A preliminary case study report
on
solar panel installation and design

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Location: Darwin, Winnellie, NT

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Introduction:

A case study has been done by the graduate student of CDU relating to the field of hybrid and off-grid solar panel installation design for the private caravan bus. The case study entirely avoids any professional usage and practical implementation at the site. It is done for the study by the graduate student under the mutual co-operation and understanding of client/ owner of the equipment.

The case study relates with the configuration of available equipment related to solar panel installation on the roof of the bus. The generated electricity solar power will be used for operating personal electronics components by the client inside the bus for daily life usage.

Current status

A. Available Equipment Configuration:

1	SOLAR PANEL SPECIFICATION	
	TYPE A:	TYPE B
RATED POWER (STC)	160 W	160 W
VOLTAGE AT PMAX (VMP)	16.05 V	18.24 V
CURRENT AT PMAX (IMP)	10.01 A	8.77 A
OPEN-CIRCUIT VOLTAGE (VOC)	19.58 V	22.8 V
SHORT-CIRCUIT CURRENT(ISC)	11.07 A	9.37 A
MAXIMUM SYSTEM VOLTAGE	1000 VDC	1000 VDC B
TEMPERATURE RANGE	between negative 40 and positive 85	between negative 40 and positive 85
CELL TYPE	GRADE A MONOCRYSTALLINE	GRADE A MONOCRYSTALLINE
DIMENSIONS	1340x680x30MM	1340x680x30MM
WEIGHT	9.6KG	9.6KG
TOTAL SOLAR PANEL UNITS	6	6
NOTE	here from the entire 12 units from type A and type B; they will be distributed for series and parallel equally for similar outputs	

2	PV COMBINER BOX
VOLTAGE	DC 1000 V
CURRENT	100 A
DEGREE OF PROTECTION	IP67
TOTAL UNITS	2
REMARKS	Each for type A and type B panel

3	MPPT SOLAR CHARGE CONTROLLER
VOLTAGE	12 V / 24 V / Li
CURRENT	60 A
MAX. PV VOLTAGE	100 V
MAX. PV INPUT POWER	750 W (12 V), 1500 W (24 V)
SV	DSP411 ARM4.2
HV	411
UNITS	2
REMARKS	Each for type A and type B panel

4	BATTERY BANK
VOLTAGE	12 V
CURRENT	200A , 150A internal BMS
UNITS	4

5	INVERTER
VOLTAGE	24 V
POWER	3000 WATT
UNITS	2

6	SKYLLA CHARGER
VOLTAGE	24 V
CURRENT	80 A
INPUT VOLTAGE (V AC)	230
INPUT VOLTAGE RANGE (V AC)	BETWEEN 185 & 264
INPUT VOLTAGE RANGE (V DC)	BETWEEN 180 & 400
FREQUENCY (HZ)	BETWEEN 45 & 65
POWER FACTOR	1
CHARGE VOLTAGE 'ABSORPTION' (V DC)	28.5
CHARGE VOLTAGE 'FLOAT' (V DC)	26.5
CHARGE CURRENT HOUSE BATTERY. (A) (2)	80
CHARGE CURRENT STARTER BATTERY (A)	4
CHARGE CHARACTERSITICS	IUoUo (three step)
BATTERY CAPACITY (AH)	BETWEEN 400 & 800
BATTERY CONNECTION	M8 STUDS
230 V AC -CONNECTION	SCREW-CLAMP 2,5 MM2 (AWG 6)
UNITS	1
REMARKS	BACKUP TO SUPPLY BATTERY FROM EXTERNAL GRID

Area assessment and Solar Profile of Darwin:

1. Map of Darwin Region:

Fig: Geographic map of Darwin region

2. Solar Profile of Darwin

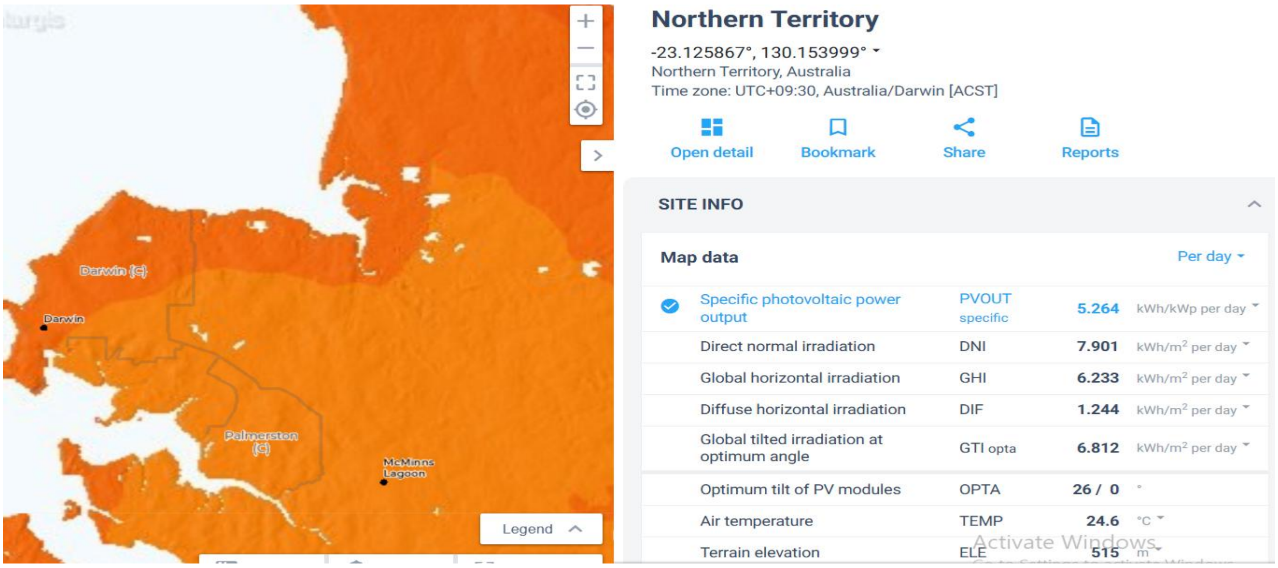

Fig: Photovoltaic power output in Darwin region

Month	Clearness Index	Daily Radiation (kWh/m²/day)
Jan	0.519	5.860
Feb	0.513	5.660
Mar	0.578	5.990
Apr	0.639	5.900
May	0.682	5.540
Jun	0.693	5.220
Jul	0.699	5.440
Aug	0.695	6.060
Sep	0.684	6.750
Oct	0.651	7.000
Nov	0.624	6.970
Dec	0.544	6.150

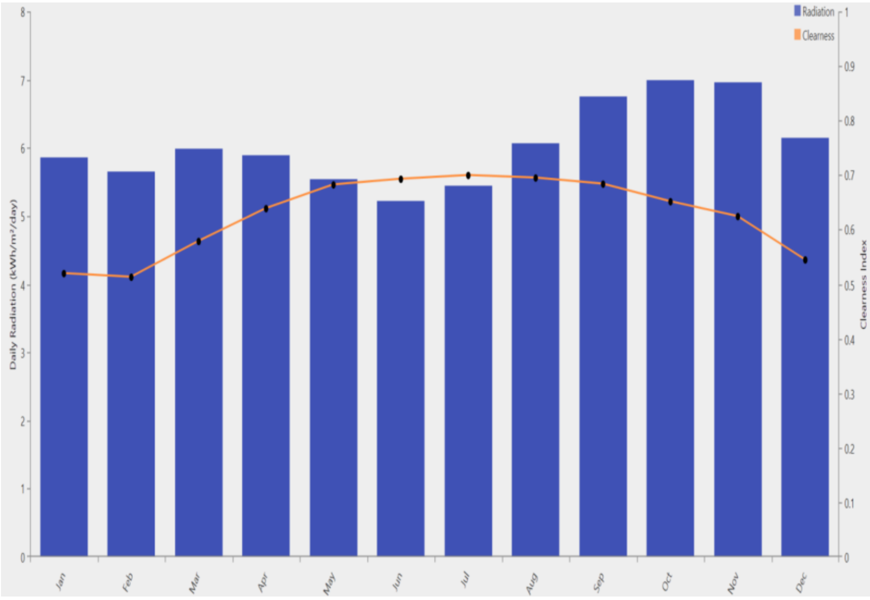

Fig: Monthly average solar global horizontal irradiance data

Calculation and evaluation

1. Maximum open-circuit output voltage calculation for both type A and type B solar panel for safe window operation from MPPT.

Here, from the characteristics of panel we have standard formula as;

$V_{ocmax} = V_{oc,stc} * [1+|\beta_{Voc}| * (T_{stc} – T_{min})$

Taking normal temperature of Darwin as;

Tstc = 25^0C, and

Worst case temperature T_{min} = -10^0C

Also,

Standard β_{Voc} = -0.30% / ^{0}C = 0.003/ ^{0}C

ΔT = 25 – (-10) = 35^0C

Case A with Panel $V_{oc,}$= 22.8 V

V_{ocmax} = 22.8 * [1 + (0.003*35)]

=25.2 V

Case B with Panel $V_{oc,}$= 19.58 V

V_{ocmax} = 19.58 * [1 + (0.003*35)]

= 21.7 V

For the 3 panels being in the series maximum V_{oc} is;

For Case A ;

V_{oc} = 22.8 V * 3 = 68.4 V

and V_{ocmax}` = 68.4 + 25.2 = 93.6 V

Which is less than 100V, which is the maximum tolerable range for given MPPT device.

Again, for Case B ;

$V_{oc,}$= 19.58 V * 3 = 58.74 V

And V_{ocmax}`= 21.7 + 58.74 = 80.44 V

This proves the safe voltage window for MPPT operation.

2. Equipment design and measurement for circuit design in the table below

Panel No	1	2	3	4	5	6	7	8	9	10	11	12
Distance to Combiner (In meter)	5.25	6.25	7.25	7.5	8.5	9.5	9.75	10.75	11.75	12	13	14
Panel type classification	Type A						Type B					
Design of panels	3S2P						3S2P					

From Panels or strings to combiner		MAX VoC	68.4V	MAX Isc	22.14A	MAX Power	1514.376W	Cable size	6		Fuse	15	Breaker	x
		Max Vmp	54.72V	Max Imp	20.02A	MAX Power	1095.4944W							
From Combiner1 to MPPT1 (m)	1	MAX Voltage	54.72V	MAX Current	17.54A	MAX Power	959.7888W	Cable size	10		Breaker	40A	Isolator	60A
From Combiner2 to MPPT2 (m)	1	MAX Voltage	48.15V	MAX Current	20.02A	MAX Power	963.963W	Cable size	10		Breaker	40A	Isolator	60A
MPPT1 to Busbar (m)	1	MAX Voltage	24V	MAX Current	60A	MAX Power	1440W	Cable size	25		Breaker	80	Fuse	
MPPT2 to Busbar (m)	1	MAX Voltage	24V	MAX Current	60A	MAX Power	1440W	Cable size	25		Breaker	80	Fuse	
Busbar to Series Battery 1&2	2	MAX Voltage	24V	MAX Current	150A	MAX Power	3600W	Cable size	50		fuse/string	150	main fuse	400A, class T
Busbar to Series Battery 3&4	2	MAX Voltage	24V	MAX Current	150A	MAX Power	3600W	Cable size	50		fuse/string	150	main fuse	400A, class T
											Main Sio	400A DC	Shunt (neg bus)	600A
Busbar to Inverter1	2	MAX Voltage	24V	Ideal Current	125A	MAX Power	3000W	Cable size	70		Breaker at Inv	250A Dc	Fuse	250, Class T
Busbar to Inverter2	2	MAX Voltage	24V	Ideal Current	125A	MAX Power	3000W	Cable size	70		Breaker at Inv	250A Dc	Fuse	250, Class T
Busbar to Charger 1	2	I/P Voltage	24V	O/P Current	80A	MAX Power	1920W	Cable size	25		Fuse	100A Dc	Fuse	
Busbar to Loads	2	MAX Voltage	24V	MAX Current	40A	MAX Power	960W	Cable size	10		Breaker		Fuse	

Note: the cable sizes are in mm^2.

Operational suggestions in the table below:

1. Cable should be PV rated insulation and UV resistant and copper wire.
2. Panels receive power in form of irradiance (W/m2) and then convert to DC I,e P = V*I
3. Inverter draws DC: Example: if AC load 2500W; DC draw ≈ 2500/ (24×0.9) ≈ 116A

S.N		Statement	Comment
1	Location	Put MPPT + combiner close to PV cables	minimise roof to controller loss
		Put Inverters close to battery / Busbars	Minimising high current cable length
		Busbars + Main Fuse + Isolation	In one accessible bay
2	Mounting PV	3 Strings with 2 series in 1 string each	Labelling to avoid Type A & B mix
3	Combiner box wiring	3 strings enter combiner box	
		Each string positive goes through 15 A gPV	Fuse
		Combiner O/P goes through 40 A DC breaker	DC breaker
		Then through PV isolator	
		Then to MPPT PV input	
4	Battery Bank Build	2 series & 2 parallel connections	
		String 1: 12V + 12V in series = 24 V	
		String 2: 12V + 12V in series = 24 V	
		Parallel the two strings then into busbars or proper battery combiner	Add 150 A Fuse on each string positive
			then join at common positive point
5	Main DC protection	Battery -> 400 A class-T fuse -> 400 A isolator -> positive Busbar	
		Battery negative -> shunt -> negative Busbar	
6	Connect devices to BusBar	MPPT 1 -> 80 A fuse/breaker -> Busbar	Fuse / Breaker
		MPPT 2 -> 80 A fuse/breaker -> Busbar	Fuse / Breaker
		Skylla charger -> 100 A fuse/ breaker - Busbar	Fuse / Breaker
		Inverter 1 -> 200 A class-T -> Busbar	Fuse
		Inverter 2 -> 200 A Class-T -> Busbar	Fuse
6	COMMISSIONING	Connect battery bank + Busbar	Verify 24 V stability
		Power MPPTS from Battery side first	Many needs battery powered before PV initially
		Close PV Isolator and CHECK PV input volatge / current	
		Then commission Skyllar charger (AC)	
		Then commission Inverter	

Circuit Design

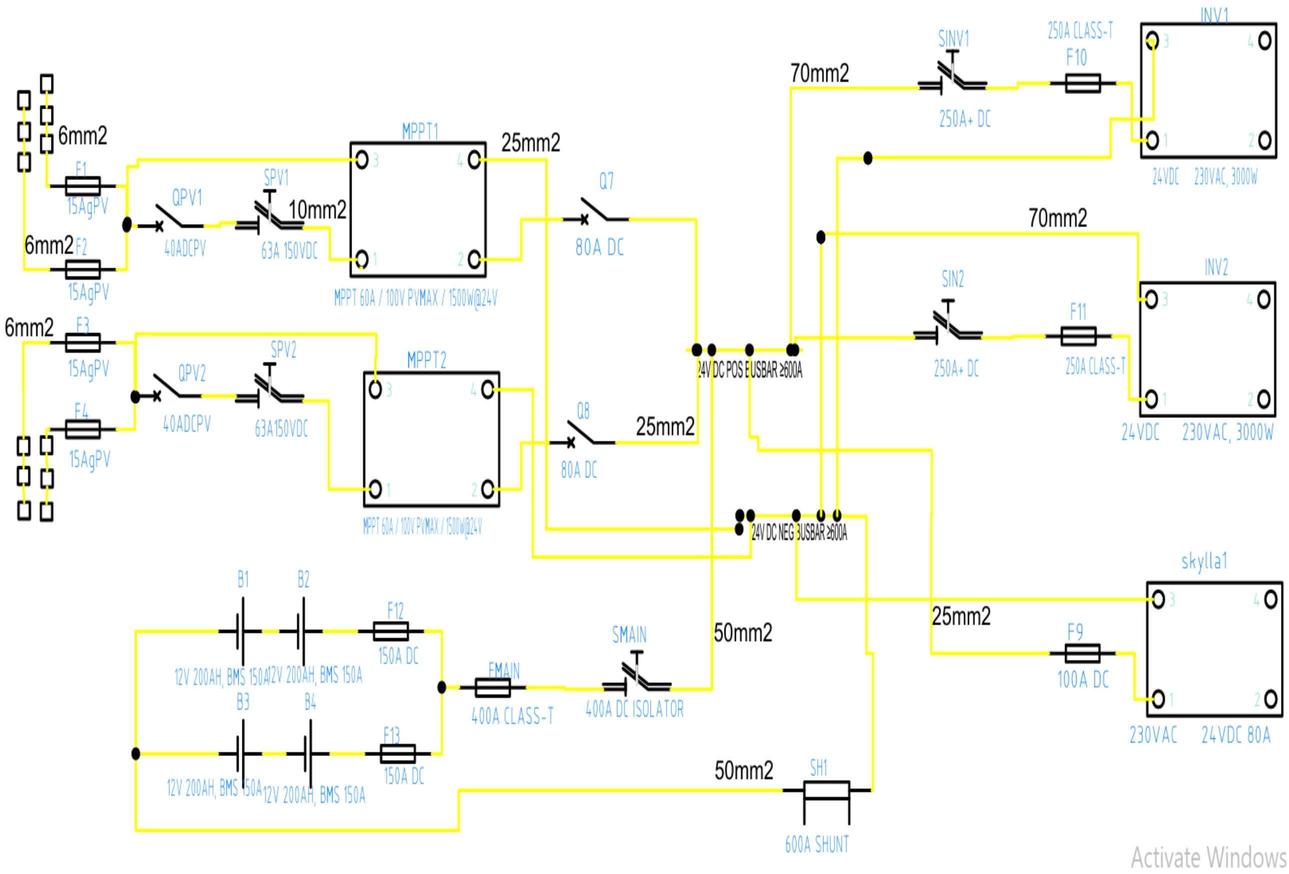

Fig: Solar panel system installation design with circuit elements

Conclusion and future recommendation

The preliminary analysis has been done after the study of available component to design the electric-circuit design of solar panel installation at the client site. This design report proposed the hybrid solution to utilize the solar power during the good sunny day and back-up charger system to charge the battery from the external AC supply to run the system.

The research-based case study is done only for educational purpose and further recommends the implication of information related to existing power utility rates, economic factor for installation and operations. Then it can further deliver the understanding the maturity of utilizing off-grid solar energy in the house or public/ private caravans as compared to externally supplied fossil-fuel powered system in the next report.

Appendix

Fig: Solar panel images

Fig: Combiner box

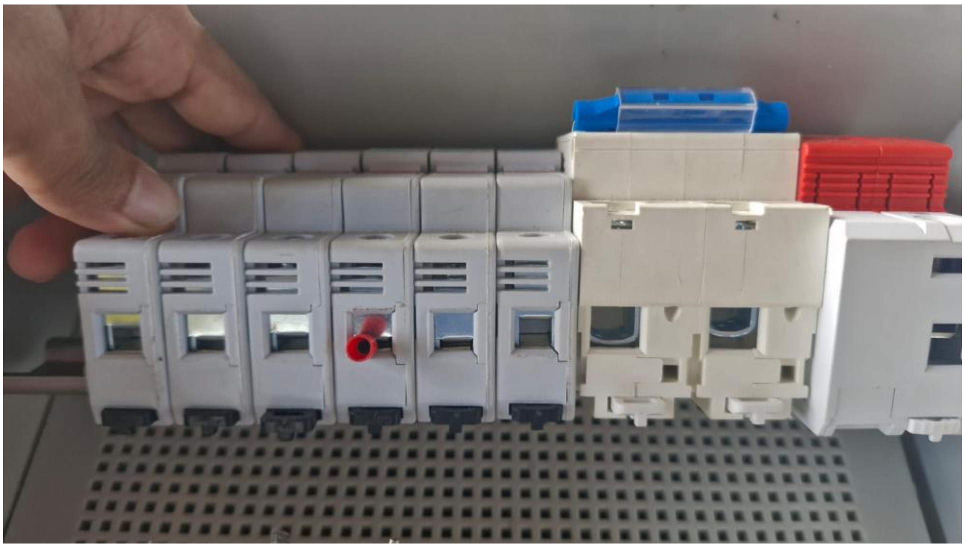

Fig: Connection points of PV strings inside Combiner box showing fuses, breaker and isolator.

Fig: MPPT box

Fig: Victron Energy smart inverter

Fig: Victron energy charger

Reference:

1. https://globalsolaratlas.info/map?c=-14.99324,103.698921,3&s=-23.125867,130.153999&m=site
2. NT Government. (2023). Renewable Energy Strategy. Retrieved from https://dme.nt.gov.au/renewables-energy-systems/renewable-energy
3. https://www.youtube.com/watch?v=9eubgFihQI4