Electrical Plan Review
Submittal Guide / Checklist

October 2015

Electrical Code

National Electrical Code (NEC) 2014
Bellevue Electrical Ordinance – Washington Cities Electrical Code (excluding the Administrative portion, instead use Bellevue Construction Code Administrative section 23.05)

Introduction

The following pages describe the information that needs to be submitted in order to complete the electrical plan review for your project. Included in this Submittal Guide are:

- The City of Bellevue's criteria for when electrical plan review is required along with RCW, WAC, and Washington Cities Electrical Code requirements for electrical plan review.
- The Electrical Plan Review Checklist. This is the form that will be used by the electrical plans examiner when performing the electrical plan review.
- A list of equipment required to be on the Emergency or Legally Required Systems.
- Smoke Control plan review requirements
- Examples of typical items included in electrical plans

The intention of the City of Bellevue's electrical plan review program is to assist you in assembling an accurate and complete presentation that will demonstrate that your proposed design is in compliance with the appropriate codes. Your submittal may use our forms, or you may create your own (as long as they are in accordance with our requirements), except for large projects that require extensive fault current calculations. Our goal is to provide you with the quickest turn around time possible. Providing complete submittal information will help to achieve this goal.

All applicants for an electrical permit in the City of Bellevue are required to complete an Electrical Permit application. Please provide a specific description of the work to be completed.

Although your electrical plans will be checked for compliance with many sections of the National Electrical Code, the main focus of our review will be the load on the electrical system and life-safety issues. Your review will begin at the individual branch circuit and will investigate all equipment and conductors in the load path back to the service point.

We welcome your constructive comments. If you have any comments, questions, or concerns with the City of Bellevue's electrical plan review program, please contact:

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Requirements for Electrical Plan Review

Submit electrical plans for the following installations:

- Multifamily: 3 units and larger.
- All work on electrical systems operating at over 600 volts.
- All educational, institutional, and health or personal care occupancies classified or defined in WAC 296-46B-010(14).
    - All commercial generator or UPS installations.
    - All wind, solar, or fuel cell installations for commercial or residential occupancies.
- All work in areas determined to be a hazardous (classified) location by the NEC.
- Existing tenant alterations 2,500 square feet and greater, where the load is increased by 100 amperes or greater, or the service is altered. This will include sub panels, transformers, UPS systems, and generators.
- Other installations under 2,500 square where there is a significant increase in load (100amps or more) or the service is altered.
- If 60% or more of lighting fixtures change, contact the electrical plan reviewer.
- Temporary Services 400 amps and larger 120/208 volts
- Temporary Services – 277/480 volts

Design, signature, and stamp requirements by a registered electrical engineer are required for the following electrical installations:

- All services or feeders rated 1600 amperes or larger or any special considerations to the service.
- Installations that require engineering supervision by the NEC.
- Per the requirements of the City of Bellevue ordinances. Ord:23.05.105 (All educational facilities, hospitals, and nursing homes)
- As required by the building official for installations, which by their nature, are complex or hazardous or pose unique design problems.

Checklist – Electrical Plan Review

The intent of this checklist is to provide a general guideline for electrical plan review. This checklist may not include all items to be verified for every plan review encountered. This checklist may include more items than a specific set of electrical plans may encompass. Please tailor this checklist for the electrical plans submitted and the scope of your particular job.

Submittal Items (2 copies of each of the following)

____ Electrical plans showing power and lighting for each floor & the location of all panelboards.

____ Electrical plans that are stamped and bear the engineer's signature who is a Registered Professional Electrical Engineer by the State of Washington (where required).

____ Electrical panel schedules showing individual loads in VA or KVA and the A.I.C. rating.

____ Riser or one-line diagram with wire and raceway size, type, and grounding methods.

____ Electrical load calculations, including a load summary showing connected loads and all demand/diversity factors.

____ Fault current calculations and arc flash calculations through the subpanelboard level.

____ Lighting budget calculations per the current adopted Washington State Energy Code.

____ Selective coordination information for Emergency, Legally Required, and Elevator systems.

____ Arc flash hazard calculations

____ PV system one-line and module description sheet

On the 2 Plan copies or PDF format plans, provide the following information:

Electrical Load Calculations

____ Breakdown of connected loads into proper NEC categories (lighting, receptacles, motors, HVAC, kitchen equipment, appliances, etc.)

____ NEC demand factors applied to each category of load.

____ Total connected load in VA or KVA.

____ Total calculated load in amps and KVA.

____ Panelboard load calculation worksheet completed for all panelboards.

____ Starting loads for the worst case (max. starting loads with everything starting that is required to start at the same time) and any starting variables (soft start, variable frequency drives, etc.) for the Emergency, Legally Required, and Optional Standby systems.

Fault Current Calculations on the Riser Diagram

____ Submitted on a City of Bellevue form and providing enough information on the riser diagram to verify calculations. Very large projects will require a "Fault Current Summary".

Fault Current Summary must include the following;

__ The starting nodes for fault current in a cascading format as they relate to the one line diagram.
__ The starting fault current at the beginning of each conductor.
__ The ending fault current at the ending of the conductor.
__ The conductor's impedance, size and length.
__ The date when the study was performed
__ The conduit type (Metallic or Non-Metallic)
__ The A.I.C. rating of the service, panelboards, and overcurrent devices.

____ Utility transformer size in KVA, impedance (%Z), and available fault current.

____ Complete the fault current information through the subpanelboard level or provide calculations to below the minimum AIC rating of the electrical equipment and overcurrent devices.

____ Available fault current shown on the one-line diagram for all nodes

____ Series rated systems - indicate on the one-line or the panel schedules the circuit breaker model numbers for every panel or switchboard involving a series rated system. Also please provide corresponding series rating charts from the manufacturer (with arrows indicating the breaker types) so the series rated system can be verified.
This information should be provided in a systematic way as it relates to the one-line diagram, down to the point in the system that the fault current is less than the fully rated or series rated overcurrent protective device and gear.

Riser Diagram (one-line)

____ Clearly identify the service point.

____ Identify voltages and number of phases

____ Service conduit(s) size & type, number of parallel runs, conductor(s) size & type, insulation type, and number of conductors.

____ Service equipment ampacity, A.I.C. rating and the A.I.C. ratings of the overcurrent protection.

____ Indicating points (nodes) at line and load points along the one-line diagram. The nodes should state the AIC levels at key points of terminations of electrical equipment.

____ Indication of ground fault protection of equipment when required.

____ Size of the grounded service conductor for the maximum unbalanced load.

____ Grounding electrode system, including concrete encased electrode, the sizing of the grounding electrode conductor, and main bonding jumper for the service equipment.

____ Feeder(s) conduit size & type, conductor size & type, and number of conductors.

____ Type of equipment grounding conductor and equipment bonding jumper for feeder(s), size if applicable.

____ Panelboard(s) ampacity, A.I.C. rating and overcurrent protection.

____ Transformer(s) secondary tap conductor length to overcurrent protective device.

____ Grounding electrode system and grounding electrode conductor for transformer(s).

____ Size of equipment bonding jumper and system bonding jumper for the transformer(s).

____ Overcurrent protection of transformer(s) complies with NEC 450-3 and overcurrent protection of secondary "taps" per 240.21.

____ Identify all fuse types (class type)

Floor Plan (Lighting)

____ Electrical plans denote the type and location of all lighting fixtures.

____ Electrical plans denote all required switch locations.

____ Home-run conduit(s) showing size, type, and number of conductors.

____ Branch circuit(s) properly sized for the load.

____ Emergency lighting clearly denoted on plans.

____ Unit equipment used for egress lighting complies with NEC 700-12(e).

____ Photometric plans for Egress lighting in parking garages. Please provide, for each level of building parking, photometric drawings of the emergency egress lighting per IBC section 1006.4, showing 1 ft. candle average and .1 ft. candle minimum, in a pathway down each drive isle leading to each exit.

Energy Code Compliance

____ Electrical plans correspond to the lighting summary; including number and wattage of the lighting fixtures, type of lighting fixture, the occupancy type, and the watts per square foot allowed specifically based on the Building Area Method or the Space by Space method.

____ Lighting control complies with the currently adopted Washington State Energy Code. (When required) http://www.neec.net/energy-codes Chapter C405

____ Completed copies of a lighting summary form. See http://neec.net/sites/default/files/neec_codes/forms12/LTG12-v3a.xlsm

Floor Plan (Power)

____ Electrical plans denote the location of all switchboard(s), panelboard(s), and transformer(s).

____ All electrical equipment has working clearance shown as required by NEC Article 110.

____ Receptacle outlet locations. Receptacles required by local amendments, for rooftops, for show windows, etc., and as required by NEC 210.52 and Bellevue City Codes and Ordinances.

____ Electrical equipment schedule.

____ Locations denoted on electrical plans for all motors, compressors, heaters, stationary appliances, etc.

____ Homerun conduit(s) showing size, type, and number of conductors.

____ Branch circuit(s) properly sized for the load.

____ Over 112.5 KVA transformers require 1 hour rated construction surrounding them.

____ Diagram of any transformer vaults including drain pipes, curbing, venting, and fire ratings.

Panel Schedules

____ Panelboard(s) are identified by naming convention and consistent throughout the plans.

____ Panelboard busbar rating in amps shown.

____ Panelboard voltage rating is shown.

____ Main breaker size or main lug only is shown.

____ Panel schedule denotes double lugs or feed-through lugs.

____ The description or coding is provided for each branch circuit (IE: motors, lighting, general use receptacles, etc.).

____ The connected load of each branch circuit is shown in VA or KVA.

____ The total connected load is shown in VA or KVA.

____ The demand load totals with each branch circuit denoted with a designator as to what kind of load it is (lighting, motor, general use receptacle, specific use receptacle, etc.)

____ The A.I.C. rating of the panelboard and overcurrent devices

____ Time/current curves showing compliance with the selective coordination requirements for elevators and escalators, , emergency, legally required systems, and essential electrical systems in health care facilities. This needs to be provided for both the normal power and emergency/legally required standby sides of the automatic transfer switch(es).

For elevators and escalators, this shall be shown to the next common overcurrent device (common to more than one driving machine) above the elevator overcurrent device to the level of .01 time line, for emergency and legally required systems to the .01 timeline and for essential electrical systems in health care facilities to beyond the .1 timeline.

____ Arc flash hazard calculations where required (see below under the heading Arc Flash Hazard Calculations)

Emergency, Legally Required Standby, or Optional Standby Systems

See also the section on Equipment System Designations, which follows this section.

____ Generator capacity and voltage including starting and running capacity.

____ UPS capacity and voltage.

____ System properly sized for the load.

____ Indicate that the room, that houses the emergency generating system, has a 2 hour fire rating (NFPA 20)

____ Emergency system is totally separate from all other systems.

____ Individual transfer switches required.

____Grounding electrode conductor properly sized (When required for separately derived systems). State the number of "poles" in the transfer switch.

____ Signage as required by NEC is denoted on plans.

____ Selective coordination of overcurrent protective devices for Emergency and Legally Required systems down to the .01 timeline – overlaid time/current curves for each branch from each power source to each branch circuit overcurrent protective device on one sheet. This needs to be provided for both the normal power and emergency/legally required standby sides of the automatic transfer switch(es).

____ Provide 2 hour protection of the pressurization fan(s) circuit(s) from the emergency generator to the fan.

____ Provide separation of the pressurization circuits from other electrical system components

____ On a high rise building, if there are electrical fire pumps, they need to be calculated into the generator load calculation and service load calculation if fed through the service

____ Provide 2 hour protection for feeders from emergency generator to Fire Service Elevators

Peak Demand Records (NEC 220.87 or WCEC 220.87(1) exception)

____ Starting and ending dates of the metering.

____ Highest reading of the metering period clearly shown.

____ Calculation per 220.87 shown

____ Power factor adjustment shown, when necessary.

____ Explain the details of seasonal and occupancy adjustment factors.

____ Utility demand records or recordings of demand metering for the peak period must accompany the submittal.

____ Signature of the “administrator or engineer” who took the readings.

Healthcare Facilities

____ Clear definition of area use (i.e.: dental, medical, chiropractic, etc.)

____ Indicate the ceiling height as it pertains to a Patient Care Area

____ Clear definition of rooms uses (i.e.: patient room, nurses’ station, critical care, general care, etc.)

____ One-line showing separate transfer switches for equipment, life safety, and critical branches

____ Ground Fault Protection where required and at the next level as required.

____ Wiring methods in patient care areas.

____ Selective coordination of overcurrent protective devices for the emergency and essential electrical system and subfeeds (where required)

Hazardous Locations

____ Clear definition of area use. Where the classified location starts and stops.

____ Wiring methods (type of conduit).

____ Location of sealing fittings where required, and identify the location. (Class 1 Div.1 etc.)

____ Depth of buried conduit.

____ Diagram of sump pump showing motors, drain pipes, and all chambers.

Smoke Control Systems (high rises, places of assembly of 1000 or more persons and other building types where required)

____ Panel schedule (industry standard type) for the emergency panel with connected and demand loads.

____ Schedule of smoke control components showing equipment, its' load in amps or volt-amps, conduit type and size, conductor type and size, and breaker type and size.

____ Floor plans showing the location of the smoke control components.

____ Show all emergency system wiring methods pertaining to the smoke control.

____ Schedule of individual smoke control components running loads.

____ The total combined loads of smoke control components for start up and run (start up and run shown separately).

____ Identify the color marking, protection, and routing of the conduit from the generator to the pressurization fan(s).

Arc Flash Calculation

____ Provide**:** (1) the incident energy level calculation in cal/cm squared at 18" from the flash hazard; (2) the flash hazard category, and (3) the flash hazard boundary for each service, distribution board, and panel (4) the date the arc flash calculation was done.
Provide this in a cascading format relating to the one line or riser showing:

- the device rating and identification
- the voltage
- the arc duration
- the bolted fault current or the available fault current

The nomenclature used must match the one line diagram for panel/ distribution identification. Please see COB ordinance 110.16. http://www.mybuildingpermit.com/Misc/WA%20Cities%20Elect%20Code%2011-12-09.pdf

Verification of the calculation will not be required where it is stamped and signed by an electrical engineer currently licensed in the State of Washington.

An exception allows no flash hazard analysis where all the following conditions exist:

- The circuit is rated 240volts or less
- The circuit is supplied by one transformer
- The transformer supplying the circuit is rated less than 125kva

____ Provide the arc flash values stated above on the one-line for each service, distribution board, and panel

Electric Vehicle Charging Systems

____ Provide the level of the supply equipment
____ Site or floor plan with location of the system including physical protection specifics if required
____ Conduit and conductor sizes to the outlets or equipment
____ Ratings of equipment
____ Panel schedule with demand and connected load

Photovoltaic Systems – NEC and WAC 51-54A-0605

____ One-line diagram of the system showing conduit and conductor sizes, connection to the existing service, overcurrent size(s) (see examples below)
____ Grounding electrode conductor sizes and location of connection(s) to the system
____ Physical location of the inverter
____ Plan view of the array layout on the roof (clearly showing setbacks from the roof edge and peak)
____ Spec sheet showing the power ratings etc.
____ Penetration location of the conductors into the house or attic
____ Derating calculation of the conductors on the roof and/or in the attic
____ Panels/modules installed on residential buildings with roof hips and valleys shall be located no closer than 18”(457mm) to a hip or valley where panels/modules are to be placed on both sides of a hip or valley
____ Panels/modules installed on residential buildings shall be located no higher than 18” (457mm) below the ridge
____ Location of DC conductors on residences. Conduit, wiring systems, and raceways for PV circuits shall be located as close as possible to the ridge or hip or valley and from the hip or valley as directly as possible to an outside wall to reduce trip hazards and maximize ventilation opportunities. Conduit runs between sub arrays and to DC combiner boxes shall be installed in a manner that minimizes the total amount of conduit on the roof. DC combiner boxes shall be located such that conduit runs are minimized in the pathways between arrays
____ Panel schedule(s) showing loads in demand and connected KVA
____ Show method of the connection per NEC article 705.12

Revisions made after Plans approval

____ Provide revision symbols (clouds or other effective means) around changes with something to indicate the date it was changed. These need to stay on the plans throughout the project.

____ Provide descriptions of specific changes that are proposed in the revised areas
____ Full sets of electrical plans are required for all revisions

Temporary Services (see above categories for specifics on each item below)

____ One-line diagram of the system
____ Load calculations
____ Panel schedule(s)
____ Fault current calculations
____ Arc flash hazard calculations (where required)

Emergency and Legally Required Systems Equipment

(what type equipment needs to be on which system, max. time to energize, and min. run time)

TABLE 403(1)

STANDBY (LEGALLY REQUIRED) AND EMERGENCY POWER

Type of Equipment	Maximum Time to Energize Loads	Minimum Run Time (Duration)	IBC Section	IFC or NFPA Section
Emergency Power Systems[1]				
Exit signs	10 seconds	2 hours for generator power; or 90 minutes for battery backup	1011.5.3	604.2.15 High rises 604.2.16 Underground buildings 1011.5.3 2403.12.6.1 Temporary tents, canopies, membrane structures
Exit illumination	10 seconds	8 hours	1006.3	1006.3 604.2.15 High rises 604.2.16 Underground buildings
Any emergency voice/alarm communication including area of refuge communication systems (barrier-free and horizontal exits)	NFPA 72	24 hours	402.12 Covered mall buildings 403.11 High rises 405.10 Underground buildings 907.2.1.2 Assembly occupancies	604.2.14 Covered mall building 604.2.15 High rises 604.2.16 Underground buildings 907.2.1.2 Assembly occupancies NFPA 72
Fire detection and fire alarms	NFPA 72	24 hours	403.11 High rises	604.2.15 High rises

			405.10 Underground buildings 909.20.6.2 Smokeproof enclosures 907	604.2.16 Underground buildings 907.2.8.3 and 907.2.10.2 NFPA 72
Smoke control systems in high-rise buildings, underground buildings and covered mall buildings including energy management systems are used for smoke control or smoke removal	60 seconds	2 hours	403.11 High rises 404.6 Atriums 405.10 Underground buildings 909.11 Smoke control	909.11
Fire pumps in high-rise buildings and underground buildings	10 seconds	8 hours (NFPA 20)	403.11 High rises 405.10 Underground buildings	604.2.15 High rises and NFPA 20 604.2.16 Underground buildings 913.2 All Fire Pumps
Smokeproof enclosures and elevator shaft pressurization	60 seconds for ventilation	4 hours	403.11 High rises 909 and 909.20.6.2	
Any shaft exhaust fans required to run continuously in lieu of dampers	60 seconds	4 hours	716	
Elevator car operation in high-rise and underground buildings (including control system, motor controller, operation control, signal equipment, machine room cooling/heating, etc.)	60 seconds	4 hours	3003	604.2.15 High rises 604.2.16 Underground buildings
Elevator car lighting and communications in high-rise and underground buildings	10 seconds	4 hours	3003	604.2.15 High rises 604.2.16

				Underground buildings 604.2.19 Elevators
Lights, heating, and cooling for building fire command center and mechanical equipment rooms serving the fire command center	60 seconds	24 hours		604.2.15 High rises
Power (other than lights, heating and cooling) for building fire command center	60 seconds	4 hours		
Mechanical and electrical systems required by IFC 27 (hazardous materials including UPS rooms)	60 seconds	4 hours		Article 27
Legally Required Standby[1]				
Pressurization equipment for low-rise buildings	60 seconds	4 hours	909 909.20	
Exhaust fans for any loading dock located interior to a building	60 seconds	4 hours		
Operation of elevators used as accessible means of egress in low-rise buildings (including car lighting, communications, control system, motor controller, operation control, signal equipment, machine room cooling/heating, etc.)	60 seconds	4 hours	1007.4 and .5 3003	604.2.19 Elevators 1007.4 and .5
Fire pumps in low-rise buildings	10 seconds	8 hours		913.2 and NFPA 20
Transformer vault ventilation equipment	60 seconds	4 hours		
Heat tape for sprinkler lines and heating in sprinkler riser rooms	60 seconds	24 hours		
Fuel pump system for any legally-required system	60 seconds	4 hours		
Sewage disposal pumps	60 seconds	4 hours		

TABLE 403(1) FOOTNOTES:

1. The fuel pump and associated systems for the emergency or legally required generator shall be provided with power from the generator to maintain fuel supply.

Forms

Copies of these forms are found on the following pages:

Fault Current Calculation Form
Sample One-Line Diagram
Sample Single-Phase Panel Schedule
Sample 3-Phase Panel Schedule
Generator Calculation Form
Sample Fault Current Calculation Summary Form
Photovoltaic System One-Line, Spec Sheet, and site plan

Your submittal may use our forms, or you may create your own (as long as they are in accordance with our requirements), except for large projects that require more extensive fault current calculations.

Reminders and Notes

- The seismic bracing calculations and diagrams by engineering standards submitted to the building reviewer for equipment between 75 lbs and 400 lbs. at 4' or more above the floor or roof level, or equipment more than 400lbs. at ground level or any height.
- NEC 110.16 & NFPA 70E field marked warning labels to warn workers (qualified) of the potential electric flash hazards.
- Washington Cities Electrical Code 110.16 A plate or label is required and shall include the flash hazard category, the incident energy level in cal/cm(squared) at 18 inches from the flash hazard, and the flash hazard boundary and the date the arc flash calculations were done.
- Bellevue Fire Department requires the circuit and control wiring going to the stairway and elevator shaft pressurization fans be separate and protected from all other systems in the building. They are required to be protected by a 2 hour rated assembly. They shall be separated from the emergency system from the transfer switch (if specific to the pressurization fans) or the first distribution point after the transfer switch to the fans.
- Revisions to the original approved plans need to be clouded and dated indicating when the change took place. The revisions need to be accompanied by a narrative explaining what the change is particular to each cloud and plan sheet.

Fault Current Calculation Form

Permit Number:_____ **Project Name:**_____

Date:_____ **Contractor Name:**_____

The following fault current calculation form must be completed and submitted prior to service approval. See instructions and impedance table on reverse side. Continue these steps until each panel has been addressed or the fault current is below the minimum equipment rating.

A. UTILITY TRANSFORMER **Value** **Total Impedance** **Fault Current**

1. Rated Capacity _____KVA
2. Secondary Voltage _____V _____∅
3. Nameplate % Impedance _____%
   Or
4. Transformer Short Circuit Amps _____Amps
5. Ohmic Impedance (**V** (see **V** defined in step 1 page 2) divided by the short circuit amps)
   _____Ohms (step #1)

B. SERVICE CONDUCTORS

1. Conductor Size _____ Type_____(CU or AL)
2. Length _____Ft
3. Type of Conduit (metal or PVC) _____
4. Impedance per 1000' _____Ohms per 1000'
5. Number of Parallel Runs _____
6. Conductor Impedance (Imp. per 1000' x length divided by (# of parallel runs x 1000))
   _____Ohms (step #2)
7. Total Impedance to Source (**A**5 + **B**6) _____Ohms
8. Fault Current to Load Terminals (**V** (see **V** defined in step 1 page 2) divided by **B**7) _____Amps (step #3)

C. SERVICE ENTRANCE EQUIPMENT

1. Equipment Rating _____Amps
2. Interrupting Rating _____A.I.C.

D. FEEDER CONDUCTOR

1. Conductor Size _____ Type _____(CU or AL)
2. Length _____Ft
3. Type of Conduit _____
4. Impedance per 1000' _____Ohms per 1000'
5. Number of Parallel Runs _____
6. Conductor Impedance (Imp. Per 1000' x length divided by (# of parallel runs x 1000))
   _____Ohms
7. Total Impedance to Source (**B**7 + **D**6) _____Ohms
8. Fault Current at Load Terminals (**V** (see **V** defined in step 1 page 2) divided by **D**7)
   _____Amps
   (step #3)

E. FEEDER PANEL

1. Equipment Rating _____Amps
2. Interrupting Rating _____A.I.C.

TRANSFORMER REPLACEMENTS: Replacements that result in a higher possible fault current, than that of the existing equipment, SHALL be addressed to this department, prior to reconnection of existing service equipment.

----------FAULT CURRENT CALCULATION INSTRUCTIONS----------

(STEP #1)

Secondary Transformer (I.C. Rating) at its rated voltage, calculate Z-ohms as follows:

Transformer Z-ohms = $\frac{\text{V}}{\text{Short Circuit Current}}$ ("V" as defined below)

		V
120/240V	1∅ 3-wire	120
208Y/120V	3∅ 4-wire	120
240 Delta	3∅ 4-wire	140
480Y/277V	3∅ 4-wire	277
480 Delta	3∅ 3-wire	277

(STEP #2) (Using Cable Impedance Data Table Below)

Conductor Impedance = $\frac{\text{(impedance per 1000') X length}}{\text{1000 X number of parallel runs}}$

(STEP #3)

Service I.C. = $\frac{\text{"V"}}{\text{Total Z}}$ (total Z = transformer Z + cable Z)

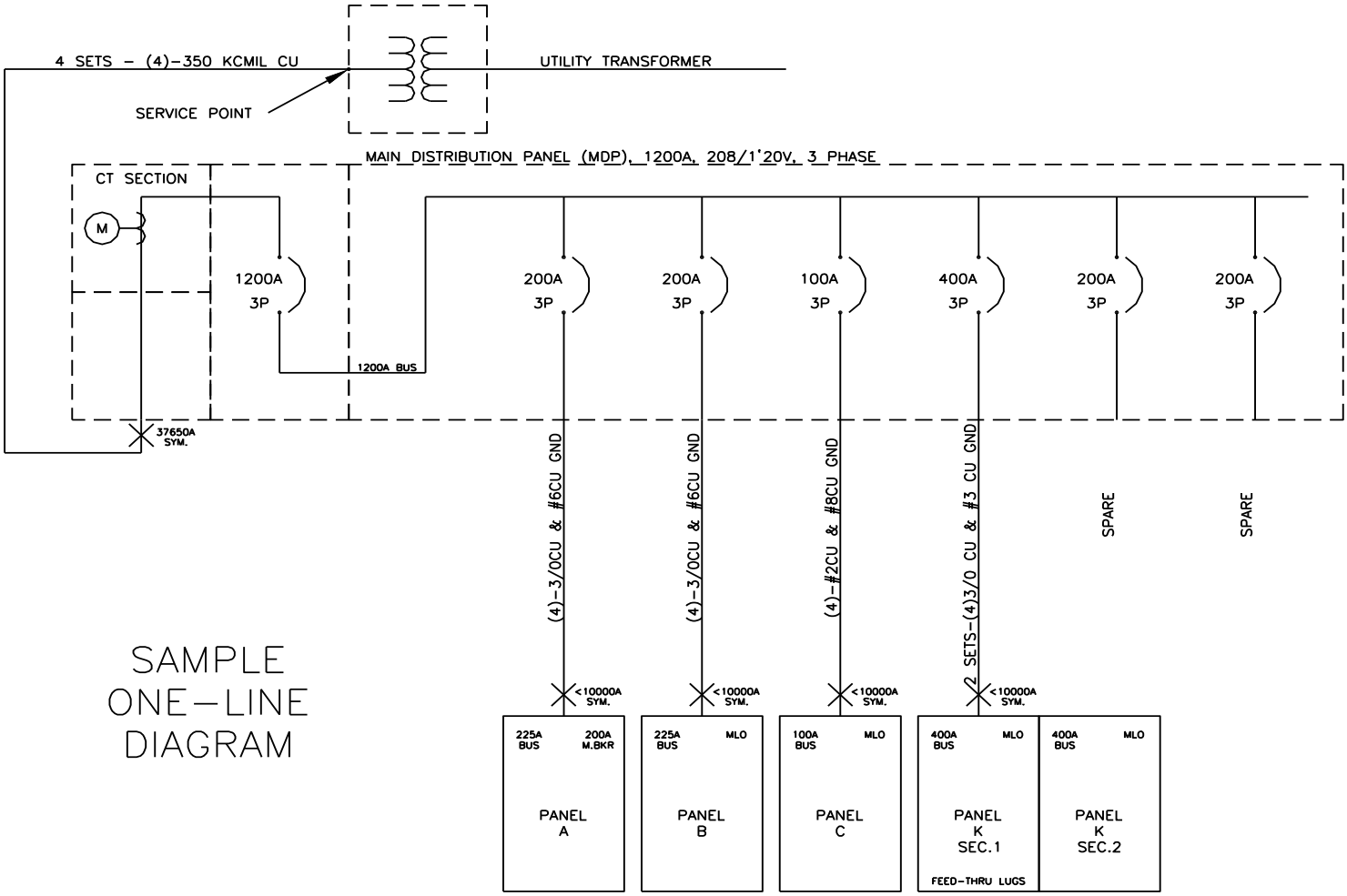
(STEP #4)

Subpanel I.C. = $\frac{\text{"V"}}{\text{Total Z}}$ (total Z = transformer Z + cable Z)

Note:
Continue these steps until each panel has been addressed or the fault current is below the minimum equipment rating.

CABLE IMPEDANCE DATA (ohms per 1000 feet)

Conductors	**Copper**		**Aluminum**	
AWG or KCMIL	**Magnetic Duct**	**Non-Magnetic Duct**	**Magnetic Duct**	**Non-Magnetic Duct**
#2	**0.20**	**0.19**	**0.32**	**0.32**
#1	**0.16**	**0.15**	**0.25**	**0.25**
#1/0	**0.12**	**0.12**	**0.20**	**0.20**
#2/0	**0.10**	**0.10**	**0.16**	**0.16**
#3/0	**0.079**	**0.077**	**0.13**	**0.13**
#4/0	**0.063**	**0.062**	**0.10**	**0.10**
250KCM	**0.054**	**0.052**	**0.086**	**0.085**
300KCM	**0.045**	**0.044**	**0.072**	**0.071**
350KCM	**0.039**	**0.038**	**0.063**	**0.061**
400KCM	**0.035**	**0.033**	**0.055**	**0.054**
500KCM	**0.029**	**0.027**	**0.045**	**0.043**
600KCM	**0.025**	**0.023**	**0.038**	**0.036**
750KCM	**0.021**	**0.019**	**0.031**	**0.029**



SAMPLE
ONE–LINE
DIAGRAM

Sample 1Ø Panel Schedule

PANEL NO.	SECTION: OF	Bus: 240 120 Volts	☐ Main C.B., AMP
Location:	Serving: Normal Power	1 PH, 3 Wire, AMP	☐ Main Lugs Only
Fully Rated SC Rating: RMS SYM AMPS	☐ Feed Thru Lugs ☐ SubFeed Lugs	☐ Iso. Gnd. Bus	☐ Flush Mnt. ☐ Surface Mnt. ☐ Top Feed ☐ Bot. Feed

Load Type	Circuit Description	CONN KVA	C.B. AMP	C.B. Pole	CKT	PH	CKT	C.B. Pole	C.B. AMP	CONN KVA	Circuit Description	Load Type
					1	A	2					
					3	B	4					
					5	A	6					
					7	B	8					
					9	A	10					
					11	B	12					
					13	A	14					
					15	B	16					
					17	A	18					
					19	B	20					
					21	A	22					
					23	B	24					
					25	A	26					
					27	B	28					
					29	A	30					
					31	B	32					
					33	A	34					
					35	B	36					
					37	A	38					
					39	B	40					
					41	A	42					

Total Receptacle (R) Load @ 180VA/ea., 100% for first 10,000VA, & 50% for remainder:			KVA
Total Noncoincident (E) Load	KVA (Not included in demand load)	Total HVAC (H) Load:	KVA
Total Specific Purpose Receptacles	KVA	Total NonContinuous (N) Load:	KVA
Total Motor (M) Load:	KVA	Largest Motor @ 25%: HP	KVA

Total Lighting (L) Load @ 1.25%:	CONNECTED AMP	A	B		MINIMUM FEEDER CAPACITY
TOTAL CONNECTED LOAD: KVA	Total / Phase				KVA A

Sample 3Ø Panel Schedule

PANEL NO.	SECTION: OF	Bus: 480 /277 Volts	☐ Main C.B., AMP
Location:	Serving: Normal Power	3 PH, 4 Wire, AMP	☐ Main Lugs Only
Fully Rated SC Rating: RMS SYM AMPS	☐ Feed Thru Lugs ☐ SubFeed Lugs	☐ Iso. Gnd. Bus	☐ Flush Mnt. ☐ Surface Mnt. ☐ Top Feed ☐ Bot. Feed

Load Type	Circuit Description	CONN KVA	C.B. AMP	C.B. Pole	CKT	PH	CKT	C.B. Pole	C.B. AMP	CONN KVA	Circuit Description	Load Type
					1	A	2					
					3	B	4					
					5	C	6					
					7	A	8					
					9	B	10					
					11	C	12					
					13	A	14					
					15	B	16					
					17	C	18					
					19	A	20					
					21	B	22					
					23	C	24					
					25	A	26					
					27	B	28					
					29	C	30					
					31	A	32					
					33	B	34					
					35	C	36					
					37	A	38					
					39	B	40					
					41	C	42					

Total Receptacle (R) Load @ 180VA/ea., 100% for first 10,000VA, & 50% for remainder:			0.00 KVA
Total Noncoincident (E) Load	0.00 KVA (Not included in demand load)	Total HVAC (H) Load:	0.00 KVA
Total Lighting (L) Load @ 1.25%:	0.00 KVA	Total NonContinuous (N) Load:	0.00 KVA
Total Motor (M) Load:	0.00 KVA	Largest Motor @ 25%: HP	0.00 KVA

TOTAL CONNECTED LOAD:	CONNECTED AMP	A	B	C	MINIMUM FEEDER CAPACITY	
0.00 KVA	Total / Phase	0	0	0	0.00 KVA	0.0 A

LOAD SUMMARY - GENERATOR

750 kW/937kVA, 480Y/277V, 3-PHASE, 4-WIRE Power Factor .8

DESCRIPTION	HORSE POWER	FULL LOAD AMPS	STARTING LOAD(KW)	START kVA	RUN kVA	RUN kW	STARTING MODE
1ST SEQUENCE							
PRIMARY FIRE PUMP	100	115	126.5	159.0	106.0	84.8	REDUCED VOLTAGE
ELEVATOR #3	25	35	119.2	149.0	27.0	21.6	ACROSS THE LINE
ELEVATOR #4	10	15	53.6	67.0	11.0	8.8	ACROSS THE LINE
BASE LOAD			Example		0.0		
LIGHTS				40.0	50.0	40.0	
HEAT OR COOLING				4.0	5.0	4.0	
HEAT OR COOLING				14.0	17.5	14.0	
TOTAL - SEQUENCE 1		165		433.0	216.5	173.2	
2ND SEQUENCE							
FIRE PUMP	250	272		397.5	249.0	199.2	REDUCED VOLTAGE
ELEVATOR #1	15	22		100.0	16.3	13.0	ACROSS THE LINE
ELEVATOR #2	15	22		100.0	16.3	13.0	ACROSS THE LINE
ELEVATOR #5	17.5	24		104.1	19.6	15.7	ACROSS THE LINE
TOTAL - SEQUENCE 2		340	0.0	701.6	301.1	240.9	
3RD SEQUENCE							
EPF1	15	21		100.0	16.3	13.0	ACROSS THE LINE
EPF2	5	7.6		42.5	5.8	4.6	ACROSS THE LINE
EPF3	7.5	11		56.6	8.6	6.9	ACROSS THE LINE
JOCKEY PUMP	2	3.4		17.0	2.4	1.9	ACROSS THE LINE
SEF1	2	3.4		17.0	2.4	1.9	ACROSS THE LINE
SEF2 & EF-4	2	3.4		17.0	2.4	1.9	ACROSS THE LINE
SEF-3	0.3	1		6.4	0.8	0.6	ACROSS THE LINE
SEF4	0.3	1		6.4	0.8	0.6	ACROSS THE LINE
SPF1	3	4.8		25.5	3.5	2.8	ACROSS THE LINE
SPF-10	0.75	1.4		8.0	1.9	1.5	ACROSS THE LINE
SPF-11	1	1.8		9.5	2.0	1.6	ACROSS THE LINE
SPF2	3	4.8		25.5	3.5	2.8	ACROSS THE LINE
SPF3	2	3.4		17.0	2.4	1.9	ACROSS THE LINE
SPF4	2	3.4		17.0	2.4	1.9	ACROSS THE LINE
SPF5	1.5	2.6		12.8	1.8	1.4	ACROSS THE LINE
SPF6	1.5	2.6		12.8	1.8	1.4	ACROSS THE LINE
SPF7	1.5	2.6		12.8	1.8	1.4	ACROSS THE LINE
SPF8	0.75	1.4		8.0	1.0	0.8	ACROSS THE LINE
SPF-9	0.3	1		6.4	0.8	0.6	ACROSS THE LINE
SPRINKLER COMP.	1	1.8		9.5	2.0	1.6	ACROSS THE LINE
SSP1	1	1.8		9.5	2.0	1.6	ACROSS THE LINE
TOTAL - SEQUENCE 3		85.2	0.0	437.0	66.1	52.9	
TOTAL - SEQUENCE 1,2 & 3		**590.2**	**0.0**	**1571.6**	**583.8**	**467.0**	

Please Note:

This spreadsheet is an example only. The values are not representativ
any particular job. Please remove the values and equipment and add
those that reflect your job.

Sequence #1 KVA	Running	Starting	Totals
	216.5	433	
Sequence #2 KVA	Running	Starting	
	301.1	701.6	
Total of Running Seq. #1 plus Starting Seq. #2			918.1
should be less than gen. capacity in KVA			
Sequence #3	Running	Starting	
	66.1	437	
Total of Running Seq. #1 & 2 plus Starting Seq. #3			954.6
should be less than gen. capacity in KVA			
*continue down for the total number of sequences			

Utility XFRM	Voltage	AIC (Start)	Date	Project Title:	City of Bellevue Permit Number:	Page

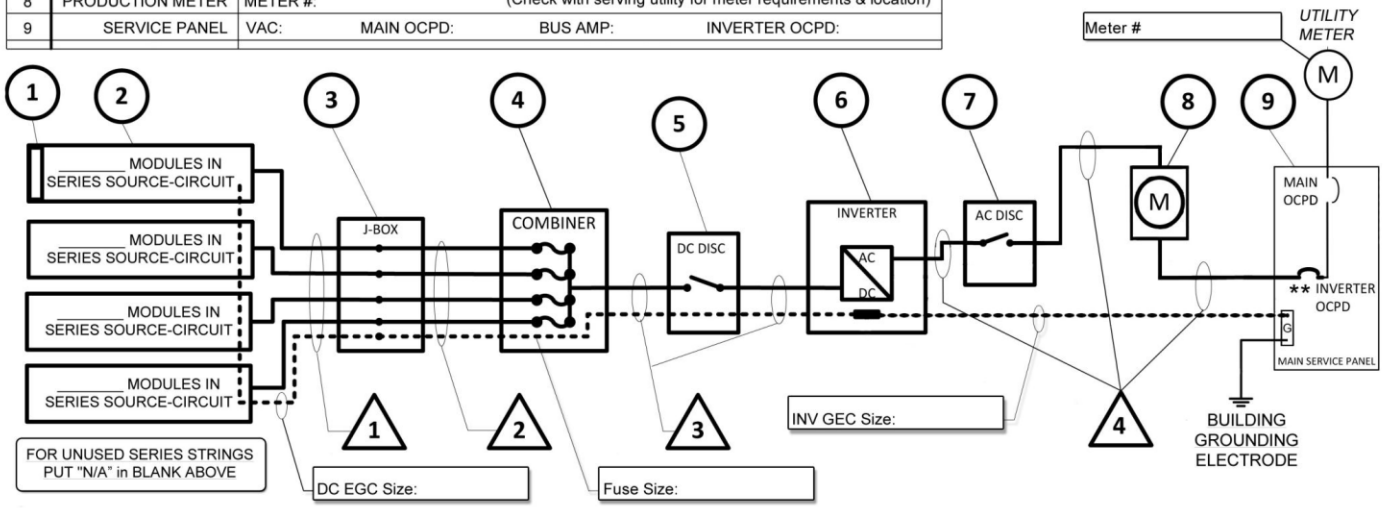
Conductor	Conductor	Conductor Description:					Raceway:	AIC	AIC	AIC	Checked
From	To	Size	Type (CU/AL)	Length/Ft.	Imp./1K Ft.	Qty./Ph.	Metal/PVC	Start	End	Equip/Brkr*	

* The AIC rating of the equipment is the lowest value between the breaker and equipment

Please confirm that the AIC values are shown on the one line/riser diagram

TAG	EQUIPMENT SCHEDULE				
1	SOLAR PV MODULE	MAKE:	MODEL:		(Attach Cut Sheet - See notes for ratings)
2	PV ARRAY	WEIGHT:	HEIGHT FROM ROOF:		(Attach cut sheet of mounting system)
3	J-BOX	LENGTH:	WIDTH:	HEIGHT:	NEMA RATING:
4	COMBINER	MAKE:	MODEL:		(Attach cut sheet)
5	DC DISCONNECT	VDC:	DC AMP:	MAKE:	
6	DC/AC INVERTER	MAKE:			(Attach cut sheet - See notes for ratings)
7	AC DISCONNECT	VAC:	AMPS:	MODEL:	
8	PRODUCTION METER	METER #:			(Check with serving utility for meter requirements & location)
9	SERVICE PANEL	VAC:	MAIN OCPD:	BUS AMP:	INVERTER OCPD:

Contractor - Installer Information	
Permit #:	Date:
Name:	
Address:	
Contact Name:	
Contact Phone:	
Email:	



TAG	Conductor Insulation Type	CU/AL	Conductors Size	Conductors Amps	Conductors Num	*Derated Amps	Raceway Size	Raceway Type	Ambient Temp Roof	Ambient Temp Attic	Distance off Roof	
1												
2												
3												
4												

* Note: Derating of conductors based on number of conductors in raceway, ambient temp and distance off roof where applicable. (NEC 310.15)
** Note: Conductors and overcurrent devices shall be sized to carry not less than 125 percent of the maximum currents. (NEC 690.8(B))

Standard Electrical Diagram - Residential Small Scale PV System
Central Inverter Systems

THIS PLAN MUST BE PROVIDED TO THE INSPECTOR AT THE JOB SITE

Site Name:

Site Address:

This plan is NOT intended to be used with micro inverters or transformer-less inverters. Conductors, where installed outdoors in raceways shall be "W" rated and have an insulation rating of 90 deg C.

Rev - 02/21/2013

NOTES for Residential Small Scale PV System Electrical Diagram	
Permit #:	Date:
Contractor:	
Job Address:	
Contact Name:	
Contact Phone:	

SIGNS

SIGN FOR DC DISCONNECT

PHOTOVOLTAIC POWER SOURCE	
RATED MPP CURRENT	A
RATED MPP VOLTAGE	V
MAX SYSTEM VOLTAGE	V
MAX CIRCUIT CURRENT	A
WARNING: ELECTRICAL SHOCK HAZARD–LINE AND LOAD MAY BE ENERGIZED IN OPEN POSITION	

SIGN FOR INVERTER OCPD AND AC DISCONNECT (IF USED)

SOLAR PV SYSTEM AC POINT OF CONNECTION	
AC OUTPUT CURRENT	A
NOMINAL AC VOLTAGE	V
THIS PANEL FED BY MULTIPLE SOURCES (UTILITY AND SOLAR)	

PV MODULE RATINGS

MODULE MAKE	
MODULE MODEL	
MAX POWER-POINT CURRENT (I_{MP})	A
MAX POWER-POINT VOLTAGE (V_{MP})	V
OPEN-CIRCUIT VOLTAGE (V_{OC})	V
SHORT-CIRCUIT CURRENT (I_{SC})	A
MAX SERIES FUSE (OCPD)	A
MAXIMUM POWER (P_{MAX})	W
MAX VOLTAGE (TYP 600V_{DC})	V
VOC TEMP COEFF (mV/ºC □ or %/ºC □)	
IF COEFF SUPPLIED, CIRCLE UNITS	

INVERTER RATINGS

INVERTER MAKE	
INVERTER MODEL	
MAX DC VOLT RATING	V
MAX POWER @ 40ºC	W
NOMINAL AC VOLTAGE	V
MAX AC CURRENT	A
MAX OCPD RATING	A

LOWEST EXPECTED AMBIENT TEMP:	ºC
HIGHEST CONTINUOUS TEMPERATURE:	ºC

NEC 690.8(B) Photovoltaic system currents shall be considered continuous.

NEC 690.8(B)(1) The circuit conductors and overcurrent devices shall be sized to carry not less than125 percent of the maximum currents calculated in 690.8(A).

Exception: Circuits containing an assembly, together with its overcurrent device(s), that is listed for continuous operation at 100 percent of its rating shall be permitted to be utilized at 100 percent of its rating.

All signage and markings shall be a phenolic or metalic plate or other similar material in block letters 1/4 inch or greater in height, and suitable for the environment. Letters and background shall be in contrasting colors. Screws, rivets or other approved means shall be used to affix plates to equipment.

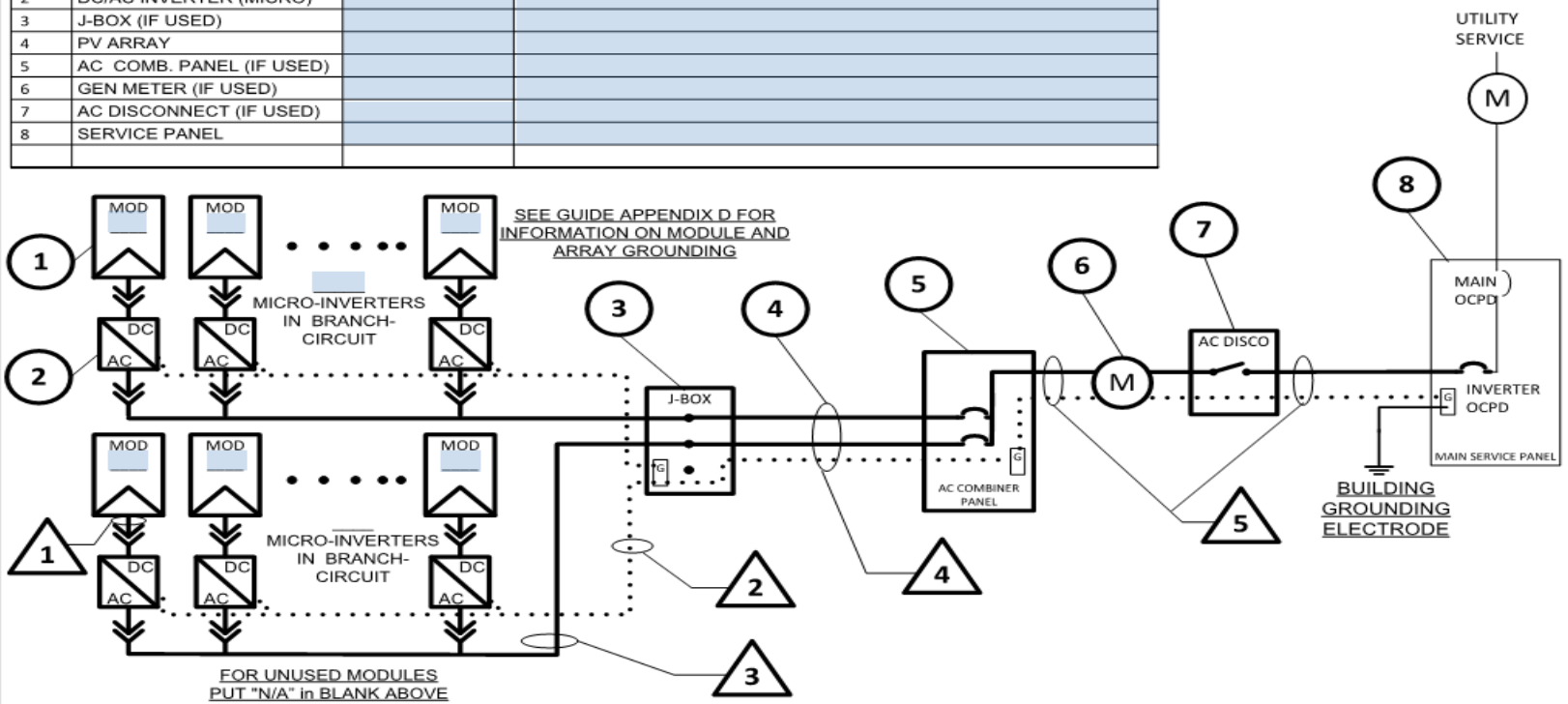
INVERTER		PANELBOARD	
Maximum Current	OCPD Size	Main Bus	Main OCPD
56 amps	70 amps	225 amps	200 amps
36 amps	45 amps	225 amps	225 amps
33 amps	40 amps	200 amps	200 amps
24 amps	30 amps	150 amps	150 amps
20 amps	25 amps	125 amps	125 amps
16 amps	20 amps	100 amps	100 amps

Rev. 02/06/2013

SITE PLAN RESIDENTIAL SMALL SCALE PV SYSTEM		Provide roof outline with location of all PV panels, j-box, combiner and DC disconnect.	
Permit #:	Date:	Contractor:	Contrator Phone:
Job Address:		Contact Name:	Contact Phone:

Micro-Inverter Electrical Diagram

EQUIPMENT SCHEDULE			
TAG	DESCRIPTION	PART NUMBER	NOTES
1	PV DC or AC MODULE		
2	DC/AC INVERTER (MICRO)		
3	J-BOX (IF USED)		
4	PV ARRAY		
5	AC COMB. PANEL (IF USED)		
6	GEN METER (IF USED)		
7	AC DISCONNECT (IF USED)		
8	SERVICE PANEL		



CONDUIT AND CONDUCTOR SCHEDULE					
TAG	DESCRIPTION OR CONDUCTOR TYPE	COND. GAUGE	NUMBER OF CONDUCTORS	CONDUIT TYPE	CONDUIT SIZE
1	USE-2 ☐ or PV WIRE ☐	MFG	MFG Cable	N/A	N/A
2	GEC ☐ EGC ☐ X ALL THAT APPLY			N/A	N/A
3	EXTERIOR CABLE LISTED W/ INV.	MFG	MFG Cable	N/A	N/A
4	THWN-2 ☐ or XHHW-2 ☐ or RHW-2 ☐				
	GEC ☐ EGC ☐ X ALL THAT APPLY			SAME	SAME
	NO DC GEC IF 690.35 SYSTEM				
5	THWN-2 ☐ or XHHW-2 ☐ or RHW-2 ☐				
	GEC ☐ EGC ☐ X ALL THAT APPLY			SAME	SAME

Contractor Name, Address and Phone:	One-Line Standard Electrical Diagram for Micro-Inverter PV Systems
	Site Name:
	Site Address:
	System AC Size:
Drawn By:	SIZE / FSCM NO / DWG NO / REV
Checked By:	SCALE NTS / Date: / SHEET

Notes for Micro-Inverter Electrical Diagram

PV MODULE RATINGS @ STC (Guide Section 5)

MODULE MAKE	
MODULE MODEL	
MAX POWER-POINT CURRENT (I_{MP})	
MAX POWER-POINT VOLTAGE (V_{MP})	
OPEN-CIRCUIT VOLTAGE (V_{OC})	
SHORT-CIRCUIT CURRENT (I_{SC})	
MAX SERIES FUSE (OCPD)	
MAXIMUM POWER (P_{MAX})	
MAX VOLTAGE (TYP 600V_{DC})	
VOC TEMP COEFF (mV/°C ☐ or %/°C ☐)	
IF COEFF SUPPLIED, CIRCLE UNITS	

NOTES FOR ALL DRAWINGS:

OCPD = OVERCURRENT PROTECTION DEVICE

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

INVERTER RATINGS (Guide Section 4)

INVERTER MAKE	
INVERTER MODEL	
MAX DC VOLT RATING	
MAX POWER @ 40°C	
NOMINAL AC VOLTAGE	
MAX AC CURRENT	
MAX OCPD RATING	

SIGNS–SEE GUIDE SECTION 7

SIGN FOR DC DISCONNECT

No sign necessary since 690.51 marking on PV module covers needed information

SIGN FOR INVERTER OCPD AND AC DISCONNECT (IF USED)

SOLAR PV SYSTEM AC POINT OF CONNECTION	
AC OUTPUT CURRENT	
NOMINAL AC VOLTAGE	
THIS PANEL FED BY MULTIPLE SOURCES (UTILITY AND SOLAR)	

NOTES FOR ARRAY CIRCUIT WIRING (Guide Section 6 and 8 and Appendix E):

1.) LOWEST EXPECT AMBIENT TEMPERATURE BASED ON ASHRAE MINIMUM MEAN EXTREME DRY BULB TEMPERATURE FOR ASHRAE LOCATION MOST SIMILAR TO INSTALLATION LOCATION. LOWEST EXPECTED AMBIENT TEMP ____°C

2.) HIGHEST CONTINUOUS AMBIENT TEMPERATURE BASED ON ASHRAE HIGHEST MONTH 2% DRY BULB TEMPERATURE FOR ASHRAE LOCATION MOST SIMILAR TO INSTALLATION LOCATION. HIGHEST CONTINUOUS TEMPERATURE ____°C

2.) 2009 ASHRAE FUNDAMENTALS 2% DESIGN TEMPERATURES DO NOT EXCEED 47°C IN THE UNITED STATES (PALM SPRINGS, CA IS 44.1°C). FOR LESS THAN 9 CURRENT-CARRYING CONDUCTORS IN ROOF-MOUNTED SUNLIT CONDUIT AT LEAST 0.5" ABOVE ROOF AND USING THE OUTDOOR DESIGN TEMPERATURE OF 47°C OR LESS (ALL OF UNITED STATES),

a) 12 AWG, 90°C CONDUCTORS ARE GENERALLY ACCEPTABLE FOR MODULES WITH Isc OF 7.68 AMPS OR LESS WHEN PROTECTED BY A 12-AMP OR SMALLER FUSE.
b) 10 AWG, 90°C CONDUCTORS ARE GENERALLY ACCEPTABLE FOR MODULES WITH Isc OF 9.6 AMPS OR LESS WHEN PROTECTED BY A 15-AMP OR SMALLER FUSE.

NOTES FOR INVERTER CIRCUITS (Guide Section 8 and 9):

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 PHOTOVOLTAIC POWER SOURCE (DC) CONDUCTORS BASED ON MAX CURRENT ON NEC 690.53 SIGN OR OCPD RATING AT DISCONNECT

4) SIZE INVERTER OUTPUT CIRCUIT (AC) CONDUCTORS ACCORDING TO INVERTER OCPD AMPERE RATING. (See Guide Section 9)

5) TOTAL OF ____ INVERTER OUTPUT CIRCUIT OCPD(s), ONE FOR EACH MICRO-INVERTER CIRCUIT. DOES TOTAL SUPPLY BREAKERS COMPLY WITH 120% BUSBAR EXCEPTION IN 690.64(B)(2)(a)? YES ☐ NO ☐

Contractor Name, Address and Phone:	Notes for One-Line Standard Electrical Diagram for Single-Phase PV Systems			
	Site Name:			
	Site Address:			
	System AC Size:			
Drawn By:	SIZE	FSCM NO	DWG NO	REV
Checked By:	SCALE NTS	Date:	SHEET	