

TITLE : PROCUREMENT OF PHOTOVOLTAIC SOLAR PANEL SYSTEM WITH 6KW AND 12KW 5TH GENERATION
HYBRID INVERTER AND LI-ION BATTERY

LOCATION : DPWH CAMARINES SUR 2nd DEO, (GAD Bldg.) BARAS, CANAMAN, CAMARINES SUR

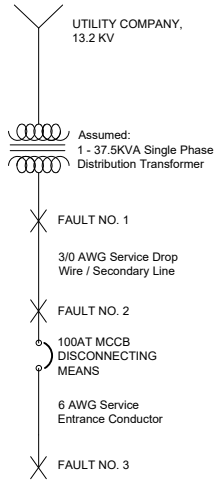
1 DESIGN ANALYSIS
E1 SCALE NTS

STRING PROTECTION DEVICES	
I _{SC}	12.28
I _{CB}	I _{SC} x 125%
I _{CB}	15.35
Protection Device : 16AT DC BREAKER, 1000V SPD Solar Conductor : 2C-4.0 mm ² DC Wire + 1-C 3.5mm ² TW Conduit : 34.5mm ² HDPE Conduit UV Rated	
INVERTER PROTECTION DEVICE	
I _{CB - Inverter}	P _{Inverter} / 230V
P _{Inverter}	12000
I _{CB - Inverter}	52.17
Protection Device : 50AT RCBO Miniature Circuit Breaker, 5KAIC SPD Service Conductor : 2C-14mm ² Copper Wire + 1C-8.0mm ² THHN (G) Conduit : 32mm ø PVC	
BATTERY PROTECTION DEVICE	
I _{CB - Battery}	P _{Inverter} / 52.1V
P _{Inverter}	12000
I _{CB - Battery}	230.33
Protection Device : 225AT Miniature Circuit Breaker, 10KAIC SPD Service Conductor : 2 - 35mm ² DC Battery Wire (Red and Black)	
NOTE : WARNING SHOULD BE MOUNTED ON OR ADJACENT TO THE VISIBLE DISCONNECTION DEVICE AND SHALL BE READ PROMINENTLY.	

CABLE LOSSES	
P _{PV}	2 x I ² x R x L
Resistance (Ohm / Km)	5.09
Length (Km)	0.03
I _{SC}	12.28
P _{PV}	46.05
Power Cable Loss per String : 46.05	
P _{PV(Input)}	P _{PV(Peak)} - P _{PV(Cable)}
P _{PV(Peak)}	500
Panel _{String}	4.00
Tolerance	± 3.00%
P _{PV(Input)}	2013.95
Power Input per String : 2013.95	
V _{PV @ P_{MAX}}	V _{PV} x No. of string
V _{PV @ P_{MAX}}	42.80
V _{PV @ P_{MAX}}	171.20
Voltage PV @ P _{MAX} : 171.20 V	
V _{DROP-CABLE}	2 x I x R x L
V _{DROP-CABLE (V)}	3.75
V _{DROP-CABLE (%)}	2.19

CABLE LOSSES	
P _{PV}	2 x I ² x R x L
Resistance (Ohm / Km)	5.09
Length (Km)	0.03
I _{SC}	12.28
P _{PV}	46.05
Power Cable Loss per String : 46.05	
P _{PV(Input)}	P _{PV(Peak)} - P _{PV(Cable)}
P _{PV(Peak)}	500
Panel _{String}	5.00
Tolerance	± 3.00%
P _{PV(Input)}	2528.95
Power Input per String : 2528.95	
V _{PV @ P_{MAX}}	V _{PV} x No. of string
V _{PV @ P_{MAX}}	42.80
V _{PV @ P_{MAX}}	214.00
Voltage PV @ P _{MAX} : 214 V	
V _{DROP-CABLE}	2 x I x R x L
V _{DROP-CABLE (V)}	3.75
V _{DROP-CABLE (%)}	1.75

CABLE LOSSES	
P _{PV}	2 x I ² x R x L
Resistance (Ohm / Km)	5.09
Length (Km)	0.03
I _{SC}	12.28
P _{PV}	46.05
Power Cable Loss per String : 46.05	
P _{PV(Input)}	P _{PV(Peak)} - P _{PV(Cable)}
P _{PV(Peak)}	500
Panel _{String}	6.00
Tolerance	± 3.00%
P _{PV(Input)}	3043.95
Power Input per String : 3043.95	
V _{PV @ P_{MAX}}	V _{PV} x No. of string
V _{PV @ P_{MAX}}	42.80
V _{PV @ P_{MAX}}	256.80
Voltage PV @ P _{MAX} : 256.80 V	
V _{DROP-CABLE}	2 x I x R x L
V _{DROP-CABLE (V)}	3.75
V _{DROP-CABLE (%)}	1.46



2 SHORT CIRCUIT ANALYSIS
E1 SCALE NTS

Transformer Rating (KVA) :	37.5	Length of Conductor to the fault no. 1 :	1.600 m	52.48 ft
Transformer Impedance %Z _t :	1.50 ± 10%	Length of Conductor to fault no. 2 :	20.00 m	65.60 ft
Voltage _{LL} :	240	Size of Secondary Conductors :	325.0 mm2	500 AWG
Phase :	Single Phase	Size of Service Entrance Conductors :	14.0 mm2	6 AWG

Line - Line Fault
A. Fault X₁ :
$$I_{N1} = \frac{KVA}{Voltage_{L-L}} = \frac{37.5}{240} = 156.25 A$$

$$Multiplier = \frac{100}{\%Z_T \times 0.9} = \frac{100}{1.5 \times 0.9} = 79.365$$

$$I_{SC_{L-L}} = Multiplier \times I_{N1} = 12,400.79 A$$

***** Phase 1 Short Circu Current At Transformer Secondary**
B. Fault X₂ :
$$Factor (f) = \frac{2 \times L \times I_{SC_{L-L}}}{C \times n \times V_{L-L}} = 0.244$$

Where :
L = length (feet) of conductor to the fault
C = constant from Table 4 of "C" values for conductor.
n = Number of conductors per phase (adjusts C value for parallel runs)
I_{SC} = Available short circuit current in amperes at beginning of circuit.
V_{LL} = Voltage of circuit.
$$Multiplier = \frac{1}{1+f} = 0.804$$

$$I_{SC_{L-L}} = Multiplier \times I_{N1} = 9,964.82 A$$

*****Use 10 KAIC MCCB for Main Circu Breaker**
C. Fault X₃ :
$$Factor (f) = \frac{2 \times L \times I_{SC_{L-L}}}{C \times n \times V_{L-L}} = 2.246$$

$$Multiplier = \frac{1}{1+f} = 0.308$$

$$I_{SC_{L-L}} = Multiplier \times I_{N1} = 3,049.53 A$$

*****Use 5/10 KAIC MCCB for Branch Circu Breaker**

Voltage & Phase	KVA Rating	Full Load Ampere	%Z Impedance	Table 4 "C" Values for Conductors	
				AWG or kcmil	600V
120/240 1 Phase	25	104	1.5 ± 10%	14	367
	37.5	156	1.5 ± 10%	12	617
	50	208	1.5 ± 10%	10	961
	75	313	1.5 ± 10%	8	1557
	100	417	1.5 ± 10%	6	2425
120/208 3 Phase	45	125	1.0 ± 10%	4	3806
	75	208	1.0 ± 10%	3	4774
	112.5	312	1.1 ± 10%	2	5907
	150	416	1.07 ± 10%	1	7293
	225	625	1.12 ± 10%	1/0	6925
277/480 3 Phase	300	833	1.1 ± 10%	2/0	10755
	400	1098	1.24 ± 10%	3/0	12844
	750	2082	3.50 ± 10%	4/0	15902
	1000	2776	3.50 ± 10%	250	16483
	1500	4164	3.50 ± 10%	300	18177
277/480 3 Phase	2000	5552	4.00 ± 10%	350	19704
	2500	6940	4.00 ± 10%	400	21566
	75	90	1.0 ± 10%	500	22185
	112.5	135	1.0 ± 10%	600	22945
	150	181	1.2 ± 10%	750	24137
277/480 3 Phase	225	271	1.2 ± 10%	1000	25276
	300	361	1.2 ± 10%		
	500	602	1.3 ± 10%		
	750	903	3.5 ± 10%		
	1000	1204	3.5 ± 10%		
277/480 3 Phase	1500	1806	3.5 ± 10%		
	2000	2408	4.0 ± 10%		
	2500	3011	4.0 ± 10%		

Short circuit amps can be affected by this tolerance. Therefore, for high end worst case, multiply %Z by 0.9. For low end of worst case, multiply %Z by 1.1.

4 12KW HYBRID INVERTER
E1 SCALE NTS

BATTERY INPUT DATA

Battery Type	Lead-acid or Lithium-ion
Battery Voltage Range (V)	40-60V
Max. Charging Current (A)	220A
Max. Discharging Current (A)	220A

PV STRING INPUT DATA

Max. DC Input Power (W)	24000W
PV Input Voltage (V)	500V
MPPT Range (V)	125V-425V
Start-up Voltage (V)	125V
Rated PV Input Voltage	370V
Max Input Short-Circuit Current	44+44+44
Max Operating PV Input Current	26+26+26
No. of MPPT Trackers	3
No. of Strings Per MPPT Tracker	2+2+2

AC OUTPUT DATA

Rated AC Output and UPS Power (W)	12000
Max. AC Output Power (W)	13200
Peak Power (off grid)	2 times of rated power, 10 S
Rated AC Input/Output Current (A)	54.5/52.2
Max AC Input/Output Current	60/57.4
Max Continuous AC Passthrough (grid-load)	100
Rated Input/Output Voltage/Range(V)	220V/230 0.85Un-1.1Un
Rated Input/Output Grid Frequency/Range	60Hz/55Hz-65Hz
Power Factor Adjustment Range	0.8 leading-0.8lagging

EFFICIENCY

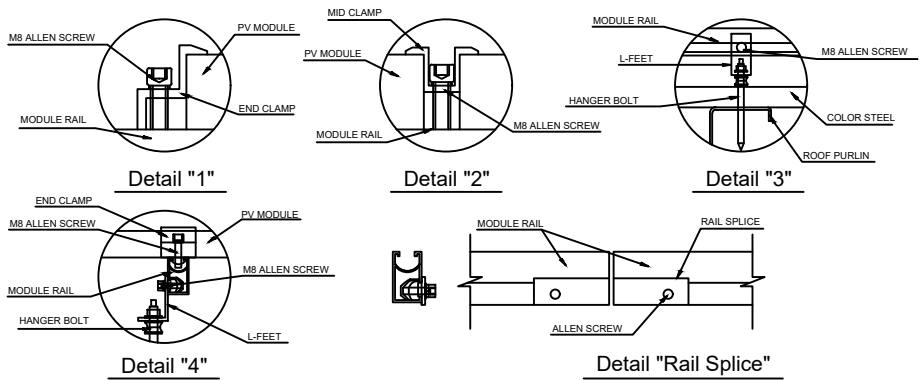
Max. Efficiency	97.60%
Euro Efficiency	96.50%
MPPT Efficiency	>99.00%

5 VICINITY MAP
E1 SCALE NTS



LOCATION : DPWH Camarines Sur 2nd DEO (Maintenance Building)
Baras, Canaman, Camarines Sur

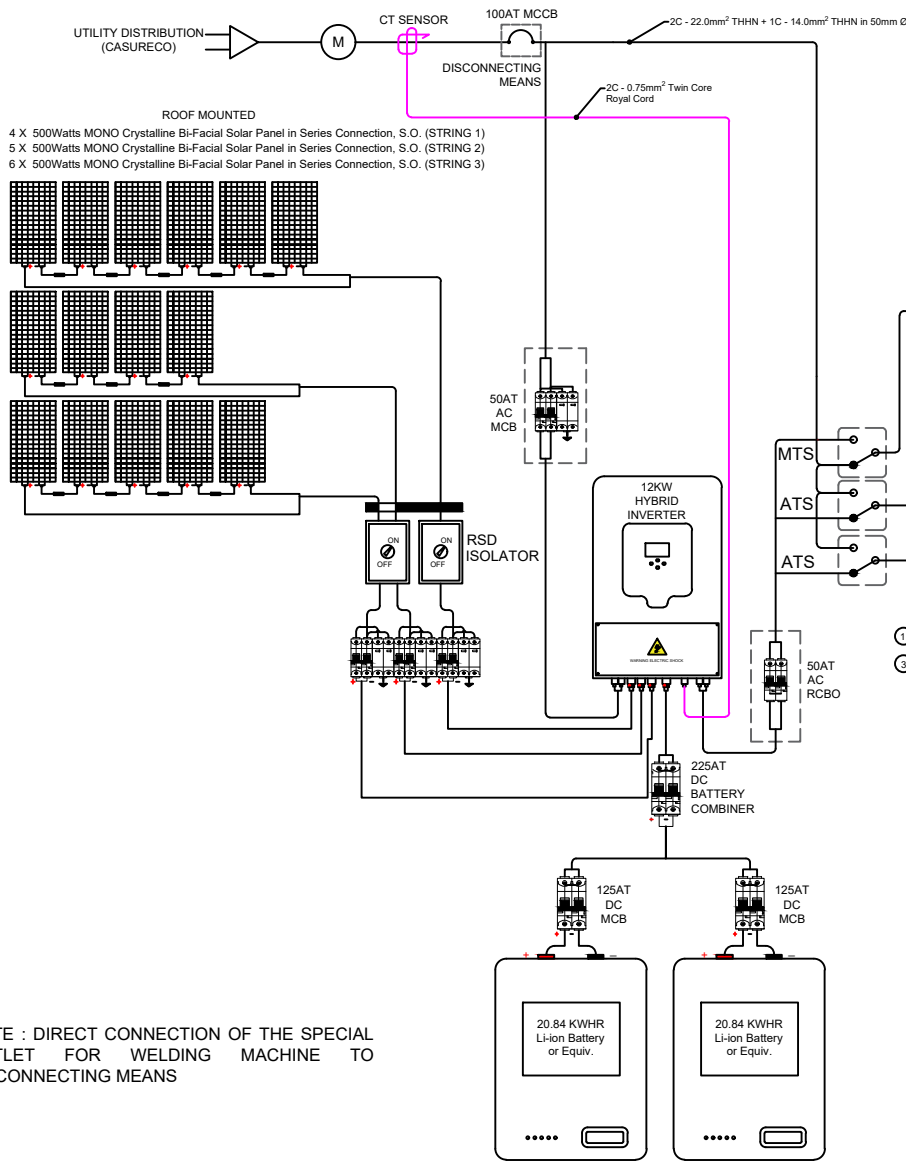
3 MOUNTING BRACKET DETAILS
E1 SCALE NTS



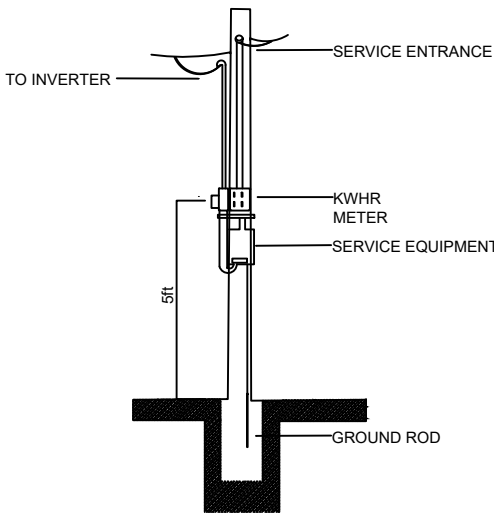
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HYBRID INVERTER AND LI-ION BATTERY

LOCATION : DPWH CAMARINES SUR 2nd DEO, (GAD Bldg.) BARAS, CANAMAN, CAMARINES SUR

1 SINGLE LINE DIAGRAM
E 2 SCALE NTS



2 SERVICE ENTRANCE DETAIL
E 2 SCALE NTS



3 SOLAR ELECTRICAL NOTES
E 2 SCALE NTS

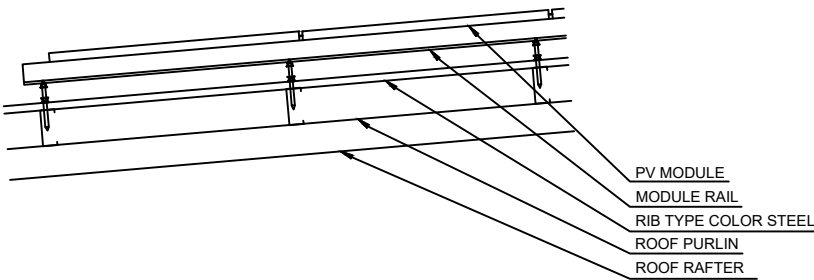
- UTILITY HAS 24HRS UNRESTRICTED ACCESS TO ALL PV SYSTEM COMPONENTS LOCATED AT SERVICE ENTRANCE.
- MODULES CONFORM TO AND ARE LISTED UNDER UL 1703
- CONDUCTORS EXPOSED TO SUNLIGHT SHALL BE LISTED AS SUNLIGHT RESISTANCE AS PER PEC SUNLIGHT RESISTANCE AS PER PEC
- CONDUCTORS/DEVICES EXPOSED TO WET LOCATION SHALL BE SUITABLE FOR USE WET LOCATION OR WITH A PROTECTION RATING OF IP68.
- PHOTOVOLTAIC SOLAR PANEL MOUNTING REQUIREMENT: 4-POINT RAIL SUPPORT SYSTEM

5 SOLAR PANEL
E 2 SCALE NTS

RATED MAXIMUM POWER	500W
CURRENT AT PMAX	11.69A
VOLTAGE AT PMAX	42.80V
SHORT CIRCUIT CURRENT	12.28A
OPEN CIRCUIT VOLTAGE	51.70V

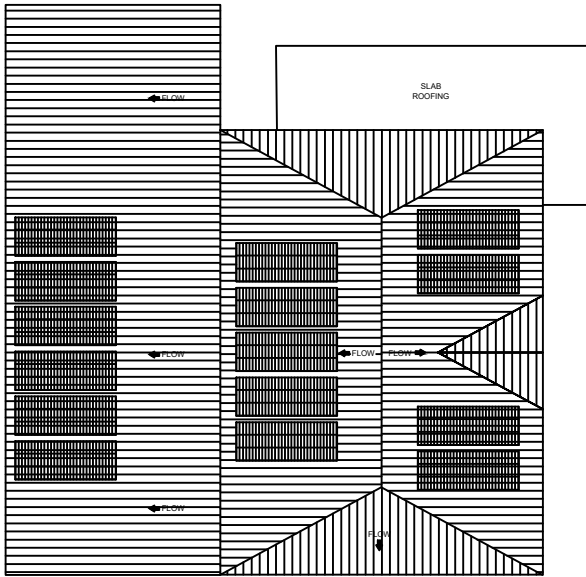
4 ELECTRICAL NOTES
E 2 SCALE NTS

- ALL ELECTRICAL WORKS INDICATED SHALL BE DONE IN ACCORDANCE WITH THE LATEST PROVISION OF THE PHILIPPINES ELECTRICAL CODE RULES AND REGULATION.
- ALL MATERIALS TO BE USED SHALL BE NEW AND APPROVED TYPE FOR ALL LOCATION AND PURPOSES.
- ALL INVERTERS AND ESS MUST HAVE AN AI TECHNOLOGY WITH A FIFTH GENERATION MODEL AND CAN BE PARALLEL UP TO 10 UNITS.
- ALL ELECTRICAL DEVICES MUST HAVE AN INGRESS PROTECTION RATING OF IP66.
- ALL INSTALLATION SHALL BE DONE IN GOOD AND NEAT WORKMANSHIP.
- ALL ELECTRICAL WORKS SHALL BE DONE UNDER THE DIRECT SUPERVISION OF PROFESSIONAL ELECTRICAL / REGISTERED ELECTRICAL ENGINEER



5 ON ROOF PHOTOVOLTAIC SOLAR PANEL CONNECTION
E 2 SCALE NTS

6 ON ROOF PHOTOVOLTAIC SOLAR PANEL PLAN
E 2 SCALE NTS



TITLE: PROCUREMENT OF PHOTOVOLTAIC SOLAR PANEL SYSTEM WITH 6KW AND 12KW 5TH GENERATION
HYBRID INVERTER AND LI-ION BATTERY
LOCATION: TAMBO, PAMPLONA, CAMARINES SUR

1 DESIGN ANALYSIS
SCALE NTS

STRING PROTECTION DEVICES		
I _{SC}		12.28
I _{CB}		I _{SC} x 125%
I _{CB}		15.35

Protection Device : 16AT DC BREAKER, 1000V SPD
Solar Conductor : 2C-4.0 mm² DC Wire + 1-C 3.5mm² TW
Conduit : 34.5mm² HDPE Conduit UV Rated

INVERTER PROTECTION DEVICE		
I _{CB - Inverter}		P _{Inverter} / 230V
P _{Inverter}		6000
I _{CB - Inverter}		26.09

Protection Device : 25AT RCBO Miniature Circuit Breaker, 5KAIC SPD
Service Conductor : 2C-8.0mm² Copper Wire + 1C-5.5mm² THHN (G)
Conduit : 32mm ø PVC

BATTERY PROTECTION DEVICE		
I _{CB - Battery}		P _{Inverter} / 52.1V
P _{Inverter}		6000
I _{CB - Battery}		115.16

Protection Device :100AT Miniature Circuit Breaker, 10KAIC SPD
Service Conductor : 2 - 35mm² DC Battery Wire (Red and Black)

NOTE : WARNING SHOULD BE MOUNTED ON OR ADJACENT TO THE VISIBLE DISCONNECTION DEVICE AND SHALL BE READ PROMINENTLY.

CABLE LOSSES		
P _{PV}		2 x I ² x R x L
Resistance (Ohm / Km)		5.09
Length (Km)		0.03
I _{SC}		12.28
P _{PV}		46.05

Power Cable Loss per String : 60.46W

P _{PV(Input)}	P _{PV(Peak)} - P _{PV(Cable)}
P _{PV(Peak)}	500
Panel String	4.00
Tolerance	± 3.00%
P _{PV(Input)}	2013.95

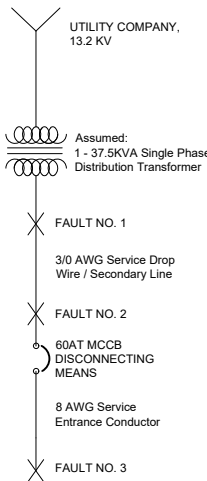
Power Input per String : 4043.24

V _{PV} @ P _{MAX}	V _{PV} x No. of string
V _{PV} @ P _{MAX}	42
V _{PV} @ P _{MAX}	168.00

Voltage PV @ P_{MAX} : 336 V

V _{DROP-CABLE}	2 x I x R x L
V _{DROP-CABLE} (V)	3.75
V _{DROP-CABLE} (%)	2.23

2 SHORT CIRCUIT ANALYSIS
SCALE NTS



SYSTEM DATA :

Transformer Rating (KVA) :	37.5	length of Conductor to the fault no. 1 :	18.00 m	52.48 ft
Transformer Impedance %Z ₁ :	1.50 ± 10%	length of Conductor to the fault no. 2 :	20.00 m	65.61 ft
Voltage L-L :	240	Size of Secondary Conductors :	325.0 mm ²	500 AWG
Phase :	Single Phase	Size of Service Entrance Conductors :	8.0 mm ²	8 AWG

Line - Line Fault

A. Fault X₁ :

$I_{sc} = \frac{KVA}{\sqrt{3} \times V_{oltage} \times \sqrt{1-Z^2}}$ = 156.25 A

Multiplier = $\frac{100}{\sqrt{3} \times \sqrt{1-Z^2}}$ = 79.365

$I_{sc-L-L} = Multiplier \times I_{sc} = 12,400.79 A$

*** Phase 1 Short Circuit Current At Transformer Secondary

B. Fault X₂ :

Factor (F) = $\frac{2 \times L \times \sqrt{1-Z^2}}{C \times n \times \sqrt{1-Z^2}}$ = 0.244

Where :
L = length (feet) of conductor to the fault
C = constant from table 4 of NEC values for conductors.
n = Number of conductors per phase (3-phase C=3 for parallel run)
I_{sc} = Available short-circuit current in amperes at beginning of circuit.
V_{L-L} = Voltage of circuit.

Multiplier = $\frac{1}{1+F}$ = 0.804

$I_{sc-L-L} = Multiplier \times I_{sc} = 9,944.82 A$

***Use 10 KAIC MCCB for Main Circuit Breaker

C. Fault X₃ :

Factor (F) = $\frac{2 \times L \times \sqrt{1-Z^2}}{C \times n \times \sqrt{1-Z^2}}$ = 3.499

Multiplier = $\frac{1}{1+F}$ = 0.222

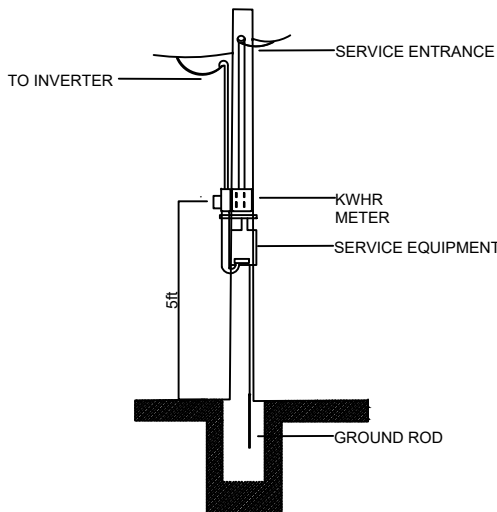
$I_{sc-L-L} = Multiplier \times I_{sc} = 2,215.04 A$

***Use 5/10 KAIC MCB for Branch Circuit Breaker

Voltage & Phase	KVA Rating	Full Load Ampere	%Z Impedance	Table 4. C' Values for Conductors
120/240 1 Phase	25	104	1.5 ± 10%	AWG or kcmil
	37.5	156	1.5 ± 10%	600V
	40	208	1.5 ± 10%	14
	75	313	1.5 ± 10%	12
	100	417	1.5 ± 10%	8
	167	696	1.5 ± 10%	6
	48	125	1.0 ± 10%	4
	75	208	1.0 ± 10%	3
	112.5	312	1.11 ± 10%	2
	150	416	1.07 ± 10%	1
120/208 3 Phase	225	625	1.12 ± 10%	1/0
	350	893	1.11 ± 10%	2/0
	400	1088	1.24 ± 10%	3/0
	750	2082	3.50 ± 10%	4/0
	1000	2776	3.50 ± 10%	250
	1500	4164	3.50 ± 10%	200
	2000	5552	4.00 ± 10%	350
	2500	6940	4.00 ± 10%	400
	75	6	1.0 ± 10%	600
	112.5	115	1.0 ± 10%	600
277/480 3 Phase	150	181	1.2 ± 10%	750
	225	271	1.2 ± 10%	1000
	225	271	1.2 ± 10%	1000
	225	271	1.2 ± 10%	1000
	225	271	1.2 ± 10%	1000
	225	271	1.2 ± 10%	1000
	225	271	1.2 ± 10%	1000
	225	271	1.2 ± 10%	1000
	225	271	1.2 ± 10%	1000
	225	271	1.2 ± 10%	1000

Short circuit amps can be collected by the tolerance. Therefore, for high-end worst case, multiply %Z by 0.3. For low end of worst case, multiply %Z by 1.1.

3 SERVICE ENTRANCE DETAIL
SCALE NTS



4 SOLAR ELECTRICAL NOTES
SCALE NTS

- UTILITY HAS 24HRS UNRESTRICTED ACCESS TO ALL PV SYSTEM COMPONENTS LOCATED AT SERVICE ENTRANCE.
- MODULES CONFORM TO AND ARE LISTED UNDER UL 1703
- CONDUCTORS EXPOSED TO SUNLIGHT SHALL BE LISTED AS SUNLIGHT RESISTANCE AS PER PEC SUNLIGHT RESISTANCE AS PER PEC
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- PHOTOVOLTAIC SOLAR PANEL MOUNTING REQUIREMENT: 4-POINT RAIL SUPPORT SYSTEM

5 SOLAR PANEL
SCALE NTS

RATED MAXIMUM POWER	500W
CURRENT AT P _{MAX}	11.69A
VOLTAGE AT P _{MAX}	42.80V
SHORT CIRCUIT CURRENT	12.28A
OPEN CIRCUIT VOLTAGE	51.70V

6 ELECTRICAL NOTES
SCALE NTS

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7 VICINITY MAP
SCALE NTS



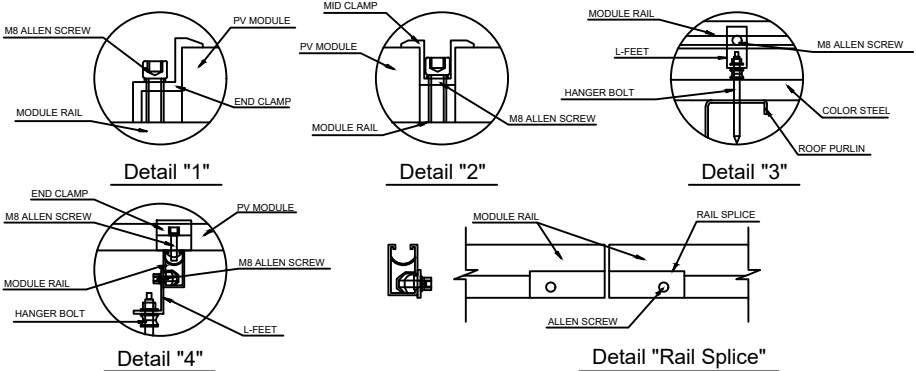
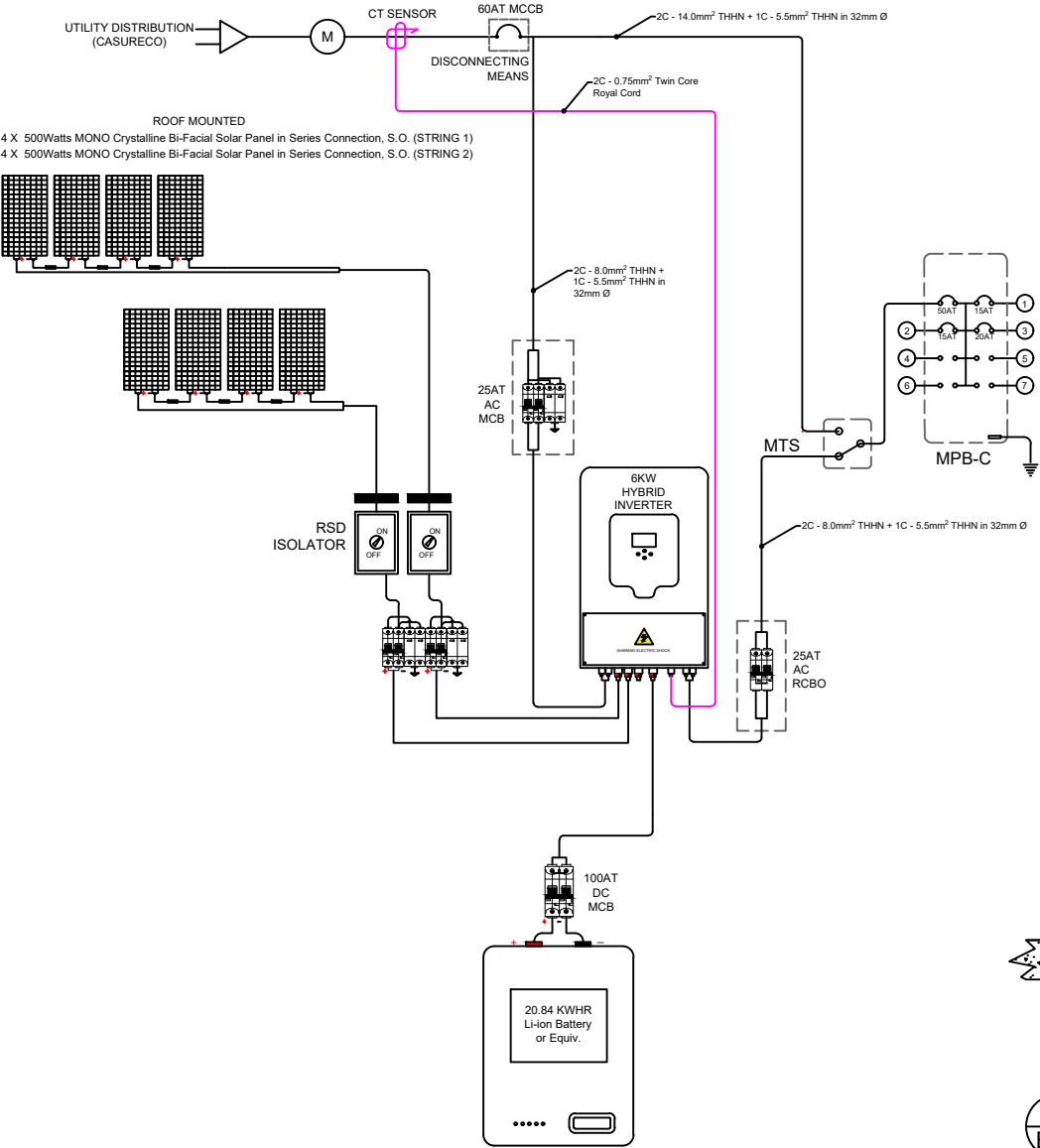
LOCATION : DPWH Camarines Sur 2nd DEO (Sub-Office)
Bgy. Tambo, Pamplona, Camarines Sur

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GENERATION HYBRID INVERTER AND LI-ION BATTERY
LOCATION: TAMBO, PAMPLONA, CAMARINES SUR

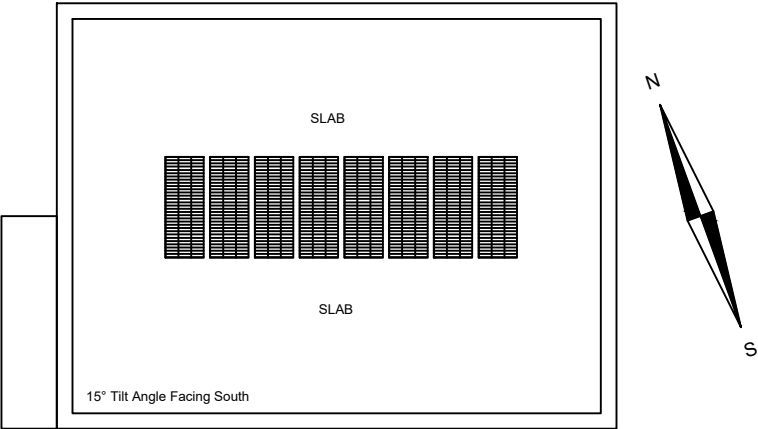
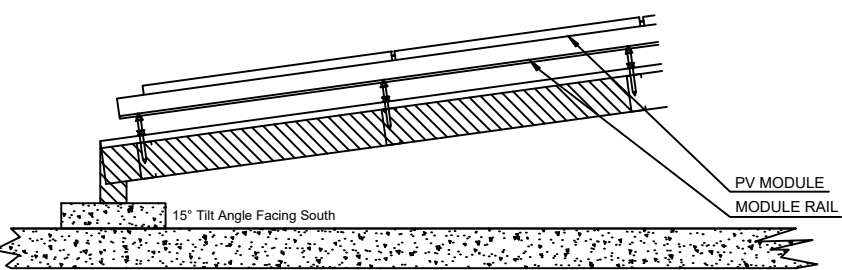
1 SINGLE LINE DIAGRAM
E/2 SCALE NTS

2 MOUNTING BRACKET DETAILS
E/2 SCALE NTS

3 6KW HYBRID INVERTER
E/2 SCALE NTS



BATTERY INPUT DATA	
Battery Type	Lead-acid or Lithium-ion
Battery Voltage Range (V)	40-60V
Max. Charging Current (A)	135A
Max. Discharging Current (A)	135A
PV STRING INPUT DATA	
Max. DC Input Power (W)	12000W
PV Input Voltage (V)	500V
MPPT Range (V)	150V-425V
Start-up Voltage (V)	125V
Rated PV Input Voltage	370V
Max Input Short-Circuit Current	17+17
Max Operating PV Input Current	13+13
No. of MPPT Trackers	2
No. of Strings Per MPPT Tracker	1+1
AC OUTPUT DATA	
Rated AC Output and UPS Power (W)	6000
Max. AC Output Power (W)	6600
Peak Power (off grid)	2 times of rated power, 10 S
Rated AC Input/Output Current (A)	27.3/26.1
Max AC Input/Output Current	30/28.7
Max Continuous AC Passthrough (grid-load)	40
Rated Input/Output Voltage/Range(V)	220V/230 0.85Un-1.1Un
Rated Input/Output Grid Frequency/Range	60Hz/55Hz-65Hz
Power Factor Adjustment Range	0.8 leading-0.8lagging
EFFICIENCY	
Max. Efficiency	97.60%
Euro Efficiency	96.50%
MPPT Efficiency	>99.00%



4 ON ROOF PHOTOVOLTAIC SOLAR PANEL CONNECTION
E/2 SCALE NTS

5 ON ROOF PHOTOVOLTAIC SOLAR PANEL PLAN
E/2 SCALE NTS