SOLA4012-PV System Design

Commercial PV Design Project

FEDEX Logistics, Botany,NSW
Project Type: Commercial

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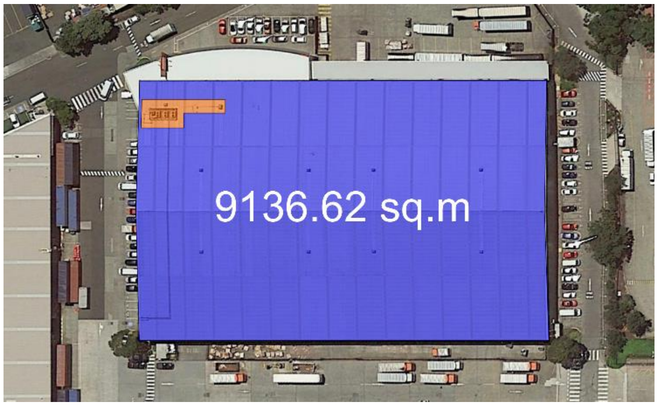
1. Executive Summary

The project aims to design and develop a roof-mounted grid-connected commercial PV System for FEDEX Express Logistics Warehouse located at Port Air Industrial Estate, Botany, NSW (33.94°S, 151.19°E)

SPREE Energy is committed to designing a large-scale commercial PV system for FEDEX Logistics The design aims to comply with all the requirements from the Clean Energy Regulator, to be eligible for the Large-Scale Generation Certificate. As per the requirement, the designed system is a non-exporting PV System, serving the internal demands of the building across the year, developed with optimized PV Design and reliable inverters.

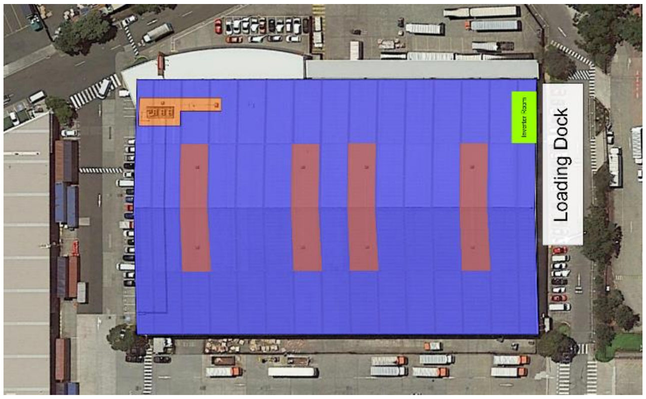


Site Orientation and Roof Assessment

Location:	Store 5/1a Hale St, Botany NSW 2019	Roof Area	9136.62m2
Length:	120.3m	Building Azimuth	10°
Breadth	75.76m	Roof Tilt Angle	6°
Building Height	10.75m	Roofing Material	Steel Roofing
Roof Type	Gable Roof	Weather Station	Sydney International Airport

Accessibility to Roof

This building has a Gable Roof, covered with metal roofing and stripes of polycarbonate sheets for natural lighting. Since the roof has been mounted on metal beams running across the building, the roof is analyzed to withstand higher loads on top. The roof is at an elevation of 10.75m from ground level, hence shading due to trees, lamps, and posts is avoided. compatible for solar PV installation. The roof is easily accessible from all sides; the loading of heavy components could be lifted from either side of the building.



Weather and Solar Insolation Assessment

The hourly data of annual weather and solar insolation are obtained from BOM recorded at Sydney International Airport. A preliminary analysis of Solar Irradiation, Temperature, and wind speed are analyzed with the help of SAM, to structure, orient, and design a PV system. The overall change in irradiance and temperature are monitored across the year to estimate the yield of the designed system.

Weather and Solar Insolation Assessment			
Beam Irradiance DNI (kWh/m2/day)	10.28	Max-Dry Bulb Temperature (°C)	39.34
Diffuse Irradiance DHI (kWh/m2/day)	2.42	Min Dry Bulb Temperature (°C)	5.32
Global Irradiance GHI (kWh/m2/day)	8.40	Max Wind Speed (km/h)	11km/h

Building Load Analysis

The given load Demand is analyzed for missing data; it is observed that roughly around 54 Rows of data have been missing. The Data entries were filled using two methodologies

1. Linear Interpolation Method.
2. Mean of the Load from consecutive hours of the next and previous days.

The load demand of the building is scaled to a rate where the Energy intensity of the building is 150kWh/m2/year with the overall area of the roof. A summary of the analysis is showshownTable2.

Load Analysis			
Roof Area	9136.62m2	Max Load (kW)	353.33
Total Energy Demand (kWh/yr)	1370493.00	Min Load (kW)	74.92
Energy Intensity (kWh/sqm/yr)	150	Average Load (kW)	80.23

On observing the demand profile of the building, there is a significant difference between the maximum and minimum Load. It is observed that the demand for the building increases significantly over the winter months compared to that summer. With a parallel comparison of Solar Insolation for the respective seasons, it's observed that Solar insolation falls significantly during the months of winter; thus creating a requirement for a scaled-up PV system.

Building Load Seasonal Demand			
Season	Energy Usage (kWh)	Average Demand (kW)	Average Solar Insolation (PSH)/Season
Summer	291730.787	97243.6	6.34
Autumn	352069.293	117356.4	3.90
Winter	377287.542	125762.5	3.06
Spring	349405.378	116468.5	5.91

2. PV System Design

The PV System has been designed to provide optimal performance during the worst month of solar insolation in the year. The components such as modules ad inverters, used in the project are approved by the Clean Energy Council. The design approach is initiated by the selection of an inverter of significant size.

Inverters

The DC/AC Conversion system includes 2 Inverters from Growatt MAX 125KTL3-X-LV Series (AC Rating 125kW) with 10MMPTs.

- Growatt Inverters meet the CEC standards with an efficiency of 98.4% with IP66 certification and Smart Cooling Technology which enables the possibility for outdoor installation.
- Transformer less system with low power consumption
- Designed with Protection systems like Type II SPD for AC/DC Surge Protection, Ground Fault Monitoring systems, Arc Fault Detection, and Insulation resistance monitoring.
- LAN/WLAN/4G Integrated system with a web application for continuous remote performance monitoring.
- 10 MPPT Fuse free Design with Smart IV Scan and Diagnosis.

Selection of PV Modules

This project will use the Vertex series of Trina Solar (TSM-DE18M(II) 510W) 150cell module. The module has been selected due to its higher efficiency rate of 21.2%, to maximize the solar power generated/sqm tr of area. With the latest technology of 1/3 cut cells, the cost of the module has been significantly reduced offering a lower LCOE in the economics of the project. The module has a lower degradation factor, providing a reliable output across the years. Based on the inverter the PV Modules are configured to match the inverter MPPT settings. The modules have a high OCPR Rating of 20A/25A

The PV System is designed to maintain a DC/AC ratio of 1.18 to ensure, the full capacity of AC Production during lowered solar insolation and to reduce the effect of PV degradation of the DC system on the AC output.

System Configuration

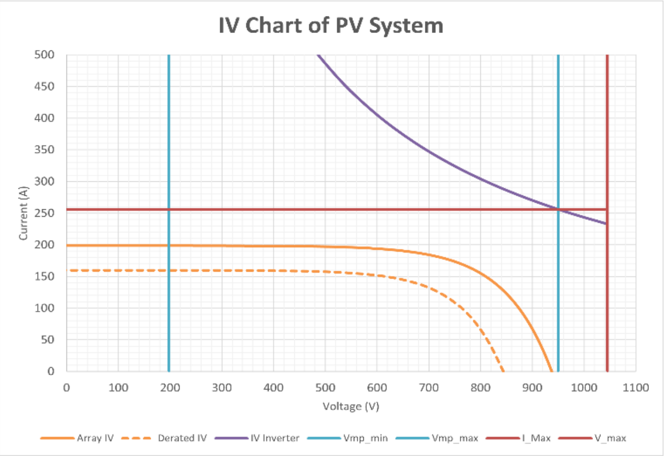
- A total of 576 Modules in the PV System with 288 Modules per inverter
- 18 Modules per String
- 2 Strings per Array- MPPT Input

System Configuration and Panel Orientation			
Modules /String	18	Max Power Output of a module	510W
String / MPPT	2	Max DC Power Input/Inverter	187.5kW
No. of MPPT (used in the System)	8	Max AC Output/Inverter	125kW
No. of Modules/ Inverter	288	Designed DC Input to Inverter	146.8kW
No. of inverters	2	Designed DC/AC Ratio	1.18
Total No.of Modules	576	Module Azimuth/Tilt Angle	10°/6°

Inverter Size Matching

	Voltage Window Check			**Current/ Power Check**		
	Vmppt_min	**Vmppt_max**	**Voc_max**	**Max Current**	**Max Power**	**Derated Power**
Array	638	833	985	31.05	18360	15234.86
MPPT	198	950	1045	32	18750	16875
Check	YES	YES	YES	YES	YES	YES

The inverter size matching calculations are shown in the Nameplate details sheet in Excel. The voltage, current, and power checks are performed and are verified to be under the limits of the inverter rating (as per AS/NSZ 5033 and AS/NSZ 4777 Standards). The IV Curve of the PV system, Inverter and the limits of the inverter is represented with Yellow, Purple and Red Lines respectively, in the graph. We can also observe that the system is designed to function between the MPPT Voltage limits.



Cable Sizing

On the DC Side, 2 Core Conduit cabling is designed for this system, to avoid exposure of conductors to external climatic factors like sun, rain, and dust. The minimum cross Sectional Area (CSA) for the DC String is been derived based on the length, Voltage, Current Carrying Capacity and the resistance of the Conductor specified in Table 35 from AS/NZS 3008. The effect of ambient temperature is also considered. The overall voltage drop caused by the wires in DC System/ MPPT is restricted to <3%.A separate circuit of 2.5mm2 wires is used for non-functional earthing of PV Modules.

DC Cable Sizing						
	Max Reqd. Length	Current Rating	Voltage Rating	Minimum CSA	Chosen CSA	Voltage Drop
String	50m	19A	985V	2.5mm2	4mm2	1.08%
Array	60m	32A	985V	4mm2	6mm2	1.46%

As per the design requirements since, the inverter is located on the ground floor, A 3 phase conduit (4Core) wiring is used to connect the inverter with the AC Switch box and MSB. In compliance with AS-NZS 5033-2021 Table4.6 , a 6mm earthing wire is used to provide non-functional earthing across the PV System

AC Cable Sizing				
	Max Reqd. Length	Min. Current Rating	Min. Voltage Rating	Chosen CSA
Inverter to MSB	50m	198.5A	230V	25mm2

System Protection

System protection is mandatory to protect the components of the system, at times of undesirable surges, and faults in the system. The system protection in our system mandates the use of a disconnector and an SPD device on the DC Side. The requirement and sizing of Fuses and Isolators are calculated in Outputs Sheet as per the AS/NSZ 3088, and AS/NSZ 5033. Based on our current selection of components in our system, the modules have the support of 20A/25A Over Current Protection Rating Fuses, and the inverters have a Type 2 SPD in-built for AC/DC Surge Protection, earth fault indicator, DC Reverse Polarity, and AC Short Circuit Protection.

Fuse Protection Rating				
MPPT 1-8	**Min Current**	**Max Current**	**Min Voltage**	**Required (YES/NO)**
String	19A	20A	985V	NO
Array	32A	N/A	985V	NO

As observed in the calculation, since the I OCPR of the module is greater than the minimum current of the string, and the number of the parallel strings is not more than 2, the use of fuses is avoided. To ensure protection for the inverter a 1000V 32A SPD I/II is used to prevent voltage surges above 1000V.And to ensure DC Circuit isolation ZFV32(rated 32A 1000V DC) isolator is placed after the SPD I/II near the combiner box of the string and at the DC Isolation box near the inverter, incompliance with Figure4.2 in AS/NZS 5033:2021, the earth wire for SPD is chosen to be 6mm as per standards.

Switches/ Isolators Protection Rating		
MPPT 1-8	**Min Current (per pole)**	**Min Voltage**
String	19A	985V
Array	32A	985V

3. Lightning and Wind Assessment

Lightning Surge Protection

The site is located in a lightning strike-prone zone. Since the site does not have an on-site Lightning Protection System, the array is more vulnerable to taking direct strikes, SPD 1 is selected and is placed next to the combiner box of the string (closer to an array) and one near the inverter before the DC Isolation Box, as directed by Figure G.2 AS/NZS 5033.2021 . The distance of the array from the PCE is estimated to be >50m. ZBeny BUD-S1000 is chosen as the usable SPD which has both Type 1 and Type 2 Surge Class with a rated voltage of 1000V and can protect up to 10kV and 12.5kA current.

Wind Load Assessment

Wind Load assessment is performed based on the classification of the region, terrain category, shielding factor, and topology of the location. On analysing the wind data of the location, the highest wind speed experienced by the location is 11km/h. To ensure high solar irradiation the PV Panels are installed facing north (the northern part of the roof). Considering the wind directions at the location, the modules are placed in the Downwind End of the roof zone.

Based on AS/NZS1127 the wind load factors are assessed.

Wind Load Factors	
Geometry	C_{shp}=-1.1,+0.5
Wind Region	A3
Terrain	TC3
Topographic Effect	T1

4. Project Performance and Economics

Project Performance

The annual and monthly energy yield, specific yield and performance ratio is calculated using the PV Design Tool Excel sheet. And since the PV system design, is scaled by inverter; keeping the PV configuration constant, the EY, SY, and PR of the individual system is the half of the overall system.To simulate in a real-time condition, the PV system is implemented on a System Advisory Model (SAM) and the performance of the system is simulated for a span of 25years and is plotted in various graphs such as Generation vs Demand, Monthly Energy Production of the system, Annual Energy Production over a span of 25 years.

	Energy yield	**Specific yield**	**Performance ratio**
Jan	25484	1388	0.839
Feb	18456	1005	0.845
March	19523	1063	0.845
Apr	13356	727	0.855
May	12102	659	0.865
Jun	9623	524	0.870
Jul	9846	536	0.872
Aug	16592	904	0.869
Sep	19362	1055	0.857
Oct	23361	1272	0.857
Nov	24615	1341	0.845
Dec	27021	1472	0.843
Annual	219341	1564	0.855

Project Economics

The direct capital costs of the PV system include the investment required to purchase the key components like the PV modules, inverters, wires, protection devices, BOS and services like installation, Logistics in terms of $/W is calculated and is simulated.

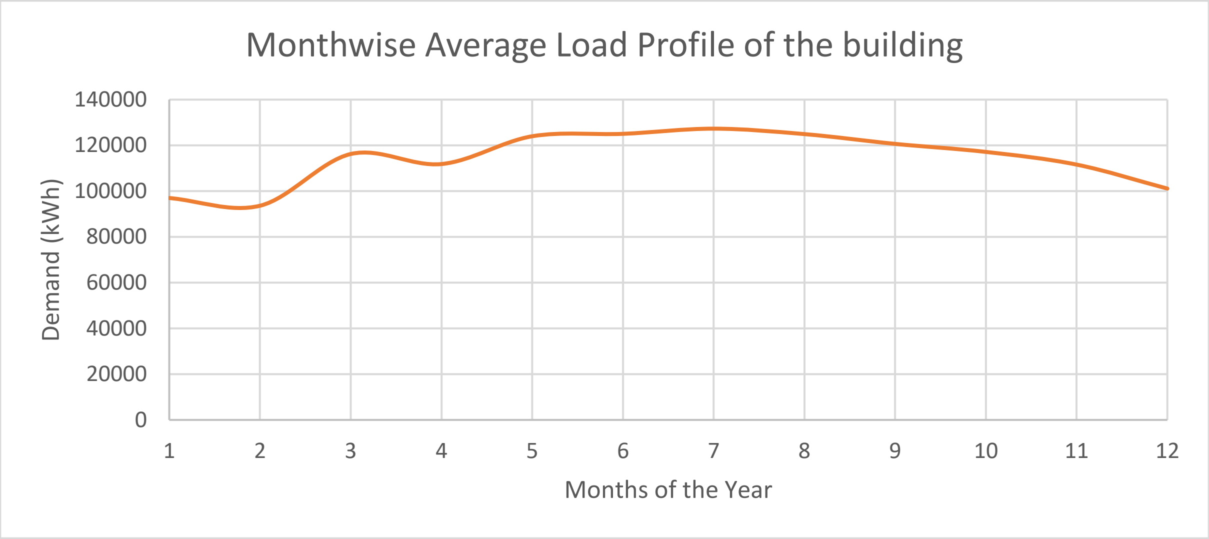
Estimated Direct Project Costs used in SAM		
Module	0.87$/Wdc	$255667.41
Inverter	0.15$/Wdc	$ 44,080.59
Balance of System	0.72$/Wdc	$ 211,586.81
Installation	0.23$/Wdc	$ 67,590.23

Further costs such as contingency cost, Logistics, and maintenance cost add up to the indirect investments inside the project. The tariff rate of the current provider is estimated for different tiers to calculate the overall savings by the PV system and to calculate the overall LCOE of the system in $/kW. With the current incentive of LGC which is valued at $48.50/ certificate, the LGC incentive (0.0436$/kWh) is also added to the simulation for a period of 8 years until 2030.

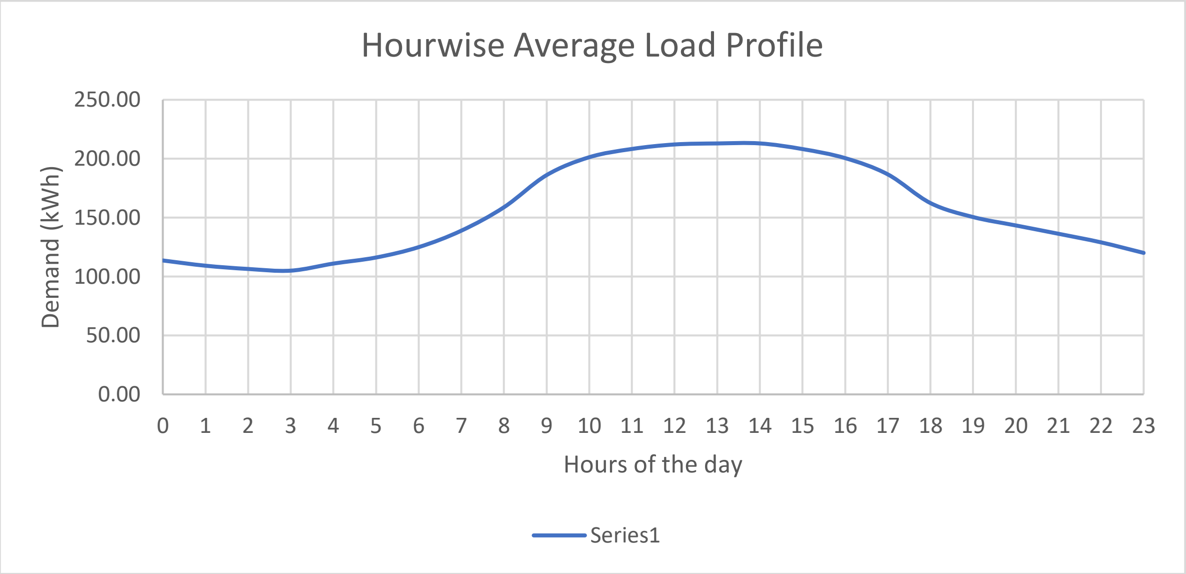
Actual Energy	495,466 kWh
Levelized COE (nominal)	7.07 ¢/kWh
Levelized COE (real)	5.62 ¢/kWh
Electricity bill without system (year 1)	$343,977
Electricity bill with system (year 1)	$218,761
Simple payback period	6.4 years
Discounted Payback Period	9.7 years

5. Appendix

Appendix A: Load, Irradiance, Weather and System Calculations and Visualizations



Appendix A: Figure 1 Monthwise Average Load Profile of the building

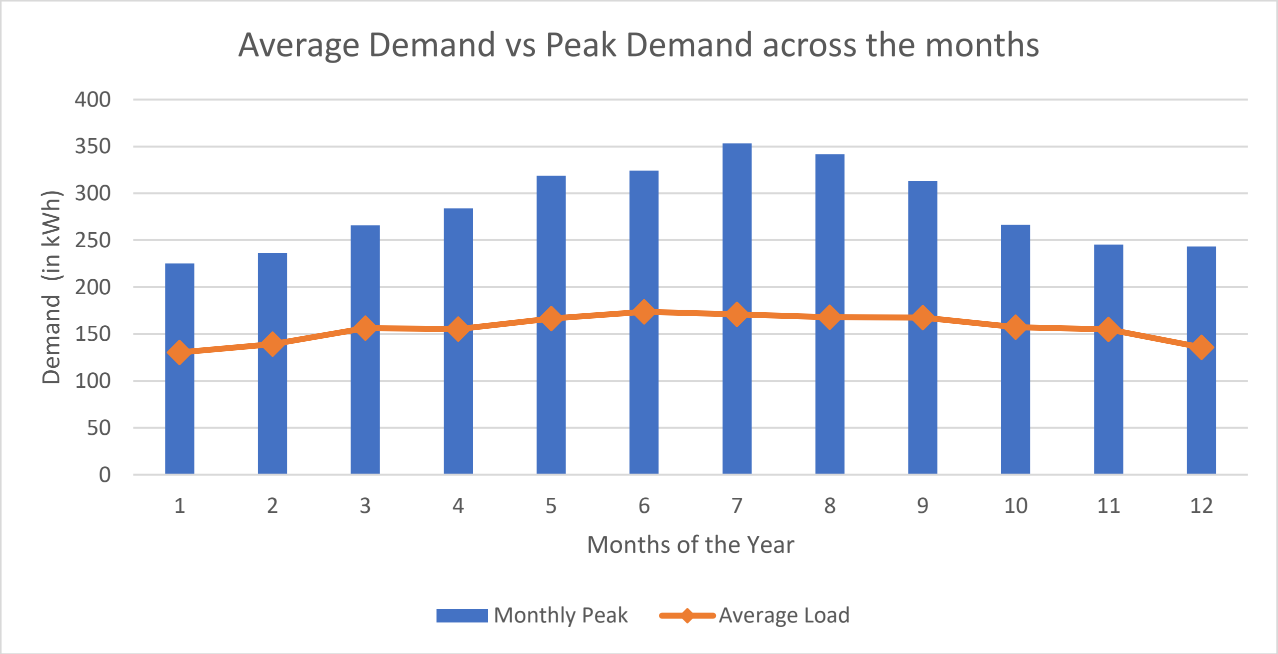


Appendix A: Figure 2 Hour-wise Average of Demand

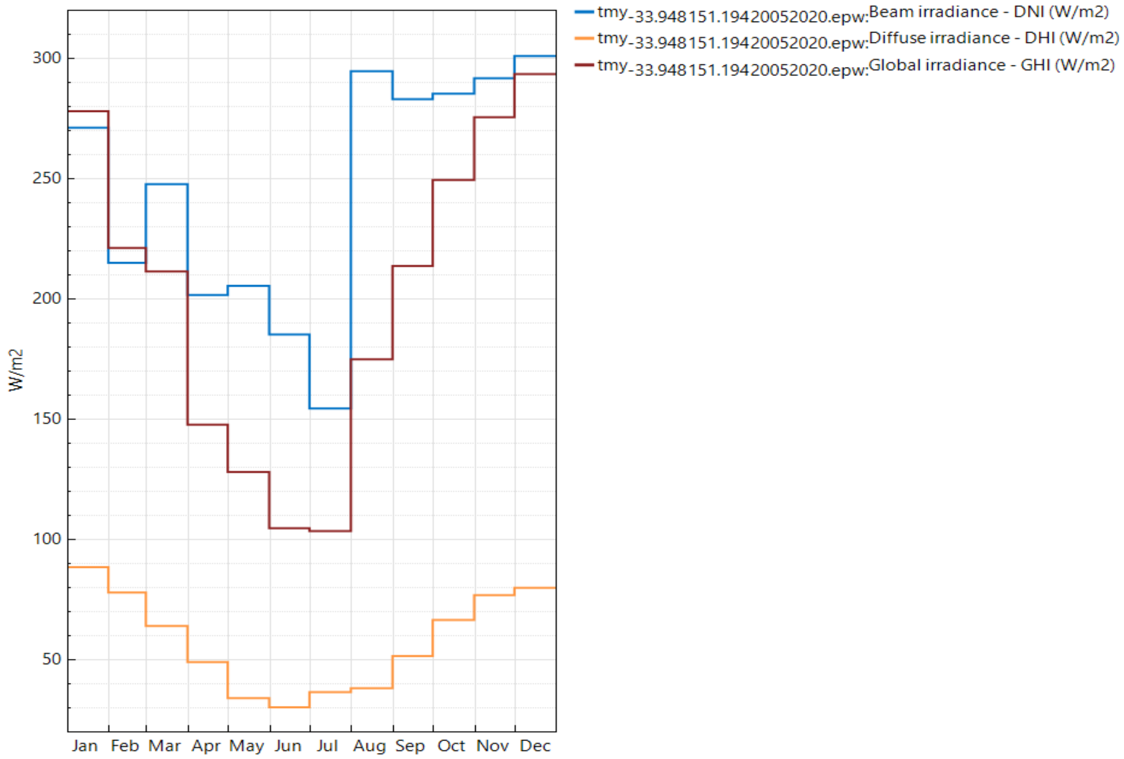
Month Wise

Months	Energy Demand(kWh)	Monthly Peak (kWh)	Average Load (kWh)
1	96990.55121	225.3052396	130.3636441
2	93619.2189	236.207106	139.3143138
3	116235.0709	265.8378199	156.229934
4	111845.8817	284.0075973	155.3415023
5	123988.3401	318.9494769	166.6509948
6	125048.9271	324.2606426	173.6790654
7	127304.7283	353.3322864	171.1085057
8	124933.8868	341.5918148	167.9218909
9	120656.5465	313.0792411	167.5785368
10	117147.8227	266.39689	157.456751
11	111601.009	245.4317622	155.0014014
12	101121.0168	243.475017	135.9153452

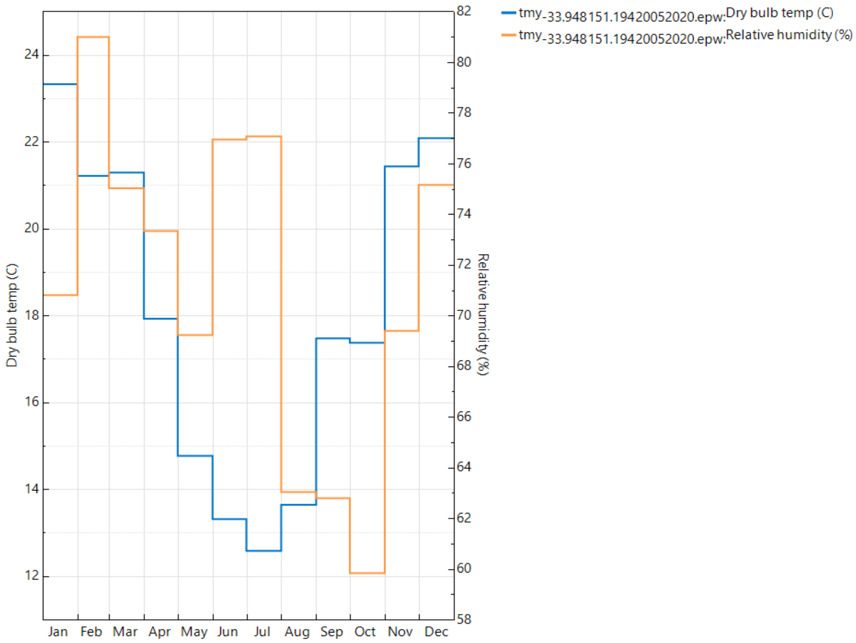
Appendix A: Figure 3 Monthly Cumulative , Peak and Average Building Demand



Appendix A: Figure 4 Average Demand vs Monthly Peak Demand across the year

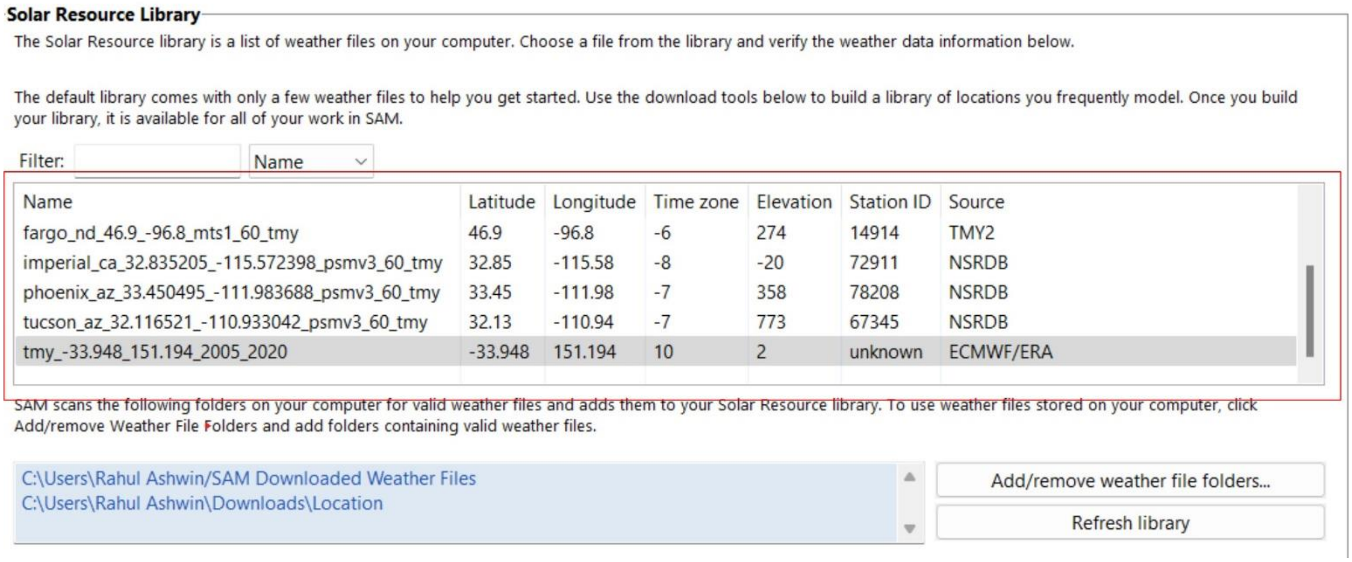


Appendix A: Figure 5 Monthly DNI,DHI and GHI of the location



Appendix A: Figure 6 Monthly Temperature and Relative Humidity of the location

Appendix B: SAM Configurations for Simulation



Solar Resource Library

The Solar Resource library is a list of weather files on your computer. Choose a file from the library and verify the weather data information below.

The default library comes with only a few weather files to help you get started. Use the download tools below to build a library of locations you frequently model. Once you build your library, it is available for all of your work in SAM.

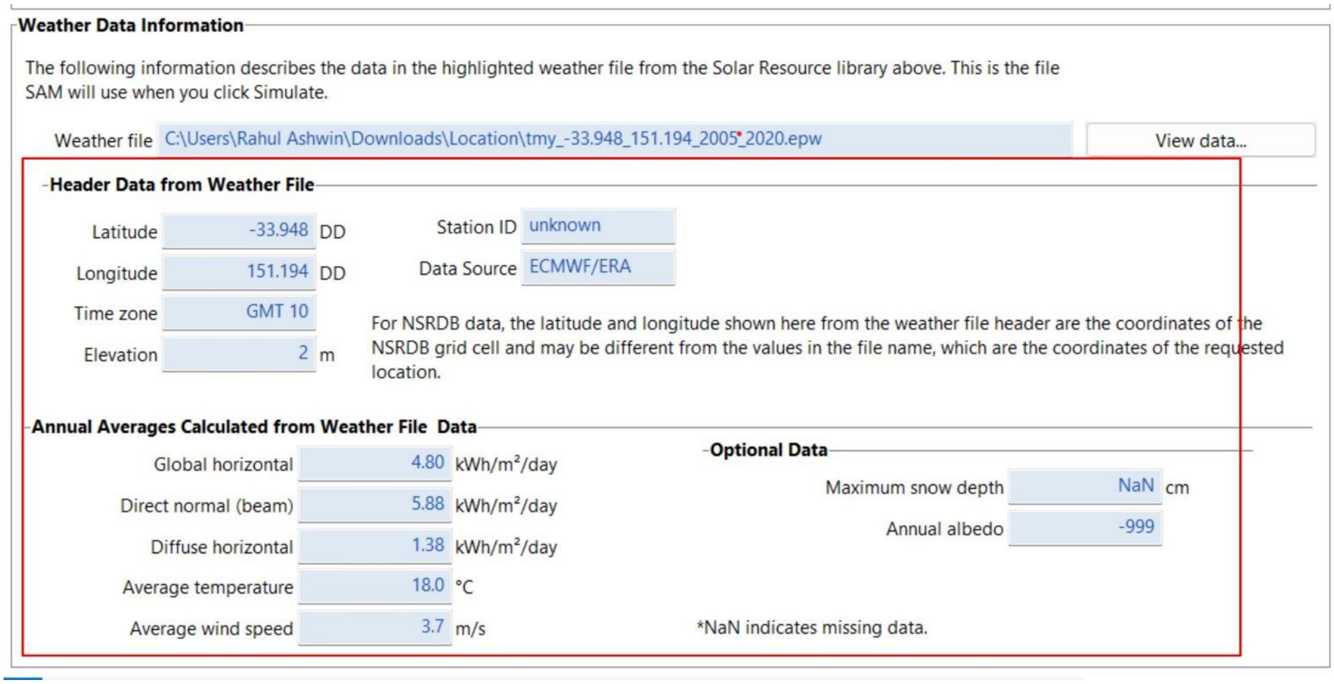
Filter: Name

Name	Latitude	Longitude	Time zone	Elevation	Station ID	Source
fargo_nd_46.9_-96.8_mts1_60_tmy	46.9	-96.8	-6	274	14914	TMY2
imperial_ca_32.835205_-115.572398_psmv3_60_tmy	32.85	-115.58	-8	-20	72911	NSRDB
phoenix_az_33.450495_-111.983688_psmv3_60_tmy	33.45	-111.98	-7	358	78208	NSRDB
tucson_az_32.116521_-110.933042_psmv3_60_tmy	32.13	-110.94	-7	773	67345	NSRDB
tmy_-33.948_151.194_2005_2020	-33.948	151.194	10	2	unknown	ECMWF/ERA

SAM scans the following folders on your computer for valid weather files and adds them to your Solar Resource library. To use weather files stored on your computer, click Add/remove Weather File Folders and add folders containing valid weather files.

C:\Users\Rahul Ashwin/SAM Downloaded Weather Files
C:\Users\Rahul Ashwin\Downloads\Location

Appendix B: Figure 1 TMY Weather Data input for the location



Weather Data Information

The following information describes the data in the highlighted weather file from the Solar Resource library above. This is the file SAM will use when you click Simulate.

Weather file C:\Users\Rahul Ashwin\Downloads\Location\tmy_-33.948_151.194_2005_2020.epw

Header Data from Weather File

Latitude -33.948 DD
Longitude 151.194 DD
Time zone GMT 10
Elevation 2 m
Station ID unknown
Data Source ECMWF/ERA

For NSRDB data, the latitude and longitude shown here from the weather file header are the coordinates of the NSRDB grid cell and may be different from the values in the file name, which are the coordinates of the requested location.

Annual Averages Calculated from Weather File Data

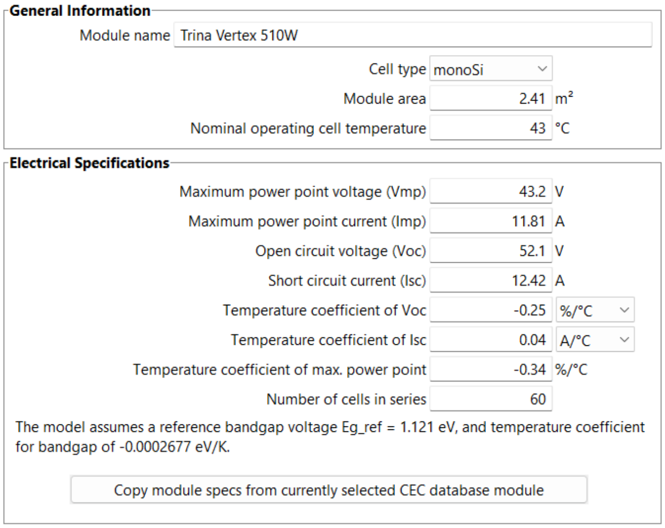
Global horizontal 4.80 kWh/m²/day
Direct normal (beam) 5.88 kWh/m²/day
Diffuse horizontal 1.38 kWh/m²/day
Average temperature 18.0 °C
Average wind speed 3.7 m/s

Optional Data

Maximum snow depth NaN cm
Annual albedo -999

*NaN indicates missing data.

Appendix B: Figure 2 Annual Averages of GHI, DNI and DHI



General Information

Module name Trina Vertex 510W

Cell type monoSi

Module area 2.41 m²

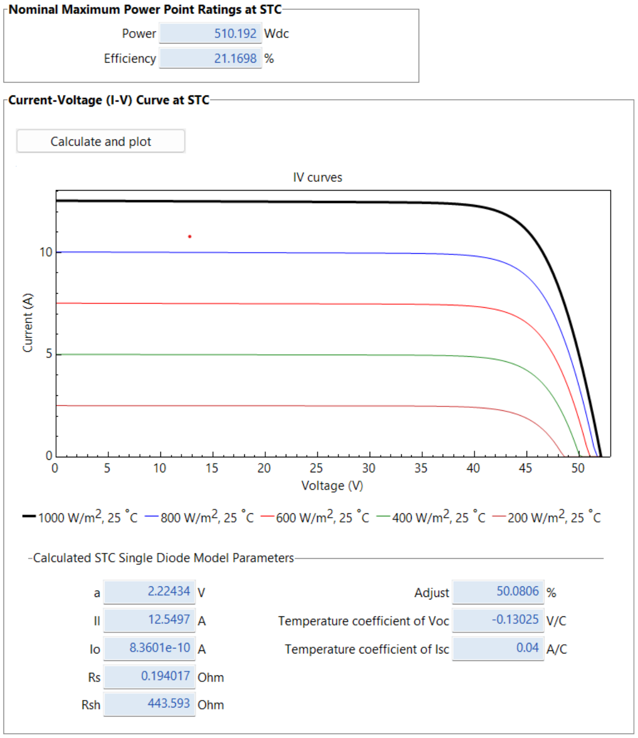
Nominal operating cell temperature 43 °C

Electrical Specifications

Maximum power point voltage (Vmp)	43.2	V
Maximum power point current (Imp)	11.81	A
Open circuit voltage (Voc)	52.1	V
Short circuit current (Isc)	12.42	A
Temperature coefficient of Voc	-0.25	%/°C
Temperature coefficient of Isc	0.04	A/°C
Temperature coefficient of max. power point	-0.34	%/°C
Number of cells in series	60	

The model assumes a reference bandgap voltage Eg_ref = 1.121 eV, and temperature coefficient for bandgap of -0.0002677 eV/K.

Appendix B: Figure 3 IV Plot of the Selected Module



Nominal Maximum Power Point Ratings at STC

Power 510.192 Wdc

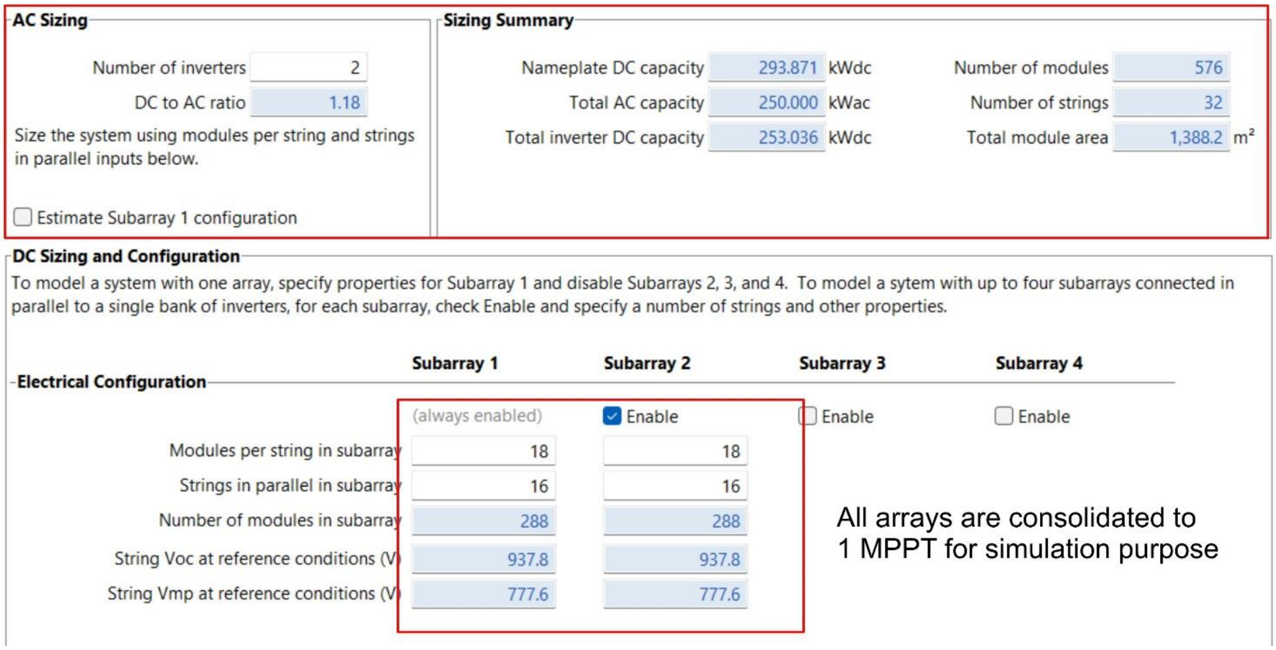
Efficiency 21.1698 %

Current-Voltage (I-V) Curve at STC

Calculated STC Single Diode Model Parameters

a	2.22434	V	Adjust	50.0806	%
Il	12.5497	A	Temperature coefficient of Voc	-0.13025	V/C
Io	8.3601e-10	A	Temperature coefficient of Isc	0.04	A/C
Rs	0.194017	Ohm			
Rsh	443.593	Ohm			

Appendix B: Figure 4 Module Data input for modelling



AC Sizing

Number of inverters 2

DC to AC ratio 1.18

Size the system using modules per string and strings in parallel inputs below.

☐ Estimate Subarray 1 configuration

Sizing Summary

Nameplate DC capacity	293.871	kWdc	Number of modules	576	
Total AC capacity	250.000	kWac	Number of strings	32	
Total inverter DC capacity	253.036	kWdc	Total module area	1,388.2	m²

DC Sizing and Configuration

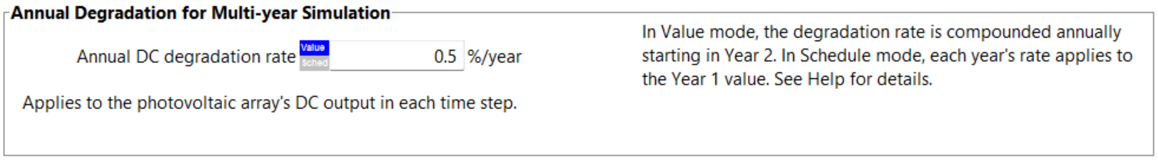
To model a system with one array, specify properties for Subarray 1 and disable Subarrays 2, 3, and 4. To model a sytem with up to four subarrays connected in parallel to a single bank of inverters, for each subarray, check Enable and specify a number of strings and other properties.

Electrical Configuration

	Subarray 1	Subarray 2	Subarray 3	Subarray 4
	(always enabled)	☑ Enable	☐ Enable	☐ Enable
Modules per string in subarray	18	18		
Strings in parallel in subarray	16	16		
Number of modules in subarray	288	288		
String Voc at reference conditions (V)	937.8	937.8		
String Vmp at reference conditions (V)	777.6	777.6		

All arrays are consolidated to
1 MPPT for simulation purpose

Appendix B: Figure 5 PV System Scaling



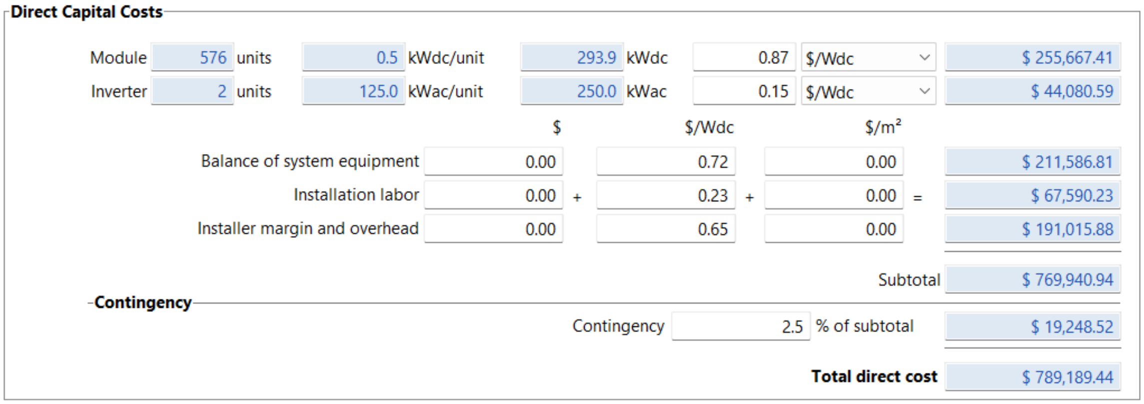
Annual Degradation for Multi-year Simulation

Annual DC degradation rate 0.5 %/year

Applies to the photovoltaic array's DC output in each time step.

In Value mode, the degradation rate is compounded annually starting in Year 2. In Schedule mode, each year's rate applies to the Year 1 value. See Help for details.

Appendix B: Figure 6 Degradation of DC Side set to 0.5%/year based on Module Degradation



Direct Capital Costs

Module	576 units	0.5 kWdc/unit	293.9 kWdc	0.87 $/Wdc	$ 255,667.41
Inverter	2 units	125.0 kWac/unit	250.0 kWac	0.15 $/Wdc	$ 44,080.59

	$	$/Wdc	$/m²	
Balance of system equipment	0.00	0.72	0.00	$ 211,586.81
Installation labor	0.00	0.23	0.00	$ 67,590.23
Installer margin and overhead	0.00	0.65	0.00	$ 191,015.88

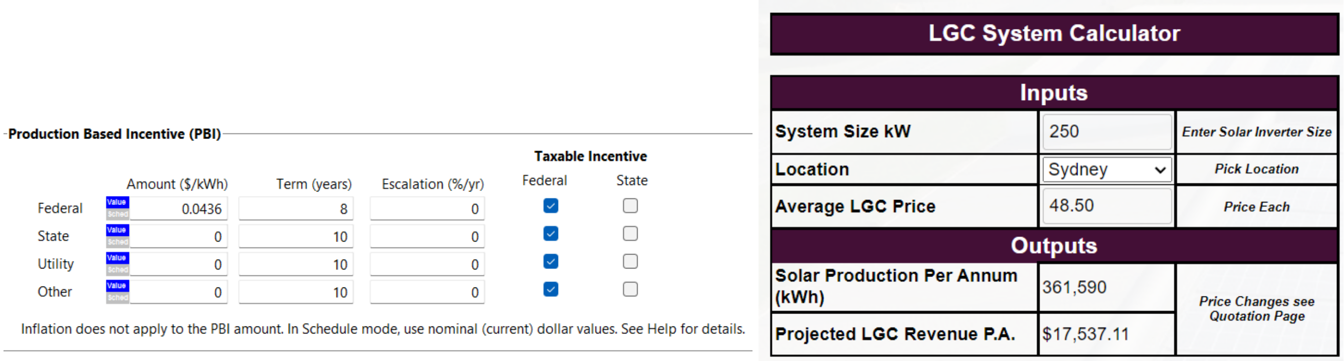
Subtotal $ 769,940.94

Contingency

Contingency 2.5 % of subtotal $ 19,248.52

Total direct cost $ 789,189.44

Appendix B: Figure 7 Direct Capital Cost in terms of $/Wdc



Production Based Incentive (PBI)

	Amount ($/kWh)	Term (years)	Escalation (%/yr)	Taxable Incentive Federal	Taxable Incentive State
Federal	0.0436	8	0	☑	☐
State	0	10	0	☑	☐
Utility	0	10	0	☑	☐
Other	0	10	0	☑	☐

Inflation does not apply to the PBI amount. In Schedule mode, use nominal (current) dollar values. See Help for details.

LGC System Calculator

Inputs		
System Size kW	250	*Enter Solar Inverter Size*
Location	Sydney	*Pick Location*
Average LGC Price	48.50	*Price Each*
Outputs		
Solar Production Per Annum (kWh)	361,590	*Price Changes see Quotation Page*
Projected LGC Revenue P.A.	$17,537.11	

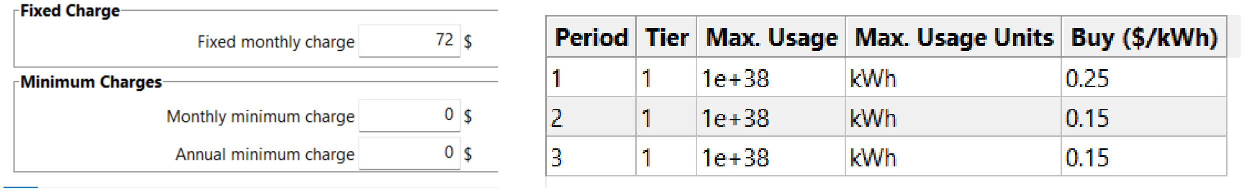
Appendix B: Figure 8 Production-based Incentive Calculated based on LGC

Market prices (spot*)

STCs	$39.90
LGCs	$48.50
VEECs	$56.50
ESCs	$34.25

*The spot price is for a minimum parcel size of 5000 created certificates.
Prices are compiled using the latest reported market data.

Appendix B: Figure 9 Market Spot Prices for LGC



Fixed Charge

Fixed monthly charge 72 $

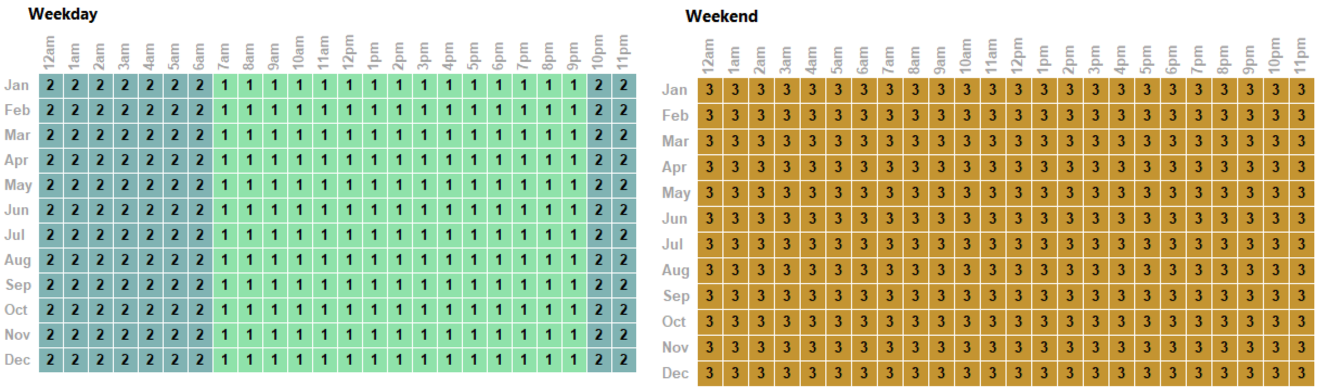
Minimum Charges

Monthly minimum charge 0 $

Annual minimum charge 0 $

Period	Tier	Max. Usage	Max. Usage Units	Buy ($/kWh)
1	1	1e+38	kWh	0.25
2	1	1e+38	kWh	0.15
3	1	1e+38	kWh	0.15

Appendix B: Figure 10 Given Customer Electricity Tariff



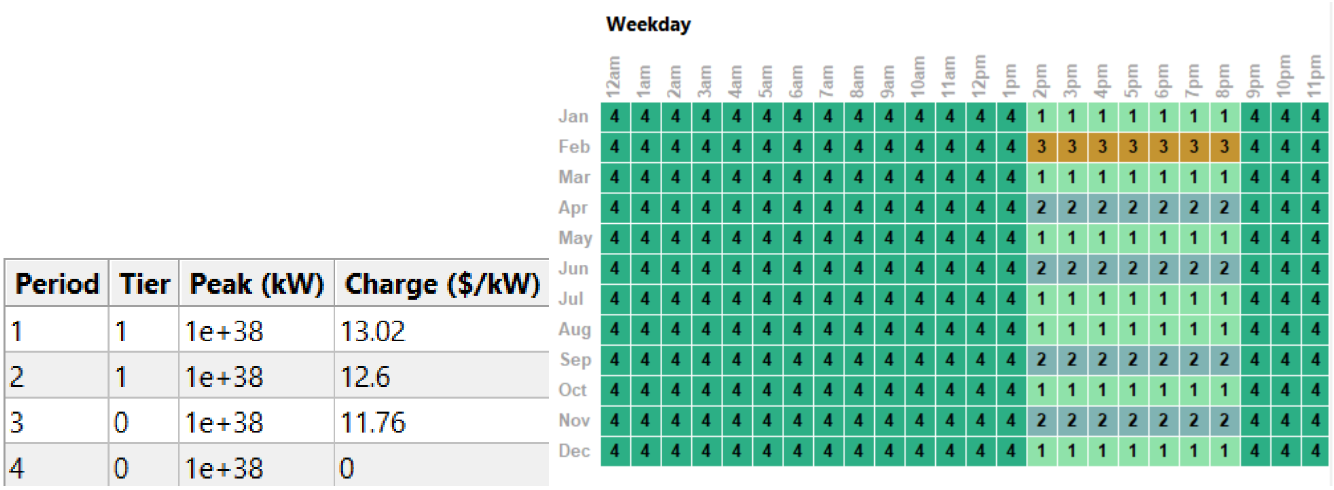
Weekday

	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Jan	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Feb	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Mar	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Apr	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
May	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Jun	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Jul	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Aug	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Sep	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Oct	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Nov	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Dec	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2

Weekend

	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Jan	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Feb	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Mar	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Apr	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
May	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Jun	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Jul	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Aug	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Sep	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Oct	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Nov	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Dec	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Appendix B: Figure 11 Customer Tariff Implemented on SAM



Period	Tier	Peak (kW)	Charge ($/kW)
1	1	1e+38	13.02
2	1	1e+38	12.6
3	0	1e+38	11.76
4	0	1e+38	0

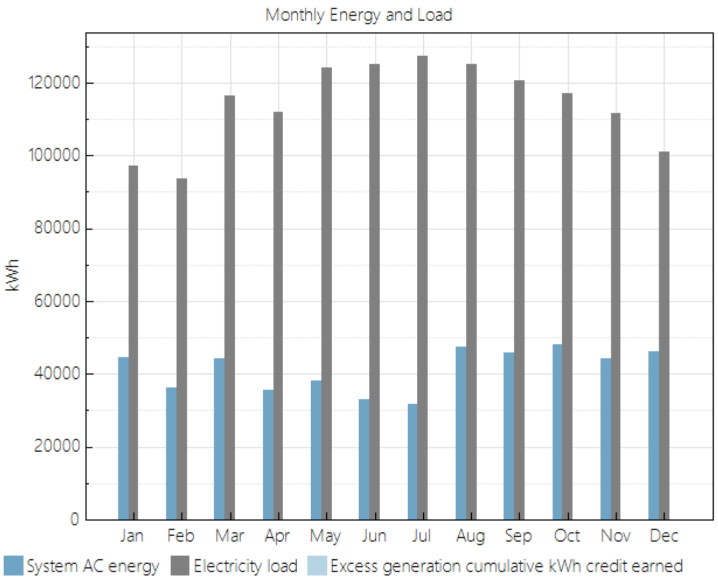
Weekday

	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Jan	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	1	1	1	1	1	1	4	4	4
Feb	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	4	4	4
Mar	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	1	1	1	1	1	1	4	4	4
Apr	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2	2	4	4	4
May	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	1	1	1	1	1	1	4	4	4
Jun	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2	2	4	4	4
Jul	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	1	1	1	1	1	1	4	4	4
Aug	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	1	1	1	1	1	1	4	4	4
Sep	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2	2	4	4	4
Oct	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	1	1	1	1	1	1	4	4	4
Nov	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2	2	4	4	4
Dec	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	1	1	1	1	1	1	4	4	4

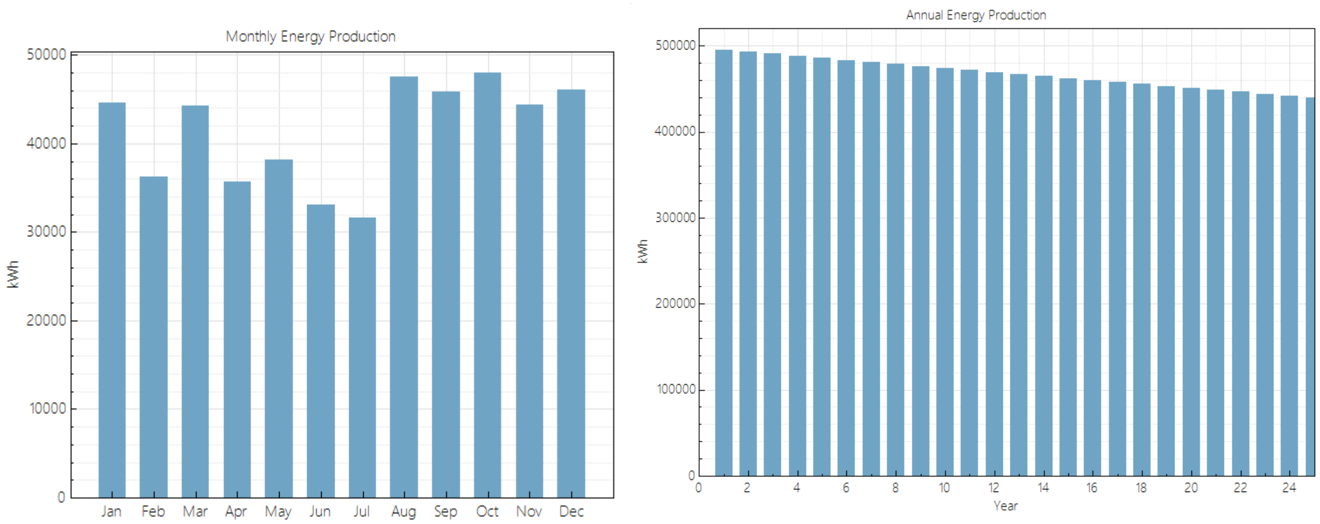
Appendix B: Figure 12 Capacity charge implemented on SAM

The Cost in $/KVA/day is converted to $/Kwh/day and is multiplied into 31,30 and 28 respectively based on the number of days in a month and is implemented on the chart.

	Energy (kWh)	Peak (kW)
Jan	97,022.31	225.38
Feb	93,649.82	236.28
Mar	116,273.04	265.92
Apr	111,882.53	284.10
May	124,028.85	319.05
Jun	125,089.92	324.37
Jul	127,346.49	353.45
Aug	124,974.84	341.70
Sep	120,695.99	313.18
Oct	117,186.06	266.48
Nov	111,637.48	245.51
Dec	101,154.07	243.55
Annual	1,370,941.38	353.45



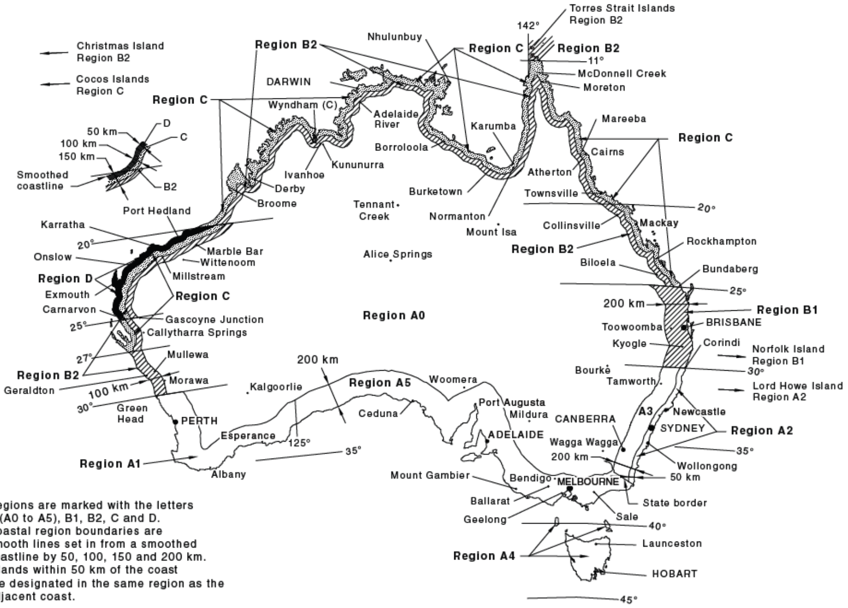
Appendix B: Figure 13 Scaled Load Demand of the Building



Appendix B: Figure 14 Monthly and Annual DC Generation

Appendix C: AS/NZS Standards

AS-NZS 1170.2

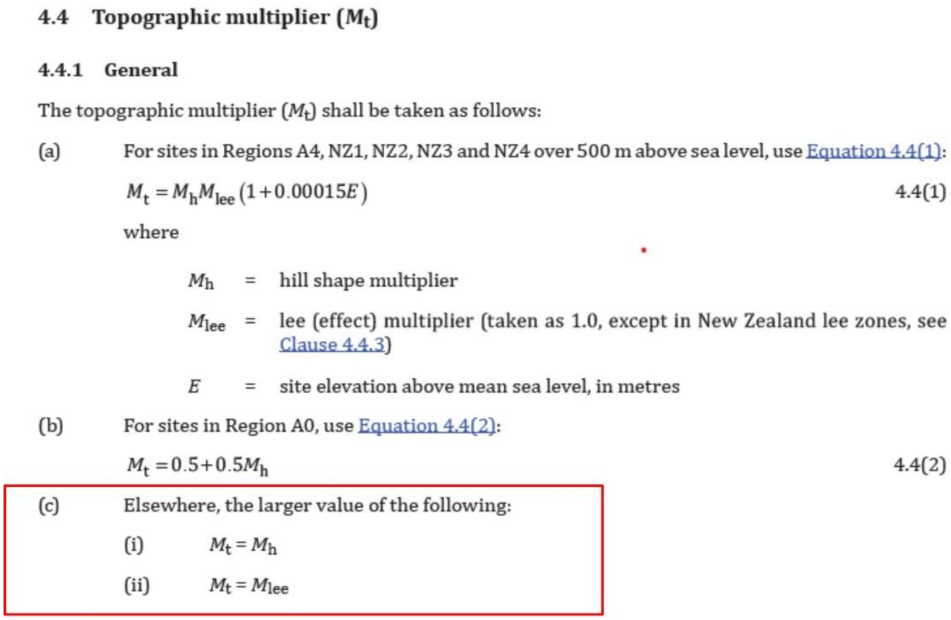


Regions are marked with the letters
A (A0 to A5), B1, B2, C and D.
Coastal region boundaries are
smooth lines set in from a smoothed
coastline by 50, 100, 150 and 200 km.
Islands within 50 km of the coast
are designated in the same region as the
adjacent coast.

Figure 3.1(A) — Wind regions — Australia

Table B.12 — Aerodynamic shape factor (C_{shp}) for calculating net pressures acting normal to panels mounted parallel to a roof surface with a gap of s = 50 to 300 mm

Wind direction	Array position	Aerodynamic shape factor (C_{shp})			
		$\alpha < 5°$	$5° \leq \alpha < 10°$	$10° \leq \alpha < 20°$	$20° \leq \alpha \leq 30°$
$\theta = 0°$	Upwind end	−1.7, +0.4	−1.1, +0.8	−1.1, +0.6	−1.0, +0.6
	Upwind central	−1.4, +0.5	−0.8, +0.5	−0.7, +0.3	−0.8, +0.3
	Downwind end	−1.3, +0.5	−1.1, +0.5	−1.4, +0.4	−1.3, +0.5
	Downwind central	−1.4, +0.5	−0.8, +0.4	−1.0, +0.4	−1.1, +0.4
			$5° \leq \alpha \leq 30°$		
$\theta = 90°$	Upwind end	−1.7, +0.4	−1.7, +0.4		
	Central	−1.4, +0.5	−1.2, +0.5		
	Downwind end	−1.3, +0.5	−1.1, +0.5		
NOTE 1 Positive C_{shp} corresponds to a net downwards pressure.					
NOTE 2 The installation of a panel may result in changes to the external pressure on the roof below the panel.					



4.4 Topographic multiplier (M_t)

4.4.1 General

The topographic multiplier (M_t) shall be taken as follows:

(a) For sites in Regions A4, NZ1, NZ2, NZ3 and NZ4 over 500 m above sea level, use Equation 4.4(1):

$$M_t = M_h M_{lee} (1 + 0.00015E) \quad 4.4(1)$$

where

M_h = hill shape multiplier

M_{lee} = lee (effect) multiplier (taken as 1.0, except in New Zealand lee zones, see Clause 4.4.3)

E = site elevation above mean sea level, in metres

(b) For sites in Region A0, use Equation 4.4(2):

$$M_t = 0.5 + 0.5M_h \quad 4.4(2)$$

(c) Elsewhere, the larger value of the following:

(i) $M_t = M_h$

(ii) $M_t = M_{lee}$

AS-NZS 1170.2

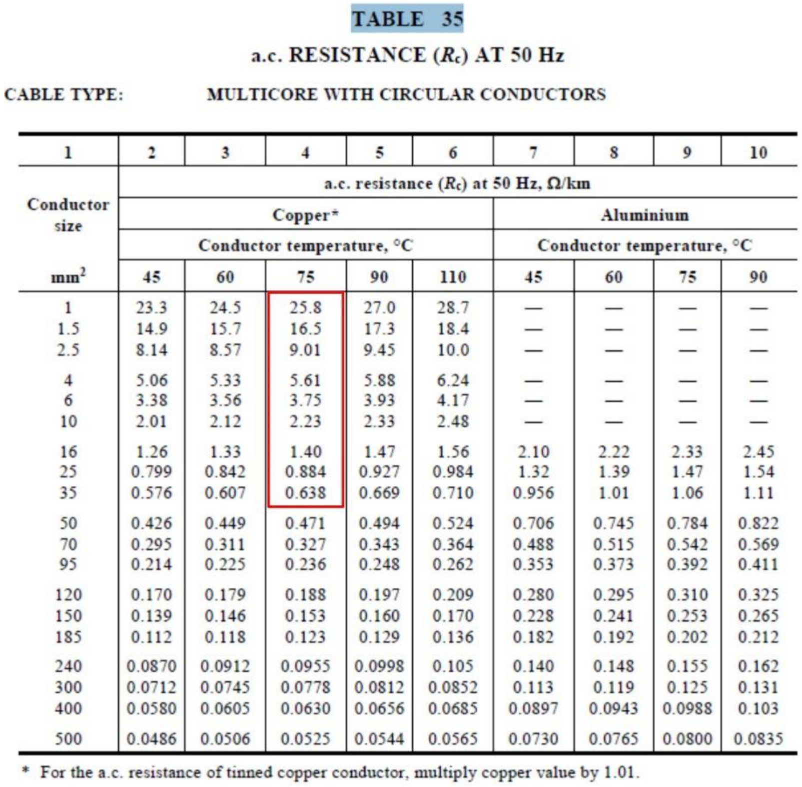


TABLE 35

a.c. RESISTANCE (R_c) AT 50 Hz

CABLE TYPE: MULTICORE WITH CIRCULAR CONDUCTORS

1	2	3	4	5	6	7	8	9	10
Conductor size	a.c. resistance (R_c) at 50 Hz, Ω/km								
	Copper*					Aluminium			
	Conductor temperature, °C					Conductor temperature, °C			
mm²	45	60	75	90	110	45	60	75	90
1	23.3	24.5	25.8	27.0	28.7	—	—	—	—
1.5	14.9	15.7	16.5	17.3	18.4	—	—	—	—
2.5	8.14	8.57	9.01	9.45	10.0	—	—	—	—
4	5.06	5.33	5.61	5.88	6.24	—	—	—	—
6	3.38	3.56	3.75	3.93	4.17	—	—	—	—
10	2.01	2.12	2.23	2.33	2.48	—	—	—	—
16	1.26	1.33	1.40	1.47	1.56	2.10	2.22	2.33	2.45
25	0.799	0.842	0.884	0.927	0.984	1.32	1.39	1.47	1.54
35	0.576	0.607	0.638	0.669	0.710	0.956	1.01	1.06	1.11
50	0.426	0.449	0.471	0.494	0.524	0.706	0.745	0.784	0.822
70	0.295	0.311	0.327	0.343	0.364	0.488	0.515	0.542	0.569
95	0.214	0.225	0.236	0.248	0.262	0.353	0.373	0.392	0.411
120	0.170	0.179	0.188	0.197	0.209	0.280	0.295	0.310	0.325
150	0.139	0.146	0.153	0.160	0.170	0.228	0.241	0.253	0.265
185	0.112	0.118	0.123	0.129	0.136	0.182	0.192	0.202	0.212
240	0.0870	0.0912	0.0955	0.0998	0.105	0.140	0.148	0.155	0.162
300	0.0712	0.0745	0.0778	0.0812	0.0852	0.113	0.119	0.125	0.131
400	0.0580	0.0605	0.0630	0.0656	0.0685	0.0897	0.0943	0.0988	0.103
500	0.0486	0.0506	0.0525	0.0544	0.0565	0.0730	0.0765	0.0800	0.0835

* For the a.c. resistance of tinned copper conductor, multiply copper value by 1.01.

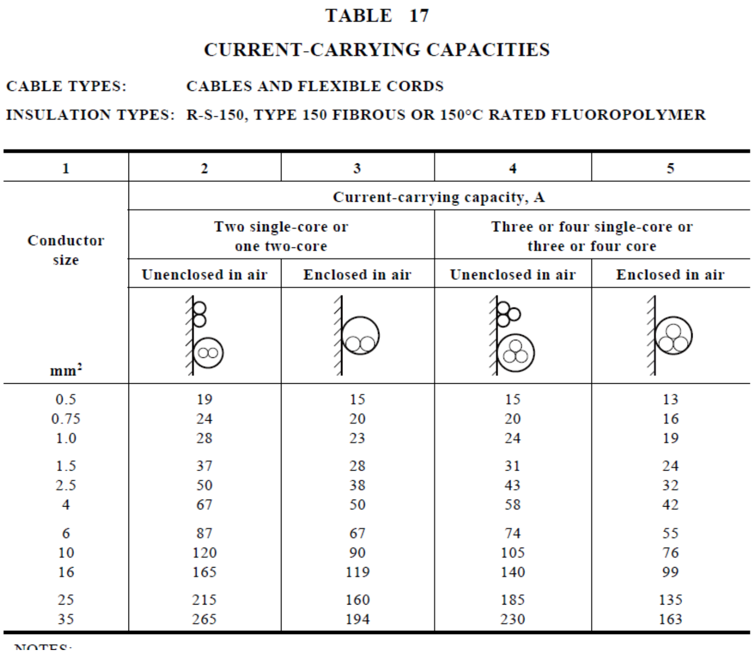


TABLE 17

CURRENT-CARRYING CAPACITIES

CABLE TYPES: CABLES AND FLEXIBLE CORDS

INSULATION TYPES: R-S-150, TYPE 150 FIBROUS OR 150°C RATED FLUOROPOLYMER

1	2	3	4	5
Conductor size	Current-carrying capacity, A			
	Two single-core or one two-core		Three or four single-core or three or four core	
	Unenclosed in air	Enclosed in air	Unenclosed in air	Enclosed in air
mm²				
0.5	19	15	15	13
0.75	24	20	20	16
1.0	28	23	24	19
1.5	37	28	31	24
2.5	50	38	43	32
4	67	50	58	42
6	87	67	74	55
10	120	90	105	76
16	165	119	140	99
25	215	160	185	135
35	265	194	230	163

NOTES:

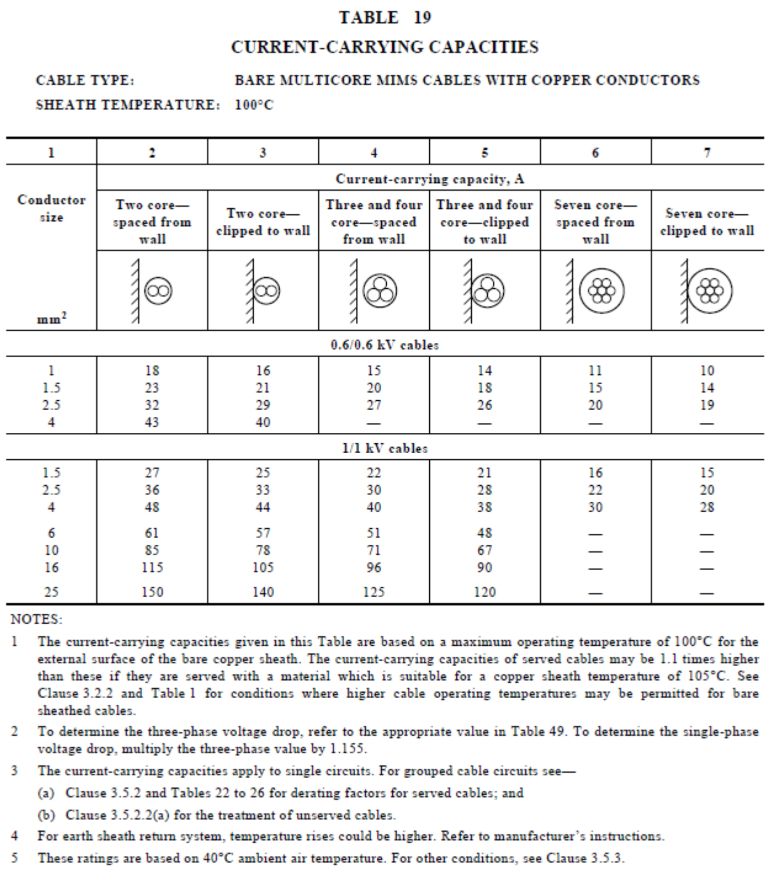


TABLE 19

CURRENT-CARRYING CAPACITIES

CABLE TYPE: BARE MULTICORE MIMS CABLES WITH COPPER CONDUCTORS

SHEATH TEMPERATURE: 100°C

1	2	3	4	5	6	7
Conductor size	Current-carrying capacity, A					
	Two core—spaced from wall	Two core—clipped to wall	Three and four core—spaced from wall	Three and four core—clipped to wall	Seven core—spaced from wall	Seven core—clipped to wall
mm²						
			0.6/0.6 kV cables			
1	18	16	15	14	11	10
1.5	23	21	20	18	15	14
2.5	32	29	27	26	20	19
4	43	40	—	—	—	—
			1/1 kV cables			
1.5	27	25	22	21	16	15
2.5	36	33	30	28	22	20
4	48	44	40	38	30	28
6	61	57	51	48	—	—
10	85	78	71	67	—	—
16	115	105	96	90	—	—
25	150	140	125	120	—	—

NOTES:

1 The current-carrying capacities given in this Table are based on a maximum operating temperature of 100°C for the external surface of the bare copper sheath. The current-carrying capacities of served cables may be 1.1 times higher than these if they are served with a material which is suitable for a copper sheath temperature of 105°C. See Clause 3.2.2 and Table 1 for conditions where higher cable operating temperatures may be permitted for bare sheathed cables.

2 To determine the three-phase voltage drop, refer to the appropriate value in Table 49. To determine the single-phase voltage drop, multiply the three-phase value by 1.155.

3 The current-carrying capacities apply to single circuits. For grouped cable circuits see—

(a) Clause 3.5.2 and Tables 22 to 26 for derating factors for served cables; and

(b) Clause 3.5.2.2(a) for the treatment of unserved cables.

4 For earth sheath return system, temperature rises could be higher. Refer to manufacturer's instructions.

5 These ratings are based on 40°C ambient air temperature. For other conditions, see Clause 3.5.3.

AS-NZS 5033-2021.1

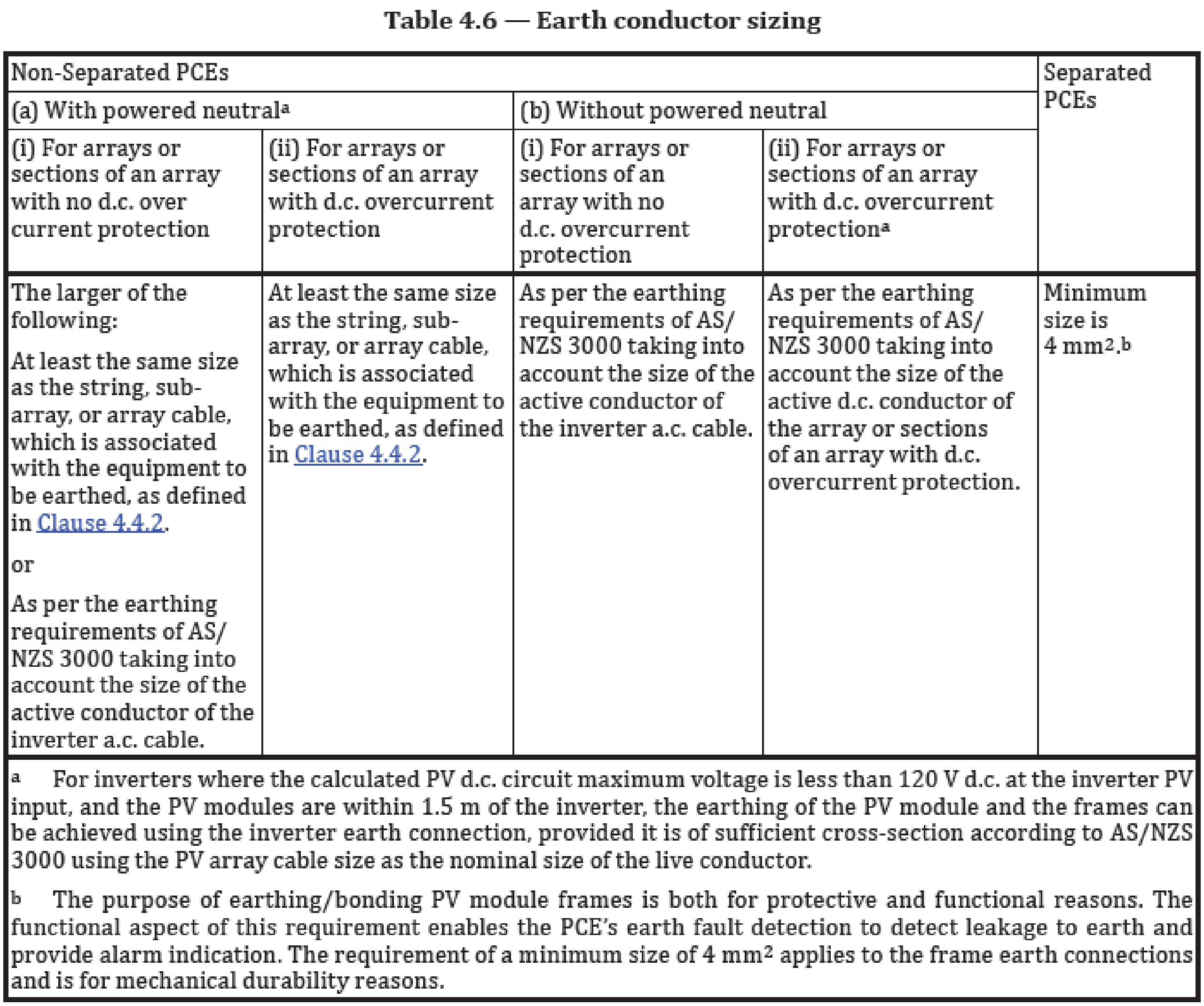
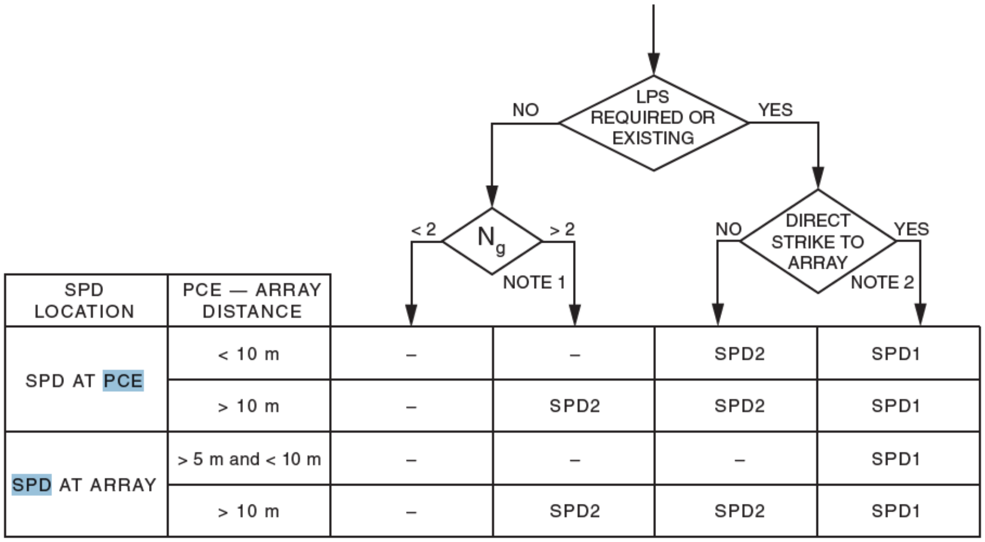


Table 4.6 — Earth conductor sizing

Non-Separated PCEs				Separated PCEs
(a) With powered neutral[a]		(b) Without powered neutral		
(i) For arrays or sections of an array with no d.c. over current protection	(ii) For arrays or sections of an array with d.c. overcurrent protection	(i) For arrays or sections of an array with no d.c. overcurrent protection	(ii) For arrays or sections of an array with d.c. overcurrent protection[a]	
The larger of the following: At least the same size as the string, sub-array, or array cable, which is associated with the equipment to be earthed, as defined in Clause 4.4.2. or As per the earthing requirements of AS/NZS 3000 taking into account the size of the active conductor of the inverter a.c. cable.	At least the same size as the string, sub-array, or array cable, which is associated with the equipment to be earthed, as defined in Clause 4.4.2.	As per the earthing requirements of AS/NZS 3000 taking into account the size of the active conductor of the inverter a.c. cable.	As per the earthing requirements of AS/NZS 3000 taking into account the size of the active d.c. conductor of the array or sections of an array with d.c. overcurrent protection.	Minimum size is 4 mm^2.[b]

[a] For inverters where the calculated PV d.c. circuit maximum voltage is less than 120 V d.c. at the inverter PV input, and the PV modules are within 1.5 m of the inverter, the earthing of the PV module and the frames can be achieved using the inverter earth connection, provided it is of sufficient cross-section according to AS/NZS 3000 using the PV array cable size as the nominal size of the live conductor.

[b] The purpose of earthing/bonding PV module frames is both for protective and functional reasons. The functional aspect of this requirement enables the PCE's earth fault detection to detect leakage to earth and provide alarm indication. The requirement of a minimum size of 4 mm^2 applies to the frame earth connections and is for mechanical durability reasons.

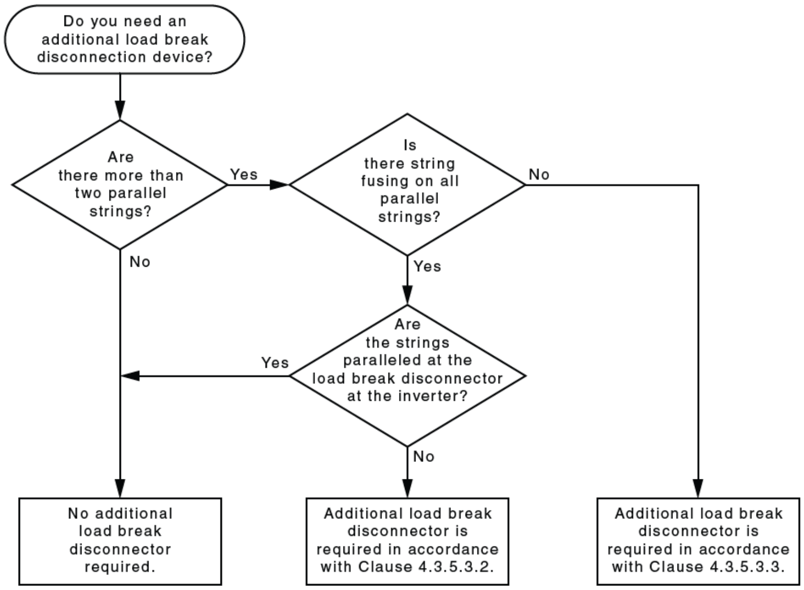


SPD LOCATION	PCE — ARRAY DISTANCE				
SPD AT PCE	< 10 m	–	–	SPD2	SPD1
	> 10 m	–	SPD2	SPD2	SPD1
SPD AT ARRAY	> 5 m and < 10 m	–	–	–	SPD1
	> 10 m	–	SPD2	SPD2	SPD1

NOTE 1 Where the array is protected by the building LPS, SPD2 should be selected.

NOTE 2 Where the array structure has its own air terminals i.e.it could take a direct lightning strike, SPD1 should be selected.

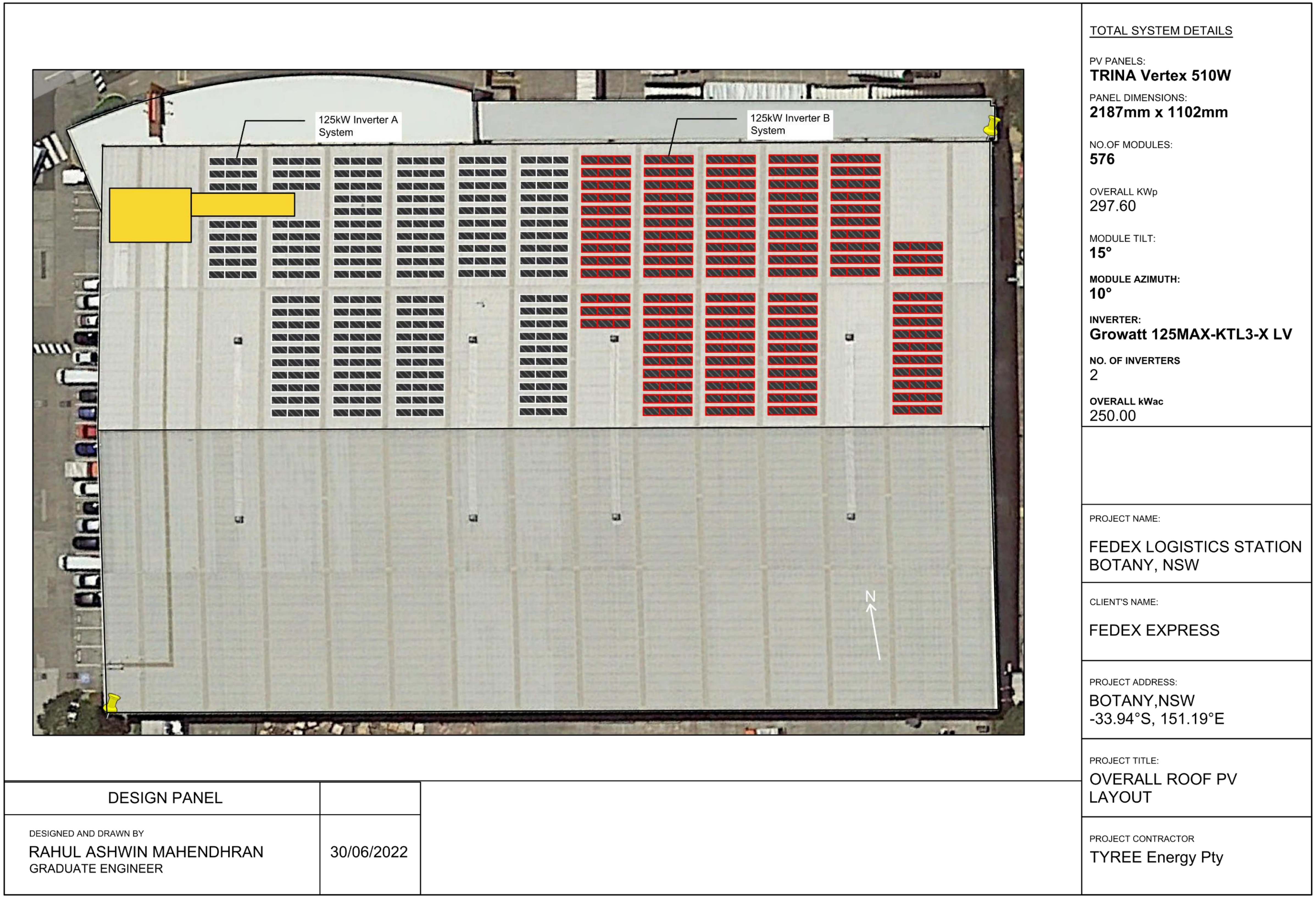
Figure G.2 — d.c. SPD requirements



NOTE The installation of wiring enclosures for the wiring system has different requirements depending on the PV isolation method, see Clause 4.4.5.2 for the installation of wiring enclosures.

Figure 4.2 — Additional load break disconnection device requirement decision tree

Appendix D: Site Layout and PV Orientation



TOTAL SYSTEM DETAILS

PV PANELS:
TRINA Vertex 510W

PANEL DIMENSIONS:
2187mm x 1102mm

NO.OF MODULES:
576

OVERALL KWp
297.60

MODULE TILT:
15°

MODULE AZIMUTH:
10°

INVERTER:
Growatt 125MAX-KTL3-X LV

NO. OF INVERTERS
2

OVERALL kWac
250.00

PROJECT NAME:
FEDEX LOGISTICS STATION
BOTANY, NSW

CLIENT'S NAME:
FEDEX EXPRESS

PROJECT ADDRESS:
BOTANY,NSW
-33.94°S, 151.19°E

PROJECT TITLE:
OVERALL ROOF PV
LAYOUT

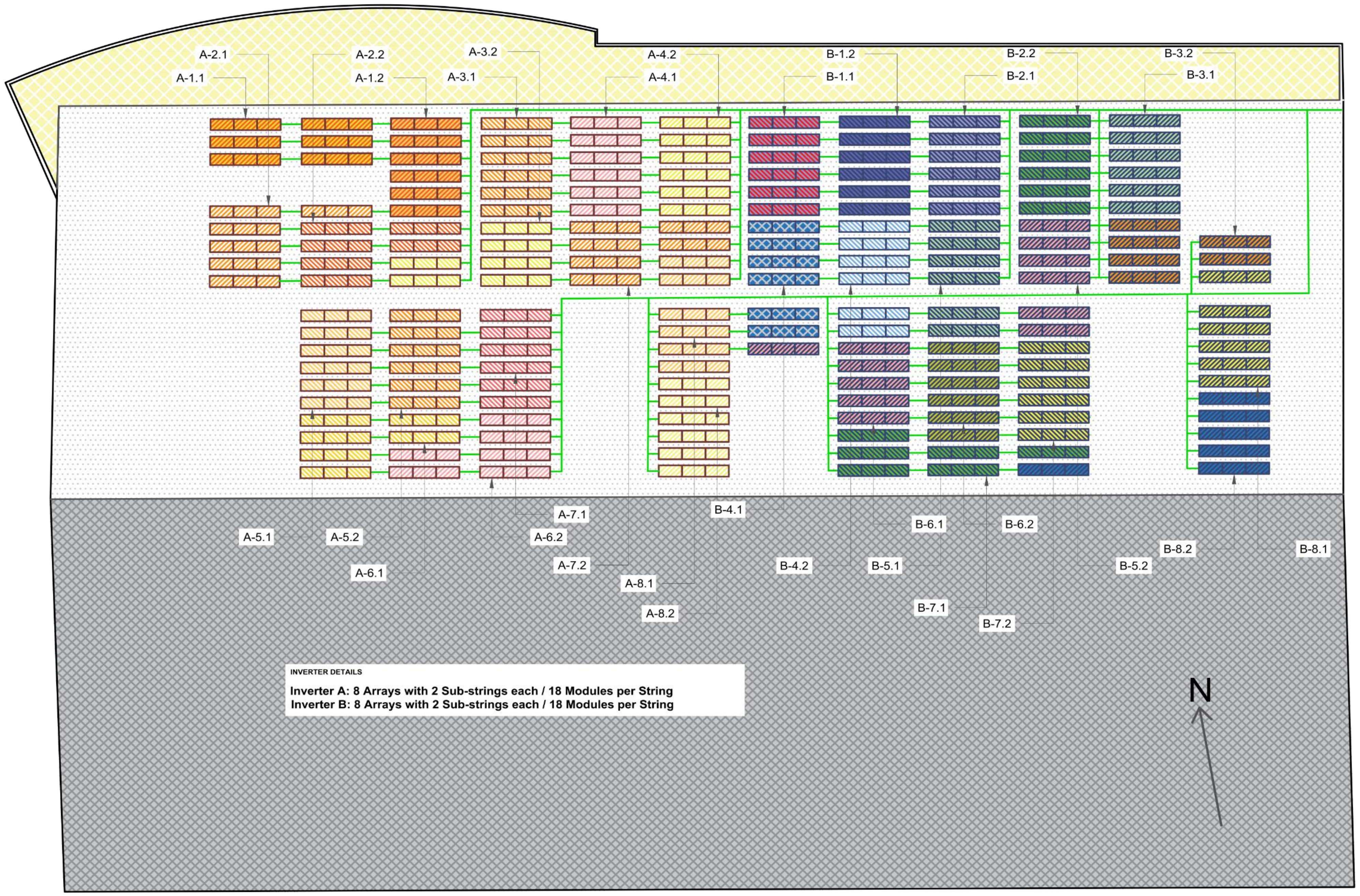
PROJECT CONTRACTOR
TYREE Energy Pty

DESIGN PANEL

DESIGNED AND DRAWN BY
RAHUL ASHWIN MAHENDHRAN
GRADUATE ENGINEER

30/06/2022

Appendix D: Figure 1 Site Layout and PV System Orientation



INVERTER DETAILS

Inverter A: 8 Arrays with 2 Sub-strings each / 18 Modules per String
Inverter B: 8 Arrays with 2 Sub-strings each / 18 Modules per String

TOTAL SYSTEM DETAILS

PV PANELS:
TRINA Vertex 510W

PANEL DIMENSIONS:
2187mm x 1102mm

NO.OF MODULES:
576

OVERALL KWp
297.60

MODULE TILT:
15°

MODULE AZIMUTH:
10°

INVERTER:
Growatt 125MAX-KTL3-X LV

NO. OF INVERTERS
2

OVERALL kWac
250.00

PROJECT NAME:

FEDEX LOGISTICS STATION
BOTANY, NSW

CLIENT'S NAME:

FEDEX EXPRESS

PROJECT ADDRESS:
BOTANY,NSW
-33.94°S, 151.19°E

PROJECT TITLE:
STRING LAYOUT

PROJECT CONTRACTOR
TYREE Energy Pty

DESIGN PANEL

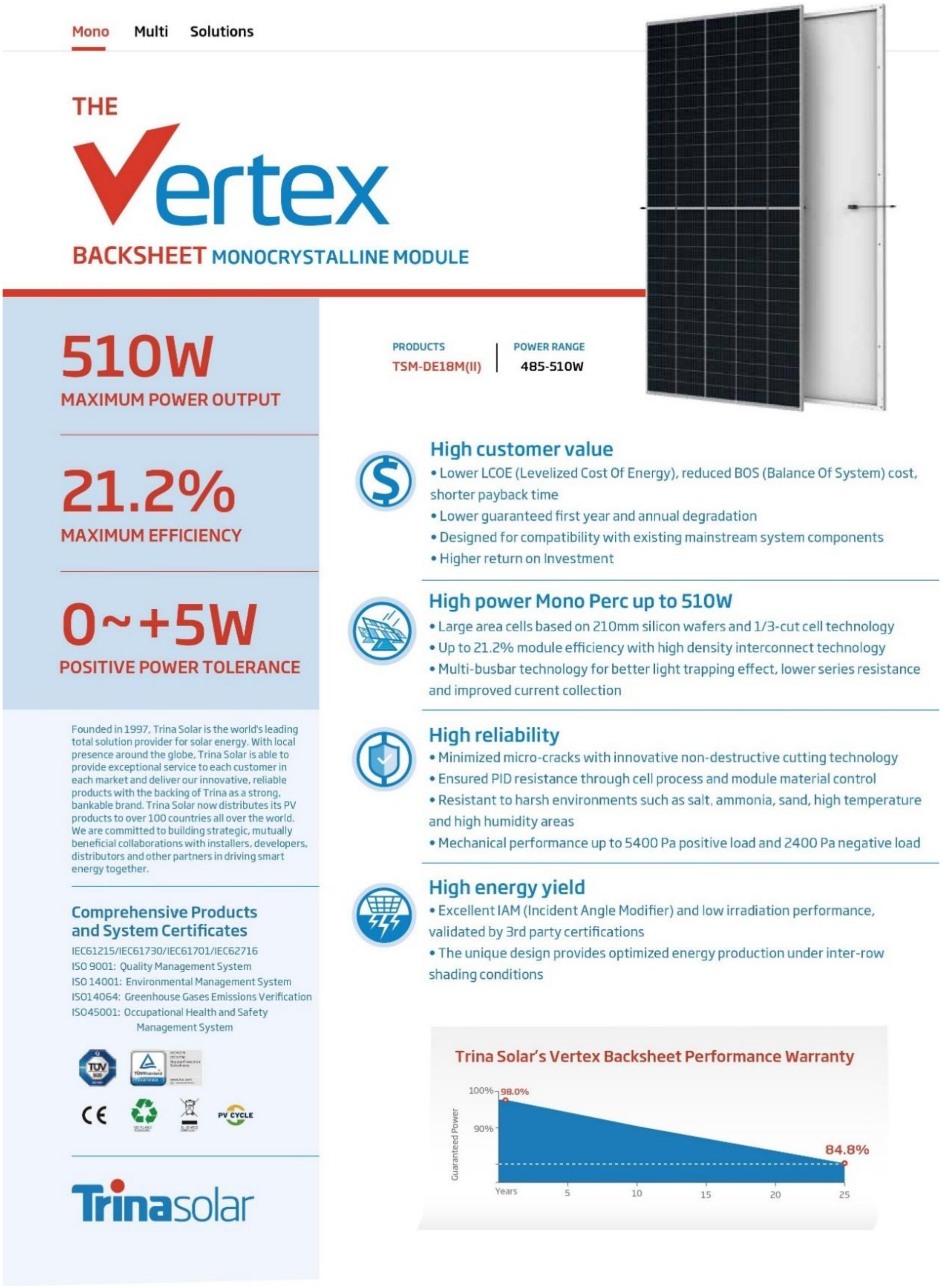
DESIGNED AND DRAWN BY
RAHUL ASHWIN MAHENDHRAN
GRADUATE ENGINEER

30/06/2022

— Earthing Wire

Appendix D: Figure 2 PV Array Structure and Earthing

Appendix E: PV Systems Component Datasheets



Mono Multi Solutions

THE Vertex

BACKSHEET MONOCRYSTALLINE MODULE

PRODUCTS
TSM-DE18M(II)

POWER RANGE
485-510W

510W
MAXIMUM POWER OUTPUT

21.2%
MAXIMUM EFFICIENCY

0~+5W
POSITIVE POWER TOLERANCE

Founded in 1997, Trina Solar is the world's leading total solution provider for solar energy. With local presence around the globe, Trina Solar is able to provide exceptional service to each customer in each market and deliver our innovative, reliable products with the backing of Trina as a strong, bankable brand. Trina Solar now distributes its PV products to over 100 countries all over the world. We are committed to building strategic, mutually beneficial collaborations with installers, developers, distributors and other partners in driving smart energy together.

Comprehensive Products and System Certificates

IEC61215/IEC61730/IEC61701/IEC62716
ISO 9001: Quality Management System
ISO 14001: Environmental Management System
ISO14064: Greenhouse Gases Emissions Verification
ISO45001: Occupational Health and Safety Management System

High customer value

- Lower LCOE (Levelized Cost Of Energy), reduced BOS (Balance Of System) cost, shorter payback time
- Lower guaranteed first year and annual degradation
- Designed for compatibility with existing mainstream system components
- Higher return on Investment

High power Mono Perc up to 510W

- Large area cells based on 210mm silicon wafers and 1/3-cut cell technology
- Up to 21.2% module efficiency with high density interconnect technology
- Multi-busbar technology for better light trapping effect, lower series resistance and improved current collection

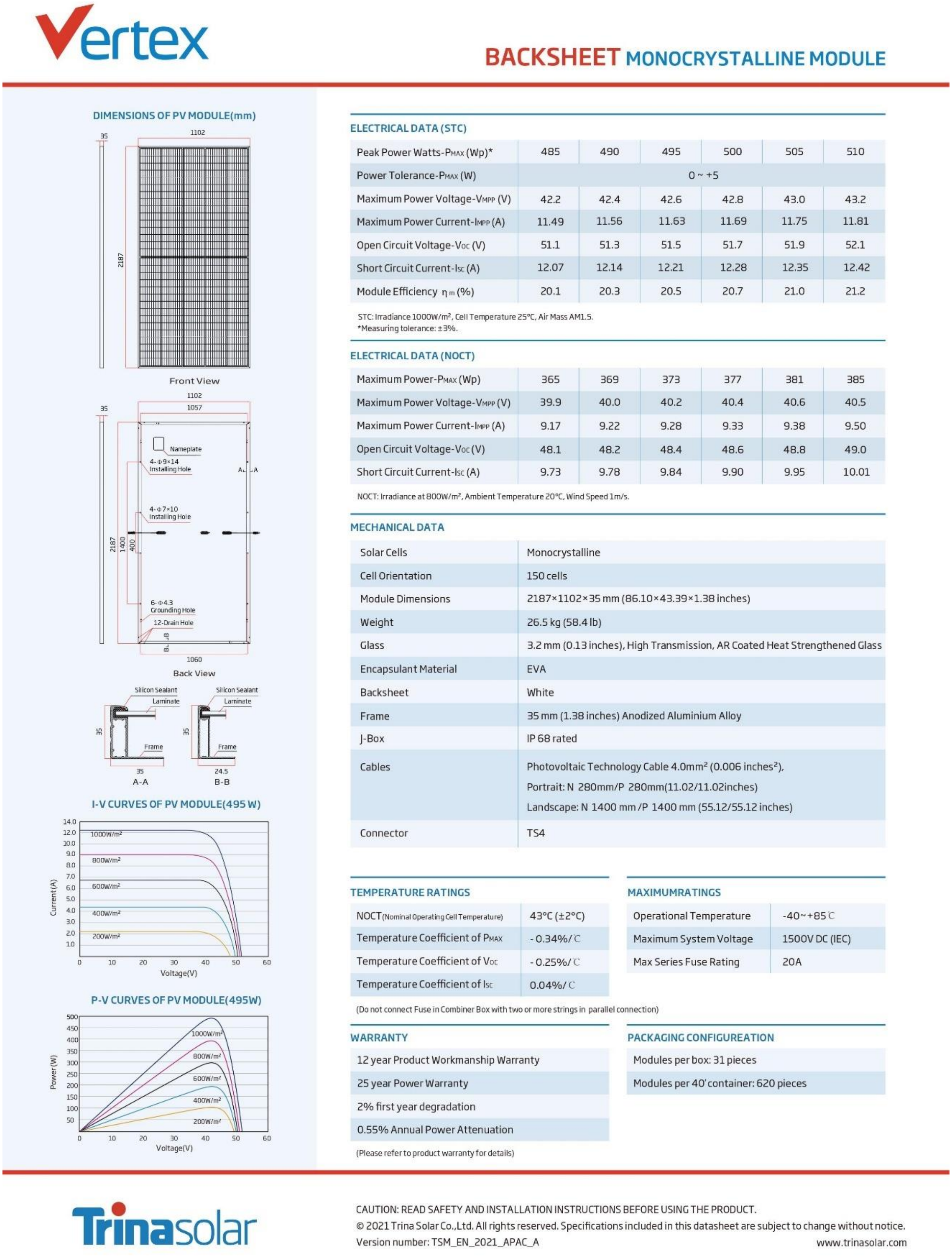
High reliability

- Minimized micro-cracks with innovative non-destructive cutting technology
- Ensured PID resistance through cell process and module material control
- Resistant to harsh environments such as salt, ammonia, sand, high temperature and high humidity areas
- Mechanical performance up to 5400 Pa positive load and 2400 Pa negative load

High energy yield

- Excellent IAM (Incident Angle Modifier) and low irradiation performance, validated by 3rd party certifications
- The unique design provides optimized energy production under inter-row shading conditions

Trina Solar's Vertex Backsheet Performance Warranty



Vertex

BACKSHEET MONOCRYSTALLINE MODULE

DIMENSIONS OF PV MODULE(mm)

I-V CURVES OF PV MODULE(495 W)

P-V CURVES OF PV MODULE(495W)

ELECTRICAL DATA (STC)

Peak Power Watts-P_{MAX} (Wp)*	485	490	495	500	505	510
Power Tolerance-P_{MAX} (W)	0 ~ +5					
Maximum Power Voltage-V_{MPP} (V)	42.2	42.4	42.6	42.8	43.0	43.2
Maximum Power Current-I_{MPP} (A)	11.49	11.56	11.63	11.69	11.75	11.81
Open Circuit Voltage-V_{OC} (V)	51.1	51.3	51.5	51.7	51.9	52.1
Short Circuit Current-I_{SC} (A)	12.07	12.14	12.21	12.28	12.35	12.42
Module Efficiency η_m (%)	20.1	20.3	20.5	20.7	21.0	21.2

STC: Irradiance 1000W/m², Cell Temperature 25°C, Air Mass AM1.5.
*Measuring tolerance: ±3%.

ELECTRICAL DATA (NOCT)

Maximum Power-P_{MAX} (Wp)	365	369	373	377	381	385
Maximum Power Voltage-V_{MPP} (V)	39.9	40.0	40.2	40.4	40.6	40.5
Maximum Power Current-I_{MPP} (A)	9.17	9.22	9.28	9.33	9.38	9.50
Open Circuit Voltage-V_{OC} (V)	48.1	48.2	48.4	48.6	48.8	49.0
Short Circuit Current-I_{SC} (A)	9.73	9.78	9.84	9.90	9.95	10.01

NOCT: Irradiance at 800W/m², Ambient Temperature 20°C, Wind Speed 1m/s.

MECHANICAL DATA

Solar Cells	Monocrystalline
Cell Orientation	150 cells
Module Dimensions	2187×1102×35 mm (86.10×43.39×1.38 inches)
Weight	26.5 kg (58.4 lb)
Glass	3.2 mm (0.13 inches), High Transmission, AR Coated Heat Strengthened Glass
Encapsulant Material	EVA
Backsheet	White
Frame	35 mm (1.38 inches) Anodized Aluminium Alloy
J-Box	IP 68 rated
Cables	Photovoltaic Technology Cable 4.0mm² (0.006 inches²), Portrait: N 280mm/P 280mm(11.02/11.02inches) Landscape: N 1400 mm /P 1400 mm (55.12/55.12 inches)
Connector	TS4

TEMPERATURE RATINGS

NOCT (Nominal Operating Cell Temperature)	43°C (±2°C)
Temperature Coefficient of P_{MAX}	- 0.34%/℃
Temperature Coefficient of V_{OC}	- 0.25%/℃
Temperature Coefficient of I_{SC}	0.04%/℃

MAXIMUMRATINGS

Operational Temperature	-40~+85℃
Maximum System Voltage	1500V DC (IEC)
Max Series Fuse Rating	20A

(Do not connect Fuse in Combiner Box with two or more strings in parallel connection)

WARRANTY

12 year Product Workmanship Warranty
25 year Power Warranty
2% first year degradation
0.55% Annual Power Attenuation

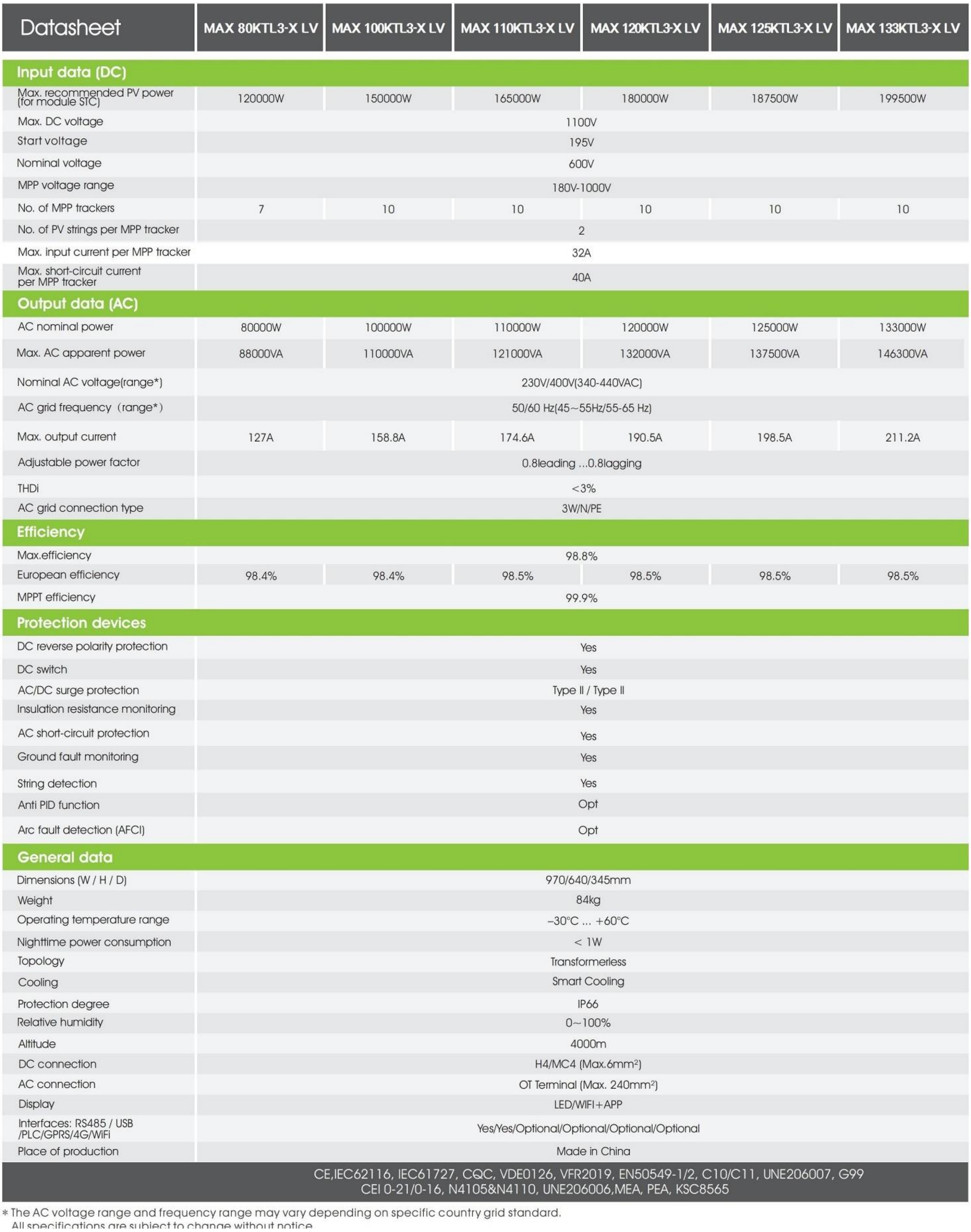
(Please refer to product warranty for details)

PACKAGING CONFIGUREATION

Modules per box: 31 pieces
Modules per 40' container: 620 pieces

CAUTION: READ SAFETY AND INSTALLATION INSTRUCTIONS BEFORE USING THE PRODUCT.

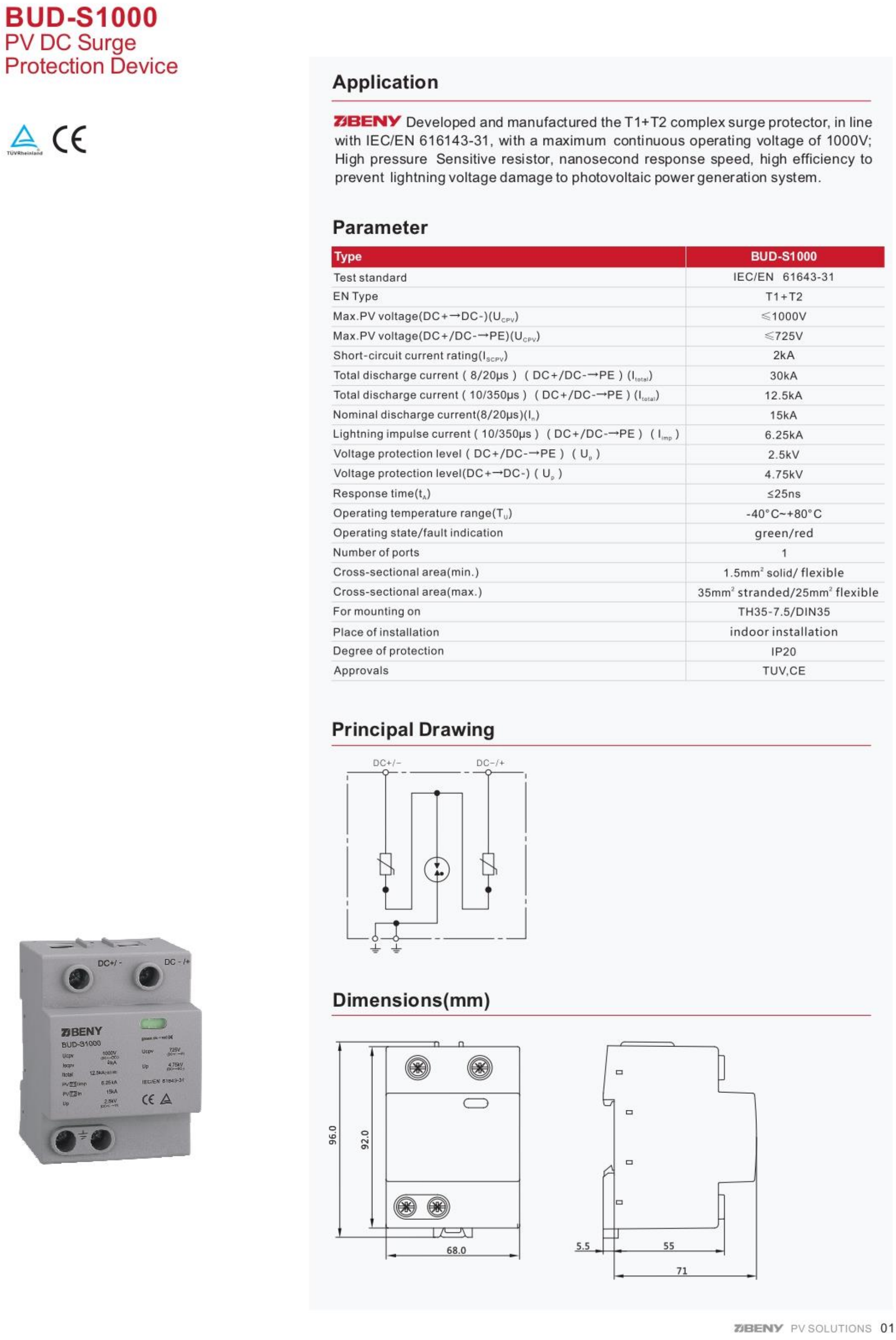
Version number: TSM_EN_2021_APAC_A
www.trinasolar.com



Datasheet	MAX 80KTL3-X LV	MAX 100KTL3-X LV	MAX 110KTL3-X LV	MAX 120KTL3-X LV	MAX 125KTL3-X LV	MAX 133KTL3-X LV
Input data (DC)						
Max. recommended PV power (for module STC)	120000W	150000W	165000W	180000W	187500W	199500W
Max. DC voltage	1100V					
Start voltage	195V					
Nominal voltage	600V					
MPP voltage range	180V-1000V					
No. of MPP trackers	7	10	10	10	10	10
No. of PV strings per MPP tracker	2					
Max. input current per MPP tracker	32A					
Max. short-circuit current per MPP tracker	40A					
Output data (AC)						
AC nominal power	80000W	100000W	110000W	120000W	125000W	133000W
Max. AC apparent power	88000VA	110000VA	121000VA	132000VA	137500VA	146300VA
Nominal AC voltage(range*)	230V/400V(340-440VAC)					
AC grid frequency（range*）	50/60 Hz(45~55Hz/55-65 Hz)					
Max. output current	127A	158.8A	174.6A	190.5A	198.5A	211.2A
Adjustable power factor	0.8leading ...0.8lagging					
THDi	<3%					
AC grid connection type	3W/N/PE					
Efficiency						
Max.efficiency	98.8%					
European efficiency	98.4%	98.4%	98.5%	98.5%	98.5%	98.5%
MPPT efficiency	99.9%					
Protection devices						
DC reverse polarity protection	Yes					
DC switch	Yes					
AC/DC surge protection	Type II / Type II					
Insulation resistance monitoring	Yes					
AC short-circuit protection	Yes					
Ground fault monitoring	Yes					
String detection	Yes					
Anti PID function	Opt					
Arc fault detection (AFCI)	Opt					
General data						
Dimensions (W / H / D)	970/640/345mm					
Weight	84kg					
Operating temperature range	–30°C ... +60°C					
Nighttime power consumption	< 1W					
Topology	Transformerless					
Cooling	Smart Cooling					
Protection degree	IP66					
Relative humidity	0~100%					
Altitude	4000m					
DC connection	H4/MC4 (Max.6mm^2)					
AC connection	OT Terminal (Max. 240mm^2)					
Display	LED/WIFI+APP					
Interfaces: RS485 / USB /PLC/GPRS/4G/WiFi	Yes/Yes/Optional/Optional/Optional/Optional					
Place of production	Made in China					

CE,IEC62116, IEC61727, CQC, VDE0126, VFR2019, EN50549-1/2, C10/C11, UNE206007, G99
CEI 0-21/0-16, N4105&N4110, UNE206006,MEA, PEA, KSC8565

* The AC voltage range and frequency range may vary depending on specific country grid standard.
All specifications are subject to change without notice



BUD-S1000
PV DC Surge
Protection Device

TÜVRheinland CE

Application

BENY Developed and manufactured the T1+T2 complex surge protector, in line with IEC/EN 616143-31, with a maximum continuous operating voltage of 1000V; High pressure Sensitive resistor, nanosecond response speed, high efficiency to prevent lightning voltage damage to photovoltaic power generation system.

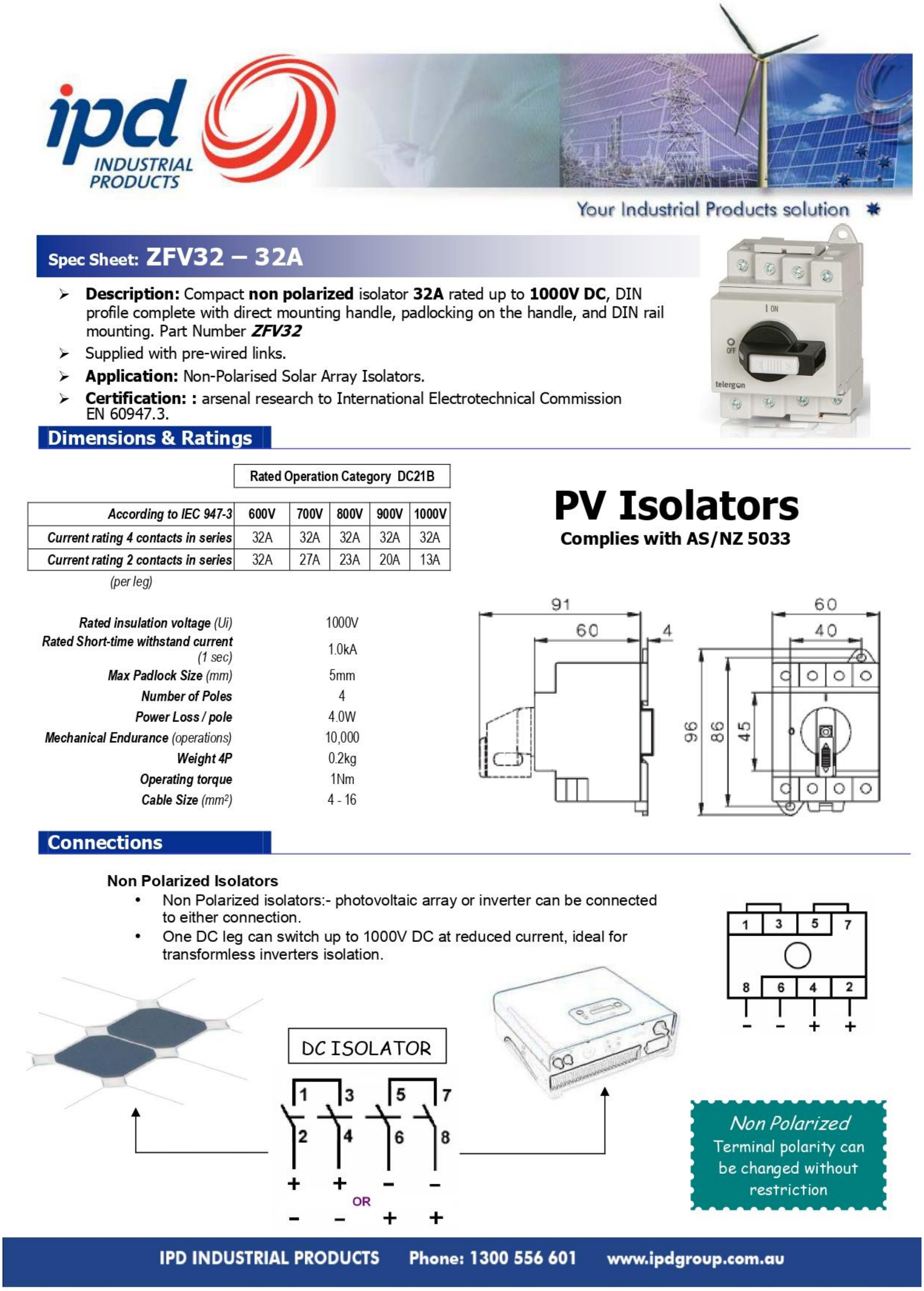
Parameter

Type	BUD-S1000
Test standard	IEC/EN 61643-31
EN Type	T1+T2
Max.PV voltage(DC+→DC-)(U_{CPV})	⩽1000V
Max.PV voltage(DC+/DC-→PE)(U_{CPV})	⩽725V
Short-circuit current rating(I_{SCPV})	2kA
Total discharge current (8/20μs) (DC+/DC-→PE) (I_{total})	30kA
Total discharge current (10/350μs) (DC+/DC-→PE) (I_{total})	12.5kA
Nominal discharge current(8/20μs)(I_n)	15kA
Lightning impulse current (10/350μs) (DC+/DC-→PE) (I_{imp})	6.25kA
Voltage protection level (DC+/DC-→PE) (U_p)	2.5kV
Voltage protection level(DC+→DC-) (U_p)	4.75kV
Response time(t_A)	≤25ns
Operating temperature range(T_U)	-40°C~+80°C
Operating state/fault indication	green/red
Number of ports	1
Cross-sectional area(min.)	1.5mm² solid/ flexible
Cross-sectional area(max.)	35mm² stranded/25mm² flexible
For mounting on	TH35-7.5/DIN35
Place of installation	indoor installation
Degree of protection	IP20
Approvals	TUV,CE

Principal Drawing

Dimensions(mm)

BENY PV SOLUTIONS 01



ipd INDUSTRIAL PRODUCTS

Your Industrial Products solution

Spec Sheet: ZFV32 – 32A

- **Description:** Compact **non polarized** isolator **32A** rated up to **1000V DC**, DIN profile complete with direct mounting handle, padlocking on the handle, and DIN rail mounting. Part Number ***ZFV32***
- Supplied with pre-wired links.
- **Application:** Non-Polarised Solar Array Isolators.
- **Certification: :** arsenal research to International Electrotechnical Commission EN 60947.3.

Dimensions & Ratings

	Rated Operation Category DC21B				
According to IEC 947-3	600V	700V	800V	900V	1000V
Current rating 4 contacts in series	32A	32A	32A	32A	32A
Current rating 2 contacts in series	32A	27A	23A	20A	13A

(per leg)

Rated insulation voltage (Ui)	1000V
Rated Short-time withstand current (1 sec)	1.0kA
Max Padlock Size (mm)	5mm
Number of Poles	4
Power Loss / pole	4.0W
Mechanical Endurance (operations)	10,000
Weight 4P	0.2kg
Operating torque	1Nm
Cable Size (mm²)	4 - 16

PV Isolators

Complies with AS/NZ 5033

Connections

Non Polarized Isolators

- Non Polarized isolators:- photovoltaic array or inverter can be connected to either connection.
- One DC leg can switch up to 1000V DC at reduced current, ideal for transformless inverters isolation.

Non Polarized
Terminal polarity can be changed without restriction

IPD INDUSTRIAL PRODUCTS Phone: 1300 556 601 www.ipdgroup.com.au

References

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[3] https://www.ato.gov.au/rates/individual-income-tax-rates/
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SOLA4012-PV System Design
Commercial PV Design Project

Botany,NSW
Project Type: Commercial

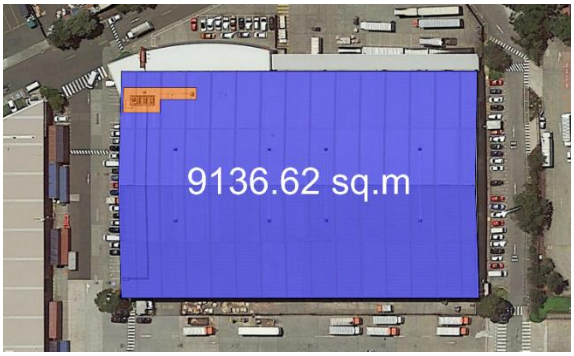
Tender Report

Rahul Ashwin Mahendhran
Z5353624

Table of Contents

1. Executive Summary

The project aims to design and develop a roof-mounted grid-connected commercial PV System for FEDEX Express Logistics Warehouse located at Port Air Industrial Estate, Botany, NSW (33.94°S, 151.19°E). The site is located at the Port Air Industrial Estate in closer vicinity to the Sydney International Airport and Botany Port. The site is elevated avoiding shading effects due to external factors.

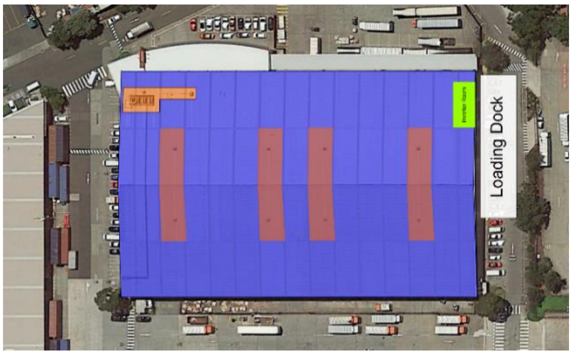


As per the requirement, the designed system is a non-exporting PV System, serving the internal demands of the building across the year, developed with optimized PV Design and reliable inverters. The PV System is designed for two scenarios:- 1. PV System without storage (250kWac), 2.PV System with storage(220kWac). The system is designed based on the scaled load demand of the building with roof insolation of 150kWh/m2/day. The PV system is designed to provide a higher energy yield at a low Levelised Cost of Electricity.

SPREE Energy is committed to designing and developing a large-scale commercial PV system for FEDEX Logistics The design aims to comply with all the requirements from the Clean Energy Regulator and AS/NZS Standards, to be eligible for the Large-Scale Generation Certificate.

2. Context and Site Assessment

Site Summary



The work site has a roof area of 9136.62sq.m and is oriented at an angle of 10° from the true north. The work site-building has a Gable Roof, covered with metal roofing and stripes of polycarbonate sheets for natural lighting. Since the roof has been mounted on metal beams running across the building, the roof is assessed to withstand higher loads on top. The roof is at an elevation of 10.75m from ground level, therefore shading due to trees, lamps, and posts is avoided. Hence, the site is physically fit for solar PV installation. The roof is easily accessible from all sides; the loading of heavy components could be lifted from either side of the building.

Location:	Store 5/1a Hale St, Botany NSW 2019	Roof Area	9136.62m2
Length:	120.3m	Building Azimuth	10°
Breadth	75.76m	Roof Tilt Angle	6°
Building Height	10.75m	Roofing Material	Steel Roofing
Roof Type	Gable Roof	Weather Station	Sydney International Airport

Weather and Solar Insolation Assessment

The hourly data of annual weather and solar insolation are sourced from BOM recorded at Sydney International Airport (066037). A preliminary analysis of Solar Irradiation, Temperature, and wind speed are analyzed with the help of SAM, to structure, orient, and design a PV system. The overall change in irradiance and temperature are monitored across the year to estimate the yield of the designed system.

Weather and Solar Insolation Assessment			
Beam Irradiance DNI (kWh/m2/day)	10.28	Max-Dry Bulb Temperature (°C)	39.34
Diffuse Irradiance DHI (kWh/m2/day)	2.42	Min Dry Bulb Temperature (°C)	5.32
Global Irradiance GHI (kWh/m2/day)	8.40	Max Wind Speed (km/h)	11km/h

As per the AS/NZS 1127 standards, the site is located at A3 Wind Region and TC3 Terrain. Based on an understanding of harsh local weather conditions, the roof attachments are recommended to be thoroughly designed and installed.

Building Load Analysis

The given load Demand is analysed for missing data; it is observed that roughly around 54 Rows of data have been missing. The Data entries were filled using two methodologies

1. Linear Interpolation Method.
2. Mean of the Load from consecutive hours of the next and previous days.

The load demand of the building is scaled to a rate where the Energy intensity of the building is 150kWh/m2/year with the overall area of the roof. A summary of the analysis is showshownTable2.

Load Analysis			
Roof Area	9136.62m2	Max Load (kW)	353.33
Total Energy Demand (kWh/yr)	1370493.00	Min Load (kW)	74.92
Energy Intensity (kWh/sqm/yr)	150	Average Load (kW)	80.23

3. PV System Design Summary

In both the scenarios of the PV System design, the design with the below-mentioned components are simulated in System Advisory Model to understand and optimize the system to perform at its best. Following that, both the scenarios follow almost the same design on the PV Side.

Inverter

The inverter is initially scaled based on the load requirement of the building. The DC/AC Conversion system includes 2 Inverters from Growatt MAX 125KTL3-X-LV Series (AC Rating 125kW) with 10MMPTs to form 250kWac PV System. The inverters are CEC Approved and operate at an efficiency of 98.4% with IP66 certification. The specifications of the inverter are attached in the Appendix. The PV System is designed to meet a DC/AC Ratio between 1.10 to 1.25, to ensure optimal performance of the system.

Modules

This project will use the Vertex series of Trina Solar (TSM-DE18M(II) 510W) 150cell module. The module has been selected due to its higher efficiency rate of 21.2%, to maximize the solar power generated/sqm tr of area. With the latest technology of 1/3 cut cells, the cost of the module has been significantly reduced and voltage has been tripled under the same area; offering a lower LCOE in the economics of the project. In addition to its design due to its higher OCPR of 20/25A BOS cost is reduced in the system. The specification of the modules can be found in the appendix.

System Configuration

The system is oriented based on the best performance of the energy yield when tilt angles of the PV system are optimal. The PV system is not scaled up for the design with the battery because of loss of Energy yield (in kWh/kW) due to south-facing roof and undesired tilt angle. Hence the DC/AC ratio is increased for the PV design with a battery, resulting in a significant rise in Energy yield to serve the loads and charge the battery simultaneously. The system configuration for the PV system without battery and PV system with battery is shown below in the tables respectively.

System Configuration and Panel Orientation for PV System without Battery			
Modules /String	18	Max Power Output of a module	510W
String / MPPT	2	Max DC Power Input/Inverter	187.5kW
No. of MPPT (used in the System)	8	Max AC Output/Inverter	125kW
No. of Modules/ Inverter	288	Designed DC Input to Inverter	146.8kW
No. of inverters	2	Designed DC/AC Ratio	1.18
Total No.of Modules	576	Module Azimuth/Tilt Angle	10°/33°

System Configuration and Panel Orientation for PV System with Battery			
Modules /String	18	Max Power Output of a module	510W
String / MPPT	2	Max DC Power Input/Inverter	187.5kW
No. of MPPT (used in the System)	9	Max AC Output/Inverter	125kW
No. of Modules/ Inverter	324	Designed DC Input to Inverter	165.3kW
No. of inverters	2	Designed DC/AC Ratio	1.32
Total No.of Modules	648	Module Azimuth/Tilt Angle	10°/33°

Inverter Size Matching

The voltage, current, and power checks are performed and are verified to be under the limits of the inverter rating (as per AS/NSZ 5033 and AS/NSZ 4777 Standards).

	Voltage Window Check			**Current/ Power Check**		
	Vmppt_min	**Vmppt_max**	**Voc_max**	**Max Current**	**Max Power**	**Derated Power**
Array	638	833	985	31.05	18360	15234.86
MPPT	198	950	1045	32	18750	16875
Check	YES	YES	YES	YES	YES	YES

Cable Sizing

Based on the system configurations of the two systems, the cable sizing on both designs is almost the same and is designed to comply with AS/NZS 3008 standards. The overall voltage drop caused by the wires in DC System/ MPPT is restricted to <3%. The details on cable sizing is shown in the appendix.

System Protection

The circuit protection in our system mandates the use of a disconnector and an SPD device on the DC Side for the system without the battery, and over current protection, device is added to the array in the case of a PV system with a battery. The requirement and sizing of Fuses and Isolators are calculated in Outputs Sheet as per the AS/NSZ 4777, AS/NSZ 3088, and AS/NSZ 5033. The protection devices added in the circuit are specified in the Appendix.

Grid Limits

The PV system is designed as a non-exporting system, hence the grid limits in the System Advisory Model is set to Zero.

Lifetime and Degradation

For an analysis period of 25 years, a DC degradation of 0.5% is set per year. Since the focus on annual energy production is prioritized, the daily lifetime losses are not considered.

System Costs

The system is designed and modelled based on the rates provided by SPREEnergy.

Components of the Project	**PV System without Battery**		**PV System with Battery**	
	Rate ($/Wdc)	**Total Cost**	**Rate ($/Wdc)**	**Total Cost**
Modules	0.87	$ 225,667.41	$ 0.87	$ 287,625.84
Inverters	0.15	$ 44,080.59	$ 0.15	$ 49590.66
Balance of System	0.07	$ 20,570.94	$ 0.07	$ 23,142.31
Installation Labour	0.23	$ 67,590.23	$ 0.23	$ 76,039.02
Contingency Plan	2.5% of Subtotal	$ 14,473.13	3% of Subtotal	$ 25,224.13
Battery DC Capacity	-	-	735$/kWh	$ 73,841.00
Battery Inverters	-	-	$ 500/kW	$30,200
Overhead and Miscellaneous		$ 191,015.88		$ 214,892.86
Total Direct Cost		$ 593,398.13		$ 778,120.31
Total installed Cost per Capacity		**$2.13/Wdc**		**$ 2.35/Wdc**

The annual operation and maintenance cost has been set on both the design scenarios has been set to 2.5% of the fixed budget and the fixed cost by capacity by 10$/kW-yr, in order to balance the cost of human resources involved in operations.

Financial Parameters

The financial parameters such as the inflation rate and the discount rate are set to 2.5% and 6% respectively as given by SPREEnergy. The analysis period for the simulation is set to 25 years. To model this system in a real-life scenario, a debt of 25% for a duration of 10 years is modelled at a 5% interest rate. A federal income tax rate of 21% is applied for the simulation.

Incentives

Considering the designed system is certified with LGC; The LGC incentive is calculated on a production basis at a cost of 0.0436$/kWh. The details of the calculation is shown in appendix.

Electricity Rates

The metering and billing nature has been set to "Net Billing" with the tariff provided by SPREEnergy. The modelled tariffs are given in the table provided in the appendix.

Battery Storage Selection and Design (PV system with Battery)

A battery is chosen at a size of 40% of installed PV system. Considering the constraints of low voltage in the grid (230V), the battery has been carefully selected to seamlessly integrate with the current system for reliable functioning. Blue Diamond ESS-60kVAv100kWh hybrid energy storage system is selected for this system design. With a robust built-in inverter, the storage system functions in 230V and with a max current of 200A. This energy system is composed of Lithium-Ion Nickel Manganese Cobalt cells. The specifications of the system is specified in the appendix. The battery dispatch controller is chosen to work under peak shaving one-day look ahead methodology, to effectively charge during excess production.

Desired Bank Capacity	100kWh	AC to DC Efficiency	96%
Desired Bank Power	60kW	DC to AC Efficiency	96%
Connection	AC Connected	Battery SoC Control	Min: 15% Max: 95%
Dispatch Control	Peak shaving one-day look ahead.		

4. PV System Optimization

PV System without battery

The PV system was initially optimized based on the tilt angle of the installed modules. The roof was tilted at 5° and an azimuth orientation of 10° from true north. The simulation was performed at different tilt angles to find the optimal angle with the highest energy yield.

Tilt Angle	Annual Energy Yield(kWh)	Energy Yield (kWh/kW)	Performance Ratio
5	223,216	1519	0.83
10	231,148	1573	0.83
15	237,511	1616	0.84
20	242,356	1649	0.84
33	247,733	1686	0.84
36	247,463	1684	0.84

On optimizing the tilt angle of a single inverter system, the design is scaled to obtain an optimal number of strings per inverter with the fixed tilt angle.

Modules Connected	Annual Energy Yield(kWh)	Energy Yield (kWh/kW)	Performance Ratio	LCOE Nominal
14x18 (252)	216,708	1686	0.84	16.83¢/kWh
16x18 (288)	247,733	1684	0.84	15.94¢/kWh
18x18 (324)	273,988	1657	0.83	15.45¢/kWh

The idea of choosing 16 parallel strings with 18modules /string came due to high energy yield and high-performance ratio, hence the system would be reliable in worst weather conditions. The next level of optimization came with scaling the number of inverter systems to increase annual yield to supply the demand.

No. of Inverters	No.of Modules	Annual Energy Yield(kWh)	Energy Yield (kWh/kW)	Performance Ratio	LCOE Nominal	Payback Period
1 Inverter	288	247,733	1684	0.84	15.94¢/kWh	5.3yrs
2 Inverters	576	495,466	1686	0.84	12.87¢/kWh	5.0yrs
3Inverters	864	700,339	1589	0.84	12.70¢/kWh	5.2yrs
4 Inverters	1152	830,921	1414	0.83	13.91¢/kWh	6yrs

Based on a higher energy yield and low payback period, the system is scaled to two inverters forming 250kWac with 576 modules. On further optimization of financial parameters like income tax rates to benefit from the higher taxpayers segment (say 37% on income above $90000) and increasing debt, would further reduce the LCOE to 7.07¢/kWh. The Figure in the appendix shows the lowest LCOE through financial optimisation.

PV System with battery

As the battery of the system is predetermined, the system was planned to be scaled to overcome the load demand of the building and the energy required to charge, the battery bank.

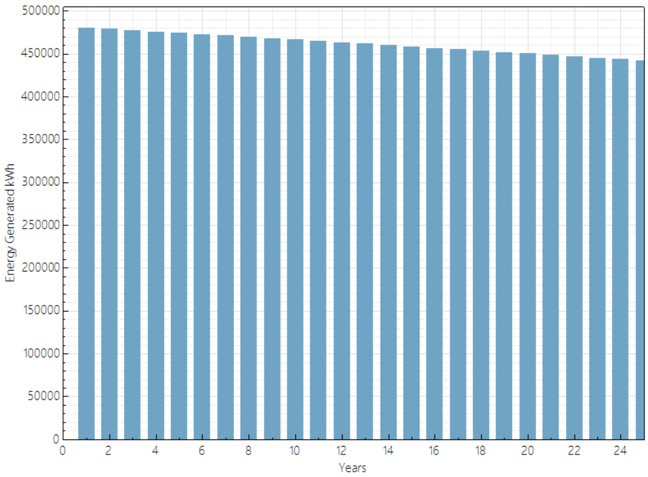
To bring down the LCOE attempts to downgrade the panels (410W Trina Fallmax TSM-410-DE15h(ii)) were made, but due to a lower DC/AC Ratio (0.99) against 125kW inverter. Increasing the number of parallel strings to 20 per inverter would increase the module to a total of 360 modules/inverter. The north-facing roof lacks sufficient space to accommodate 360 modules/inverter. Hence scaling down the inverter would lead to low annual energy yield but with low LCOE. Hence the system with 510W panels was retained to design a PV system with a battery.

The scale of the system with the current panels was increased to form 18strings per inverter making a sum of 324 modules per iinverter increasing the DC/AC ratio from 1.18 to 1.32.

No. of Inverters	No.of Modules	Annual Energy Yield(kWh)	Energy Yield (kWh/kW)	Performance Ratio	LCOE Nominal	Payback Period	Net Present Value
2 Inverters	648	480,559	1597	0.82	16.54¢/kWh	7.4yrs	$390,477
3 Inverters	972	573,099	1514	0.83	19.89¢/kWh	8.9yrs	$276,164
4 Inverters	1296	622,545	1469	0.82	23.85¢/kWh	10.6yrs	$59,285

As seen from the above table, the PV system with 2 Inverters and a battery has the lowest LCOE, payback period and high Net Present Value. On further tweaking of financial parameters such as increasing debt % and higher federal income tax rates for increased benefits, the LCOE of our designed system would reduce to 12.00¢/kWh as shown in Figure below.

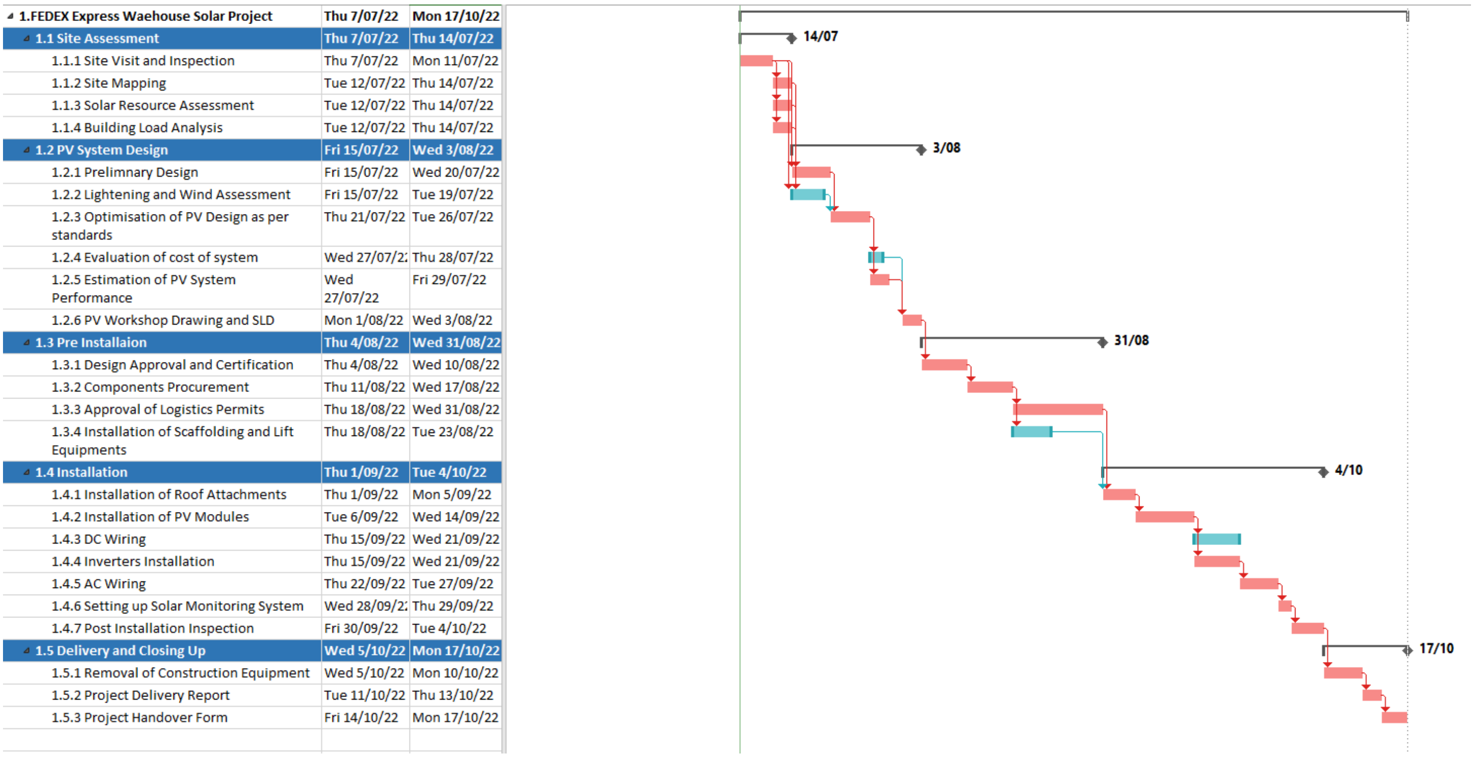
5. Performance Guarantee



Based on the above optimization of PV system, the PV system design without the battery (7.07¢/kWh) outperforms the PV system with the battery(16.54¢/kWh) , having a difference of about 10¢/kWh. The annual performance of the PV system across 25years is shown in the graph. The data is given in Appendix.

The performance of the system could be monitored by ground monitoring station that measure weather and irradiance of the vicinity. Sensors such as pyranometer and BME280 could be used to monitor irradiance, temperature, pressure and humidity respectively. Generating a forecasting model through historical data would help predict/forecast power output from the PV system. The performance could be compared against predicted output and the actual output.

6. Project Plan



1.FEDEX Express Waehouse Solar Project	**Thu 7/07/22**	**Mon 17/10/22**
1.1 Site Assessment	**Thu 7/07/22**	**Thu 14/07/22**
1.1.1 Site Visit and Inspection	Thu 7/07/22	Mon 11/07/22
1.1.2 Site Mapping	Tue 12/07/22	Thu 14/07/22
1.1.3 Solar Resource Assessment	Tue 12/07/22	Thu 14/07/22
1.1.4 Building Load Analysis	Tue 12/07/22	Thu 14/07/22
1.2 PV System Design	**Fri 15/07/22**	**Wed 3/08/22**
1.2.1 Prelimnary Design	Fri 15/07/22	Wed 20/07/22
1.2.2 Lightening and Wind Assessment	Fri 15/07/22	Tue 19/07/22
1.2.3 Optimisation of PV Design as per standards	Thu 21/07/22	Tue 26/07/22
1.2.4 Evaluation of cost of system	Wed 27/07/2	Thu 28/07/22
1.2.5 Estimation of PV System Performance	Wed 27/07/22	Fri 29/07/22
1.2.6 PV Workshop Drawing and SLD	Mon 1/08/22	Wed 3/08/22
1.3 Pre Installaion	**Thu 4/08/22**	**Wed 31/08/22**
1.3.1 Design Approval and Certification	Thu 4/08/22	Wed 10/08/22
1.3.2 Components Procurement	Thu 11/08/22	Wed 17/08/22
1.3.3 Approval of Logistics Permits	Thu 18/08/22	Wed 31/08/22
1.3.4 Installation of Scaffolding and Lift Equipments	Thu 18/08/22	Tue 23/08/22
1.4 Installation	**Thu 1/09/22**	**Tue 4/10/22**
1.4.1 Installation of Roof Attachments	Thu 1/09/22	Mon 5/09/22
1.4.2 Installation of PV Modules	Tue 6/09/22	Wed 14/09/22
1.4.3 DC Wiring	Thu 15/09/22	Wed 21/09/22
1.4.4 Inverters Installation	Thu 15/09/22	Wed 21/09/22
1.4.5 AC Wiring	Thu 22/09/22	Tue 27/09/22
1.4.6 Setting up Solar Monitoring System	Wed 28/09/2	Thu 29/09/22
1.4.7 Post Installation Inspection	Fri 30/09/22	Tue 4/10/22
1.5 Delivery and Closing Up	**Wed 5/10/22**	**Mon 17/10/22**
1.5.1 Removal of Construction Equipment	Wed 5/10/22	Mon 10/10/22
1.5.2 Project Delivery Report	Tue 11/10/22	Thu 13/10/22
1.5.3 Project Handover Form	Fri 14/10/22	Mon 17/10/22

The project is planned and scheduled for a duration of 3 months under fixed timeline, considering the expertise of SPREEnergy to manage stakeholders and deliver the project would commence from 7th July,2022 and closes before 15th October,2022.

7. Recommendation and Conclusion

On optimizing the PV system without the battery to form 16x18, the energy yield from 18x18 system is equally significant offering lower LCOE and a showing a competitive Net present value. Hence it would be recommended to design a PV system with 2 inverters (250kWac Rated) and 18Strings per inverter with 2 Strings per MPPT and 18 modules per string. The SLD for the design is shown in Appendix.

8. Appendix

APPENDIX A

TENDER RETURN A: SCHEDULE OF PRICES

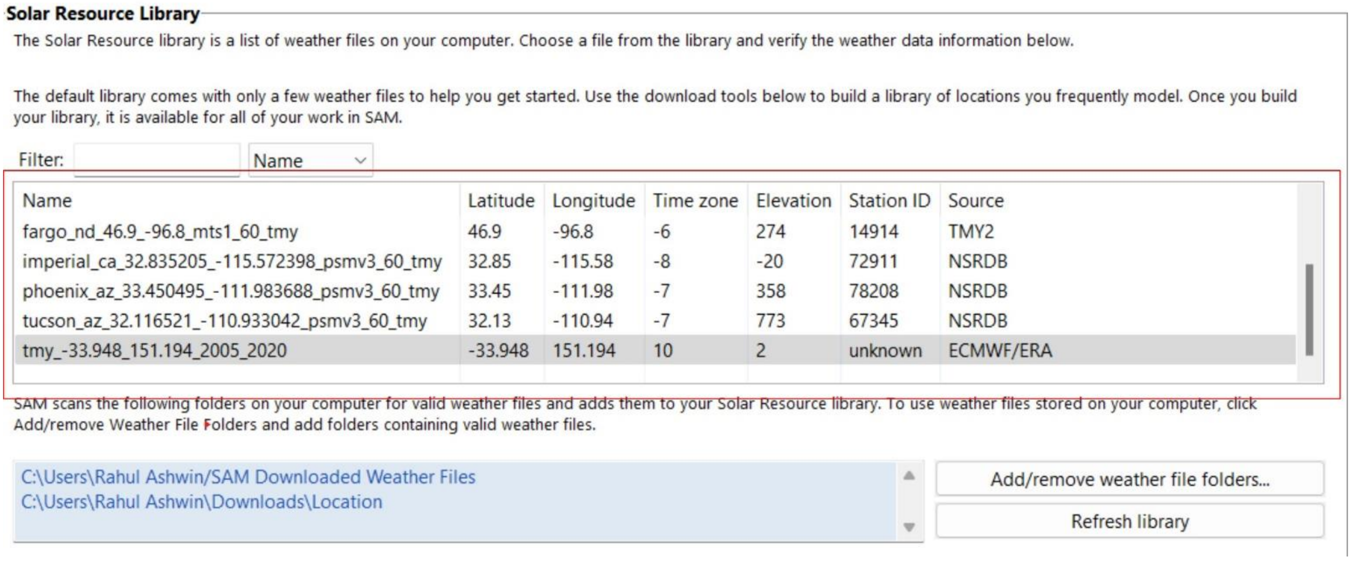
Item	Description	Option 1	Option 2
1.	Supply of Modules	$ 225,667.41	$ 287,625.84
2.	Supply of Inverters	$ 44,080.59	$ 195402.2
3.	Supply of Batteries	-	$ 73,794.00
4.	BOS: distribution boards, cabling, protection & earthing, framing, monitoring, electrical services, engineering, drafting, etc.	$ 20,570.94	$ 23,142.31
5.	Installation: modules, inverters, cables, boards, protection, etc.	$ 67,590.23	$ 76,039.02
6.	**Total Price excluding GST**	**$357,909.17**	**$656,003.37**

TENDER RETURN B: PERFORMANCE METRICS

Guaranteed Energy Yield (First Five Years)	**2453590**	kWh
	2387033	kWh
Expected Energy Yield (over 25years)	**11681366**	kWh
	11536453	kWh
Levelised Cost of Electricity (LCOE over 25 years)	**0.07**	$/kWh
	0.12	$/kWh
Net Present Value (over 25 years)	**604,416**	$
	364,543	$
Total Cost per watt Installed	**2.13**	$/Wdc
	2.35	**$/Wdc**

To emulate a real life scenario, the system is modelled with financial parameters such as Federal Income Tax is assumed to be 37% (income above $90000) with Debt upto 60% of Equity for a duration of 10years and 5% interest rate is assumed.

Supporting System configurations for APPENDIX A OUTPUT



Solar Resource Library

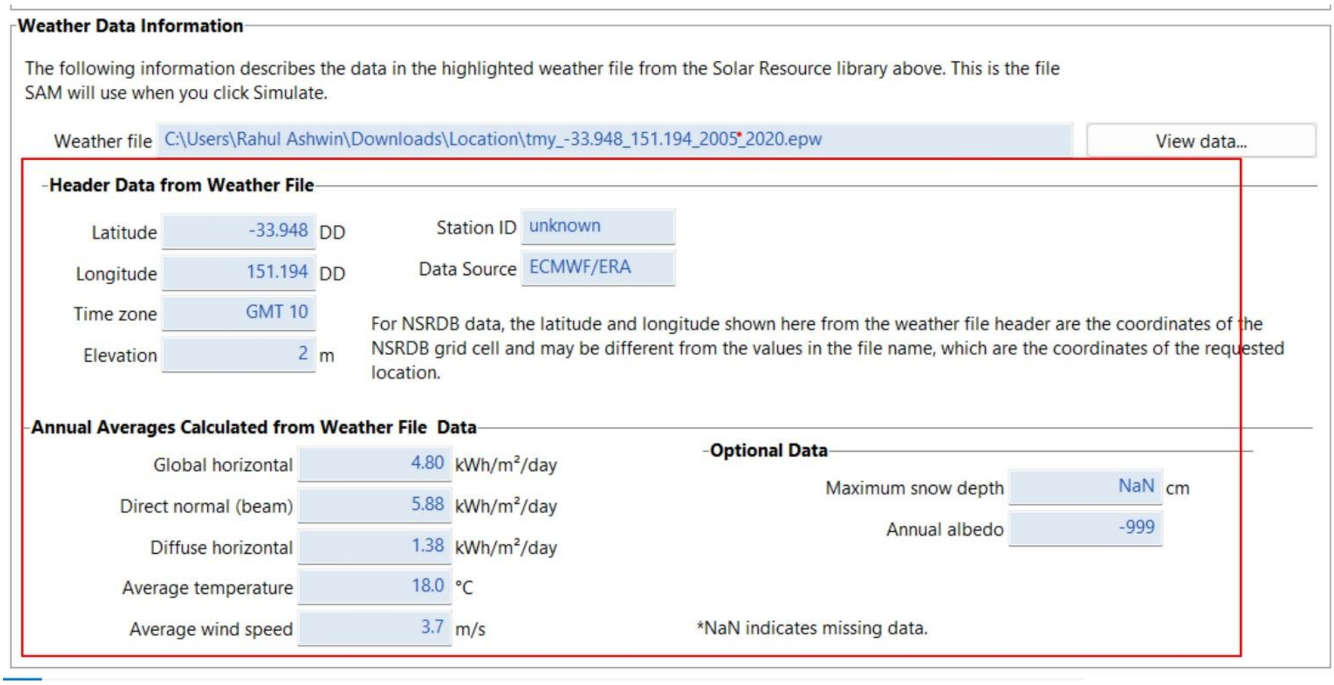
The Solar Resource library is a list of weather files on your computer. Choose a file from the library and verify the weather data information below.

The default library comes with only a few weather files to help you get started. Use the download tools below to build a library of locations you frequently model. Once you build your library, it is available for all of your work in SAM.

Name	Latitude	Longitude	Time zone	Elevation	Station ID	Source
fargo_nd_46.9_-96.8_mts1_60_tmy	46.9	-96.8	-6	274	14914	TMY2
imperial_ca_32.835205_-115.572398_psmv3_60_tmy	32.85	-115.58	-8	-20	72911	NSRDB
phoenix_az_33.450495_-111.983688_psmv3_60_tmy	33.45	-111.98	-7	358	78208	NSRDB
tucson_az_32.116521_-110.933042_psmv3_60_tmy	32.13	-110.94	-7	773	67345	NSRDB
tmy_-33.948_151.194_2005_2020	-33.948	151.194	10	2	unknown	ECMWF/ERA

SAM scans the following folders on your computer for valid weather files and adds them to your Solar Resource library. To use weather files stored on your computer, click Add/remove Weather File Folders and add folders containing valid weather files.

C:\Users\Rahul Ashwin/SAM Downloaded Weather Files
C:\Users\Rahul Ashwin\Downloads\Location



Weather Data Information

The following information describes the data in the highlighted weather file from the Solar Resource library above. This is the file SAM will use when you click Simulate.

Weather file C:\Users\Rahul Ashwin\Downloads\Location\tmy_-33.948_151.194_2005_2020.epw

Header Data from Weather File

Latitude -33.948 DD
Longitude 151.194 DD
Time zone GMT 10
Elevation 2 m
Station ID unknown
Data Source ECMWF/ERA

For NSRDB data, the latitude and longitude shown here from the weather file header are the coordinates of the NSRDB grid cell and may be different from the values in the file name, which are the coordinates of the requested location.

Annual Averages Calculated from Weather File Data

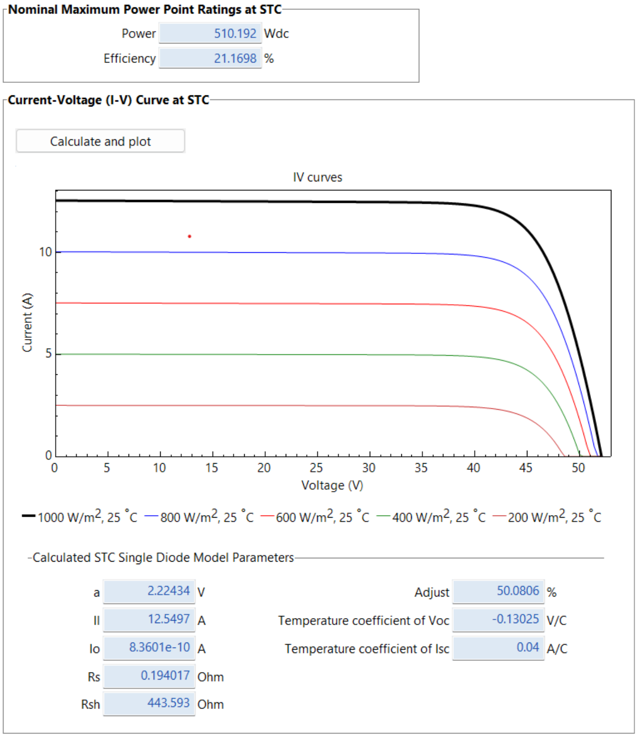
Global horizontal 4.80 kWh/m²/day
Direct normal (beam) 5.88 kWh/m²/day
Diffuse horizontal 1.38 kWh/m²/day
Average temperature 18.0 °C
Average wind speed 3.7 m/s

Optional Data

Maximum snow depth NaN cm
Annual albedo -999

*NaN indicates missing data.

Appendix A: Figure 1 Annual Averages of GHI, DNI and DHI



Nominal Maximum Power Point Ratings at STC

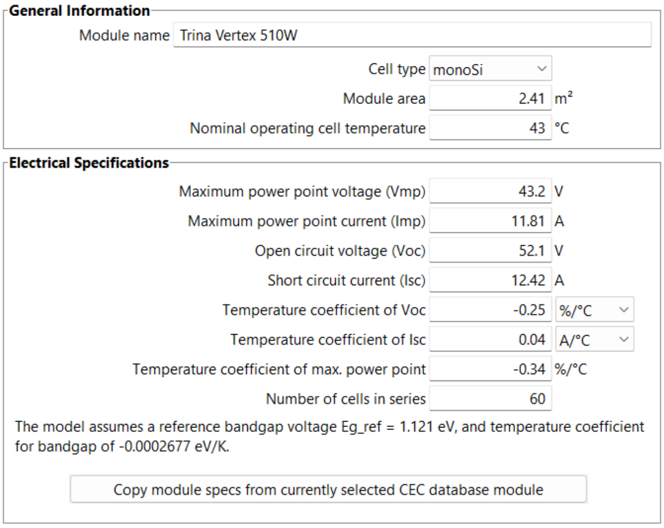
Power 510.192 Wdc
Efficiency 21.1698 %

Current-Voltage (I-V) Curve at STC

Calculated STC Single Diode Model Parameters

a 2.22434 V
Il 12.5497 A
Io 8.3601e-10 A
Rs 0.194017 Ohm
Rsh 443.593 Ohm
Adjust 50.0806 %
Temperature coefficient of Voc -0.13025 V/C
Temperature coefficient of Isc 0.04 A/C

Appendix A: Figure 2 IV Plot of the Selected Module



General Information

Module name Trina Vertex 510W
Cell type monoSi
Module area 2.41 m²
Nominal operating cell temperature 43 °C

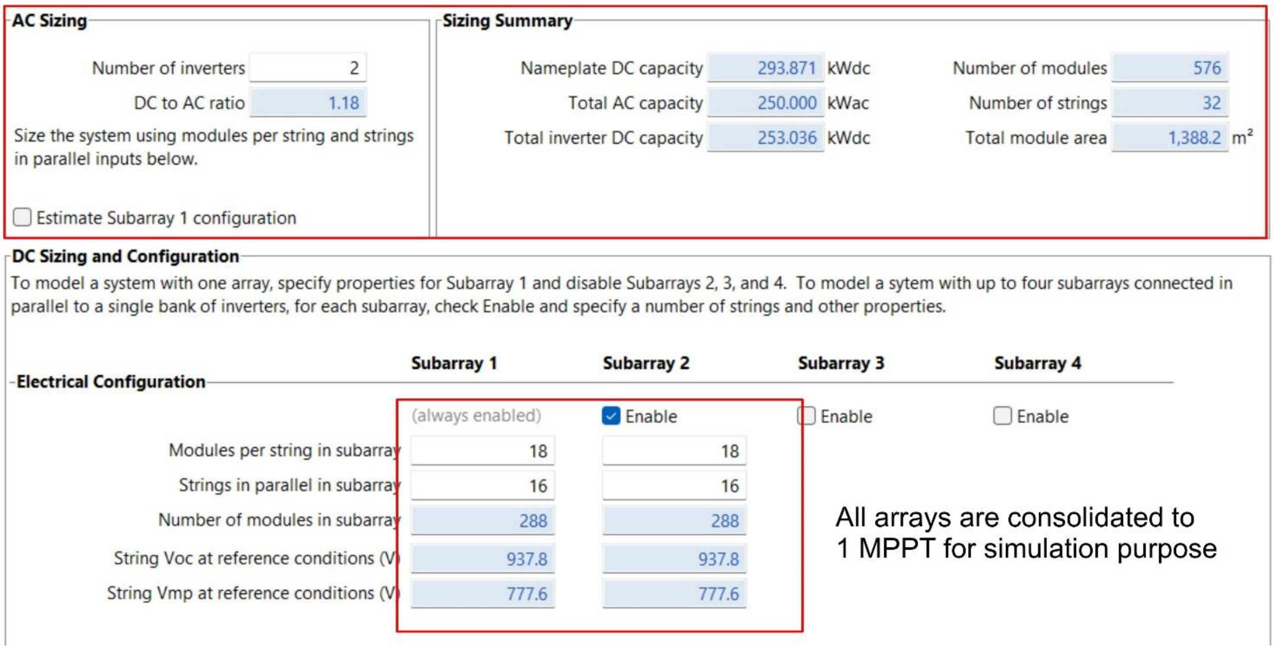
Electrical Specifications

Maximum power point voltage (Vmp) 43.2 V
Maximum power point current (Imp) 11.81 A
Open circuit voltage (Voc) 52.1 V
Short circuit current (Isc) 12.42 A
Temperature coefficient of Voc -0.25 %/°C
Temperature coefficient of Isc 0.04 A/°C
Temperature coefficient of max. power point -0.34 %/°C
Number of cells in series 60

The model assumes a reference bandgap voltage Eg_ref = 1.121 eV, and temperature coefficient for bandgap of -0.0002677 eV/K.

Appendix A: Figure 3 Module Data input for modelling

Modelled IV Curve based on module datasheet values.



AC Sizing

Number of inverters 2
DC to AC ratio 1.18

Size the system using modules per string and strings in parallel inputs below.

☐ Estimate Subarray 1 configuration

Sizing Summary

Nameplate DC capacity 293.871 kWdc
Total AC capacity 250.000 kWac
Total inverter DC capacity 253.036 kWdc
Number of modules 576
Number of strings 32
Total module area 1,388.2 m²

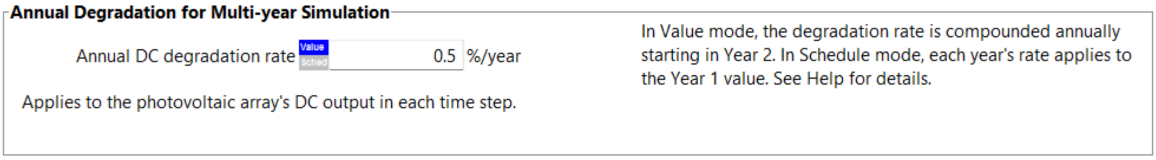
DC Sizing and Configuration

To model a system with one array, specify properties for Subarray 1 and disable Subarrays 2, 3, and 4. To model a sytem with up to four subarrays connected in parallel to a single bank of inverters, for each subarray, check Enable and specify a number of strings and other properties.

Electrical Configuration	Subarray 1	Subarray 2	Subarray 3	Subarray 4
	(always enabled)	☑ Enable	☐ Enable	☐ Enable
Modules per string in subarray	18	18		
Strings in parallel in subarray	16	16		
Number of modules in subarray	288	288		
String Voc at reference conditions (V)	937.8	937.8		
String Vmp at reference conditions (V)	777.6	777.6		

All arrays are consolidated to 1 MPPT for simulation purpose

Appendix B: Figure 4 PV System Scaling



Annual Degradation for Multi-year Simulation

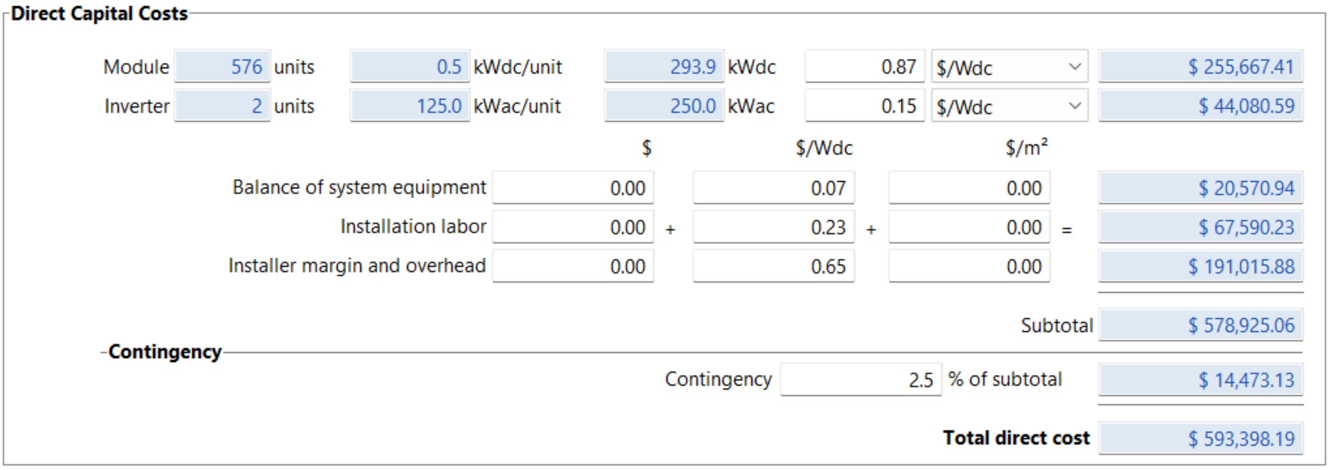
Annual DC degradation rate 0.5 %/year

Applies to the photovoltaic array's DC output in each time step.

In Value mode, the degradation rate is compounded annually starting in Year 2. In Schedule mode, each year's rate applies to the Year 1 value. See Help for details.

Appendix B: Figure 5 Degradation of DC Side set to 0.5%/year based on Module Degradation

For System without Battery



Direct Capital Costs

Module	576	units	0.5	kWdc/unit	293.9	kWdc	0.87	$/Wdc	$ 255,667.41
Inverter	2	units	125.0	kWac/unit	250.0	kWac	0.15	$/Wdc	$ 44,080.59

	$		$/Wdc		$\$/m^2$		
Balance of system equipment	0.00		0.07		0.00		$ 20,570.94
Installation labor	0.00	+	0.23	+	0.00	=	$ 67,590.23
Installer margin and overhead	0.00		0.65		0.00		$ 191,015.88

Subtotal $ 578,925.06

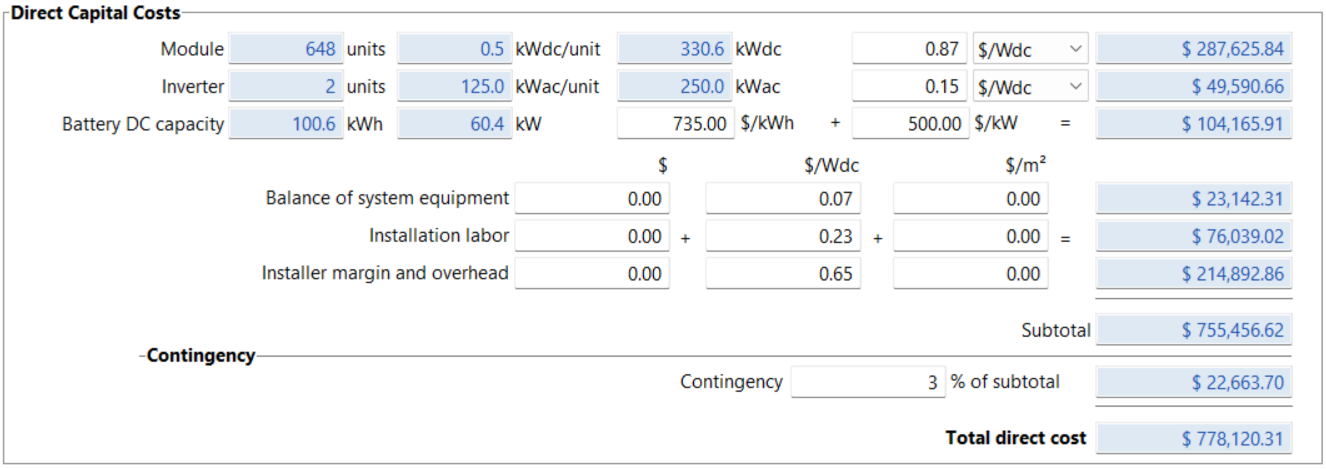
Contingency

Contingency 2.5 % of subtotal $ 14,473.13

Total direct cost $ 593,398.19

Rate of Balance of Equipment is calculated as 35/510W ~**0.07$/Wdc**
Similarly Installation cost/Wdc is calculated by 115/510~**0.23$/Wdc.**

For System with Battery



Direct Capital Costs

Module	648	units	0.5	kWdc/unit	330.6	kWdc		0.87	$/Wdc		$ 287,625.84
Inverter	2	units	125.0	kWac/unit	250.0	kWac		0.15	$/Wdc		$ 49,590.66
Battery DC capacity	100.6	kWh	60.4	kW	735.00	$/kWh	+	500.00	$/kW	=	$ 104,165.91

	$		$/Wdc		$\$/m^2$		
Balance of system equipment	0.00		0.07		0.00		$ 23,142.31
Installation labor	0.00	+	0.23	+	0.00	=	$ 76,039.02
Installer margin and overhead	0.00		0.65		0.00		$ 214,892.86

Subtotal $ 755,456.62

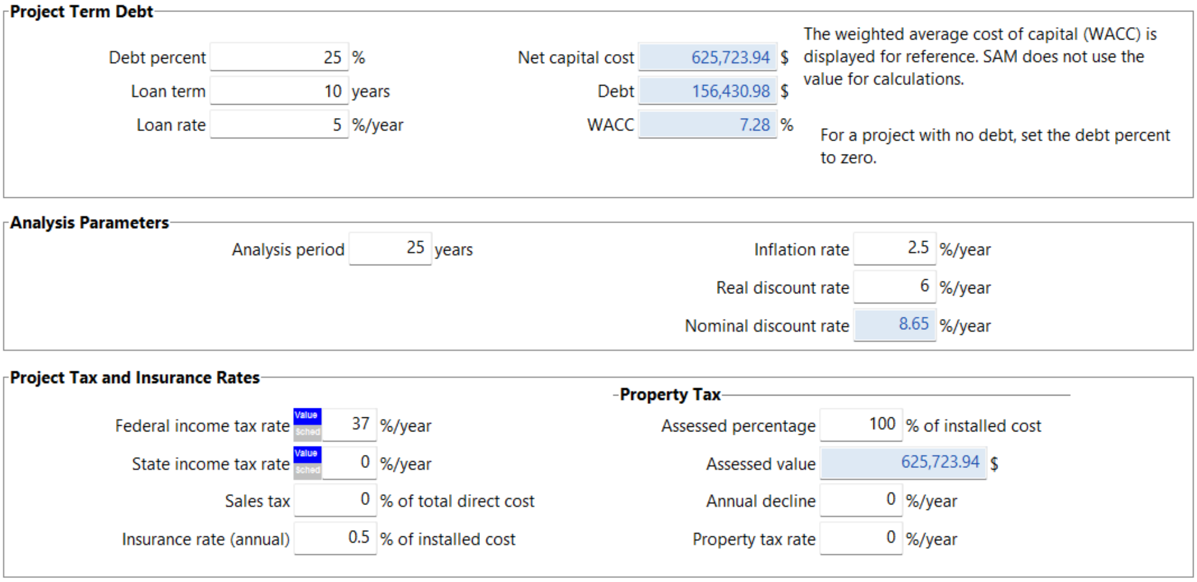
Contingency

Contingency 3 % of subtotal $ 22,663.70

Total direct cost $ 778,120.31

Financial Parameters

To emulate a real life scenario, the project involves a debt of 25% equity for a period of 10 years and 5% Rate of interest. As per the federal benchmark of income tax charged in the income earned above 90000$ AUD is utilized as benefits. Upto 37% income tax rate is charged for income above $90k.



Project Term Debt

Debt percent 25 %
Loan term 10 years
Loan rate 5 %/year
Net capital cost 625,723.94 $
Debt 156,430.98 $
WACC 7.28 %

The weighted average cost of capital (WACC) is displayed for reference. SAM does not use the value for calculations.

For a project with no debt, set the debt percent to zero.

Analysis Parameters

Analysis period 25 years
Inflation rate 2.5 %/year
Real discount rate 6 %/year
Nominal discount rate 8.65 %/year

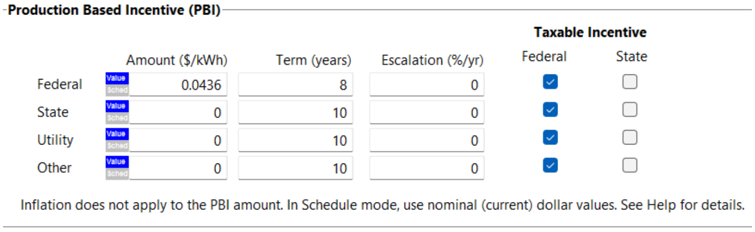
Project Tax and Insurance Rates

Federal income tax rate 37 %/year
State income tax rate 0 %/year
Sales tax 0 % of total direct cost
Insurance rate (annual) 0.5 % of installed cost

Property Tax

Assessed percentage 100 % of installed cost
Assessed value 625,723.94 $
Annual decline 0 %/year
Property tax rate 0 %/year

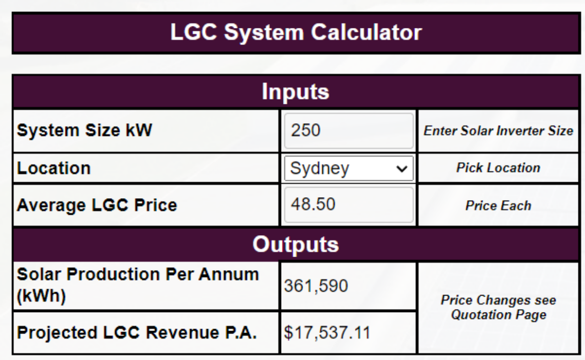
Incentives



Production Based Incentive (PBI)

	Amount ($/kWh)	Term (years)	Escalation (%/yr)	Taxable Incentive Federal	Taxable Incentive State
Federal	0.0436	8	0	☑	☐
State	0	10	0	☑	☐
Utility	0	10	0	☑	☐
Other	0	10	0	☑	☐

Inflation does not apply to the PBI amount. In Schedule mode, use nominal (current) dollar values. See Help for details.



LGC System Calculator

Inputs		
System Size kW	250	Enter Solar Inverter Size
Location	Sydney	Pick Location
Average LGC Price	48.50	Price Each
Outputs		
Solar Production Per Annum (kWh)	361,590	Price Changes see Quotation Page
Projected LGC Revenue P.A.	$17,537.11	

Appendix B: Figure 6 Production based Incentive Calculated based on LGC

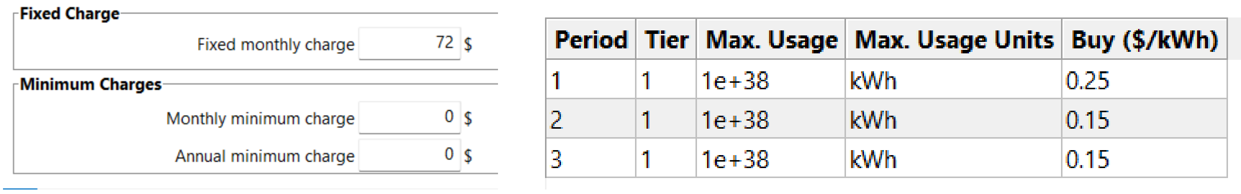
Market prices (spot*)

STCs	$39.90
LGCs	$48.50
VEECs	$56.50
ESCs	$34.25

*The spot price is for a minimum parcel size of 5000 created certificates.
Prices are compiled using the latest reported market data.

Appendix B: Figure 7 Market Spot Prices for LGC

Electricity Rates



Fixed Charge

Fixed monthly charge 72 $

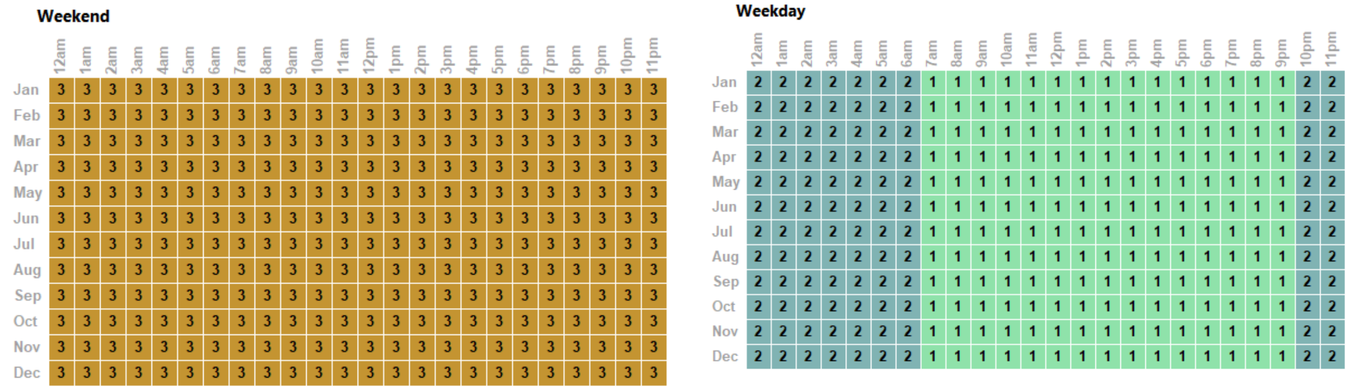
Minimum Charges

Monthly minimum charge 0 $

Annual minimum charge 0 $

Period	Tier	Max. Usage	Max. Usage Units	Buy ($/kWh)
1	1	1e+38	kWh	0.25
2	1	1e+38	kWh	0.15
3	1	1e+38	kWh	0.15

Appendix A.: Figure 8 Given Customer Electricity Tariff



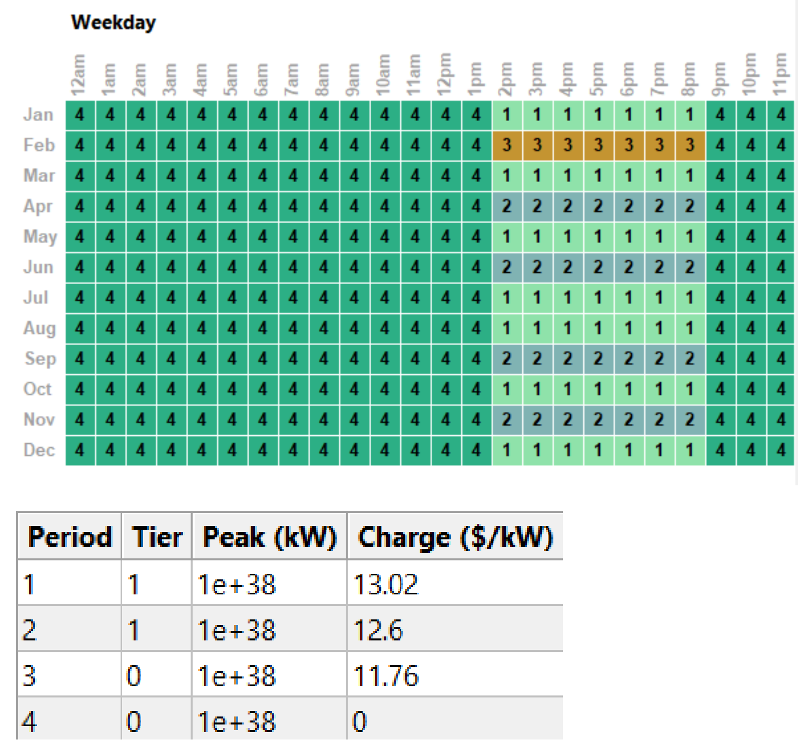
Weekend

	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Jan	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Feb	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Mar	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Apr	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
May	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Jun	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Jul	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Aug	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Sep	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Oct	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Nov	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Dec	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Weekday

	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Jan	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Feb	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Mar	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Apr	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
May	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Jun	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Jul	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Aug	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Sep	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Oct	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Nov	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2
Dec	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2

Appendix A.: Figure 9 Customer Tariff Implemented on SAM



Weekday

	12am	1am	2am	3am	4am	5am	6am	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm	4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
Jan	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	1	1	1	1	1	1	4	4	4
Feb	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	4	4	4
Mar	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	1	1	1	1	1	1	4	4	4
Apr	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2	2	4	4	4
May	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	1	1	1	1	1	1	4	4	4
Jun	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2	2	4	4	4
Jul	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	1	1	1	1	1	1	4	4	4
Aug	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	1	1	1	1	1	1	4	4	4
Sep	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2	2	4	4	4
Oct	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	1	1	1	1	1	1	4	4	4
Nov	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2	2	4	4	4
Dec	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	1	1	1	1	1	1	4	4	4

Period	Tier	Peak (kW)	Charge ($/kW)
1	1	1e+38	13.02
2	1	1e+38	12.6
3	0	1e+38	11.76
4	0	1e+38	0

Appendix A.: Figure 10 Capacity charge implemented on SAM

The Cost in $/KVA/day is converted to $/Kwh/day and is multiplied into 31,30 and 28 respectively based on the number of days in a month and is implemented on the chart.

APPENDIX B WORKSHOP DRAWINGS

Optimal PV System Design without Battery

B.1 Inverter System and Panel Orientation

B.2 Earthing Wire and Strings Layout

B.3 Single Line Diagram of optimally designed PV System without Battery

Optimal PV System Design with Battery

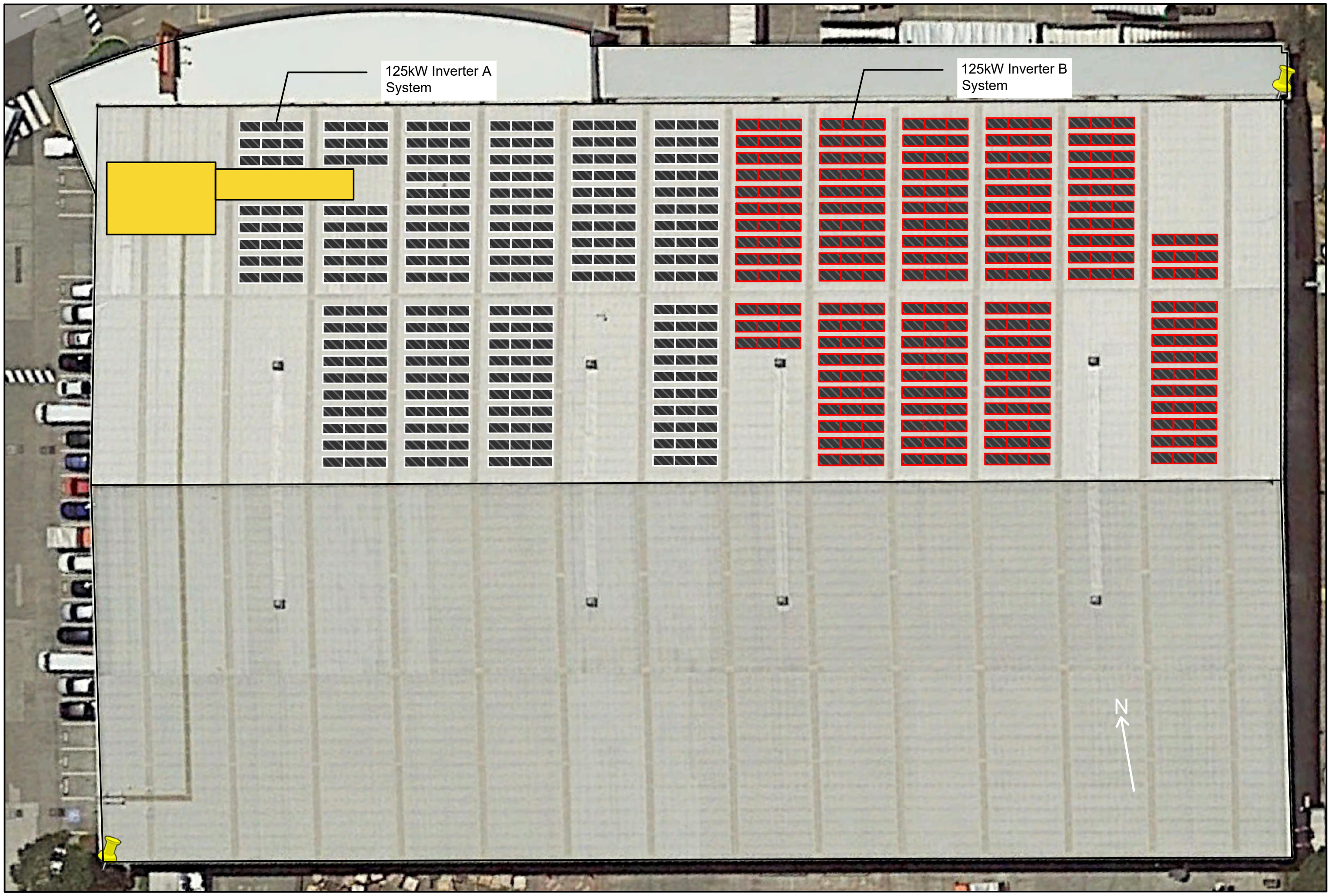
B.4 Inverter System and Panel Orientation

B.5 Earthing Wire and Strings Layout

B.6 Single Line Diagram of optimally designed PV System without Battery

Recommended PV System Design without Battery

B.7 Single Line Diagram of recommended PV System Design



TOTAL SYSTEM DETAILS

PV PANELS:
TRINA Vertex 510W

PANEL DIMENSIONS:
2187mm x 1102mm

NO.OF MODULES:
576

OVERALL KWp
297.60

MODULE TILT:
33°

MODULE AZIMUTH:
10°

INVERTER:
Growatt 125MAX-KTL3-X LV

NO. OF INVERTERS
2

OVERALL kWac
250.00

PROJECT NAME:
FEDEX LOGISTICS STATION
BOTANY, NSW

CLIENT'S NAME:
FEDEX EXPRESS

PROJECT ADDRESS:
BOTANY,NSW
-33.94°S, 151.19°E

PROJECT TITLE:
OVERALL ROOF PV
LAYOUT

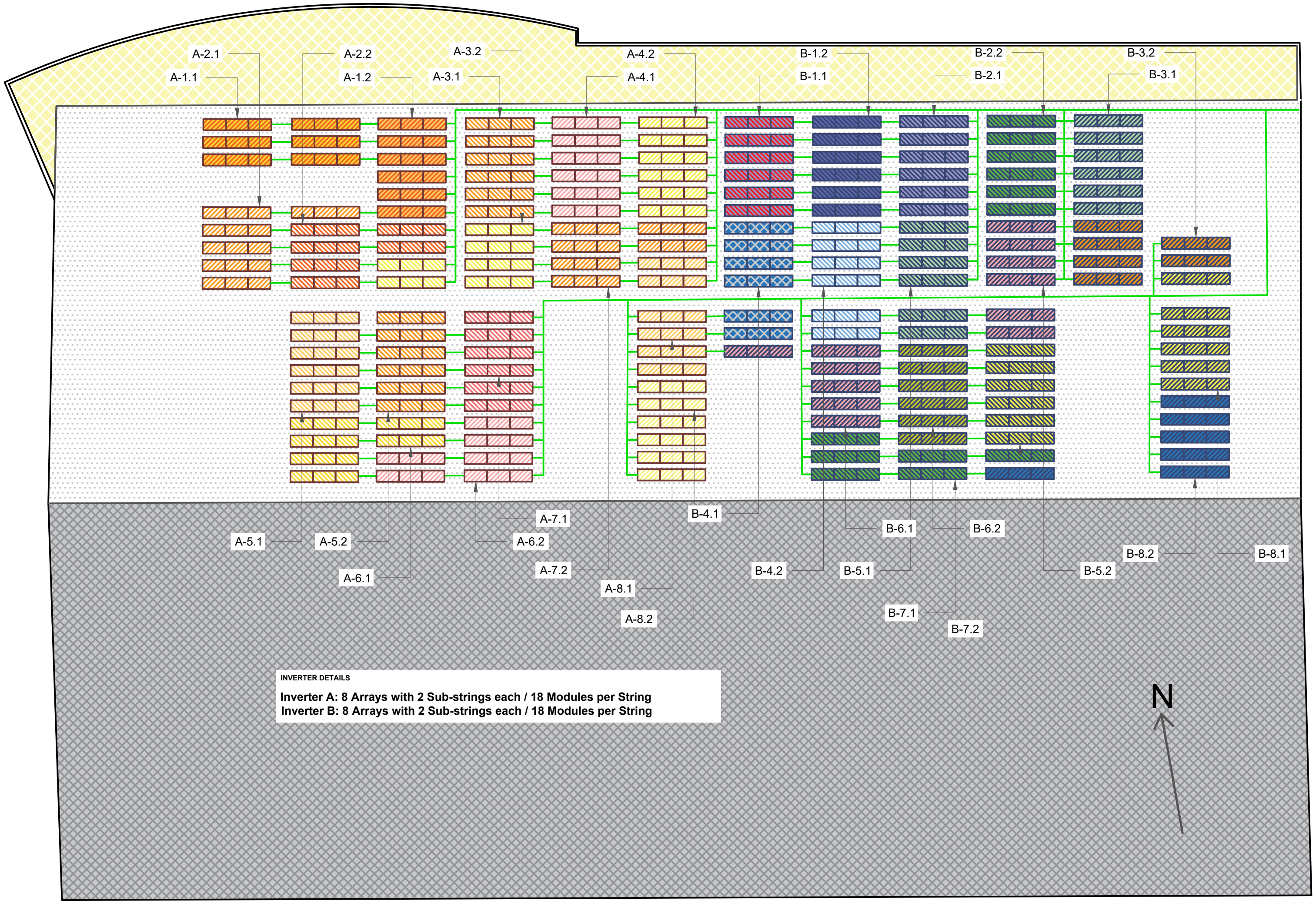
PROJECT CONTRACTOR
TYREE Energy Pty

DESIGN PANEL

DESIGNED AND DRAWN BY
RAHUL ASHWIN MAHENDHRAN
GRADUATE ENGINEER

30/06/2022

PV SYSTEM ORIENTATION AND LAYOUT
(FOR PV SYSTEM **WITHOUT BATTERY**)



INVERTER DETAILS

Inverter A: 8 Arrays with 2 Sub-strings each / 18 Modules per String

Inverter B: 8 Arrays with 2 Sub-strings each / 18 Modules per String

TOTAL SYSTEM DETAILS

PV PANELS:
TRINA Vertex 510W

PANEL DIMENSIONS:
2187mm x 1102mm

NO.OF MODULES:
576

OVERALL KWp
297.60

MODULE TILT:
15°

MODULE AZIMUTH:
10°

INVERTER:
Growatt 125MAX-KTL3-X LV

NO. OF INVERTERS
2

OVERALL kWac
250.00

PROJECT NAME:
FEDEX LOGISTICS STATION BOTANY, NSW

CLIENT'S NAME:
FEDEX EXPRESS

PROJECT ADDRESS:
BOTANY,NSW
-33.94°S, 151.19°E

PROJECT TITLE:
STRING LAYOUT

PROJECT CONTRACTOR
TYREE Energy Pty

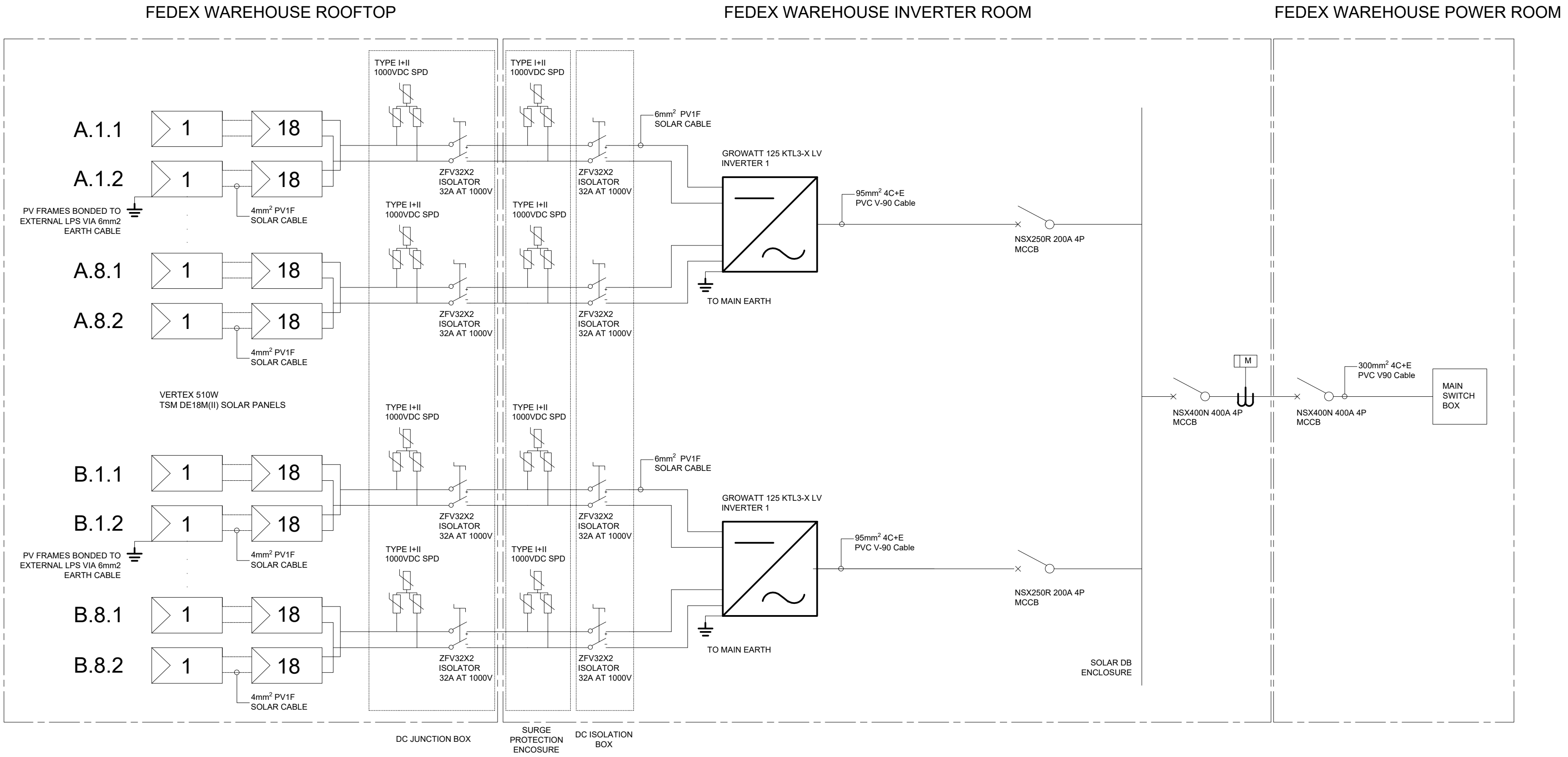
DESIGN PANEL

DESIGNED AND DRAWN BY
RAHUL ASHWIN MAHENDHRAN
GRADUATE ENGINEER

30/06/2022

— Earthing Wire

MODULE ORIENTATATION PLAN AND PV STRING LAYOUT WITH EARTHING WIRE PLAN FOR PV SYSTEM WITHOUT BATTERY



DESIGN PANEL

DESIGNED AND DRAWN BY

RAHUL ASHWIN MAHENDHRAN

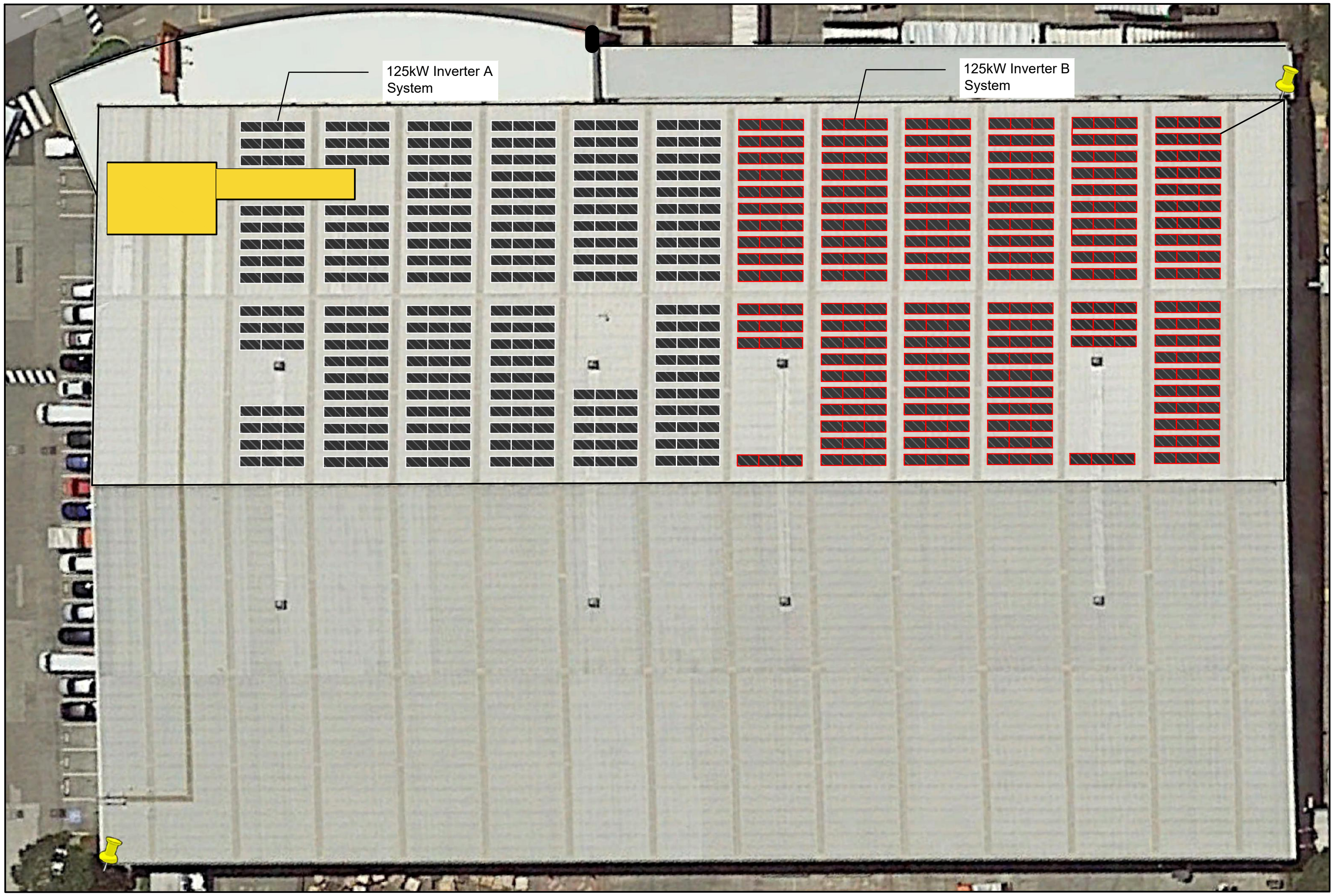
GRADUATE ENGINEER

07/07/2022

SINGLE LINE DIAGRAM OF PV SYSTEM DESIGN WITHOUT BATTERY

PROJECT CONTRACTOR

TYREE Energy Pty



TOTAL SYSTEM DETAILS

PV PANELS:
TRINA Vertex 510W

PANEL DIMENSIONS:
2187mm x 1102mm

NO.OF MODULES:
684

OVERALL KWp
297.60

MODULE TILT:
33°

MODULE AZIMUTH:
10°

INVERTER:
Growatt 125MAX-KTL3-X LV

NO. OF INVERTERS
2

OVERALL kWac
250.00

PROJECT NAME:
FEDEX LOGISTICS STATION
BOTANY, NSW

CLIENT'S NAME:
FEDEX EXPRESS

PROJECT ADDRESS:
BOTANY,NSW
-33.94°S, 151.19°E

PROJECT TITLE:
OVERALL ROOF PV
LAYOUT

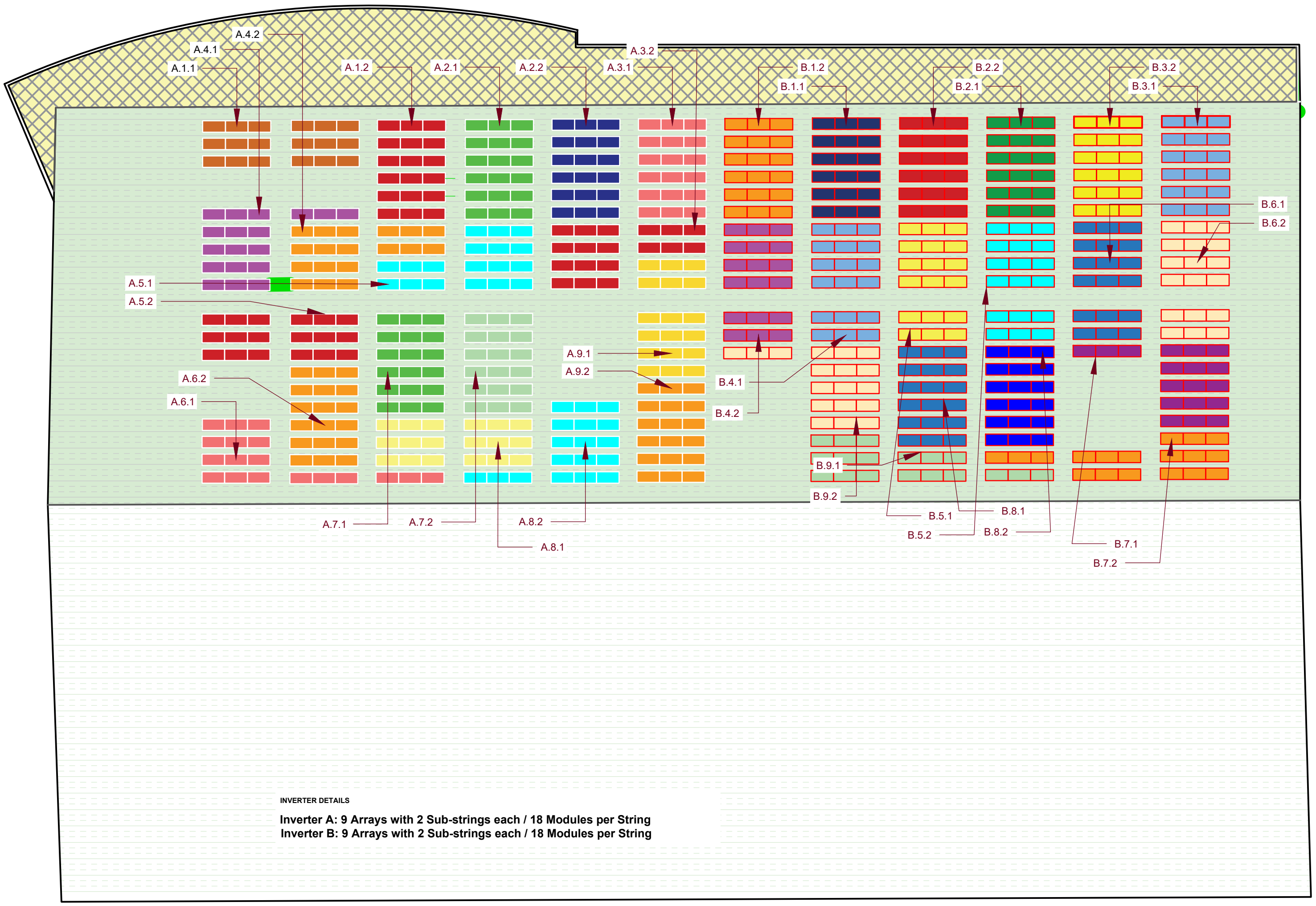
PROJECT CONTRACTOR
TYREE Energy Pty

DESIGN PANEL

DESIGNED AND DRAWN BY
RAHUL ASHWIN MAHENDHRAN
GRADUATE ENGINEER

08/07/2022

PV SYSTEM ORIENTATION AND LAYOUT
(FOR PV SYSTEM **WITH BATTERY)**



INVERTER DETAILS

Inverter A: 9 Arrays with 2 Sub-strings each / 18 Modules per String
Inverter B: 9 Arrays with 2 Sub-strings each / 18 Modules per String

TOTAL SYSTEM DETAILS

PV PANELS:
TRINA Vertex 510W

PANEL DIMENSIONS:
2187mm x 1102mm

NO.OF MODULES:
648

OVERALL KWp
330.604kWDC

MODULE TILT:
33°

MODULE AZIMUTH:
10°

INVERTER:
Growatt 125MAX-KTL3-X LV

NO. OF INVERTERS
2

OVERALL kWac
250.00

PROJECT NAME:

FEDEX LOGISTICS STATION
BOTANY, NSW

CLIENT'S NAME:

FEDEX EXPRESS

PROJECT ADDRESS:

BOTANY,NSW
-33.94°S, 151.19°E

PROJECT TITLE:

STRING LAYOUT

PROJECT CONTRACTOR

TYREE Energy Pty

DESIGN PANEL

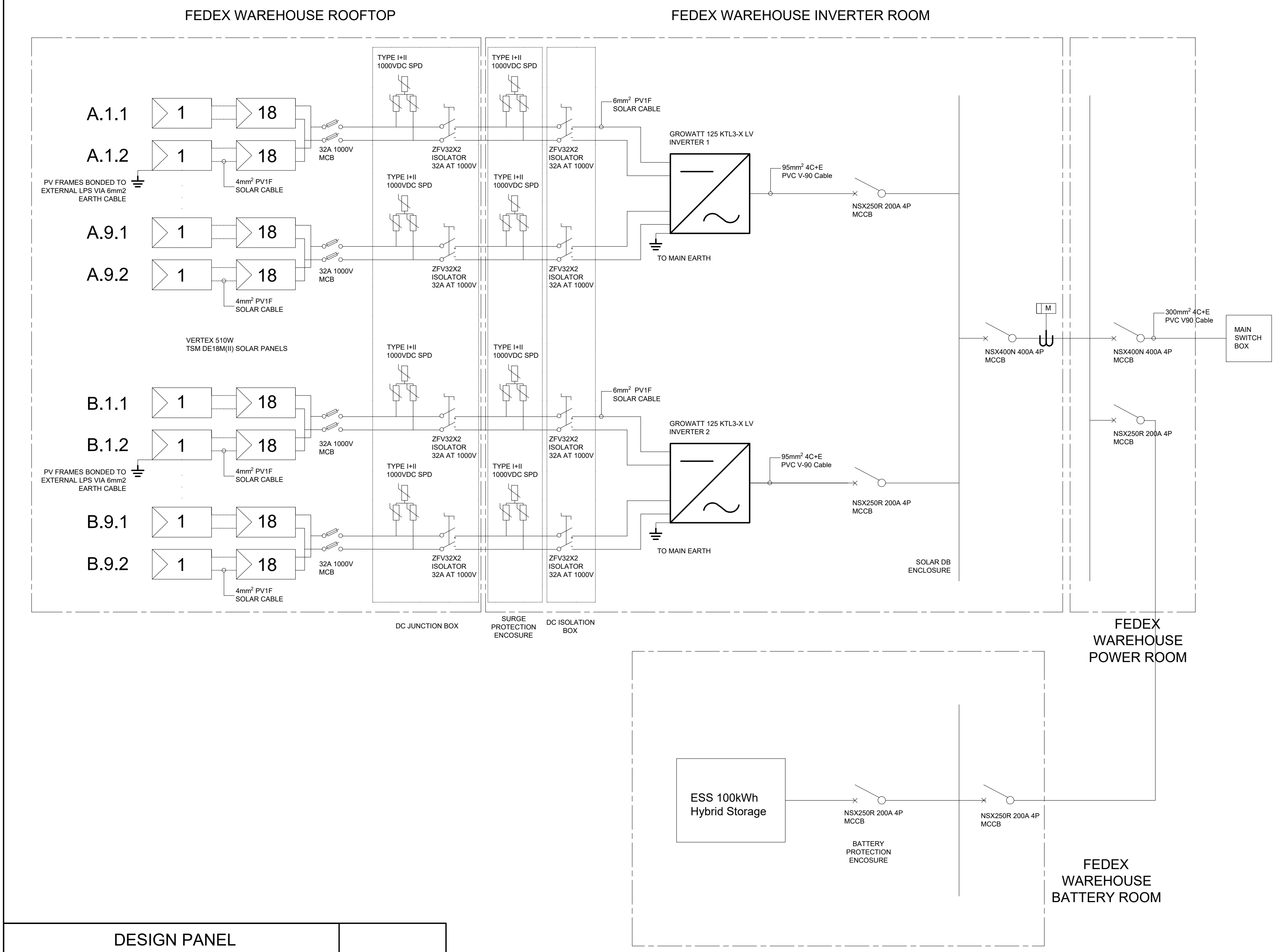
DESIGNED AND DRAWN BY

RAHUL ASHWIN MAHENDHRAN
GRADUATE ENGINEER

01/07/2022

🟩 Earthing Wire

MODULE ORIENTATION PLAN AND PV STRING LAYOUT WITH EARTHING WIRE PLAN FOR PV SYSTEM **WITH BATTERY**



DESIGN PANEL

DESIGNED AND DRAWN BY

RAHUL ASHWIN MAHENDHRAN

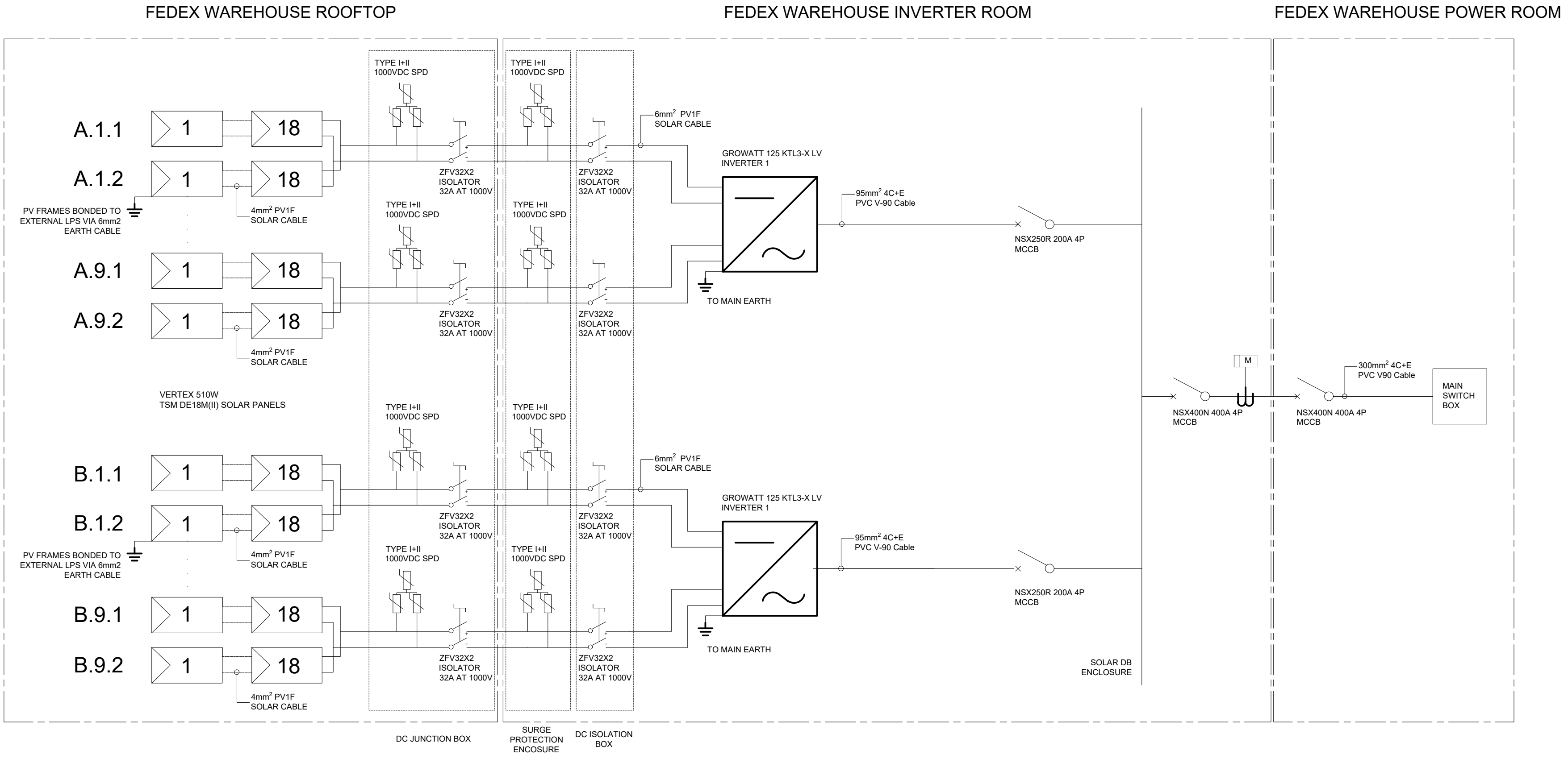
GRADUATE ENGINEER

07/07/2022

SINGLE LINE DIAGRAM OF PV SYSTEM DESIGN WITH BATTERY

PROJECT CONTRACTOR

TYREE Energy Pty



DESIGN PANEL

DESIGNED AND DRAWN BY
RAHUL ASHWIN MAHENDHRAN
GRADUATE ENGINEER

07/07/2022

SINGLE LINE DIAGRAM OF RECOMMENDED
PV SYSTEM DESIGN WITHOUT BATTERY

PROJECT CONTRACTOR
TYREE Energy Pty

THE Vertex

BACKSHEET MONOCRYSTALLINE MODULE

PRODUCTS	POWER RANGE
TSM-DE18M(II)	485-510W

510W
MAXIMUM POWER OUTPUT

21.2%
MAXIMUM EFFICIENCY

0~+5W
POSITIVE POWER TOLERANCE

Founded in 1997, Trina Solar is the world's leading total solution provider for solar energy. With local presence around the globe, Trina Solar is able to provide exceptional service to each customer in each market and deliver our innovative, reliable products with the backing of Trina as a strong, bankable brand. Trina Solar now distributes its PV products to over 100 countries all over the world. We are committed to building strategic, mutually beneficial collaborations with installers, developers, distributors and other partners in driving smart energy together.

Comprehensive Products and System Certificates

IEC61215/IEC61730/IEC61701/IEC62716
ISO 9001: Quality Management System
ISO 14001: Environmental Management System
ISO14064: Greenhouse Gases Emissions Verification
ISO45001: Occupational Health and Safety Management System

High customer value

- Lower LCOE (Levelized Cost Of Energy), reduced BOS (Balance Of System) cost, shorter payback time
- Lower guaranteed first year and annual degradation
- Designed for compatibility with existing mainstream system components
- Higher return on Investment

High power Mono Perc up to 510W

- Large area cells based on 210mm silicon wafers and 1/3-cut cell technology
- Up to 21.2% module efficiency with high density interconnect technology
- Multi-busbar technology for better light trapping effect, lower series resistance and improved current collection

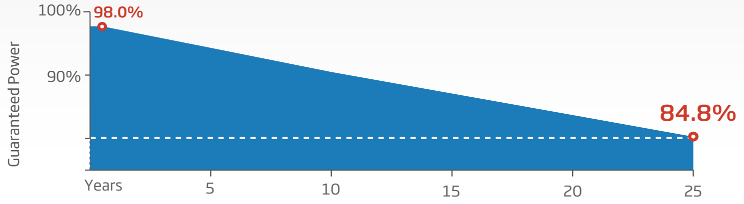
High reliability

- Minimized micro-cracks with innovative non-destructive cutting technology
- Ensured PID resistance through cell process and module material control
- Resistant to harsh environments such as salt, ammonia, sand, high temperature and high humidity areas
- Mechanical performance up to 5400 Pa positive load and 2400 Pa negative load

High energy yield

- Excellent IAM (Incident Angle Modifier) and low irradiation performance, validated by 3rd party certifications
- The unique design provides optimized energy production under inter-row shading conditions

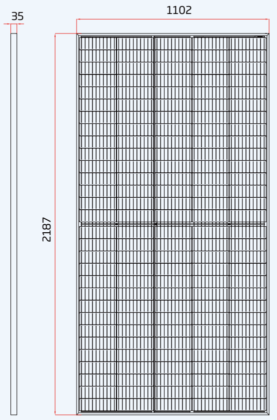
Trina Solar's Vertex Backsheet Performance Warranty



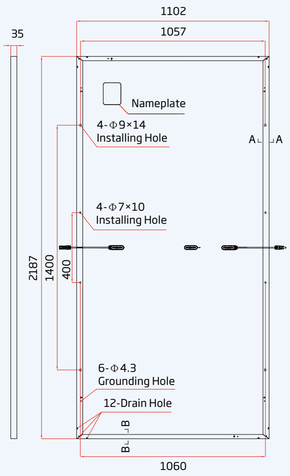
Vertex

BACKSHEET MONOCRYSTALLINE MODULE

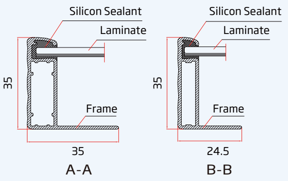
DIMENSIONS OF PV MODULE(mm)



Front View

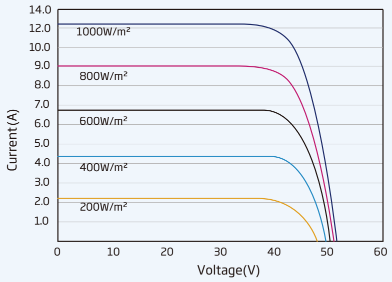


Back View

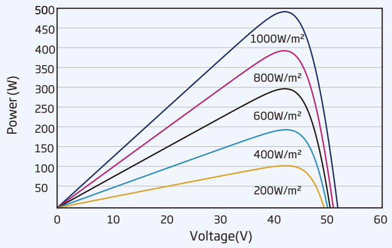


A-A B-B

I-V CURVES OF PV MODULE(495 W)



P-V CURVES OF PV MODULE(495W)



ELECTRICAL DATA (STC)

Peak Power Watts-P_{MAX} (Wp)*	485	490	495	500	505	510
Power Tolerance-P_{MAX} (W)	0 ~ +5					
Maximum Power Voltage-V_{MPP} (V)	42.2	42.4	42.6	42.8	43.0	43.2
Maximum Power Current-I_{MPP} (A)	11.49	11.56	11.63	11.69	11.75	11.81
Open Circuit Voltage-V_{OC} (V)	51.1	51.3	51.5	51.7	51.9	52.1
Short Circuit Current-I_{SC} (A)	12.07	12.14	12.21	12.28	12.35	12.42
Module Efficiency η m (%)	20.1	20.3	20.5	20.7	21.0	21.2

STC: Irradiance 1000W/m², Cell Temperature 25°C, Air Mass AM1.5.
*Measuring tolerance: ±3%.

ELECTRICAL DATA (NOCT)

Maximum Power-P_{MAX} (Wp)	365	369	373	377	381	385
Maximum Power Voltage-V_{MPP} (V)	39.9	40.0	40.2	40.4	40.6	40.5
Maximum Power Current-I_{MPP} (A)	9.17	9.22	9.28	9.33	9.38	9.50
Open Circuit Voltage-V_{OC} (V)	48.1	48.2	48.4	48.6	48.8	49.0
Short Circuit Current-I_{SC} (A)	9.73	9.78	9.84	9.90	9.95	10.01

NOCT: Irradiance at 800W/m², Ambient Temperature 20°C, Wind Speed 1m/s.

MECHANICAL DATA

Solar Cells	Monocrystalline
Cell Orientation	150 cells
Module Dimensions	2187×1102×35 mm (86.10×43.39×1.38 inches)
Weight	26.5 kg (58.4 lb)
Glass	3.2 mm (0.13 inches), High Transmission, AR Coated Heat Strengthened Glass
Encapsulant Material	EVA
Backsheet	White
Frame	35 mm (1.38 inches) Anodized Aluminium Alloy
J-Box	IP 68 rated
Cables	Photovoltaic Technology Cable 4.0mm² (0.006 inches²), Portrait: N 280mm/P 280mm(11.02/11.02inches) Landscape: N 1400 mm /P 1400 mm (55.12/55.12 inches)
Connector	TS4

TEMPERATURE RATINGS

NOCT(Nominal Operating Cell Temperature)	43°C (±2°C)
Temperature Coefficient of P_{MAX}	- 0.34%/℃
Temperature Coefficient of V_{OC}	- 0.25%/℃
Temperature Coefficient of I_{SC}	0.04%/℃

MAXIMUMRATINGS

Operational Temperature	-40~+85℃
Maximum System Voltage	1500V DC (IEC)
Max Series Fuse Rating	20A

(Do not connect Fuse in Combiner Box with two or more strings in parallel connection)

WARRANTY

- 12 year Product Workmanship Warranty
- 25 year Power Warranty
- 2% first year degradation
- 0.55% Annual Power Attenuation

(Please refer to product warranty for details)

PACKAGING CONFIGUREATION

- Modules per box: 31 pieces
- Modules per 40' container: 620 pieces

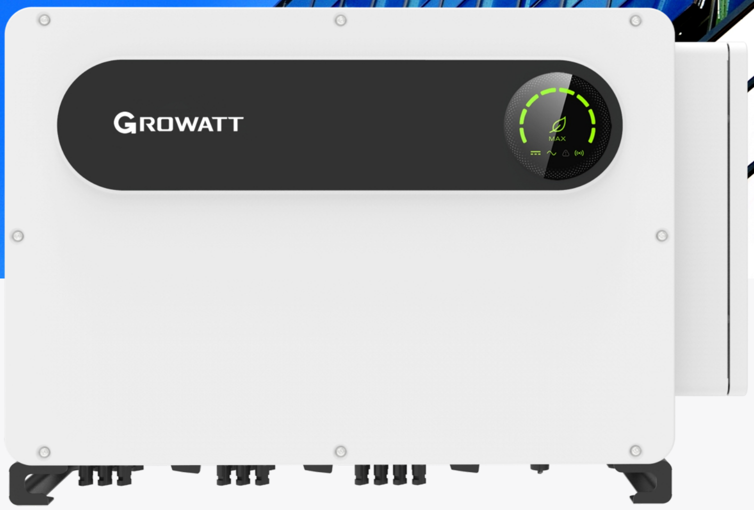
Trinasolar

CAUTION: READ SAFETY AND INSTALLATION INSTRUCTIONS BEFORE USING THE PRODUCT.

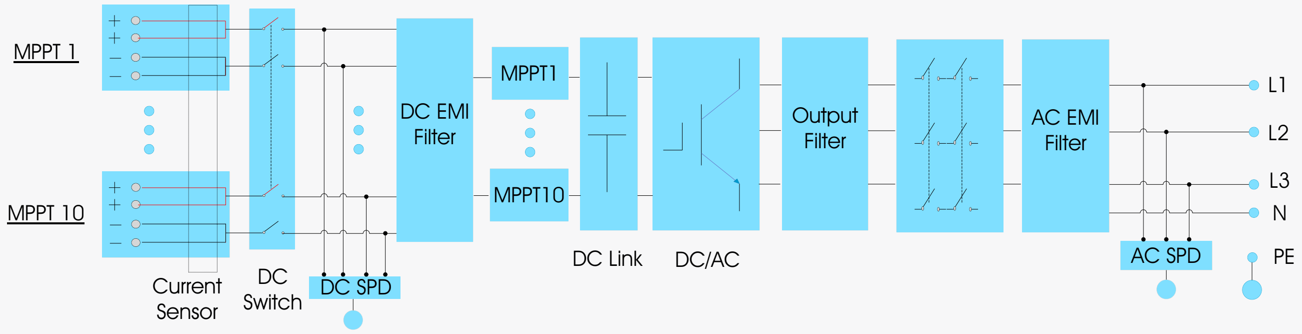
Version number: TSM_EN_2021_APAC_A www.trinasolar.com

MAX 80~133KTL3-X LV

- 7/10 MPPTs fusefree design
- Smart I/V scan and diagnosis
- Intelligent string monitoring
- AC&DC type II SPD
- IP66 and C5 protection



Topology Diagram



Primary Specification

Datasheet	MAX 80KTL3-X LV	MAX 100KTL3-X LV	MAX 110KTL3-X LV	MAX 120KTL3-X LV	MAX 125KTL3-X LV	MAX 133KTL3-X LV
Input data (DC)						
Max. recommended PV power (for module STC)	120000W	150000W	165000W	180000W	187500W	199500W
Max. DC voltage	1100V					
Start voltage	195V					
Nominal voltage	600V					
MPP voltage range	180V-1000V					
No. of MPP trackers	7	10	10	10	10	10
No. of PV strings per MPP tracker	2					
Max. input current per MPP tracker	32A					
Max. short-circuit current per MPP tracker	40A					
Output data (AC)						
AC nominal power	80000W	100000W	110000W	120000W	125000W	133000W
Max. AC apparent power	88000VA	110000VA	121000VA	132000VA	137500VA	146300VA
Nominal AC voltage(range*)	230V/400V(340-440VAC)					
AC grid frequency （range*）	50/60 Hz(45~55Hz/55-65 Hz)					
Max. output current	127A	158.8A	174.6A	190.5A	198.5A	211.2A
Adjustable power factor	0.8leading ...0.8lagging					
THDi	<3%					
AC grid connection type	3W/N/PE					
Efficiency						
Max.efficiency	98.8%					
European efficiency	98.4%	98.4%	98.5%	98.5%	98.5%	98.5%
MPPT efficiency	99.9%					
Protection devices						
DC reverse polarity protection	Yes					
DC switch	Yes					
AC/DC surge protection	Type II / Type II					
Insulation resistance monitoring	Yes					
AC short-circuit protection	Yes					
Ground fault monitoring	Yes					
String detection	Yes					
Anti PID function	Opt					
Arc fault detection (AFCI)	Opt					
General data						
Dimensions (W / H / D)	970/640/345mm					
Weight	84kg					
Operating temperature range	–30°C ... +60°C					
Nighttime power consumption	< 1W					
Topology	Transformerless					
Cooling	Smart Cooling					
Protection degree	IP66					
Relative humidity	0~100%					
Altitude	4000m					
DC connection	H4/MC4 (Max.6mm^2)					
AC connection	OT Terminal (Max. 240mm^2)					
Display	LED/WIFI+APP					
Interfaces: RS485 / USB /PLC/GPRS/4G/WiFi	Yes/Yes/Optional/Optional/Optional/Optional					
Place of production	Made in China					
CE,IEC62116, IEC61727, CQC, VDE0126, VFR2019, EN50549-1/2, C10/C11, UNE206007, G99 CEI 0-21/0-16, N4105&N4110, UNE206006,MEA, PEA, KSC8565						

* The AC voltage range and frequency range may vary depending on specific country grid standard.
All specifications are subject to change without notice.

Spec Sheet: ZFV32 – 32A

- **Description:** Compact **non polarized** isolator **32A** rated up to **1000V DC**, DIN profile complete with direct mounting handle, padlocking on the handle, and DIN rail mounting. Part Number ***ZFV32***
- Supplied with pre-wired links.
- **Application:** Non-Polarised Solar Array Isolators.
- **Certification: :** arsenal research to International Electrotechnical Commission EN 60947.3.

Dimensions & Ratings

Rated Operation Category DC21B

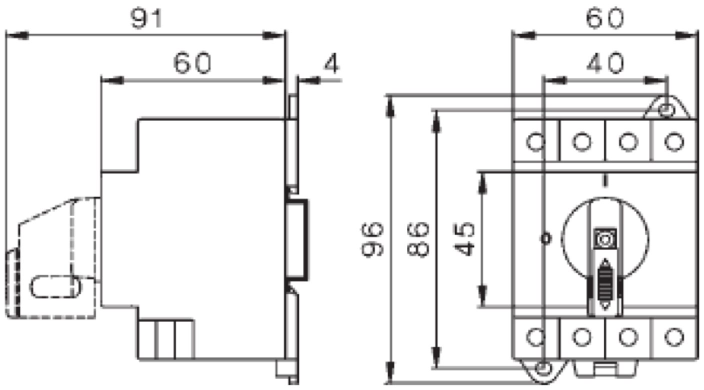
According to IEC 947-3	600V	700V	800V	900V	1000V
Current rating 4 contacts in series	32A	32A	32A	32A	32A
Current rating 2 contacts in series	32A	27A	23A	20A	13A

(per leg)

Rated insulation voltage *(Ui)*	1000V
Rated Short-time withstand current *(1 sec)*	1.0kA
Max Padlock Size *(mm)*	5mm
Number of Poles	4
Power Loss / pole	4.0W
Mechanical Endurance *(operations)*	10,000
Weight 4P	0.2kg
Operating torque	1Nm
Cable Size *(mm²)*	4 - 16

PV Isolators

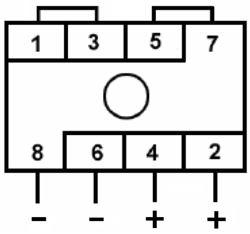
Complies with AS/NZ 5033

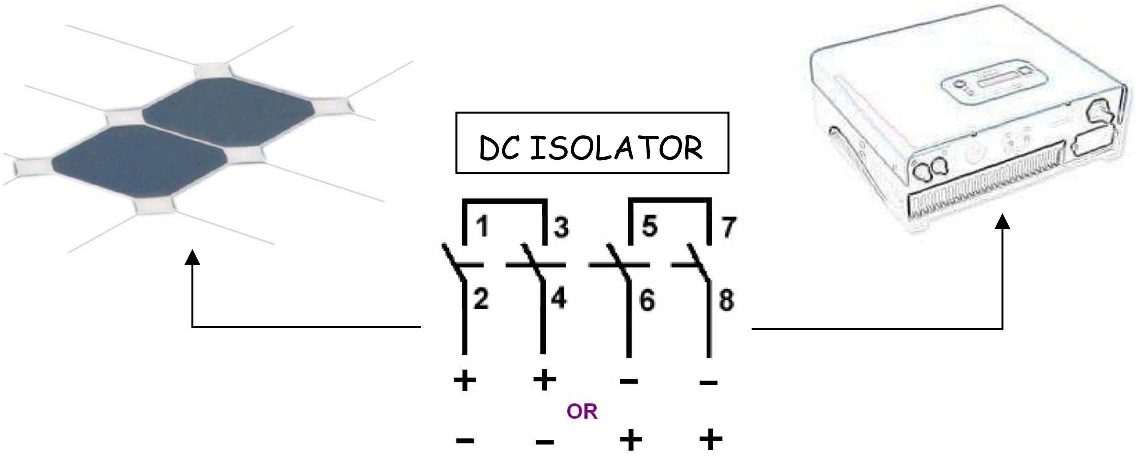


Connections

Non Polarized Isolators

- Non Polarized isolators:- photovoltaic array or inverter can be connected to either connection.
- One DC leg can switch up to 1000V DC at reduced current, ideal for transformless inverters isolation.





Non Polarized

Terminal polarity can be changed without restriction

BUD-S1000
PV DC Surge
Protection Device

TÜVRheinland

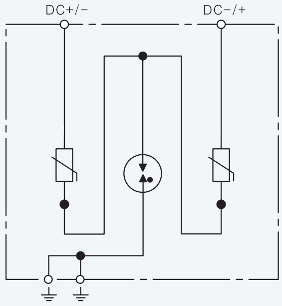
Application

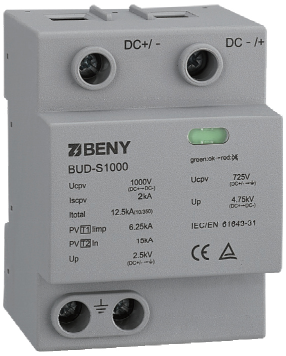
BENY Developed and manufactured the T1+T2 complex surge protector, in line with IEC/EN 616143-31, with a maximum continuous operating voltage of 1000V; High pressure Sensitive resistor, nanosecond response speed, high efficiency to prevent lightning voltage damage to photovoltaic power generation system.

Parameter

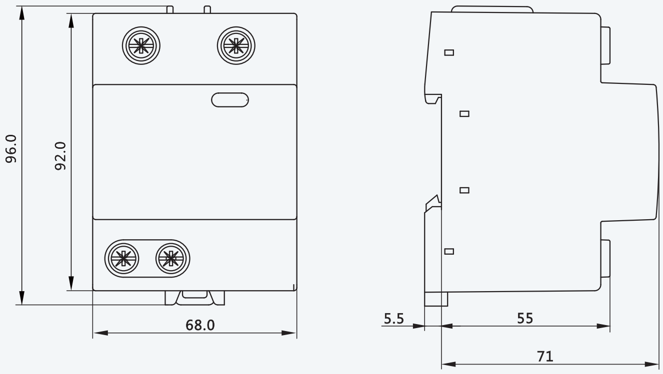
Type	BUD-S1000
Test standard	IEC/EN 61643-31
EN Type	T1+T2
Max.PV voltage(DC+→DC-)(U_{CPV})	≤1000V
Max.PV voltage(DC+/DC-→PE)(U_{CPV})	≤725V
Short-circuit current rating(I_{SCPV})	2kA
Total discharge current (8/20μs) (DC+/DC-→PE) (I_{total})	30kA
Total discharge current (10/350μs) (DC+/DC-→PE) (I_{total})	12.5kA
Nominal discharge current(8/20μs)(I_n)	15kA
Lightning impulse current (10/350μs) (DC+/DC-→PE) (I_{imp})	6.25kA
Voltage protection level (DC+/DC-→PE) (U_p)	2.5kV
Voltage protection level(DC+→DC-) (U_p)	4.75kV
Response time(t_A)	≤25ns
Operating temperature range(T_U)	-40°C~+80°C
Operating state/fault indication	green/red
Number of ports	1
Cross-sectional area(min.)	1.5mm² solid/ flexible
Cross-sectional area(max.)	35mm² stranded/25mm² flexible
For mounting on	TH35-7.5/DIN35
Place of installation	indoor installation
Degree of protection	IP20
Approvals	TUV,CE

Principal Drawing





Dimensions(mm)



Blue Diamond 60kVA

Hybrid Power System

Blue Diamond's Hybrid Power System is ideally suited to a range of applications, delivering reliable power in the most cost effective and environmentally sensitive way. Energy stored within the unit is converted electronically into AC mains voltage. Power can be derived from solar PV, connection to an external gird supply or from a diesel or hydrogen generator and wind turbine.

400/230V 50Hz 3Ø output, 60kVA
Deep cycle automotive NMC Li-Ion battery
100kWh stored energy

Full system DC isolator with pre-charge
200A pass-through capacity
Advanced EMS with touch screen control
V50 Power™ for enhanced DC bus stability

To find out more on Blue Diamond's range of renewable equipment visit: www.netzeroequipment.com.au

NetZero EQUIPMENT

BLUE DIAMOND MACHINERY • 1300 998 647 • info@bluedm.com.au

SPECIFICATIONS

Output (400/230V 50Hz 3Ø):		***Instruments, controls & connections:***	
Continuous ac (Inverter)	60kVA	Input connection (AC1 & AC2)	IEC 60309 or hardwire stud
Inverter peak power (5 seconds)	120kW	(AC2)	3Ø 400V IEC 60309 or hardwire stud
Pass-through capacity	200A	Output Connections AC	3Ø 400V IEC 60309 or hardwire stud
Input:		Battery condition	✓
AC1 Maximum input 3∅ (Option)	200A	System status control panel	✓
AC2 Maximum input 1∅	125A 230V	Battery condition	✓
System bypass capacity	200A	Battery main isolator	✓
Dimensions:		Input & Output MCB's	✓
Length	2000mm	Programmable gen auto-start signal	✓
Height	1960mm	***Optional features:***	
Width	1195mm	Integrated MPPT Solar PV charge controller	• PV
Ingress protection rating	IP34 Suitable for outdoor use	System AC bypass up to 630A (in lieu of standard)	• BPS
Standard Finish	Epoxy Powder Coat RAL 9016	Single to three phase conversion	• PC
Noise Levels	Inaudible above background	Harsh environment pack	• HE
Maximum heat rejection	12kW	Free air cooling pack	• FA

STANDARD BATTERY SPECIFICATION

Battery Type	Li-Ion NMC
Battery design life	4000 cycles to 80% dod
Nominal Battery Capacity	2200 Ahs
Useable stored energy (energy available at AC socket)	100kWhrs
Total unit weight (TBC)	2390 kg

NetZero EQUIPMENT ***supporting limited capacity grid to supply EV charging points.***

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Hybrid Power Systems

The science behind the technology

Introduction

The principle behind the concept of hybrid power generation is quite simple and easily understood. There is a common miss-conception that hybrid generation is a case of 'robbing Peter to pay Paul" but this is not so.

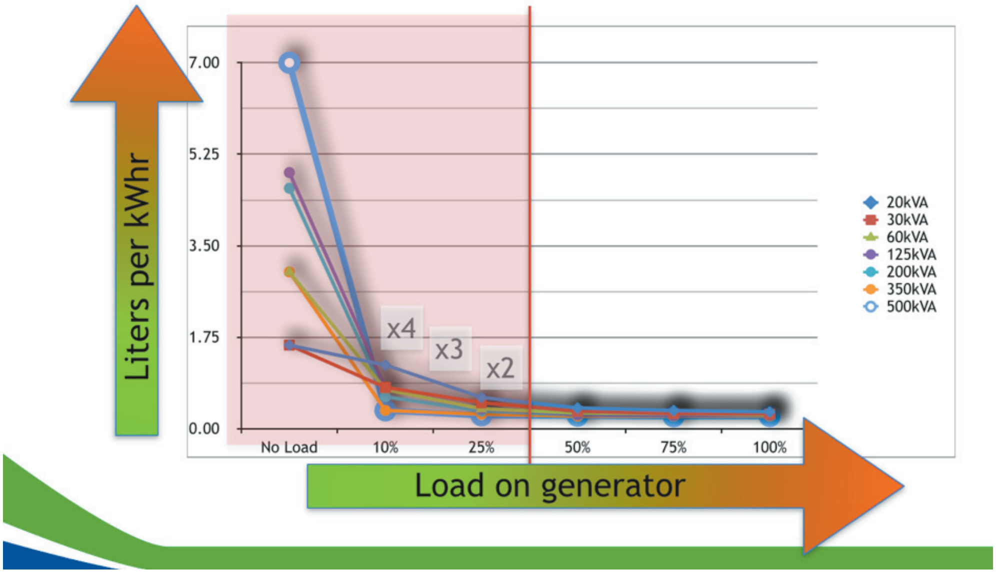
It is widely understood that driving a vehicle in an urban environment (ie: stop start and at slow speed), delivers poor fuel efficiency. The same applies to diesel generators which, after all, are based on the same internal combustion engine technology as a car or truck.

POWERCUBE, manufactured in the UK, is a hybrid power centre that is used in a variety of ways to deliver an alternative to running a generator 24/7 and so delivers significant savings in fuel consumption, reductions in emissions and other benefits. This is an overview of the principles behind the core technology and describes how and where benefits can be achieved.

Generator Fuel Efficiency

For all generators, regardless of fuel type, a relationship can be drawn between fuel efficiency and load. This will vary for different fuel types. Diesel generators are by far the most common so we will focus on the characteristics of diesel generators.

What we are concerned with is fuel consumption in litres versus output from the generator in kWhrs, (ie: litres per kWhr). The table below illustrates the relationship;



There are two things that the curves above show: Firstly, that fuel consumption, for loads above 30%, increases proportionally to increase in load and that litres burned per kWh is much the same regardless of the generator's size. Secondly, that fuel burned per kWh generated increases exponentially as load drops below 30%.
As a footnote, it is also known that lightly loaded generators run cooler and so the level of particulates and pollution generated per litre of fuel also increases.

In conclusion, generators that are lightly loaded burn more fuel, less cleanly for every kWhr of electrical energy generated

How does a hybrid system make this better?

In most situations, the electrical load on a generator is not constant; many electric loads turn on and off and those that are steady tend to consume low levels of power. The result is that a generator will see short periods of high power demand and longer periods of low power demand.

In a hybrid system, the generator turns off when there is less work to do and, when demand for power is higher, the generator turns on. When the generator is on, it is made to work harder by charging a battery so that energy can be stored. As a result, the generator runs less and works harder when it is running; less fuel is used and is burned more efficiently to generate the same amount of energy.

Less fuel, less CO2, Lower emissions, Less noise

Benefits quantified:

If we look to quantify the benefits that are achieved as a result of employing hybrid technology in temporary power systems, there are gains on many levels:

1) Fuel savings: Reductions in fuel consumption have obvious benefits that starts with a lower cost of fuel. Reductions will often be as 30-40% and can be as high as 80% depending on circumstances. In many cases, the cost of refuelling is just as significant and may even be greater. Less refuelling also means fewer road journey to deliver fuel so savings are made there too.

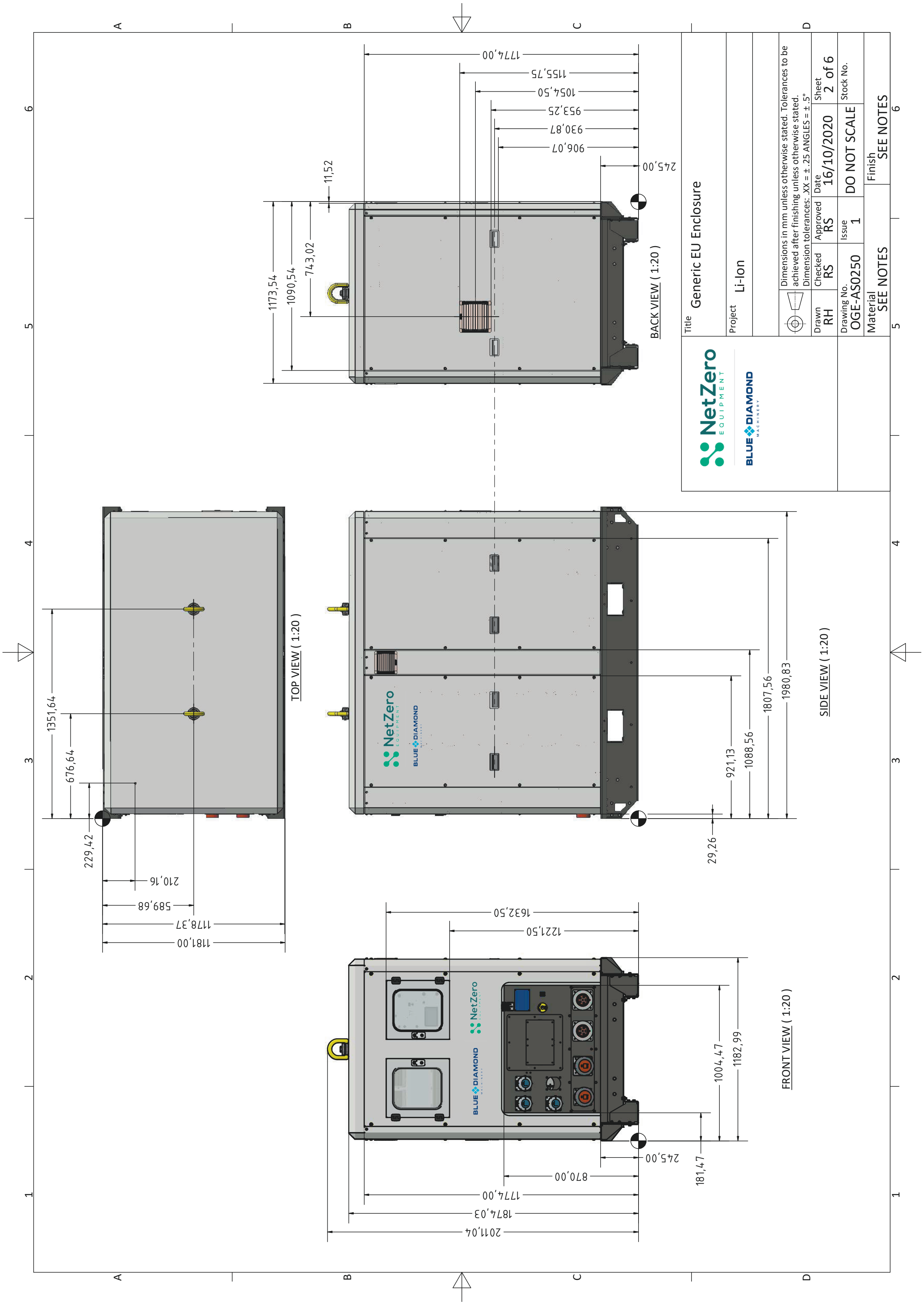
2) Lower emissions: Less fuel consumed means less CO2 created. There is a linear relationship where every litre of fuel saved reduces emissions by 2.65kg's of CO2. Pollution including NOx emissions are also reduced where the level of pollutants relates to the efficiency of combustion. Lightly loaded generators run cooler and burn less efficiently so create more pollution. For an installation with a 100kVA generator, modest savings can equate to the same as is produced by 20-30 family cars.

3) Noise reduction: For some installations, in sensitive residential areas for example, noise reduction/elimination ranks very highly in terms of environmental benefits. Enabling sites to operate longer hours or reducing nuisance or complaints can have significant benefits. It would be possible, for example, for a construction site to have the main generator turn off at the end of the working day and have the hybrid system to support the basic night-time loads through to the next morning without noise.

4) Longer generator life; less service: Another benefit of utilising hybrid power is reduced running hours of the generator. Fewer running hours means less need to service the generator saving cost and reducing the waste materials (oil, filters etc) that are created. Furthermore, the fact that the generator will be working harder results in better working conditions and greater reliability so longer service life.

5) Resilience and security: Where hybrid power provides dual sources of energy (generator and battery) an added dimension to the solution is increased power security and enables switching between power sources without loss of power.

6) Integration of renewables Hybrid technology also works as an energy



Title
Generic EU Enclosure

Project
Li-Ion

Dimensions in mm unless otherwise stated. Tolerances to be achieved after finishing unless otherwise stated.
Dimension tolerances: .XX = ± .25 ANGLES = ± .5°

Drawn	Checked	Approved	Date	Sheet
RH	RS	RS	16/10/2020	2 of 6

Drawing No.
OGE-AS0250

Issue
1

Stock No.

DO NOT SCALE

Material
SEE NOTES

Finish
SEE NOTES

Product datasheet

Specifications

Circuit breaker, ComPacT NSX250R, 200kA/415VAC, 4 poles 4D (neutral fully protected), TMD trip unit 200A

C25R4TM200

Main

Range	ComPacT new generation
Product name	ComPacT NSX new generation
Device short name	NSX250R
Product or component type	Circuit breaker
Device application	Distribution
Poles description	4P
Protected poles description	4D
Neutral position	Left
[In] rated current	200 A at 40 °C
[Ue] rated operational voltage	690 V AC 50/60 Hz
Network type	AC
Network frequency	50/60 Hz
Suitability for isolation	Yes conforming to EN/IEC 60947-2
Utilisation category	Category A
[Icu] rated ultimate short-circuit breaking capacity	200 kA Icu at 220/240 V AC 50/60 Hz conforming to IEC 60947-2 200 kA Icu at 380/415 V AC 50/60 Hz conforming to IEC 60947-2 200 kA Icu at 440 V AC 50/60 Hz conforming to IEC 60947-2 80 kA Icu at 500 V AC 50/60 Hz conforming to IEC 60947-2 65 kA Icu at 525 V AC 50/60 Hz conforming to IEC 60947-2 45 kA Icu at 660/690 V AC 50/60 Hz conforming to IEC 60947-2
Performance level	R 200 kA 415 V AC
Trip unit name	TM-D
Trip unit technology	Thermal-magnetic
Trip unit protection functions	LI
Control type	Toggle
Circuit breaker mounting mode	Fixed

Complementary

[Ui] rated insulation voltage	800 V AC 50/60 Hz
[Uimp] rated impulse withstand voltage	8 kV
[Ics] rated service short-circuit breaking capacity	200 kA at 220/240 V AC 50/60 Hz conforming to IEC 60947-2 200 kA at 380/415 V AC 50/60 Hz conforming to IEC 60947-2

	200 kA at 440 V AC 50/60 Hz conforming to IEC 60947-2 80 kA at 500 V AC 50/60 Hz conforming to IEC 60947-2 65 kA at 525 V AC 50/60 Hz conforming to IEC 60947-2 45 kA at 660/690 V AC 50/60 Hz conforming to IEC 60947-2
Mechanical durability	20000 cycles
Electrical durability	20000 cycles at 440 V In/2 10000 cycles at 440 V In 10000 cycles at 690 V In/2 5000 cycles at 690 V In
Power dissipation per pole	15.4 W
Mounting support	Backplate
Mounting position	Horizontal and vertical Flat on the back
Upside connection	Front
Downside connection	Front
Connection pitch	35 mm
Protection type	L : for overload protection (thermal) I : for short-circuit protection (magnetic)
Trip unit rating	200 A at 40 °C
Long-time pick-up adjustment type Ir (thermal protection)	Adjustable
[Ir] long-time protection pick-up adjustment range	0.7...1 x In
Long-time protection delay adjustment type tr	Fixed
[Tr] long-time protection delay adjustment range	120…400 s at 1.5 x In 15 s at 6 x Ir
Neutral protection settings	1 x Ir (4D)
Instantaneous protection pick-up adjustment type Ii	Adjustable
[Ii] instantaneous protection pick-up adjustment range	5...10 x In
Earth-leakage protection	Without
Number of slots for electrical auxiliaries	5 slot(s)
Width (W)	140 mm
Height (H)	161 mm
Depth (D)	86 mm
Net weight	2.8 kg

Environment

Standards	EN/IEC 60947
Product certifications	CCC Marine EAC
Overvoltage category	Class II
Electrical shock protection class	Class II
Pollution degree	3 conforming to IEC 60664-1
IP degree of protection	IP40 conforming to IEC 60529
IK degree of protection	IK07 conforming to IEC 62262
Ambient air temperature for operation	-25…70 °C

Ambient air temperature for storage	-50…85 °C
Relative humidity	0…95 %
Operating altitude	0...2000 m without derating 2000 m...5000 m with derating

Packing Units

Unit Type of Package 1	PCE
Number of Units in Package 1	1
Package 1 Weight	2.734 kg
Package 1 Height	14 cm
Package 1 width	15 cm
Package 1 Length	20 cm
Unit Type of Package 2	BB1
Number of Units in Package 2	1
Package 2 Weight	2.78 kg
Package 2 Height	14 cm
Package 2 width	15 cm
Package 2 Length	20 cm
Unit Type of Package 3	S03
Number of Units in Package 3	3
Package 3 Weight	8.202 kg
Package 3 Height	30 cm
Package 3 width	30 cm
Package 3 Length	40 cm

Offer Sustainability

Sustainable offer status	Green Premium product
REACh Regulation	REACh Declaration
EU RoHS Directive	Compliant EU RoHS Declaration
Mercury free	Yes
RoHS exemption information	Yes
China RoHS Regulation	China RoHS declaration Product out of China RoHS scope. Substance declaration for your information
Environmental Disclosure	Product Environmental Profile
Circularity Profile	End of Life Information
PVC free	Yes

Product data sheet

Characteristics

LV432694

circuit breaker Compact NSX400N - Micrologic 2.3 - 400 A - 4 poles 4d

Green Premium™ Product

Main

Commercial Status	Commercialised
Product or component type	Circuit breaker
Device short name	Compact NSX400N
Circuit breaker application	Distribution
Poles description	4P
Protected poles description	3t 3t + N/2 4t
Neutral position	Left
Network type	AC
Network frequency	50/60 Hz
[In] rated current	400 A (40 °C)
[Ui] rated insulation voltage	800 V AC 50/60 Hz
[Uimp] rated impulse withstand voltage	8 kV
[Ue] rated operational voltage	690 V AC 50/60 Hz
Breaking capacity code	N
Breaking capacity	Icu 42 kA at 440 V AC 50/60 Hz conforming to IEC 60947-2 42 kA at 480 V AC 50/60 Hz conforming to NEMA AB1 Icu 50 kA at 380/415 V AC 50/60 Hz conforming to IEC 60947-2 50 kA at 480 V AC 50/60 Hz conforming to UL 508 20 kA at 600 V AC 50/60 Hz conforming to UL 508 Icu 30 kA at 500 V AC 50/60 Hz conforming to IEC 60947-2 20 kA at 600 V AC 50/60 Hz conforming to NEMA AB1 Icu 10 kA at 660/690 V AC 50/60 Hz conforming to IEC 60947-2 Icu 85 kA at 220/240 V AC 50/60 Hz conforming to IEC 60947-2 Icu 22 kA at 525 V AC 50/60 Hz conforming to IEC 60947-2 85 kA at 240 V AC 50/60 Hz conforming to UL 508 85 kA at 240 V AC 50/60 Hz conforming to NEMA AB1
[Ics] rated service breaking capacity	Ics 42 kA 440 V AC 50/60 Hz conforming to IEC 60947-2 Ics 30 kA 500 V AC 50/60 Hz conforming to IEC 60947-2 Ics 50 kA 380/415 V AC 50/60 Hz conforming to IEC 60947-2 Ics 10 kA 660/690 V AC 50/60 Hz conforming to IEC 60947-2 Ics 85 kA 220/240 V AC 50/60 Hz conforming to IEC 60947-2 Ics 11 kA 525 V AC 50/60 Hz conforming to IEC 60947-2
Suitability for isolation	Yes conforming to IEC 60947-2 Yes conforming to EN 60947-2
Utilisation category	Category A
Trip unit name	Micrologic 2.3
Trip unit technology	Electronic
Trip unit protection functions	LSoI
Trip unit rating	400 A (40 °C)
Protection type	Instantaneous short-circuit protection Overload protection (long time) Short time short-circuit protection
Pollution degree	3 conforming to IEC 60664-1

Complementary

Control type	Toggle
Mounting mode	Fixed
Mounting support	Backplate
Upside connection	Front
Downside connection	Front
Mechanical durability	15000 cycles
Electrical durability	6000 cycles 690 V In/2 conforming to IEC 60947-2 6000 cycles 440 V In conforming to IEC 60947-2 3000 cycles 690 V In conforming to IEC 60947-2 12000 cycles 440 V In/2 conforming to IEC 60947-2
Connection pitch	45 mm
Local signalling	LED 105 % Ir LED 90 % Ir LED ready
Neutral protection setting	No protection 3t 1 x Ir 4t 0.5 x Ir 3t + N/2
Long time pick-up adjstment type Ir	Adjustable 9 settings
Long time pick-up adjustment range	0.9...1 x Io
Long time delay adjustment type	Fixed
[Tr] long-time delay adjustment	16 s 6 x Ir
Thermal memory	20 minutes before and after tripping
Short-time pick-up adjustment type Isd	Adjustable 9 settings
[Isd] short-time pick-up adjustment range	1.5...10 x Ir
Short-time delay adjustment type	Fixed
Instantaneous pick-up adjustment type Ii	Fixed
Instantaneous pick-up adjustment range	4800 A
Height	255 mm
Width	185 mm
Depth	110 mm
Product weight	7.9 kg

Environment

Electrical shock protection class	Class II
Standards	EN 60947-2 IEC 60947-2 NEMA AB1 UL 508
Product certifications	CSA UL
IP degree of protection	IP40 conforming to IEC 60529
IK degree of protection	IK07 conforming to IEC 62262
Ambient air temperature for operation	-35...70 °C
Ambient air temperature for storage	-55...85 °C

Offer Sustainability

Sustainable offer status	Green Premium product
RoHS	Compliant - since 0819 - Schneider Electric declaration of conformity
REACh	Reference not containing SVHC above the threshold
Product environmental profile	Available Download Product Environmental
Product end of life instructions	Need no specific recycling operations