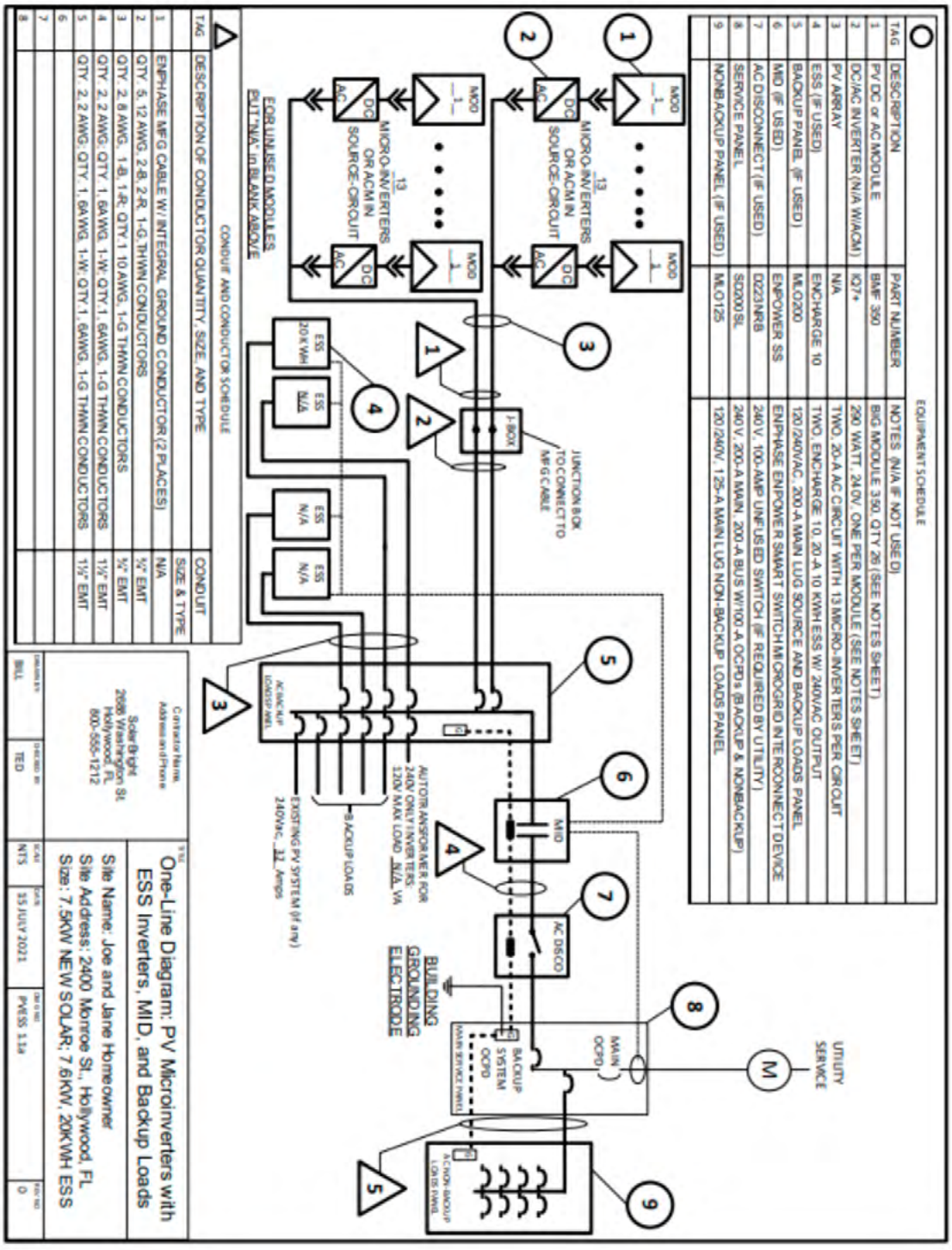
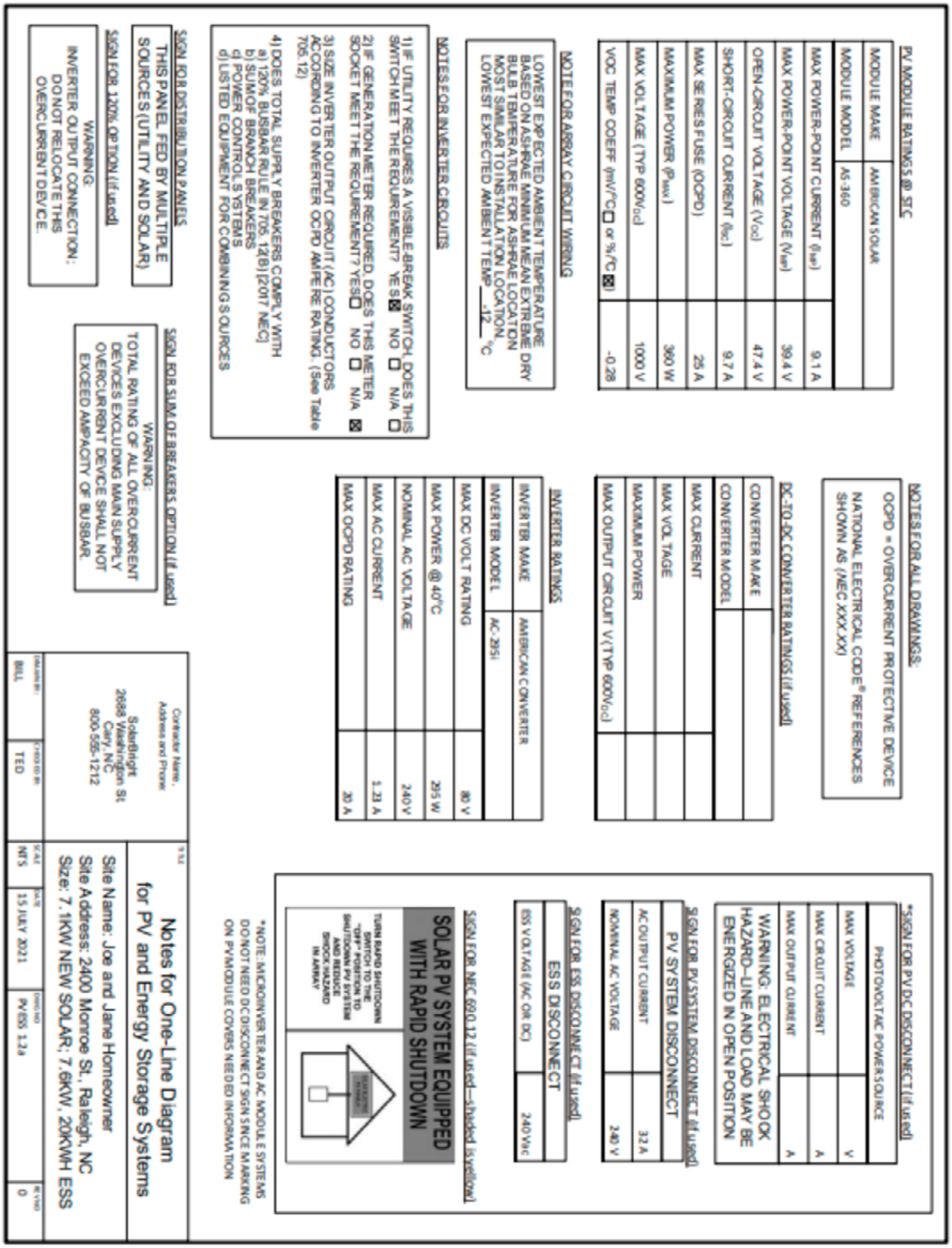


FIGURE 12: ONE-LINE PV AND ESS WITH MICROINVERTERS AND MID



PV MODULE RATINGS @ STC

MODULE MAKE	AMERICAN SOLAR
MODULE MODEL	AS-360
MAX POWER-POINT CURRENT (I_{MP})	9.1 A
MAX POWER-POINT VOLTAGE (V_{MP})	39.4 V
OPEN-CIRCUIT VOLTAGE (V_{OC})	47.4 V
SHORT-CIRCUIT CURRENT (I_{SC})	9.7 A
MAX SERIES FUSE (OCPD)	25 A
MAXIMUM POWER (P_{MAX})	360 W
MAX VOLTAGE (TYP 600V_{DC})	1000 V
VOC TEMP COEFF (mV/°C ☐ or %/°C ☒)	-0.28

NOTE FOR ARRAY CIRCUIT WIRING

LOWEST EXPECTED AMBIENT TEMPERATURE BASED ON ASHRAE MINIMUM MEAN EXTREME DRY BULB TEMPERATURE FOR ASHRAE LOCATION MOST SIMILAR TO INSTALLATION LOCATION.
LOWEST EXPECTED AMBIENT TEMP __-12__ °C

NOTES FOR INVERTER CIRCUITS

1) IF UTILITY REQUIRES A VISIBLE-BREAK SWITCH, DOES THIS SWITCH MEET THE REQUIREMENT? YES ☒ NO ☐ N/A ☐

2) IF GENERATION METER REQUIRED, DOES THIS METER SOCKET MEET THE REQUIREMENT? YES ☐ NO ☐ N/A ☒

3) SIZE INVERTER OUTPUT CIRCUIT (AC) CONDUCTORS ACCORDING TO INVERTER OCPD AMPERE RATING. (See Table 705.12)

4) DOES TOTAL SUPPLY BREAKERS COMPLY WITH
a) 120% BUSBAR RULE IN 705.12(B) [2017 NEC]
b) SUM OF BRANCH BREAKERS
c) POWER CONTROL SYSTEMS
d) LISTED EQUIPMENT FOR COMBINING SOURCES

SIGN FOR DISTRIBUTION PANELS

THIS PANEL FED BY MULTIPLE SOURCES (UTILITY AND SOLAR)

SIGN FOR 120% OPTION (if used)

WARNING:
INVERTER OUTPUT CONNECTION;
DO NOT RELOCATE THIS
OVERCURRENT DEVICE.

SIGN FOR SUM OF BREAKERS OPTION (if used)

WARNING:
TOTAL RATING OF ALL OVERCURRENT
DEVICES EXCLUDING MAIN SUPPLY
OVERCURRENT DEVICE SHALL NOT
EXCEED AMPACITY OF BUSBAR.

NOTES FOR ALL DRAWINGS:

OCPD = OVERCURRENT PROTECTIVE DEVICE

NATIONAL ELECTRICAL CODE® REFERENCES SHOWN AS (NEC XXX.XX)

DC-TO-DC CONVERTER RATINGS (if used)

CONVERTER MAKE	
CONVERTER MODEL	
MAX CURRENT	
MAX VOLTAGE	
MAXIMUM POWER	
MAX OUTPUT CIRCUIT V (TYP 600V_{DC})	

INVERTER RATINGS

INVERTER MAKE	AMERICAN CONVERTER
INVERTER MODEL	AC-295i
MAX DC VOLT RATING	80 V
MAX POWER @ 40°C	295 W
NOMINAL AC VOLTAGE	240 V
MAX AC CURRENT	1.23 A
MAX OCPD RATING	20 A

*SIGN FOR PV DC DISCONNECT (if used)

PHOTOVOLTAIC POWER SOURCE	
MAX VOLTAGE	V
MAX CIRCUIT CURRENT	A
MAX OUTPUT CURRENT	A

WARNING: ELECTRICAL SHOCK HAZARD–LINE AND LOAD MAY BE ENERGIZED IN OPEN POSITION

SIGN FOR PV SYSTEM DISCONNECT (if used)

PV SYSTEM DISCONNECT	
AC OUTPUT CURRENT	32 A
NOMINAL AC VOLTAGE	240 V

SIGN FOR ESS DISCONNECT (if used)

ESS DISCONNECT	
ESS VOLTAGE (AC OR DC)	240 Vac

SIGN FOR NEC 690.12 (if used—shaded is yellow)

SOLAR PV SYSTEM EQUIPPED WITH RAPID SHUTDOWN

TURN RAPID SHUTDOWN SWITCH TO THE "OFF" POSITION TO SHUTDOWN PV SYSTEM AND REDUCE SHOCK HAZARD IN ARRAY

*NOTE: MICROINVERTER AND AC MODULE SYSTEMS DO NOT NEED DC DISCONNECT SIGN SINCE MARKING ON PV MODULE COVERS NEEDED INFORMATION

Contractor Name, Address and Phone:
SolarBright
2688 Washington St
Cary, NC
800-555-1212

TITLE: Notes for One-Line Diagram for PV and Energy Storage Systems

Site Name: Joe and Jane Homeowner
Site Address: 2400 Monroe St., Raleigh, NC
Size: 7.1KW NEW SOLAR; 7.6KW, 20KWH ESS

DRAWN BY	CHECKED BY	SCALE	DATE	DWG NO	REV NO
BILL	TED	NTS	15 JULY 2021	PVESS 1.2a	0

FIGURE 13: NOTES FOR ONE-LINE PV AND ESS WITH MICROINVERTERS AND MID

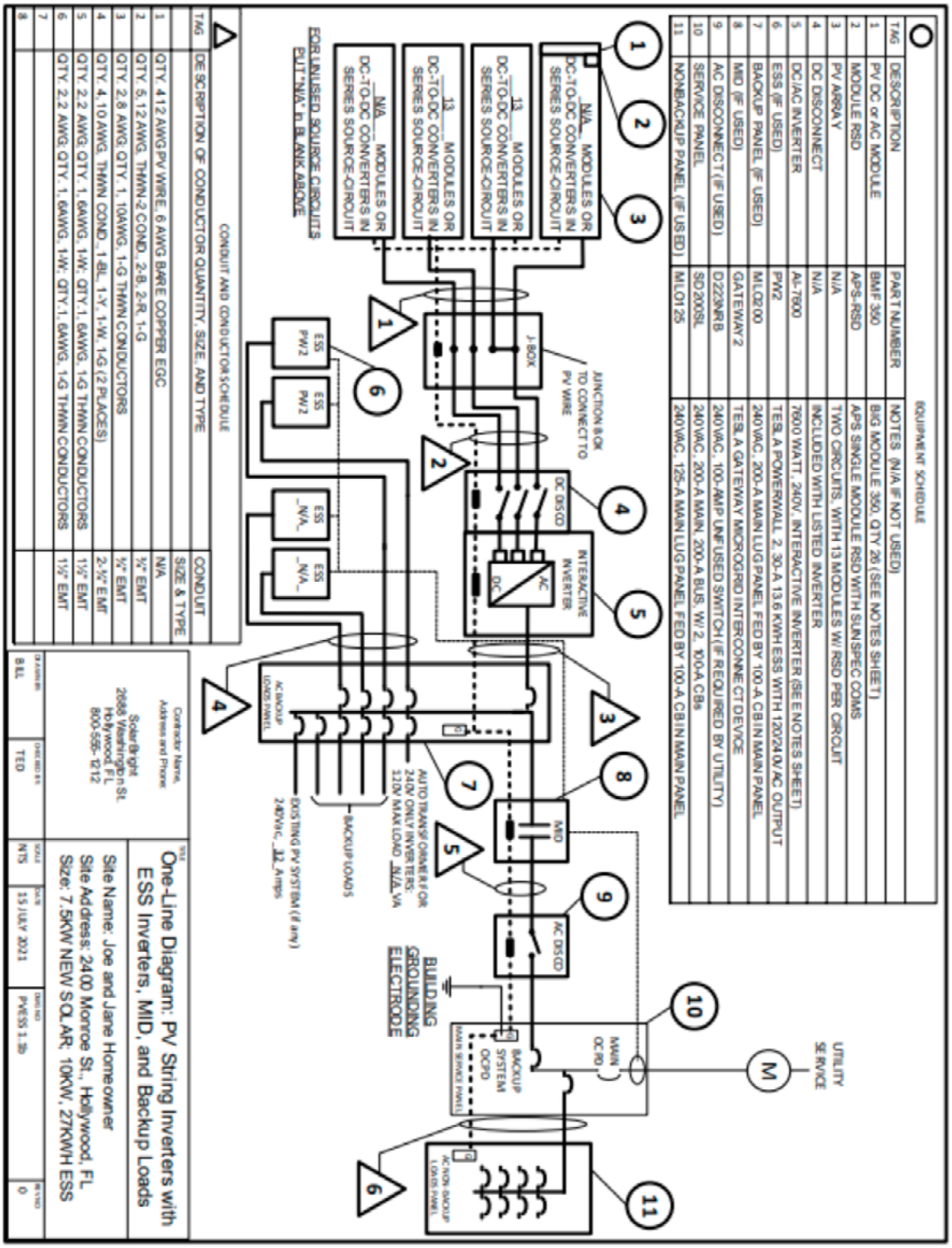


FIGURE 14: ONE-LINE PV AND ESS WITH STRING INVERTERS AND MID

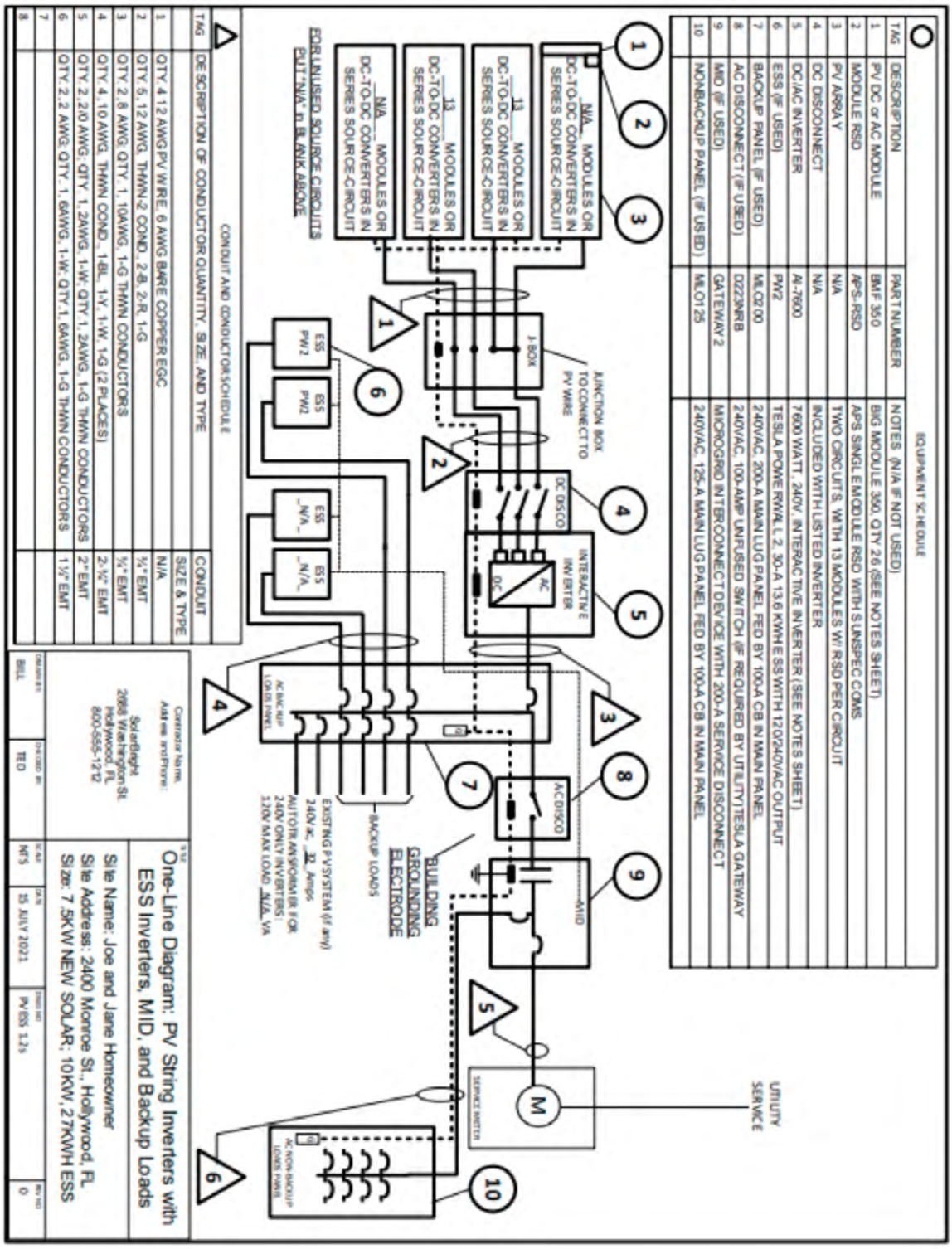


FIGURE 15: ONE-LINE PV AND ESS WITH STRING INVERTER AND MID WITH SERVICE DISCONNECT

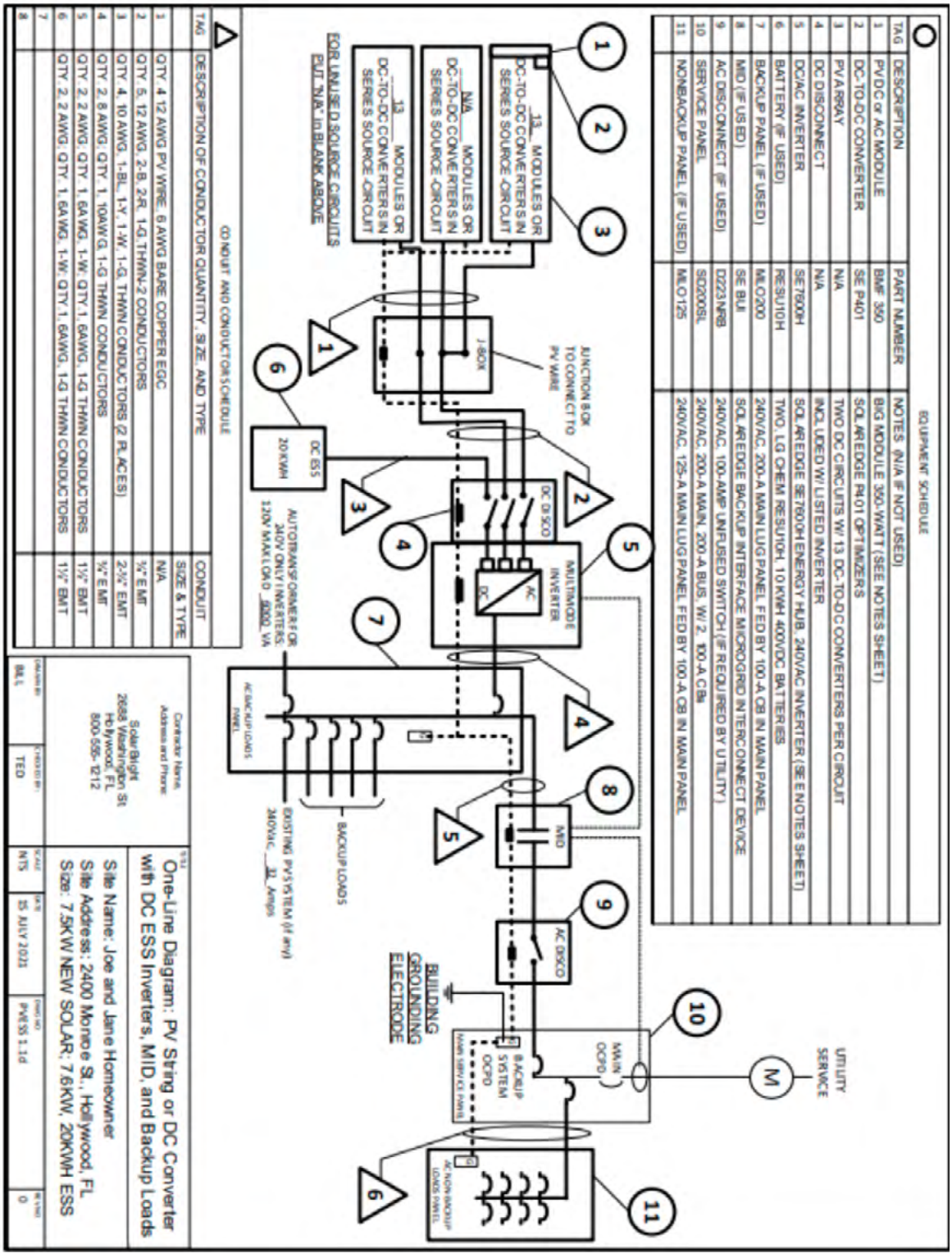


FIGURE 16: ONE-LINE PV AND ESS WITH STRING INVERTER AND DC CONVERTERS AND MID

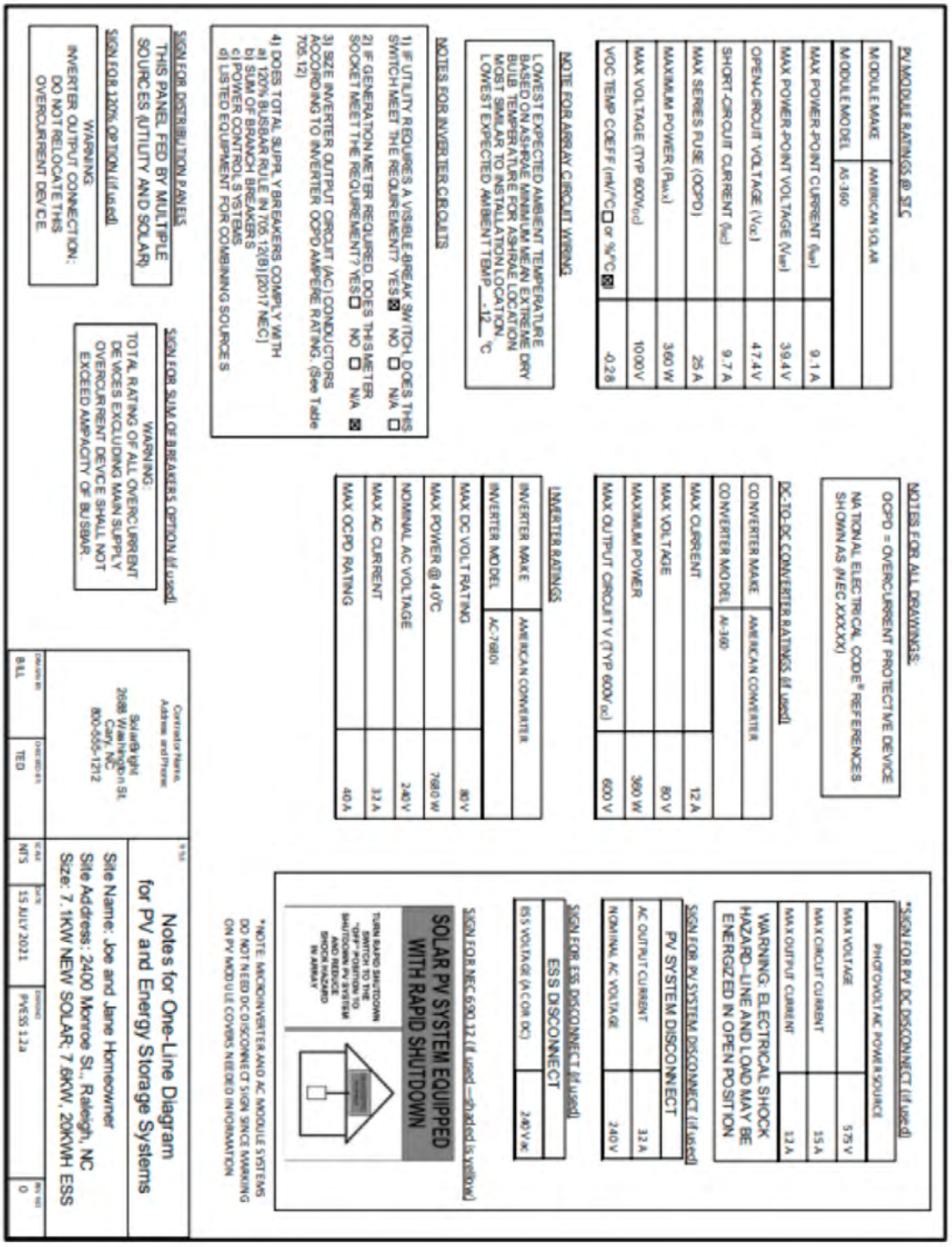


FIGURE 17: NOTES FOR ON-LINE PV AND ESS WITH STRING INVERTERS WITH DC CONVERTERS AND MID

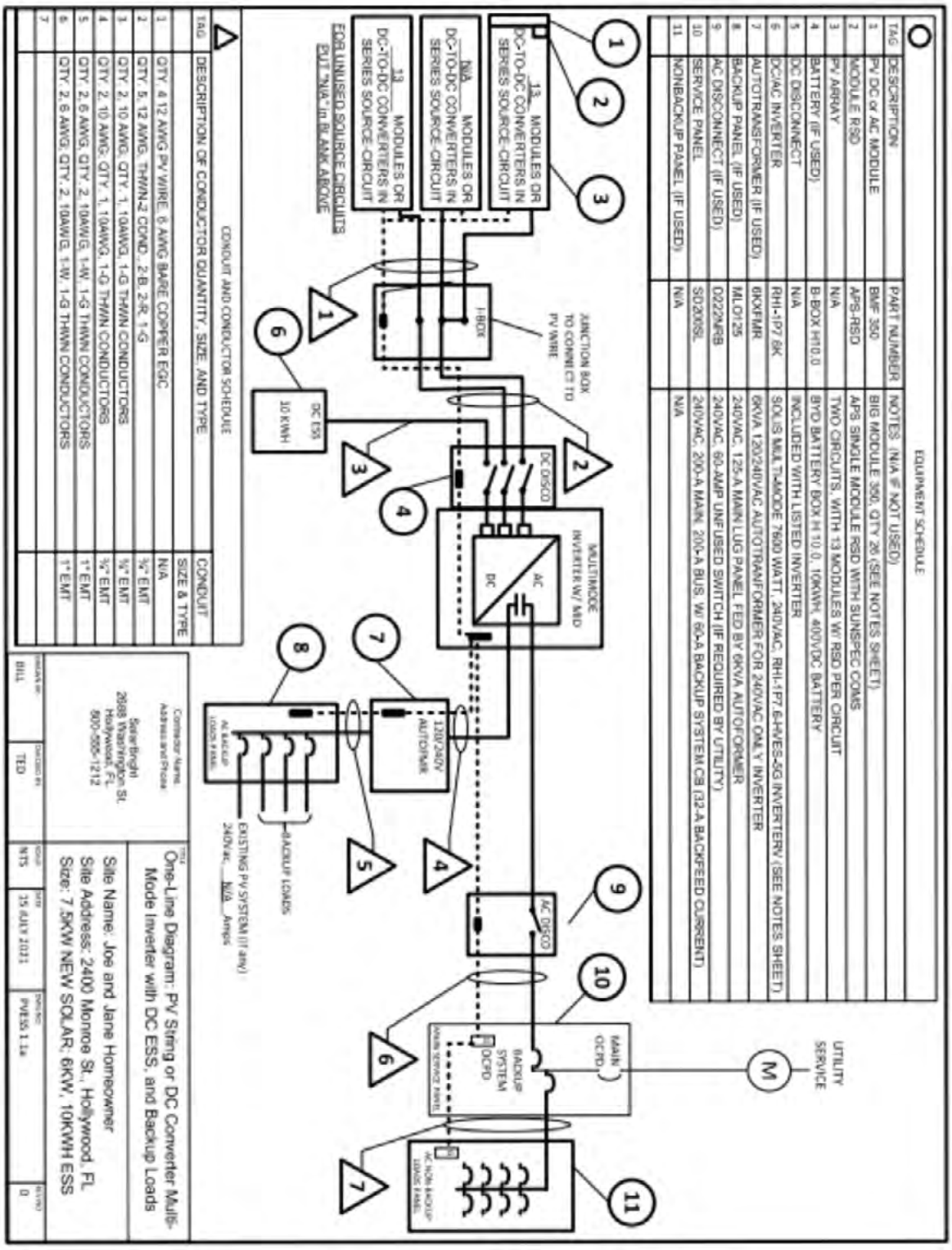


FIGURE 18: ONE-LINE PV AND ESS WITH MULTI-MODE INVERTER

earthadvantage

Earth Advantage® is a 501(c)(3) nonprofit focused on helping to create an informed and humane residential real estate marketplace that: acknowledges both the climate impacts of housing and the impact climate has on housing; provides all homebuyers and renters with access to sustainability-related information about a home; supports equitable housing outcomes, protecting those most vulnerable from the effects of climate change, and; recognizes both the personal and societal value that climate-friendly housing creates. Visit earthadvantage.org to learn more.

nbi new buildings institute

151 SW 1st Ave.
Portland, OR 97204
503 761 7339

Institute (NBI) is a nonprofit organization working to advance best practice energy efficiency and decarbonization of the built environment. Our efforts are imperative to keeping energy costs affordable, cutting carbon emissions that are fueling climate change, and delivering on improved health, safety, and resiliency for all. We work collaboratively with industry market players—governments, utilities, advocates, AEC professionals, and others—to drive leading-edge design, innovative technologies, and public policies and programs for scale. Throughout its 25-year history, NBI has become a trusted and independent resource helping to create buildings that are better for people, communities, and the planet. Visit newbuildings.org to learn more.