Green Building Technology

Renewable Energy Sources and Design/Specification Guidelines

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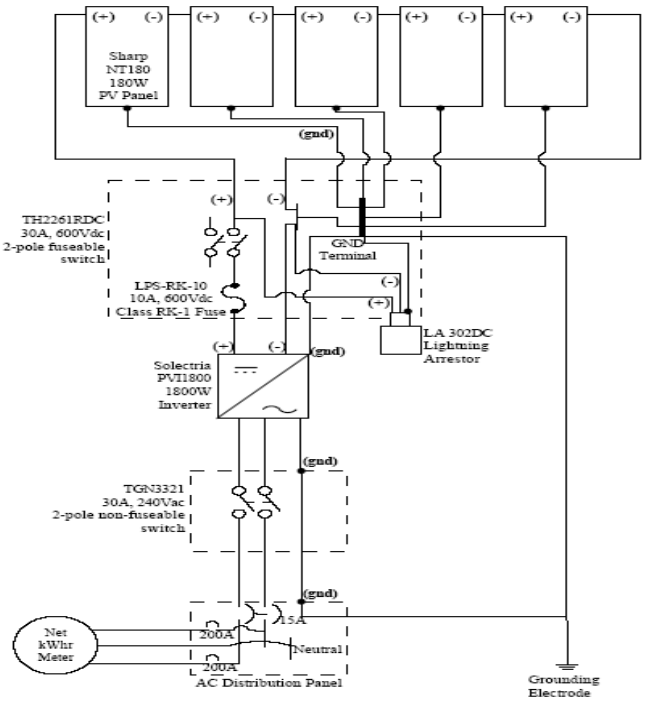
Why Renewables?

- Reduction of SO_2 and NOX along with greenhouse gases such as CO_2
- Reduce foreign dependency of oil
- Electric utility distribution line costs
- Peak shaving
- Reliable and safe

12/13/06 WWW.STANDBYPOWERSYS.COM



- 5 Sharp NT-180, 180W Modules
- 30A, 600 Vdc 2-pole fuseable switch
- Solectria PVI 1800, 1800W Inverter
- 30A, 240 Vac 2-pole non-fuseable switch

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Inverter Selection for Photovoltaic System

- Grid Tie Application – UL1741 required
- Inverter output rating should match the PV array peak watts as closely as possible.
- Each series string must have a temperature corrected open circuit voltage (Voc) that is less than the maximum allowable input voltage of the inverter.
- Voltage at maximum power (Vmp) of the series string is greater than or equal to the grid voltage.
- The PV array output current (Imp) is less than the inverter's DC input current limit.

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NEC Article 690: Solar Photovoltaic Systems

- 690.4(B): PV source circuits and output circuits shall not be contained in the same raceway, junction box, etc., as feeders or branch circuits of other systems, unless separated by partition.
- 690.4(C): Removal of a module does not interrupt a grounded conductor to another PV source circuit.
- 690.5: Ground Fault detection and interruption for PV systems is intended to prevent fires in dc PV circuits due to ground faults.

NEC Article 690: Solar Photovoltaic Systems (cont.)

- 690.7: Maximum PV system voltage – sum of rated open circuit voltage of the series connected PV modules corrected for the lowest expected ambient temperature.
- Voltage rating for selection of distribution equipment.

Ambient Temperature (°F)	Correction Factor
77 to 55	1.06
49 to 32	1.10
31 to 14	1.13
13 to -4	1.17
-5 to -40	1.25

Table 690.7 Voltage Correction Factors For Crystalline and Multicrystalline Silicon Modules

Sharp	NT-180U1
Maximum Power (Pmax)	180.0 W
Open-Circuit Voltage (Voc)	44.8 V
Short-Circuit Current (Isc)	5.60 A
Operating Voltage (Vpmax)	35.86 V
Current at Vpmax (Ipmax)	5.02 A
Maximum System Voltage	600 V
Minimum Bypass Diode	10 A
Maximum Series Fuse	10 A

modules x Voc x temp correction factor

5 x 44.8 Vdc x 1.25 = 280 Vdc

NEC Article 690: Solar Photovoltaic Systems (cont.)

- 690.8(A): Circuit Sizing - The maximum current shall be the sum of parallel module rated short-circuit currents multiplied by 125 percent.
- 690.8(B): Overcurrent Device Ratings – The circuit conductors and overcurrent devices shall be sized to carry not less than 125 percent of the maximum currents as computed in 690.8(A).

Isc X 1.25 X 1.25

5.6 A x 1.25 x 1.25 = 8.75A

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Updates to National Electric Code

- "Photovoltaic power systems shall be permitted to operate with ungrounded photovoltaic source and output circuits where the system complies with 690.35(A) through 690.35(G):
- "(A) Disconnects. All photovoltaic source and output circuit conductors shall have disconnects complying with 690, Part III.
- "(B) Overcurrent Protection. All photovoltaic source and output circuit conductors shall have overcurrent protection complying with 690.9.
- "(C) Ground-Fault Protection. All photovoltaic source and output circuits shall be provided with a ground-fault protection device or system that complies with 1 through 3:
  - 1. Detects a ground fault.
  - 2. Indicates that a ground fault has occurred.
  - 3. Automatically disconnects the conductors and/or shuts off the utility-interactive inverter or charge controller for that portion of the faulted array.

NEC Updates (cont.)

- "(D) The photovoltaic source and output conductors shall consist of sheathed (jacketed) multi-conductor cables or shall be installed in a raceway.
- "(E) The photovoltaic power system direct-current circuits shall be permitted to be used with ungrounded battery systems complying with 690.71(G).
- "(F) The photovoltaic power source shall be labeled with the following warning at each junction box, combiner box, disconnect and device where the ungrounded circuits may be exposed during service: '*Warning: Electric Shock Hazard. The direct current circuit conductors of this photovoltaic power system are ungrounded but may be energized with respect to ground due to leakage paths and/or ground faults.'*

NEC Updates (cont.)

- "(G) The inverters or charge controllers used in systems with ungrounded photovoltaic source and output circuits shall be listed for the purpose."
- Section 690.13 includes clarification regarding conductors, now stating that "a switch or circuit breaker shall not be installed in a grounded conductor unless that switch or circuit breaker is part of a groundfault detection system required by 690.5, and that switch or circuit breaker is automatically opened and indicated as a normal function of the device in responding to ground faults."

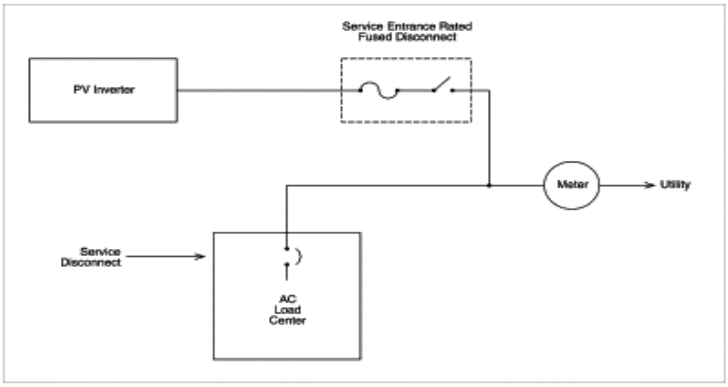
NEC Updates (cont.)

- A new code provision in section 690.14 permits situating utility-interactive inverters in non-readily accessible locations. They can be mounted on roofs or other exterior areas, according to the following conditions:
  - "Direct-current photovoltaic disconnecting means shall be mounted within sight of or in the inverter.
  - "An alternating-current disconnecting means shall be mounted within sight of or in the inverter.
  - "The alternating-current output conductors from the inverter and an additional alternating-current disconnecting means for the inverter shall comply with 690.14(C)(1).
  - "A plaque shall be installed in accordance with 705.10."

NEC Updates (cont.)

- Section 690.31 includes an addition regarding output circuits in metallic raceways in part (E), Direct-Current Photovoltaic Source and Output Circuits Inside a Building
  - "Where direct current photovoltaic source or output circuits of a utility interactive inverter from a building-integrated or other photovoltaic system are run inside a building or structure, they shall be contained in metallic raceways or enclosures from the point of penetration of the surface of the building or structure to the first readily accessible disconnecting means.

Supply Side Inter-connection Diagram



Label on AC PV Disconnect

Photo 2. Label on ac PV disconnect

Selection & Sizing of Battery for Renewable Energy System Storage

- Battery Selection Criteria
  - Battery Location
  - Environment & Temperature
  - Recharging Resource
  - Expected Battery Life
  - IEEE Standard 937-2000 : IEEE Recommended Practice for the Sizing of Lead Acid Batteries for PV Applications

Battery Technology

- Vented Lead Acid
  - Deep cycle
  - Lead antimony grids
  - Low antimony/selenium grids

Battery Technology

- Valve Regulated Lead Acid (VRLA)
  - Low calcium content grids
  - Absorbed glass matt
  - Gelled electrolyte

Battery Technology

- Nickel Cadmium (NiCd)
  - Fiber structured electrodes made of nickel composite material
  - Lower internal resistance
  - Greater efficiency of plates

CPV System

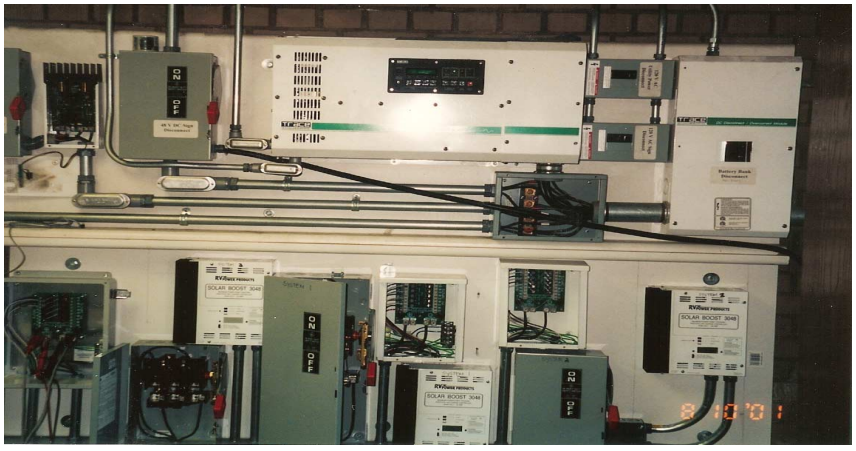
West Larkin Lake

IIT Solar Hydrogen Project

- 2.2kW & 2.7kW Arrays

IIT Solar Hydrogen Project

- Power Electronics



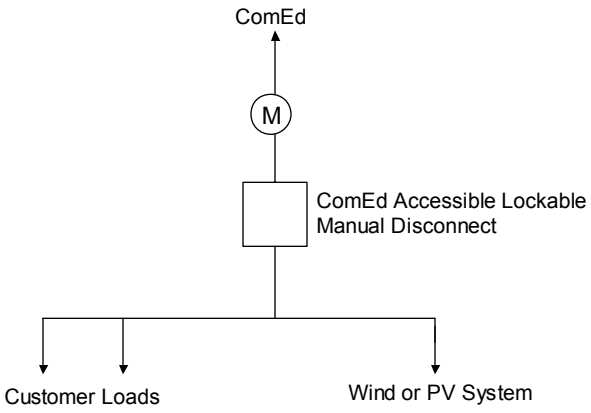
ComEd Interconnection Guidelines for Wind and Photovoltaic Generation Systems

- System is 40 kW in size or smaller
- Wind and PV systems must not adversely affect the power quality, reliability or safety of ComEd's system. The wind or PV system must meet or exceed the power quality requirements as stated in the most current version of IEEE 929.
- Approval for operation in parallel with the ComEd system must be obtained prior to operation.
- System should automatically disconnect when a loss of ComEd's supply occurs.

Interconnection Guidelines (cont.)

- A special two-channel meter that will separately measure the gross amount of electricity delivered by ComEd to the customer and the excess electricity generated by the customer that flows back to ComEd must be installed.
- A manual disconnect that is visible and accessible to ComEd and lockable with a ComEd lock must be installed.
- Inverter based generators must be installed in accordance with current IEEE 929 standards and be UL 1741-listed using utility interactive (non-islanding) inverters with non adjustable set-points.
- Set-points to conform to IEEE 1547 or manufacturers recommendation, whichever is more conservative.

Net Metering Connection



ComEd Rider 4

- Pays the customer for all power supplied at avoided costs pursuant to Rider 4.
- Option A: Sale of entire output of the Qualifying Facility to the Company, and purchase of all of the customer's electricity requirements from the Company or a Retail Electric Supplier
- Option B: Use of the output of the Qualifying Facility to provide a portion of customer's own electricity requirements, and purchase of the customer's remaining requirements from the Company or a RES. Customer may sell any excess output.

Summer Months	All Other Months	
4.55¢	**3.64¢**	**for all kW-hrs supplied during Energy Peak Periods**
2.97¢	**2.67¢**	**for all kW-hrs supplied during Energy Off-Peak Periods**