Solar PhotoVoltaic

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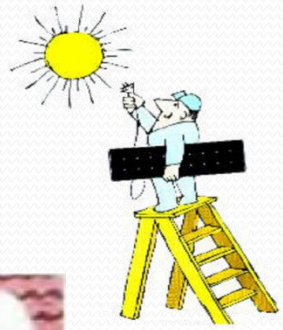
Housing & Development Board
Building Research Institute

Contents

1. Types of Solar PV
2. Installation of Solar PV system
3. Solar PV system
4. Solar PV on rooftop
5. Large Solar Installation
6. Lightning Protection requirements
7. Inspection before connecting to power grid
8. Maintenance

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Types of Solar



- Solar – Available all year round

2 Types

- Thermal – Use for heating
  - eg water heater

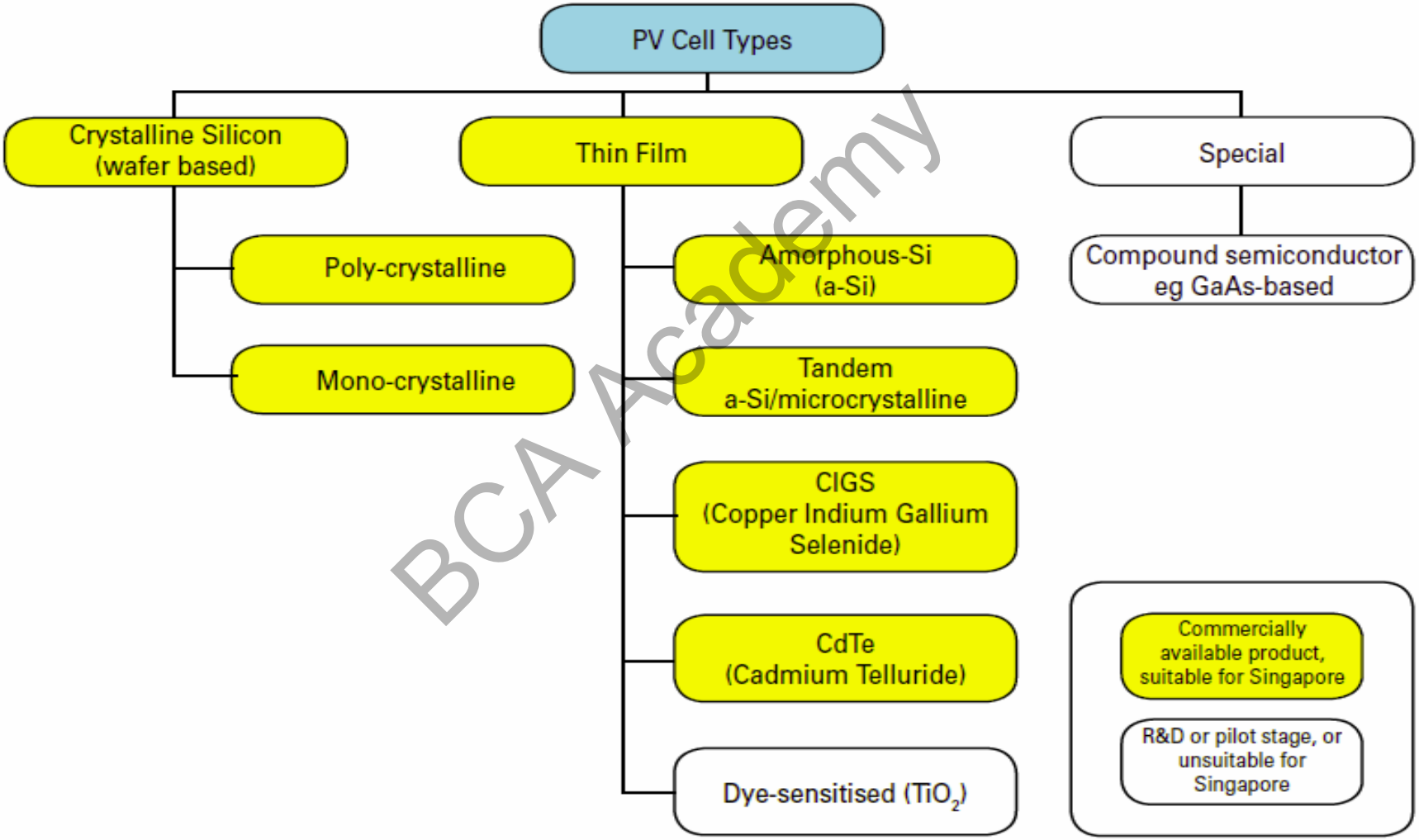


- Photovoltaic
  – generate electricity



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Different Types of Solar Cell/Modules



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Figure 5. PV technology family tree

Types of Modules





Mono-crystalline silicon



Poly-crystalline silicon



Thin-film



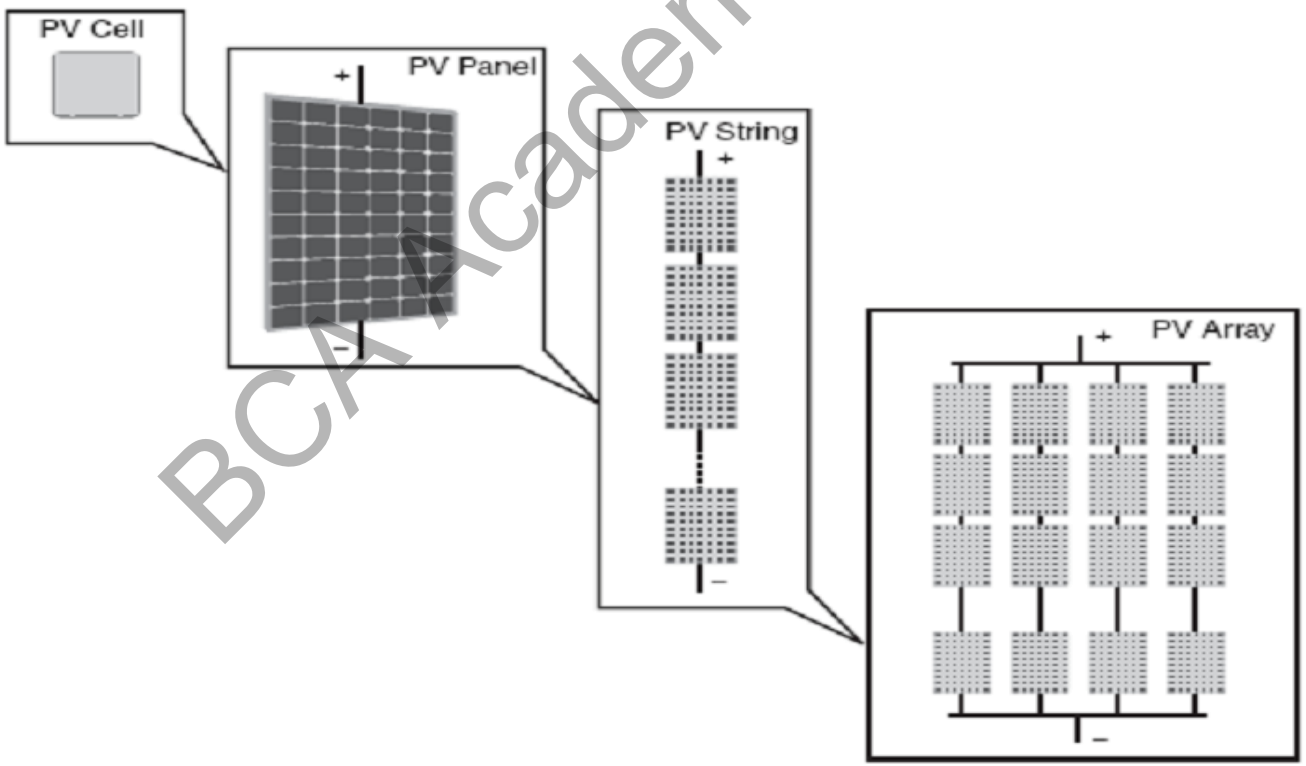
CIGS thin film

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Common PV module technologies

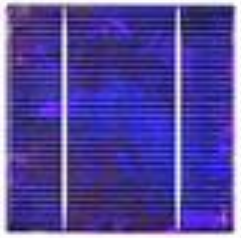
Cells into Modules

- **Cells connected in series to form a module**



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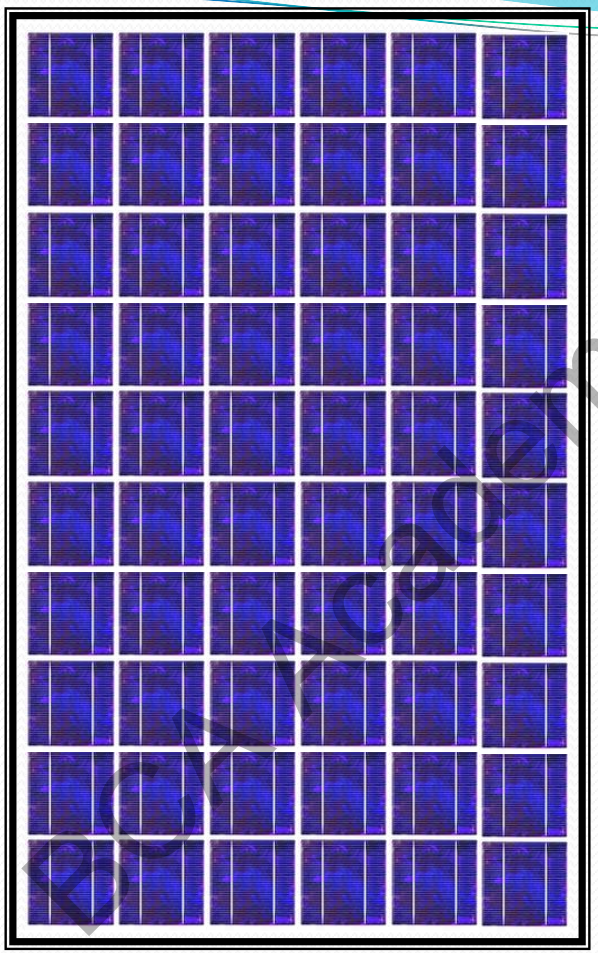
Solar Panel



155 mm

155 mm

Single Cell



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DC Volts per cell ~ 0.49V Watts per cell ~ 3.83-5.75	10 x 6 = 60 cells 0.49 V x 60 = 29.4 V > 300W	Panel size : 1.66 x 0.99 m Weight : 20 kg

Solar on HDB Roof



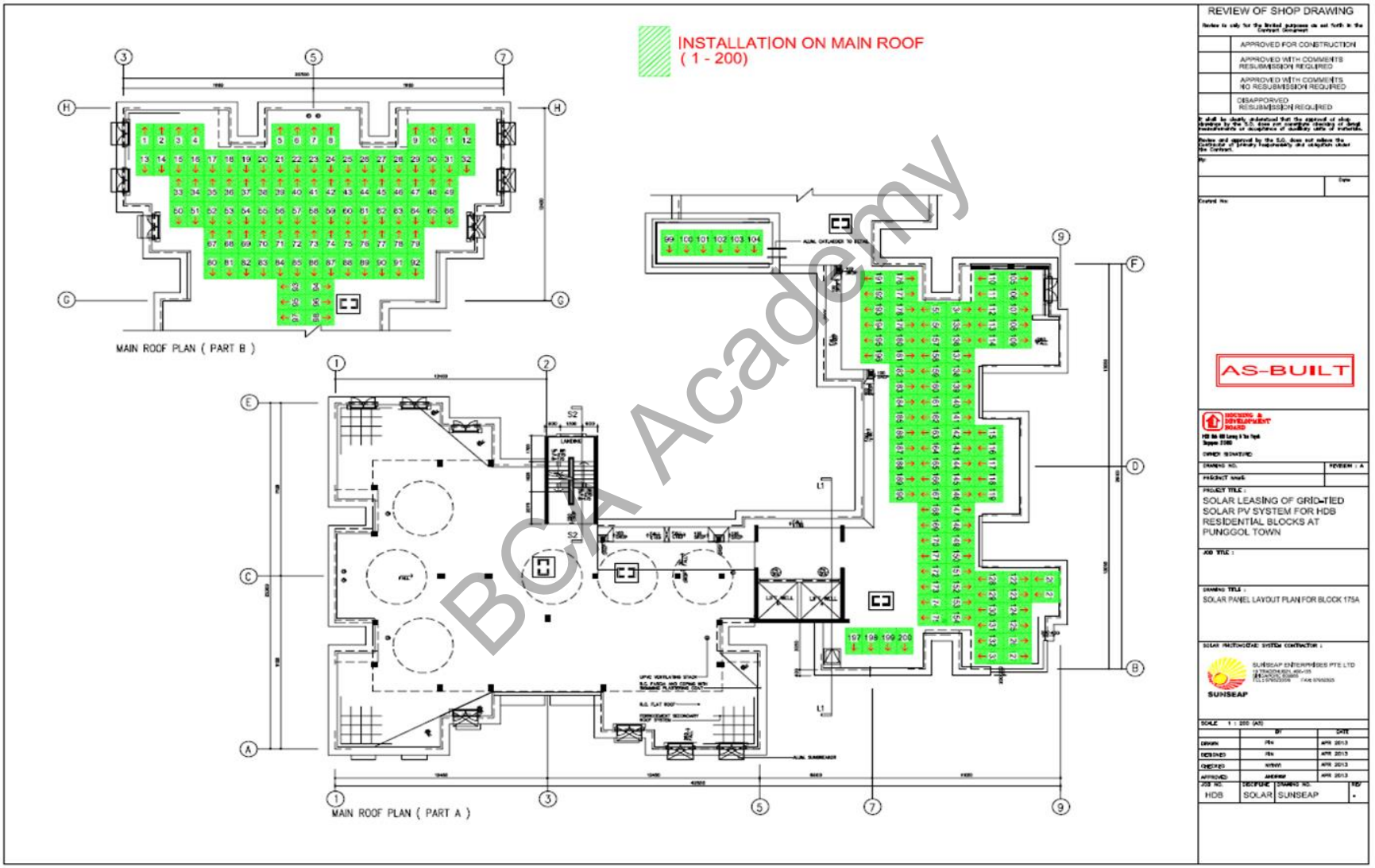




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Typical Capacity HDB Roof ~ 40-50 kWp

Solar Energy Generation/month = _____ KWp x Sun-hours/per Day x 30 days


INSTALLATION ON MAIN ROOF
(1 - 200)
MAIN ROOF PLAN (PART B)
MAIN ROOF PLAN (PART A)
REVIEW OF SHOP DRAWING
APPROVED FOR CONSTRUCTION
APPROVED WITH COMMENTS RESUBMISSION REQUIRED
APPROVED WITH COMMENTS NO RESUBMISSION REQUIRED
DISAPPROVED RESUBMISSION REQUIRED
AS-BUILT
SOLAR LEASING OF GRID-TIED SOLAR PV SYSTEM FOR HDB RESIDENTIAL BLOCKS AT PUNGGOL TOWN
SOLAR PANEL LAYOUT PLAN FOR BLOCK 175A
SUNSEAP
HDB
SOLAR
SUNSEAP
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Installation of Solar PV system

- **Electrical Installation**
  Conversion to Dc to AC
- **Structural Requirements**
  Support for PV
- **Electronic Monitoring**

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Installation of Solar PV

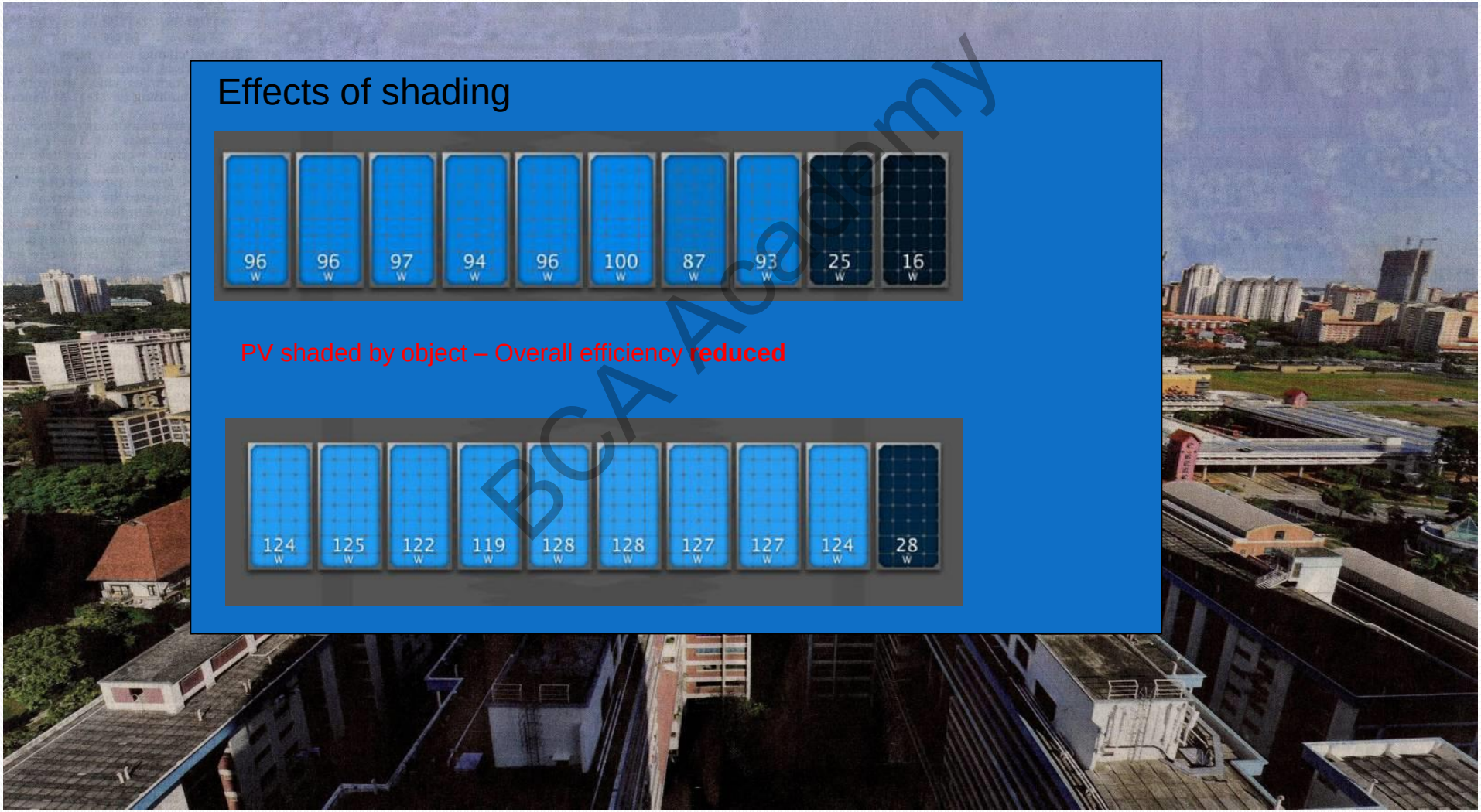
Factors to be considered

- Shading
- Structural Load
  - **Structure**
  - **Wind load & speed**
- Accessibility for maintenance
- Safety measures
- Balance of System
  - consist of all components of a renewable energy system except for the solar modules and their mounting system.

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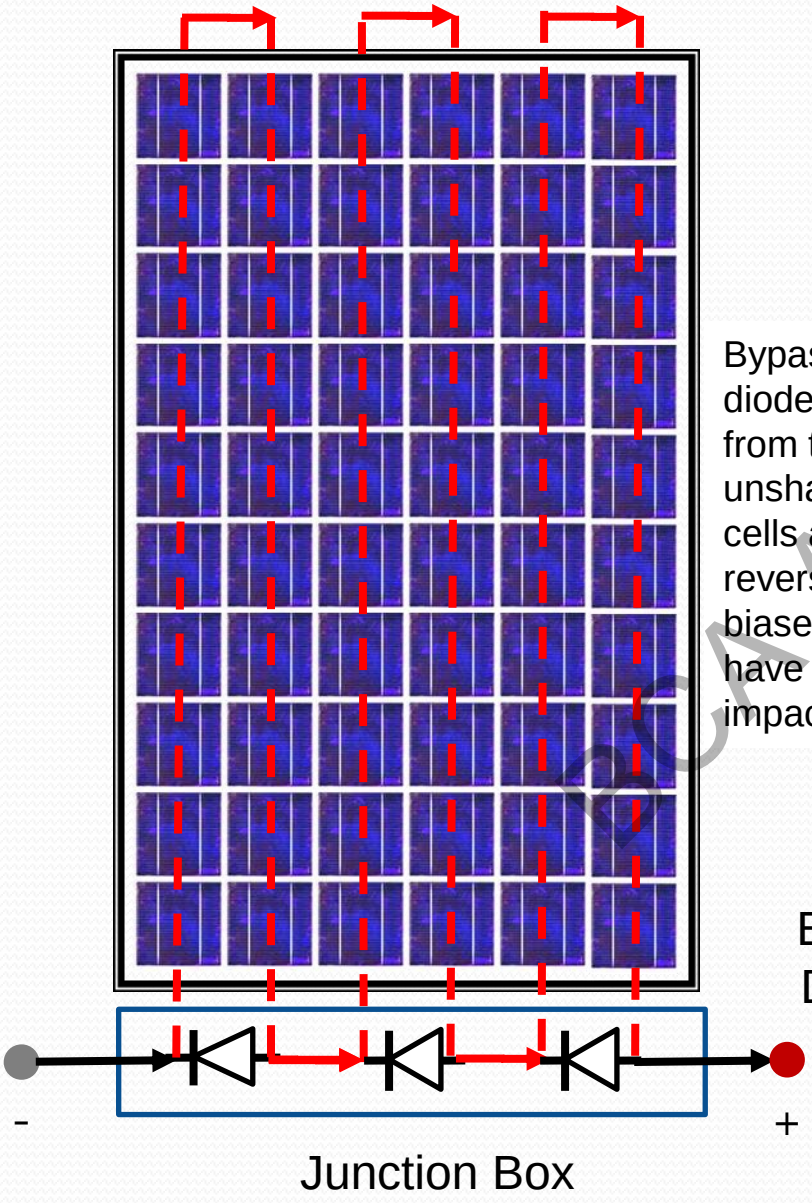
Site/location of the solar PV

- Effects of shading on solar pv string



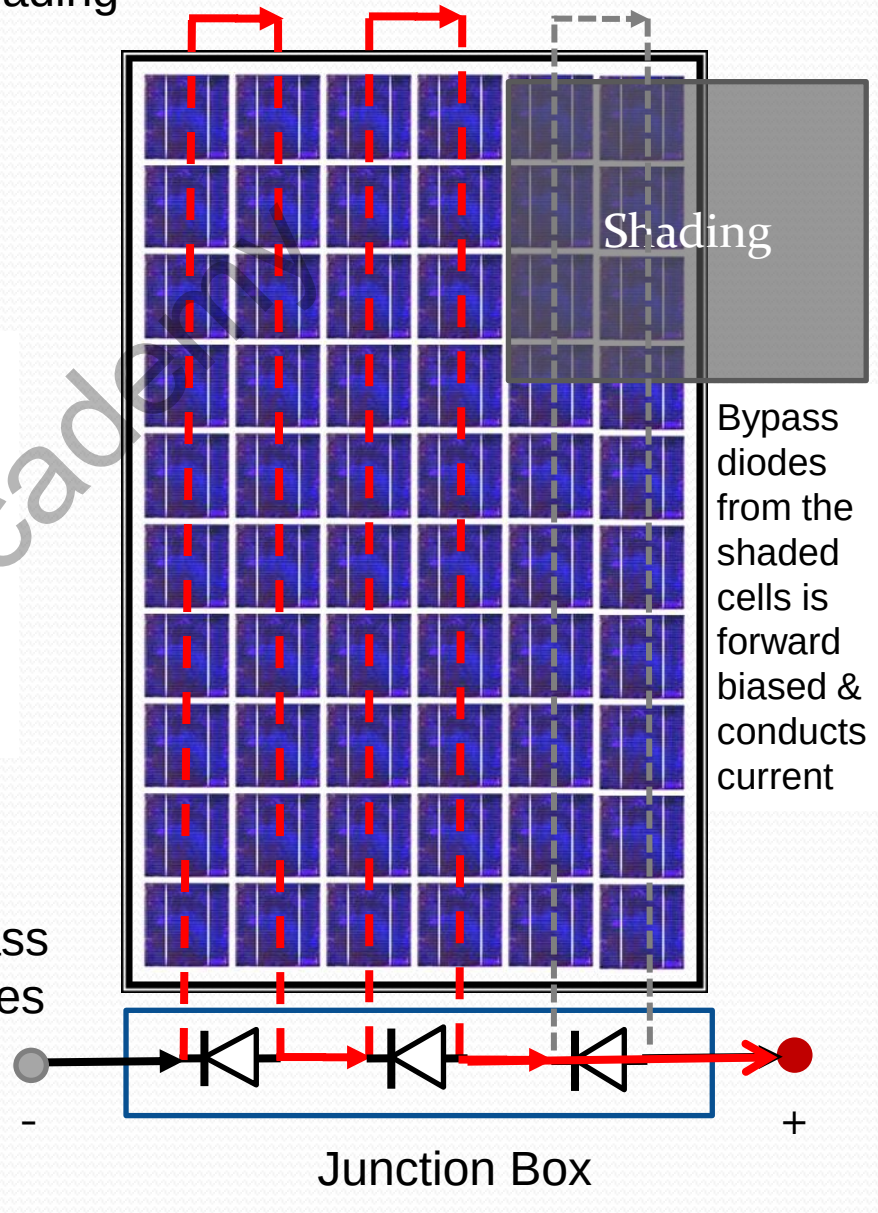
Effects of Shading

Normal



Bypass diodes from the unshaded cells are reverse biased have no impact

Shading



Bypass diodes from the shaded cells is forward biased & conducts current

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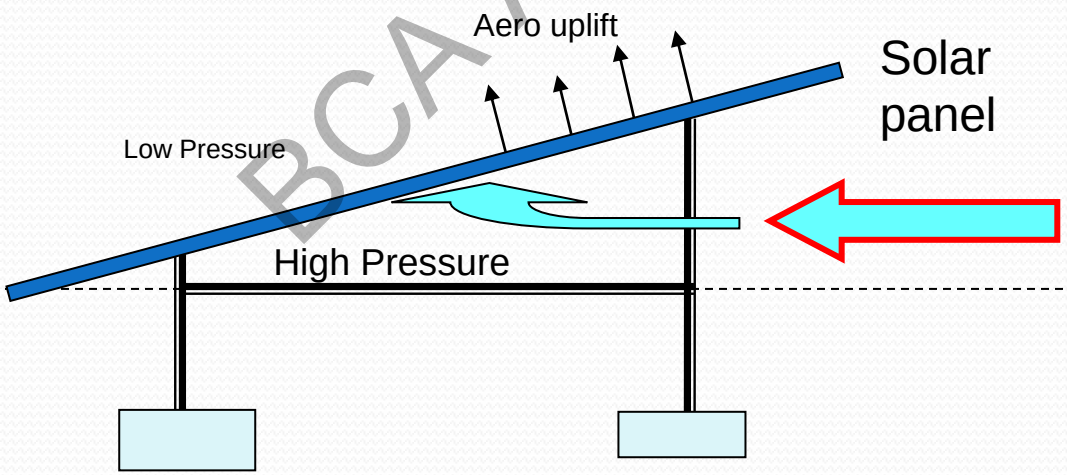
Structure

- **Structural/Mechanical strength**
- **Wind load**
- **Wind Velocity**

} Wind Uplift

- **Integration into current roof structure**

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Load varies depending on height of building

Accessibility for Maintenance

- **Space for access of maintenance**

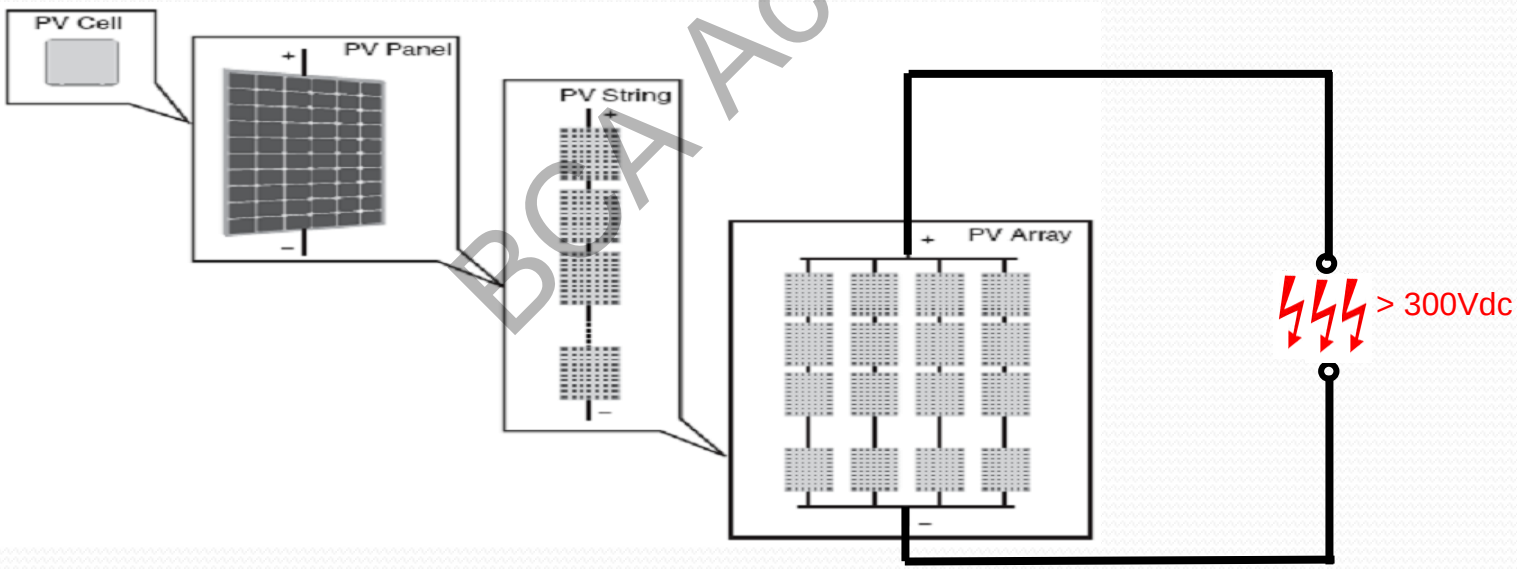




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Safety

- One cell very low voltage < 0.5V
- One module ~ 30V dc
- In array/string ≥ **300Vdc**
- Inverter input 300 - 500Vdc

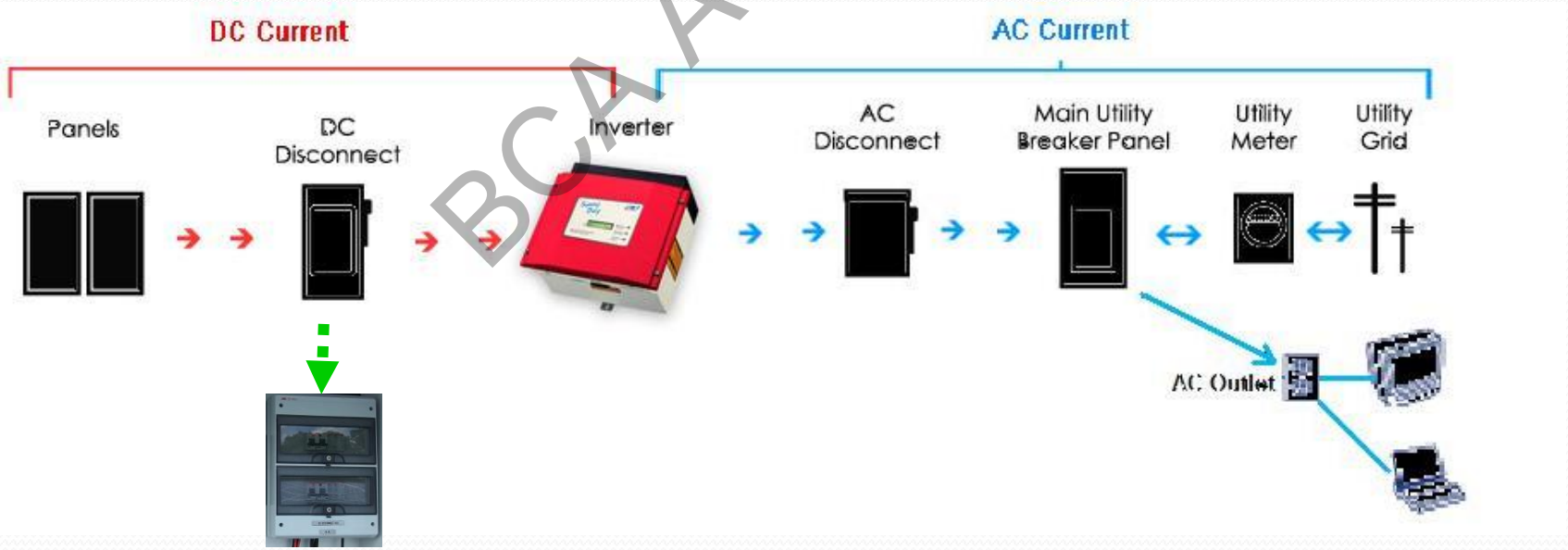


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Balance of System

- **Balance of System components**
  - **all components of a renewable energy system except for the solar modules and their mounting system.**
  - **Inverters, fuse/breakers, overcurrent protection, enclosures, batteries, charge controller.**

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Choice of Installation Materials

1. **Support structure**
   - Aluminum
   - Galvanized Iron





2. **Solar Cables & Connectors, Junction boxes**
   - Insulation – to withstand weather elements
     - Heat
     - Water
     - UV

Female Male



3. **Outdoor Installation**
   - Exposed
   - Enclosed



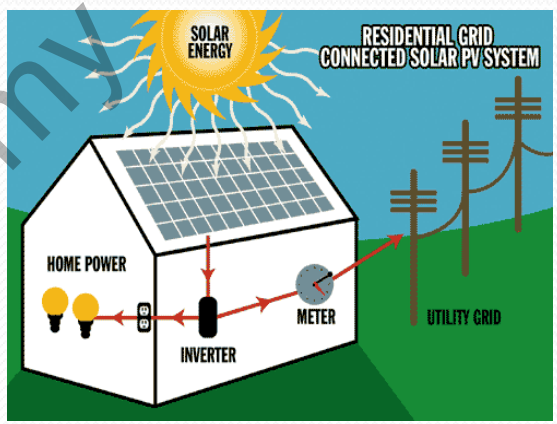
MC4

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Types of Solar PV System

System – Scheme

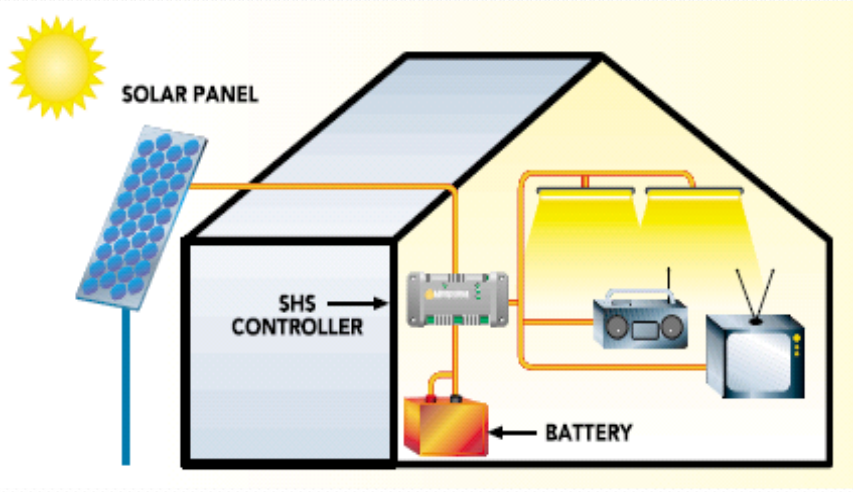
- Grid-Tied system
- Off-Grid
  - Standalone
    - Battery (Deep Cycle)
- Hybrid System



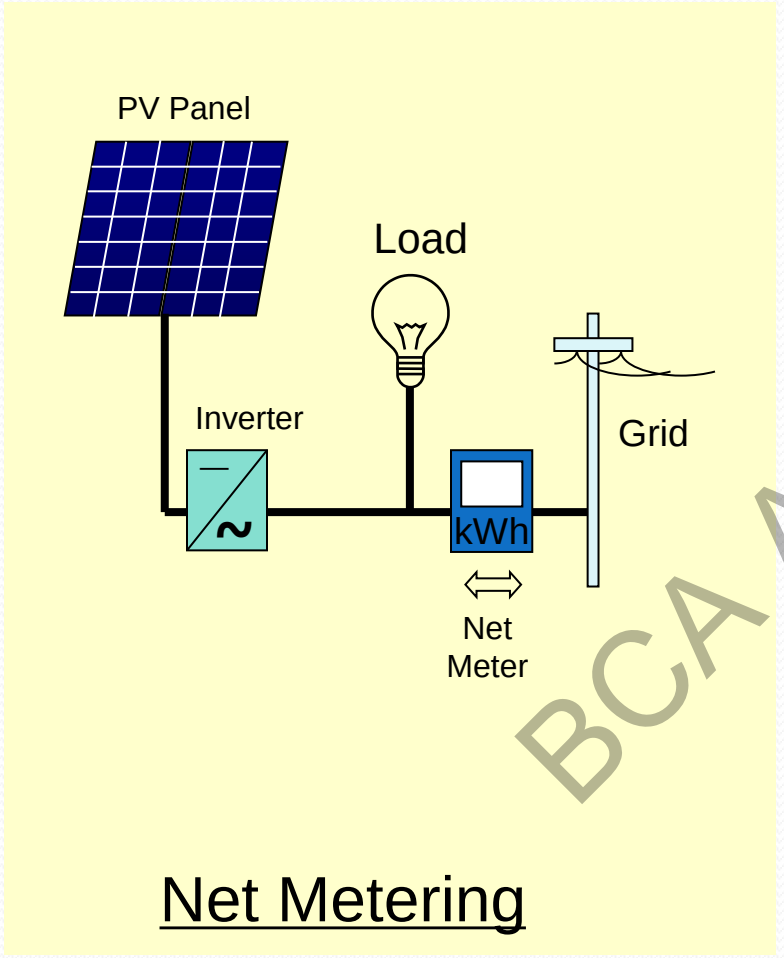
ECA Academy



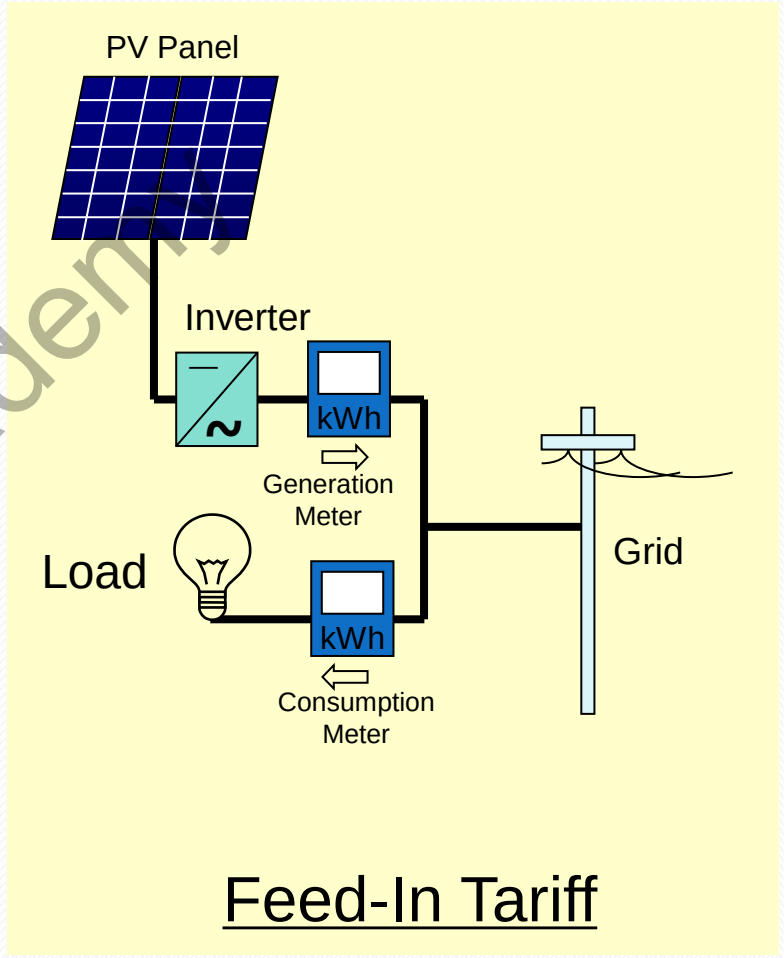




Net Metering & Feed-in Tariff



Net Metering

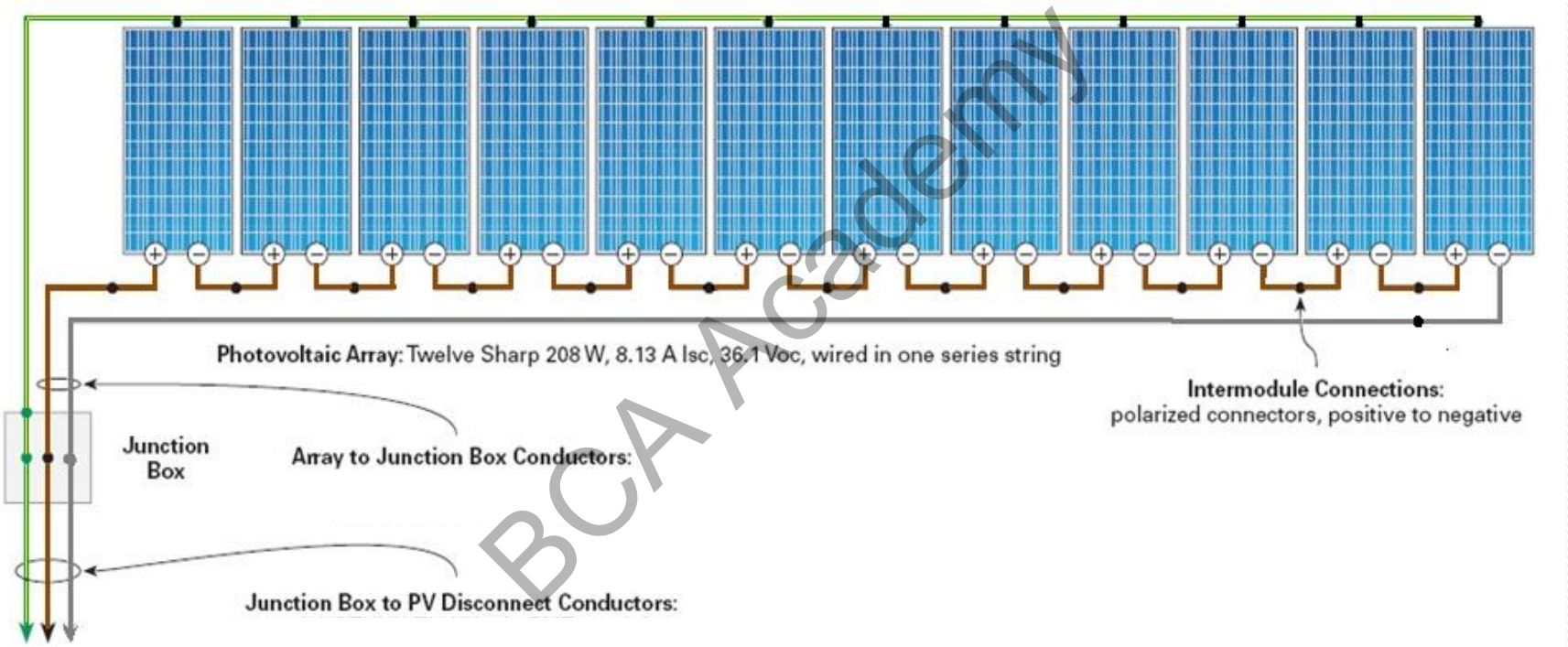


Feed-In Tariff

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Above shows the typical meter connection for Net Metering & Feed-in Tariff.

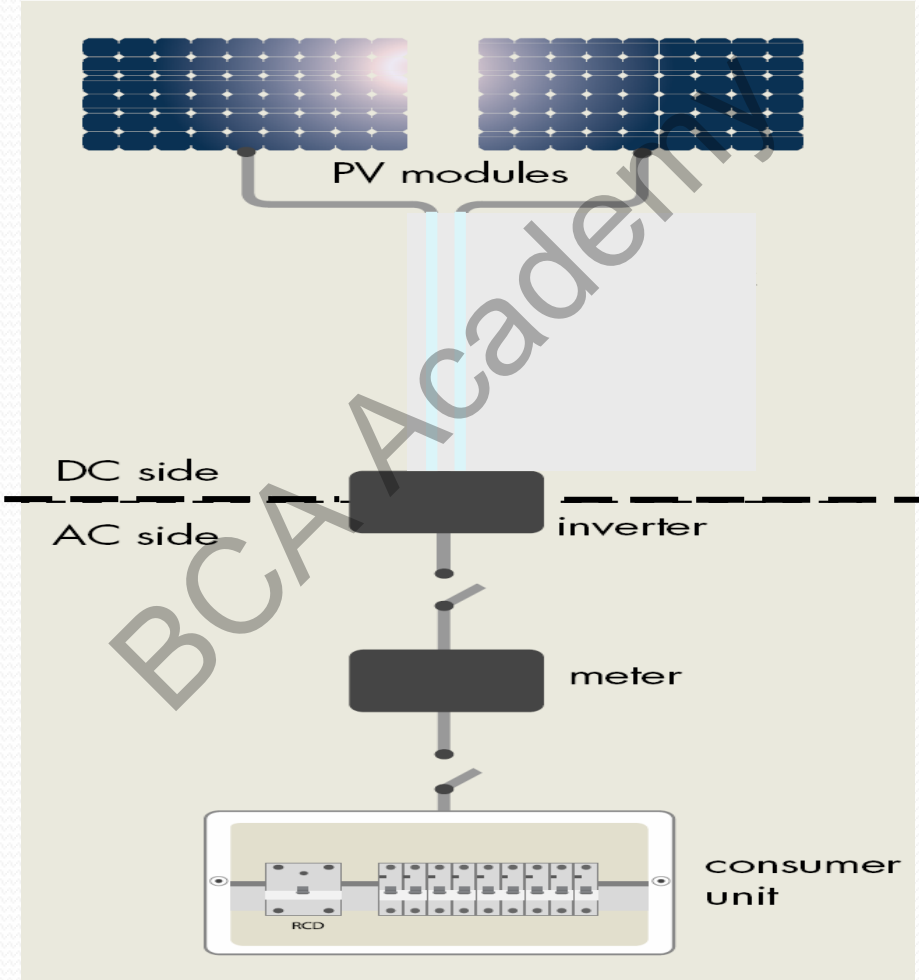
PV String



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PV String Voltage : 36.1V x 12 modules = 433.2V

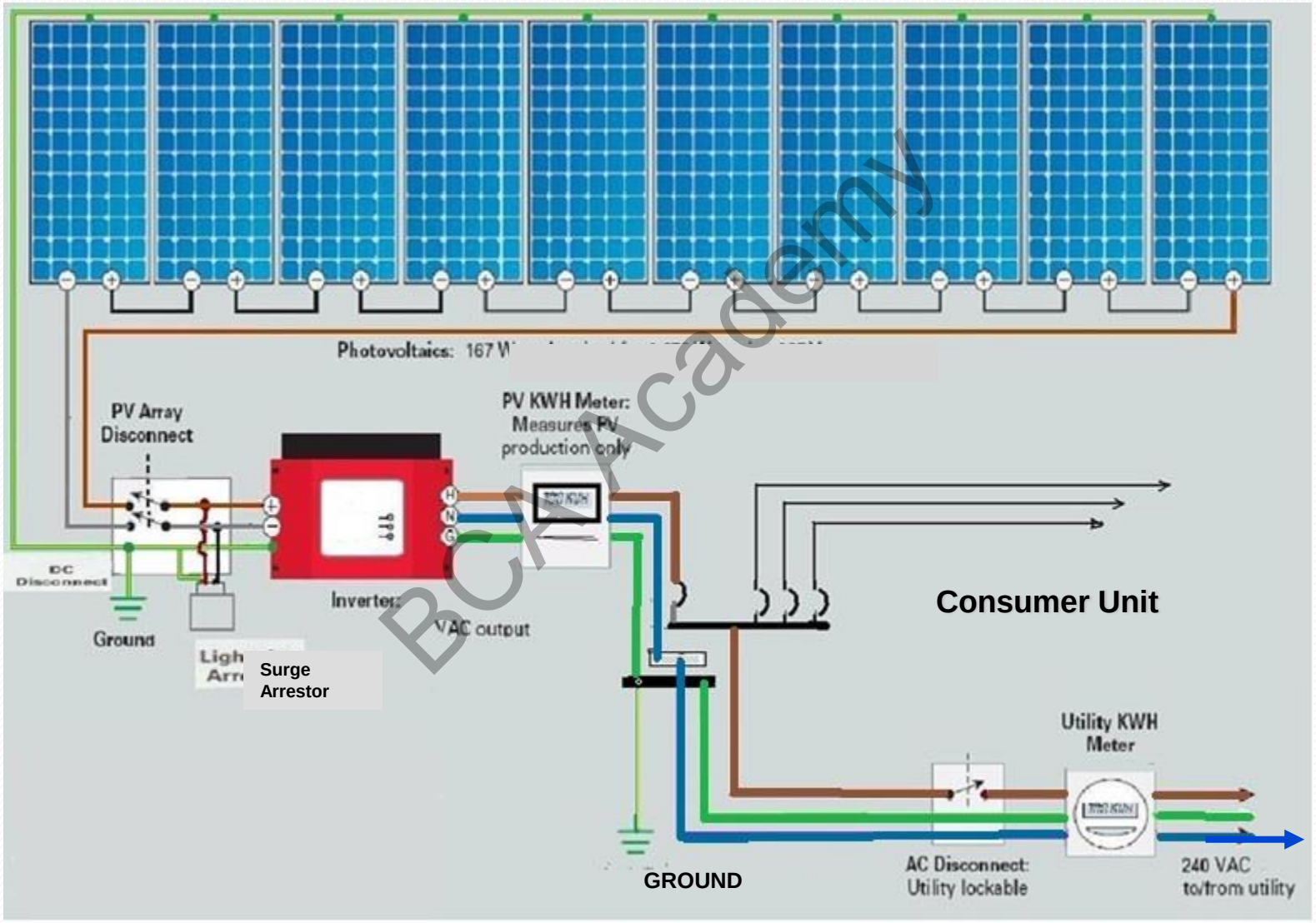
Components of Typical PV System



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Schematic Diagram - Grid Tied Systems

Single Phase Inverter



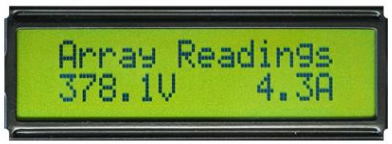
Inverters

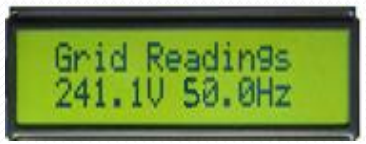
- Compliance with local power service provider requirement – EMI, DC component
- Selection of Inverters
  - Matching
- Efficiency
  - Transformer/transformerless
- ‘Islanding’ effect



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Types of Solar Inverters

- Grid-tied
  - **MICRO-INVERTERS**
    - Located on the back of single solar panel.
    - Offers panel level MPPT
    - Higher cost per watt
  - **STRING INVERTERS**
    - Most common used
    - Up to <600 Vdc
    - 3-phase variation available
  - **CENTRAL INVERTERS**
    - Similar to string inverters designed for very large string arrays
    - Low capital cost per watt
    - from 100 kW up to 1000 kW

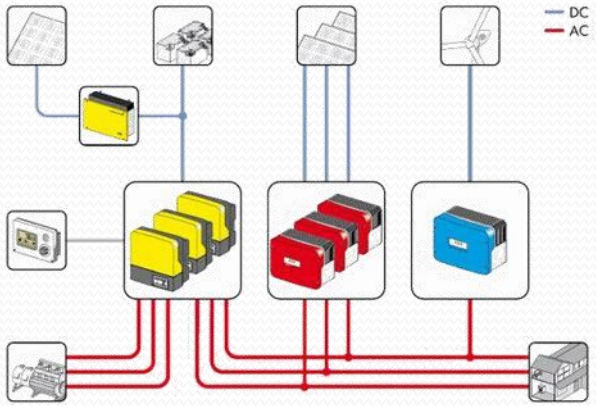
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1 MWp single site installation





3-phase inverter



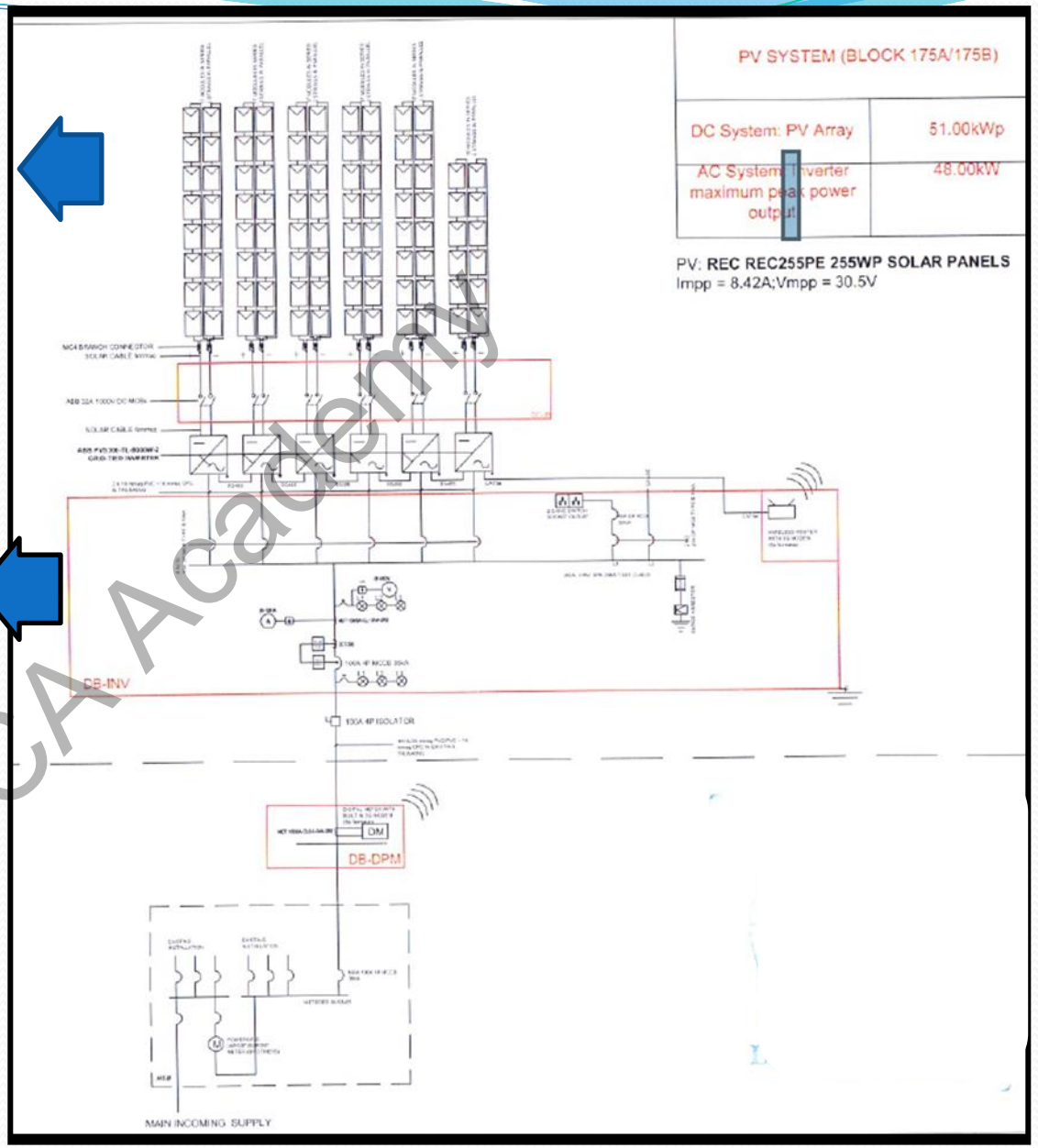
3 Phase System

Singapore American School in Woodlands







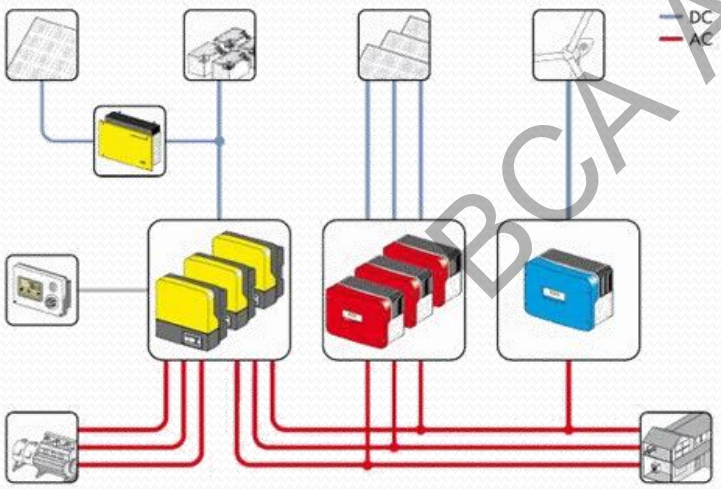

PV SYSTEM (BLOCK 175A/175B)
DC System: PV Array
51.00kWp
AC System: Inverter maximum peak power output
48.00kW
PV: REC REC255PE 255WP SOLAR PANELS
Impp = 8.42A;Vmpp = 30.5V
DB-INV
100A 4P ISOLATOR
DM
DB-DPM
MAIN INCOMING SUPPLY

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1 or 3-phase Solar Installation

1-phase

- 1-phase installation eg. home
- Capacity less than 5 kWp
- Inverters cost



3 Phase System

3-phase

- Load Balance - feed evenly across all phases
- 3-phase installation bungalows commercial/industrial
- Inverter cost

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Lightning Protection Requirements



- Lightning protection
  - Sufficient air terminals
- Bonding of the frame
  - to building LPS
- Surge arrestors



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Inspection before connecting to power Grid

- **Safety**
- **Visual Check all termination**
  - **Polarity ; Earthing**
- **Earthing/Bonding continuity**

Testing & Commissioning

a) **PV string open circuit voltage measurement**

b) **PV string current measurement**

c) **Functional tests**

I. DC and AC Disconnect
II. Operational Mode of Inverters
III. Loss of mains test

d) **Labelling and Identification**

I. Inspect all circuits, protective devices, switches and terminals are suitably label for ease of identification.
II. Single line diagram to be displayed inside the ACDB
III. Ensure that all signs and labels are suitably affixed and durable

Checklist



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Application Form to SP Services for Connection to Transmission System

URL to Supply Application Handbook

https://www.spgroup.com.sg/resources?page=1&category=Electricity%20Works

URL to Solar PV Portal

https://www.spgroup.com.sg/resources?page=1&category=Solar%20Power

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Inspection & Commissioning

Warning notices for dual supply source shall be affixed at the following locations in the installation

1. At the origin of the installation.
2. At the meter position, if remote from the origin.
3. At the consumer unit or distribution board to which the PV power supply system is connected.
4. At the points of isolation of both sources of supply.





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Warning Label : Dual Supply



Maintenance

- Cleaning of PV panels
- Monitoring of Solar PV
  - Remote monitoring
    - Energy Generation
    - Weather
    - Breakdown/Fault









Data- Logger

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Reference

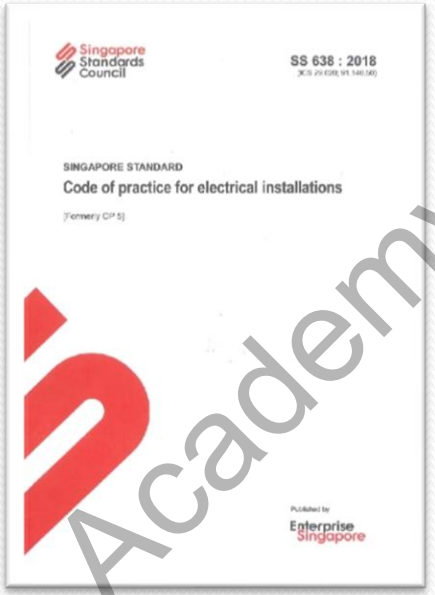
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SS 638 : 2018

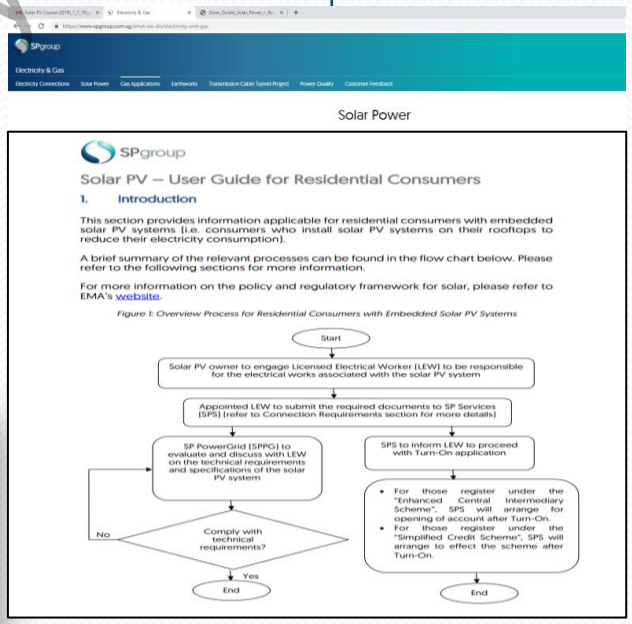
Code of Practice

For

Electrical Installations



http://https://www.spgroup.com.sg/what-we-do/electricity-and-gas



2

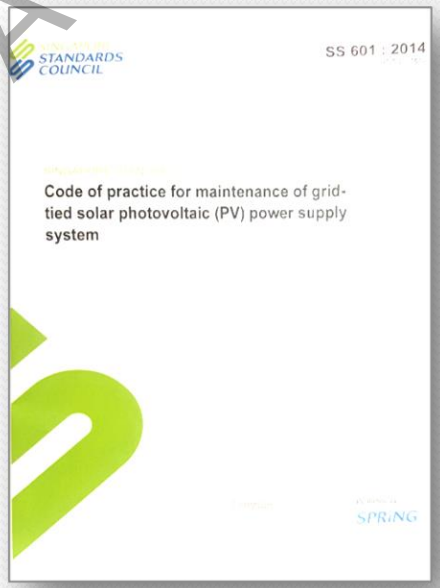
SS 601 : Part 1 : 2020

SS 601 : Part 1 : 2020
IEC 62446-1:2016+A1:2018, MOD
(ICS 27.160)

SINGAPORE STANDARD

Photovoltaic (PV) systems – Requirements for testing, documentation and maintenance

– Part 1: Grid connected systems – Documentation, commissioning tests and inspection



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Thank You

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Testing & Commissioning
Checklist for PV Installation

1 General visual inspection of module, structure & wiring installation

☐ Alignment ☐ Proper tightening ☐ Sturdy
☐ Good wire management ☐ Adequate cable ties

2 Measure the open circuit voltage (Voc) and short circuit current (Isc) of each string at the module side (compare against expected reading on Page 1)

Voc = _____ ☐ Polarity Isc = _____

3 Ensure all string connectors disconnected at trunking and at inverters side. Measure the insulation resistance of each PVC/PVC string cable

Insulation resistance = ……MΩ

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Checklist

Array No : ……. **No. of Strings : ……..**
No. of Modules Per String : ……

Module
Make / Model No : ……
Peak Power : ……... Vmpp : ……. Impp : ……. Voc : …….
Isc :
…….
String
Open circuit string voltage = No. of modules per string x Voc = …….
String operating voltage = No. of modules per string x Vmpp = ……..

Inverter
Make / Model : …….. Serial
No : ……

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Checklist

4. Connect up the string connectors located in the trunking – i.e connect to the UV resistant cables to the PVC/PVC cables

   ☐ Correct polarity ☐ Proper engagement of connectors

5. Measure the Voc and Isc of each string via the MC4 connector at the inverter side (w/o plugging in the connector to the inverter) (compare against expected reading on Page 1)

6. Check live, neutral and earth connections from DB to isolator and from isolator to inverter. Measure the voltage at the DB incoming

   ☐ Proper tightening of connections Voltage: ……

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Inverter

1	Turn on the electronic DC switch	
2	Turn on the AC supply to the inverter	
3	Observe that the green LED turns on	
4	Observe that the LED display shows the PV power, voltage, etc after about one minute	
5	Record the following operational readings at the LCD screen of the inverter	Vdc: …….. Vac:…… Pac :…… Idc: …….. IAC: ……..

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Labelling and Identification

a) Inspect all circuits, protective devices, switches and terminals are suitably label for ease of identification.

b) Single line diagram to be displayed inside the ACDB

c) Ensure that all signs and labels are suitably affixed and durable

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