



In cooperation with:



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Training on

Grid Connected Rooftop PV Systems Technical & Economic Fundamentals

2018-Ahmadabad, Jammu, Shimla, Dehradun

Dr. Sudhir Kumar

Solar Rooftop Types and Standards

G RTPV Defined by Regulators

- ❖ “Rooftop solar PV system” means the **grid interactive** solar photo voltaic power system installed on the **rooftops/ground mounted or open land** of consumer premises that uses sunlight for direct conversion into electricity through photo voltaic technology.
- ❖ “Net meter” means the **bi-directional energy meter** for measuring the quanta of electricity flowing in opposite directions and the **net quantum** of electricity consumed by the eligible consumer or injected into the distribution system of the licensee;
- ❖ “Net metering **system**” means a system consisting of a **solar meter** and **net meter** with their associated equipment.

Gross Metering and Net Metering

Gross metering:

The total energy generated by the solar rooftop plant is to be injected into the grid without allowing the generated solar energy to be consumed directly by the consumer.

Net Metering:

The energy generated by the solar rooftop plant is first allowed for self-consumption and the excess energy is injected to the grid. The bill is charged for net energy only.

Billing Sample

BSES

EBILL Customer

Date of Print Out: 24.07.2015

BSES Rajdhani Power Ltd.

Meter Details Annexure

Name : M/s. THE SECRETARY

Billing Address : NATIONAL PDODUCTIVITY COU LODHI ROAD

Address : NEW DELHI 110003

Supply Address : NATIONAL
PDODUCTIVITY COU PLOT 5&

INSTITUTIONAL AREA NEW DELHI 110003

Mobile / Tel. No. [REDACTED]

District / Division : Nizamuddin

Meter Reading Status : MR

Bill Month : JUL-15

Bill Date : 13-07-2015

Sanctioned Load : 224.00 (KW)

Contract Demand : 353.00 (KVA)

M D I : 192.00 (KVA)

Power Factor : .947

Pole No. : NA

Walking Sequence : NZ2KC0027A0AA

Cycle No. : KC

Tariff Category : Non-Domestic [HT]

CA No. [REDACTED]

Energisation Date : 17.05.2002

Meter Type : 3PSK

Supply Type : HT(11KV)

Bill No. [REDACTED]

Bill Basis : Actual

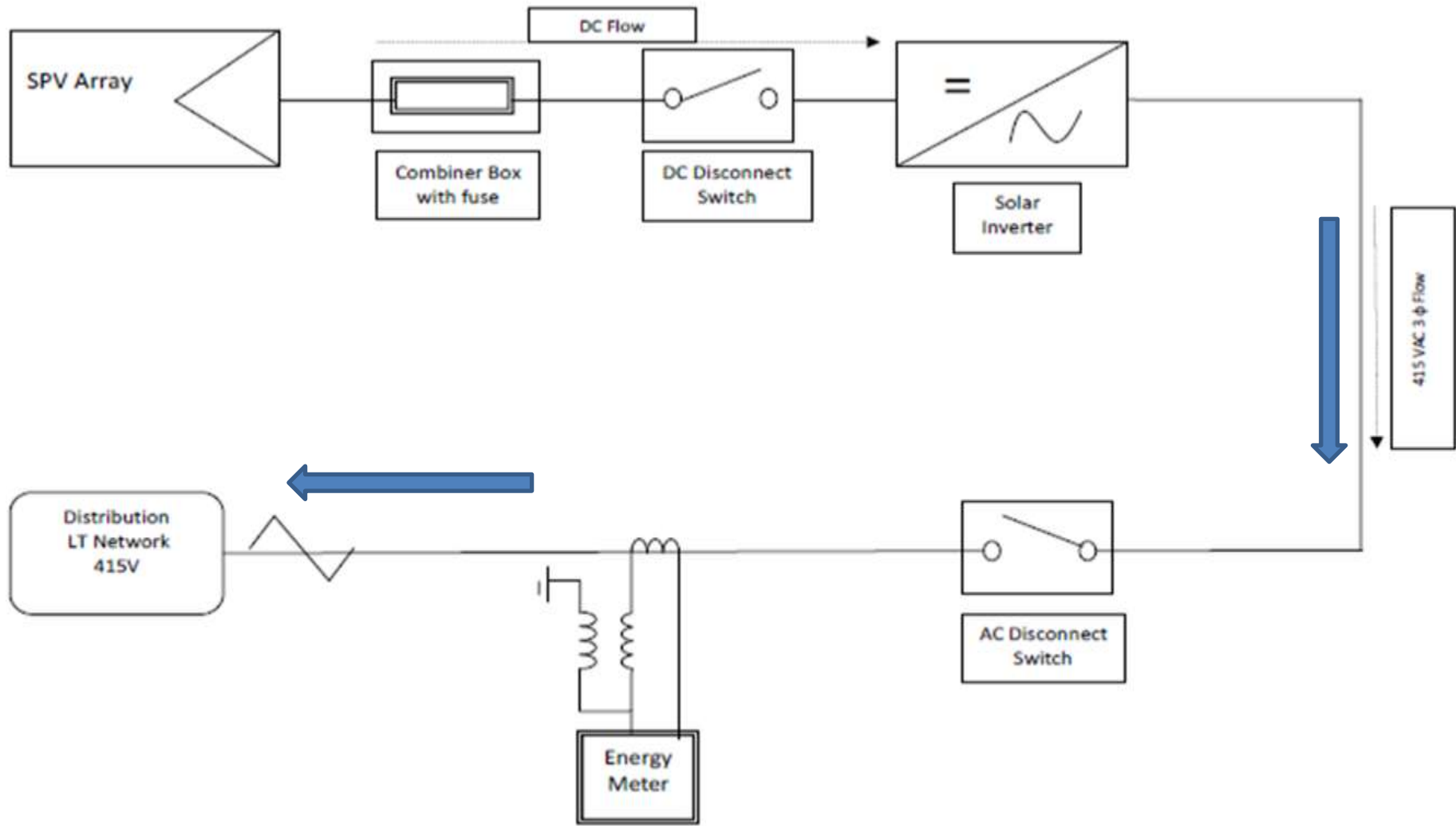
Customer Care Centre No. 39999707

Net Meter Consumption Details (Date of Reading : 30-06-2015)

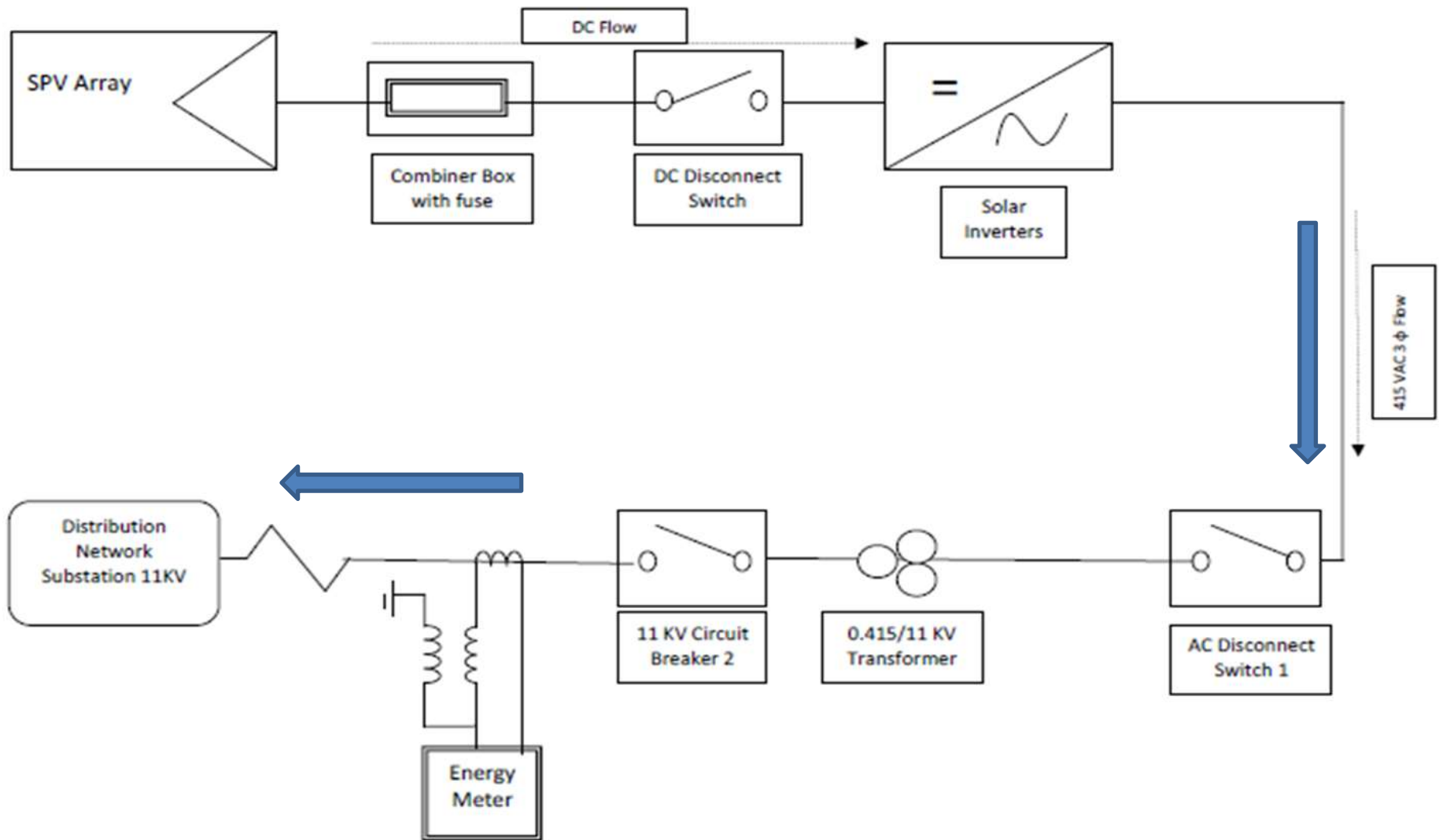
B/F Units (If any)	Export Reading			Import Reading			Net Difference			Moderated Units			C/F Units (If any)
	Normal	Peak	Offpeak	Normal	Peak	Offpeak	Normal	Peak	Offpeak	Normal	Peak	Offpeak	
0	156	78	0	16020	8742	1134	15864	8664	1134	15864	10397	851	0

Moderated units: Peak units are increased by 20% and off-peak units decreased by 25%

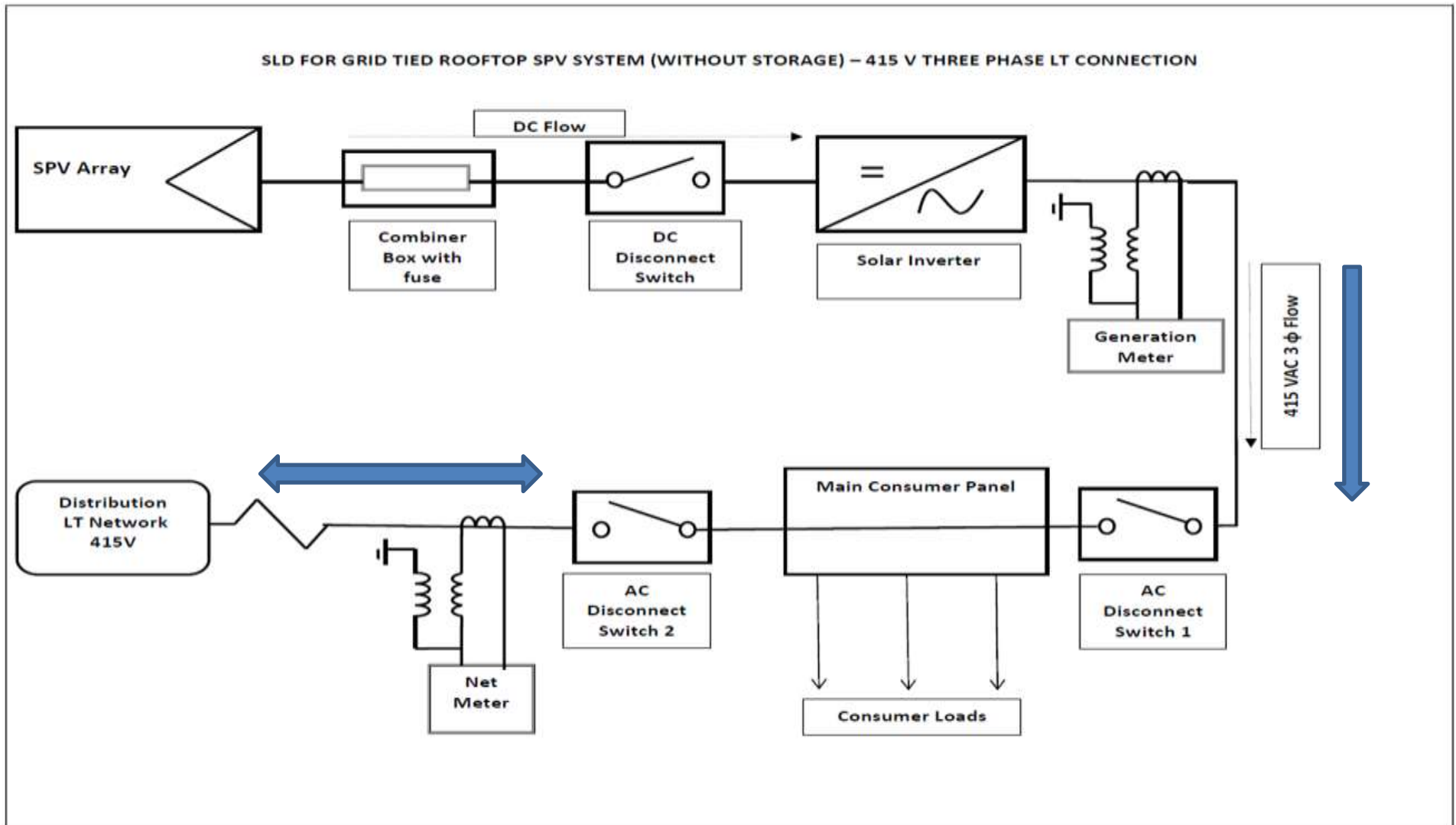
Gross Metering – Grid Tied LT



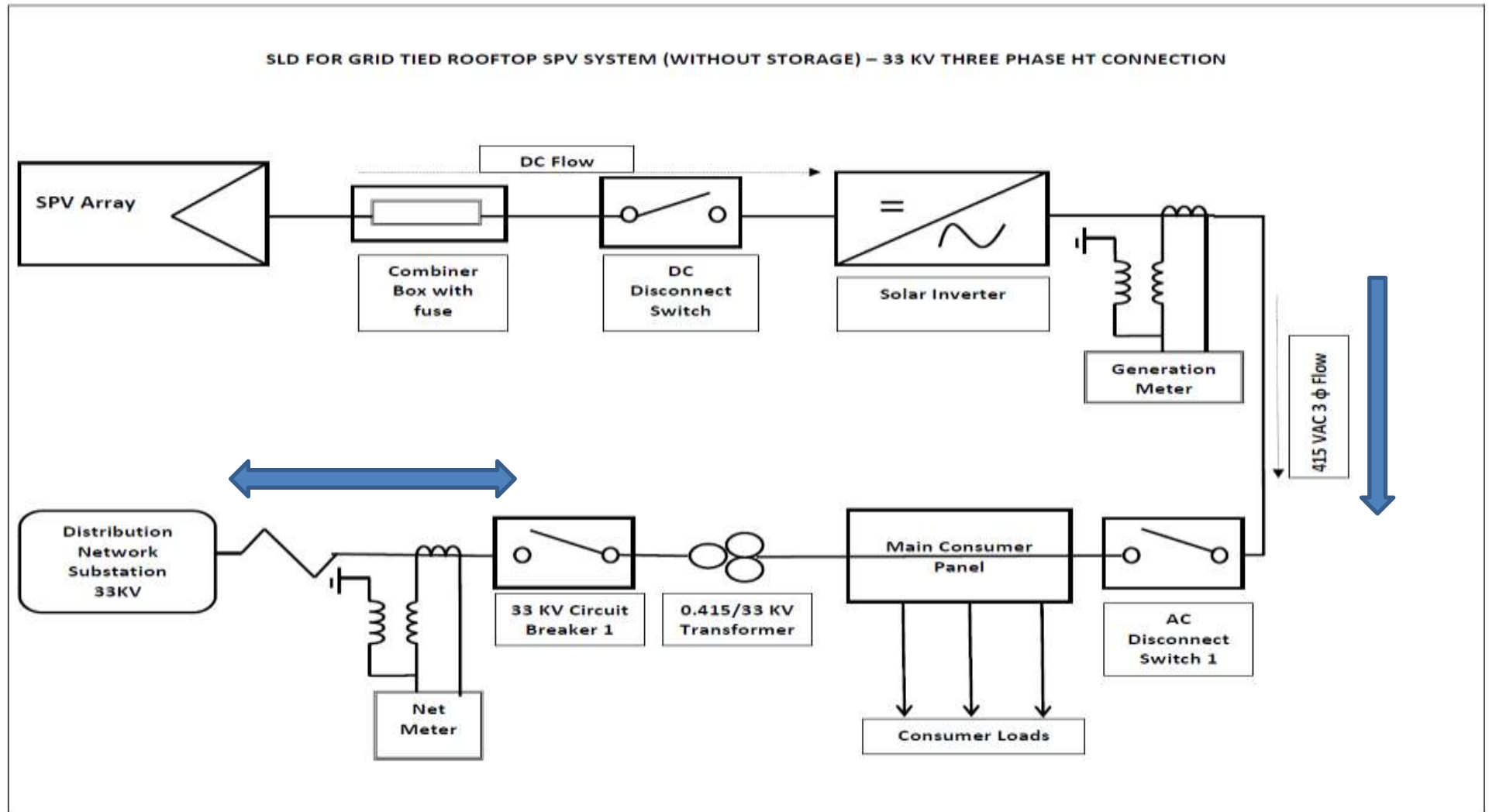
Gross Metering – Grid Tied HT



Net Metering – Grid Tied LT



Net Metering – Grid Tied HT



Rooftop- Solar Merits

- **Aesthetics:** The panels fit seamlessly with pre-existing rooftop for a more streamlined appearance.
- **Space Optimization:** With rooftop solar, there's no need to excavate land.
- **Protection:** Solar panels protect roof from weather and wear and tear and increases the lifetime of roof and structure.
- **Speed:** Rooftop solar is usually easier and faster to install than ground-mounted systems.
- **Free Power:** Generation using free solar energy

Rooftop Solar - Demerits

- **Spatial Limitations:** Some roofs are too small or have too many obstacles.
- **Shading:** If roof is surrounded by trees or tall structures nearby
- **Orientation:** Roof may not be always south facing.
- **Pre-installation Upgrade** Older roofs may need strengthening, adding to the total installation cost.
- **Neighborhood Objection:** Objections to install panels visible from the street or reflects light.

Quality Certification, Standards and Testing for Grid-Connected Rooftop Solar PV

(Govt. of India Notification No. 03/02/2014-15/GCRT
dated 09 Feb 2016)

Solar PV Modules / Panels (1/3)

IEC 61215/IS 14286	Design Qualification and Type Approval for Crystalline Silicon Terrestrial Photovoltaic (PV) Modules
IEC 61646/IS 16077	Design Qualification and Type Approval for Thin-Film Terrestrial Photovoltaic (PV) Modules
IEC 62108	Design Qualification and Type Approval for Concentrator Photovoltaic (CPV) Modules and Assemblies
IEC 61701 - As applicable	Salt Mist Corrosion Testing of Photovoltaic (PV) Modules

Solar PV Modules / Panels (2/3)

IEC 61853- Part 1/ IS 16170 : Part 1	Photovoltaic (PV) module performance testing and energy rating –: Irradiance and temperature performance measurements, and power rating
IEC 62716	Photovoltaic (PV) Modules – Ammonia (NH₃) Corrosion Testing (Advisory - As per the site condition like dairies, toilets)
IEC 61730-1,2	Photovoltaic (PV) Module Safety Qualification – Part 1: Requirements for Construction, Part2: Requirements for Testing

Solar PV Modules / Panels (3/3)

IEC 62804 (Draft Specifications)	Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation (PID). IEC TS 62804-1: Part 1: Crystalline silicon (Mandatory for system voltage is more than 600 VDC and advisory for system voltage is less than 600 VDC)
IEC 62759-1	Photovoltaic (PV) modules – Transportation testing, Part 1: Transportation and shipping of module package units

Solar PV Inverters (1/3)

<p>IEC 62109-1, IEC 62109-2</p>	<p>Safety of power converters for use in photovoltaic power systems</p> <p>Safety compliance</p> <p>(Protection degree IP 65 for outdoor mounting, IP 54 for indoor mounting)</p>
<p>IEC/IS 61683 (For stand Alone System)</p>	<p>Photovoltaic Systems – Power conditioners:</p> <p>Procedure for Measuring Efficiency (10%, 25%,50%, 75% & 90-100% Loading Conditions)</p>

Solar PV Inverters (2/3)

BS EN 50530 (Will
become IEC 62891)
(For **Grid Interactive**
system)

Overall efficiency of grid-connected photovoltaic inverters:

This European Standard provides a procedure for the measurement of the **accuracy of the maximum power point tracking (MPPT)** of inverters, which are used in grid-connected photovoltaic systems.

In that case the inverter energizes a low voltage grid of stable AC voltage and constant frequency. Both the static and dynamic MPPT efficiency is considered.

Solar PV Inverters (3/3)

IEC 62116/ UL 1741/ IEEE 1547	Utility-interconnected Photovoltaic Inverters - Test Procedure of Islanding Prevention Measures
IEC 60255-27	Measuring relays and protection equipment - Part 27: Product safety requirements
IEC 60068-2 (1, 2, 14, 27, 30 & 64)	Environmental Testing of PV System – Power Conditioners and Inverters
IEC 61000- 2,3,5	Electromagnetic Interference (EMI), and Electromagnetic Compatibility (EMC) testing of PV Inverters (as applicable)

Fuses

IS/IEC 60947 (Part 1, 2 & 3), EN 50521	General safety requirements for connectors, switches, circuit breakers (AC/DC)
IEC 60269-6	Low-voltage fuses - Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems

SURGE ARRESTORS

<p>IEC 6164-11: 2011/ IS 15086-5 (SPD)</p>	<p>Low-voltage surge protective devices - Part 11: Surge protective devices connected to low-voltage power systems - Requirements and test methods</p>
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CABLES

<p>IEC 60227/IS 694, IEC 60502/IS 1554 (Part 1 & 2)</p>	<p>General test and measuring method for PVC (Polyvinyl chloride) insulated cables (for working voltages up to and including 1100 V, and UV resistant for outdoor installation)</p>
<p>BS EN 50618</p>	<p>Electric cables for photovoltaic systems (BT(DE/NOT)258), mainly for DC cables</p>

IEC 62561 Series
(Part 1,2 & 3)
(Chemical
earthing)

IEC 62561-1

Lightning protection system components
(LPSC) - Part 1: Requirements for
connection components

IEC 62561-2

Lightning protection system components
(LPSC) - Part 2: Requirements for **conductors
and earth electrodes**

IEC 62561-7

Lightning protection system components
(LPSC) - Part 7: Requirements for **earthing
enhancing compounds**

Junction Boxes, Energy Meter, Mounting Structure

JUNCTION BOXES

IEC 60529	Junction boxes and solar panel terminal boxes shall be of the thermo plastic type with IP 65 protection for outdoor use, and IP 54 protection for indoor use
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ENERGY METER

IS 16444 or as specified by the DISCOMs	A.C. Static direct connected watt-hour Smart Meter Class 1 and 2 — Specification (with Import and Export/Net energy measurements)
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ROOF MOUNTING STRUCTURE

IS 2062/IS4759	Material for the structure mounting
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Guidelines and Best Practices

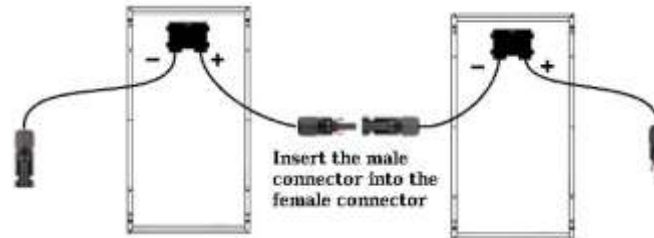
Roof Mounting Structure	Aluminum frames will be avoided for installations in coastal areas .
Solar Panels	Plants installed in high dust geographies like Rajasthan and Gujarat must have the solar panels tested with relevant dust standards (Applicable standard would be IEC 60068-2-68)
Fuse 	The fuse shall have DIN rail mountable fuse holders and shall be housed in thermoplastic IP 65 enclosures with transparent covers.

Cables

- ❖ For the **DC cabling**, XLPE or, XLPO insulated and sheathed, UV-stabilized **single core flexible copper** cables shall be used; **Multi-core cables shall not be used.** (XLPE - Cross-Linked Polyethylene XLPO - Cross-Linked Polyolefin. Have high chemical, moisture, UV and thermal resistance)
- ❖ For the **AC cabling**, PVC or, XLPE insulated and PVC sheathed **single or, multi-core flexible copper cables** shall be used; Outdoor AC cables shall have a UV-stabilized outer sheath.
- ❖ The total **voltage drop** on the cable segments from the **solar PV modules to the solar grid inverter shall not exceed 2.0%**
- ❖ The total **voltage drop** on the cable segments from the **solar grid inverter to the building distribution board shall not exceed 2.0%**

CABLES

- ❖ The DC cables from the SPV module array shall run through a **UV-stabilized PVC conduit pipe** of adequate diameter with a minimum wall thickness of 1.5mm.
- ❖ Cables and wires used for the interconnection of solar PV modules shall be provided with solar **PV connectors (MC4)** and couplers.



- ❖ All cables and conduit pipes shall be clamped to the rooftop, walls and ceilings with thermo-plastic clamps at intervals not exceeding 50 cm; the **minimum DC cable size shall be 4.0 sq mm copper**; the **minimum AC cable size shall be 4.0 sq mm copper**. In three phase systems, the size of the neutral wire size shall be equal to the size of the phase wires.

Guidelines and Best Practices

CABLES

- ❖ The DC cables from the SPV module array shall run through a **UV-stabilized PVC conduit pipe** of adequate diameter with a minimum wall thickness of 1.5mm.
- ❖ Cables and wires used for the interconnection of solar PV modules shall be provided with solar **PV connectors (MC4)** and couplers.
- ❖ All cables and conduit pipes shall be clamped to the rooftop, walls and ceilings with thermo-plastic clamps at intervals not exceeding 50 cm; the **minimum DC cable size shall be 4.0 sq mm copper**; the **minimum AC cable size shall be 4.0 sq mm copper**. In three phase systems, the size of the **neutral wire size shall be equal to the size of the phase wires**.

REVIEW

- ❖ Solar Cell: Basetype, Layertype
- ❖ Electron flow inside cell from to type
- ❖ Ideal band gap....., Best material
- ❖ STC means, NOCT means, Normal NOCT value.....
- ❖ AM1.5 means ratio of path length of sun at and Angle
- ❖ Temp coefficient is more forcells compared tocells
- ❖ Impact of temperature is mainly on and that of radiation is on
- ❖ Design value of radiation
- ❖ Voltage increases in parallel or series connection?
- ❖ Effect of mismatch in series and parallel
- ❖ Efficiency of which type of cell is maximum?
- ❖ Efficiency of concentrating solar cell? Why is it not popular?
- ❖ Which type of cell is the best compromise?
- ❖ Difference in tier, grade (appearance) and application class?
- ❖ Grid tied, gross, net metering difference?
- ❖ What is prosumer?

Thank You