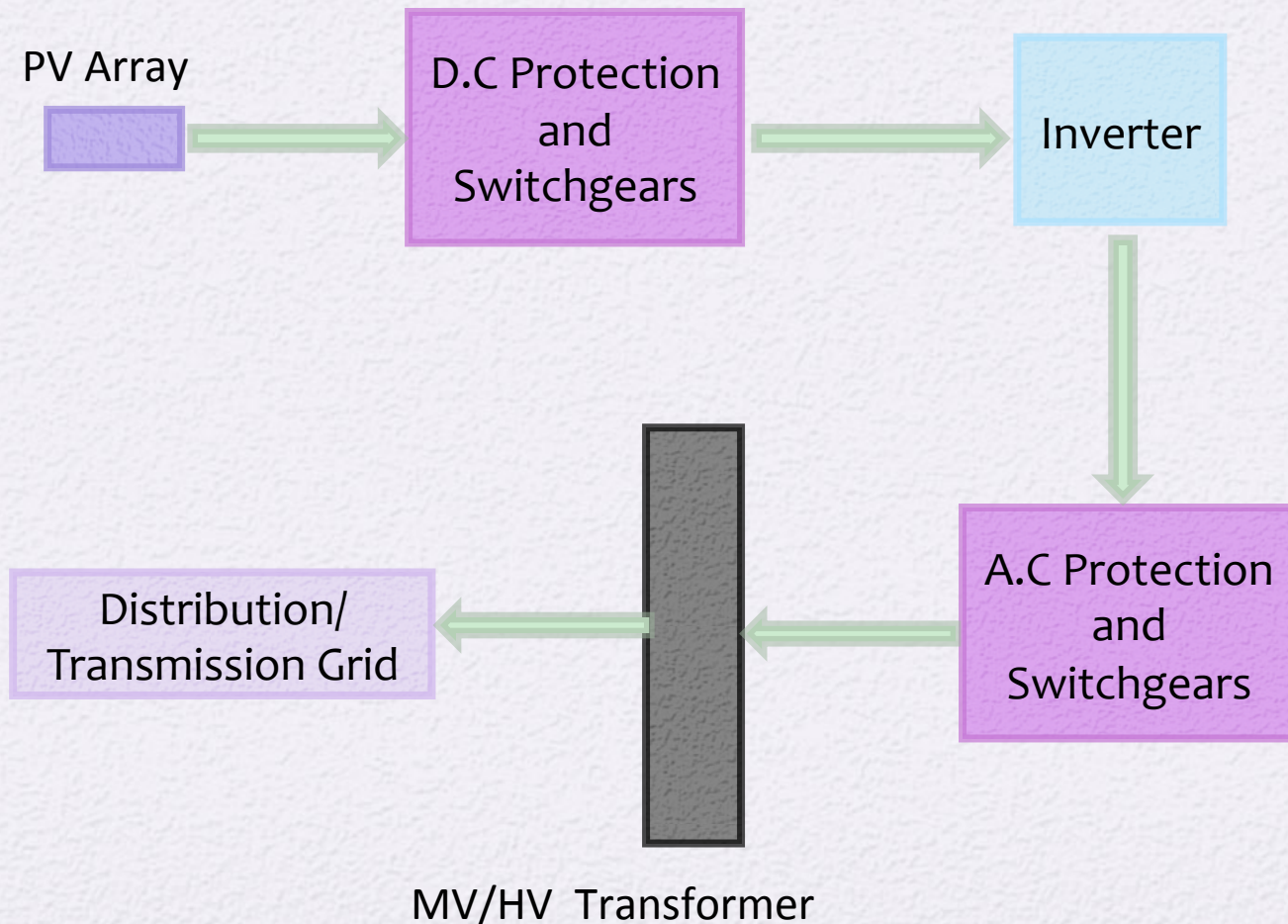# Grid Connected SPV Rooftop Power Plant Technology

Grid Integration of small scale DRE systems Workshop
Prayas Group Pune and NCPRE at IIT, Bombay
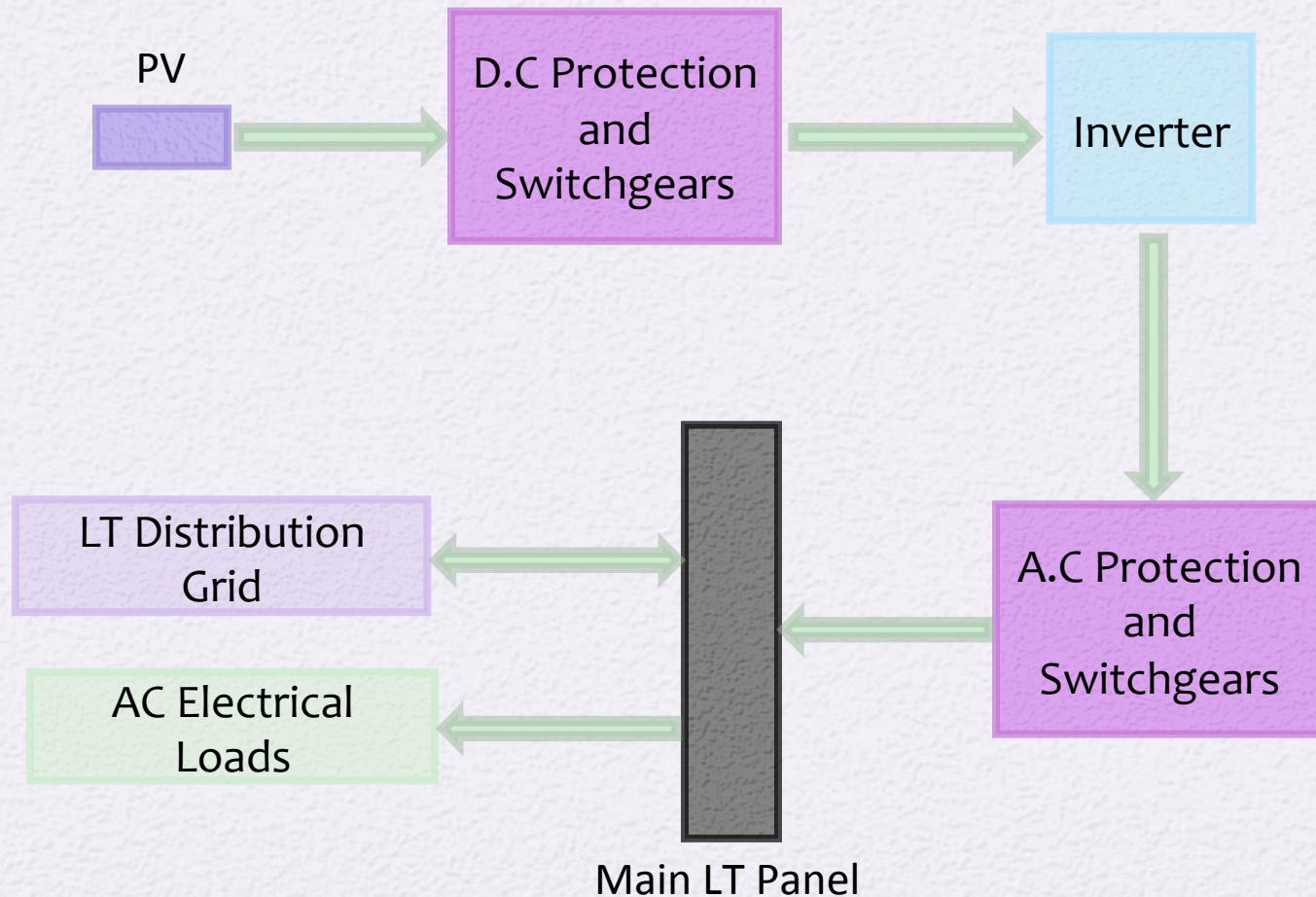
Address by Dr. Farooq Abdullah

- National consultation in New Delhi on net metering in grid solar projects on Dec. 20, 2011.

- "Prepare an action plan for introducing **net metering** in **commercial and residential roof top solar projects**."

- "With solar power cost coming down from **Rs. 18/-** per unit in 2010 to **Rs. 8/-** per unit in 2012, it should be possible to allow consumers **feed extra power to the grid.**"

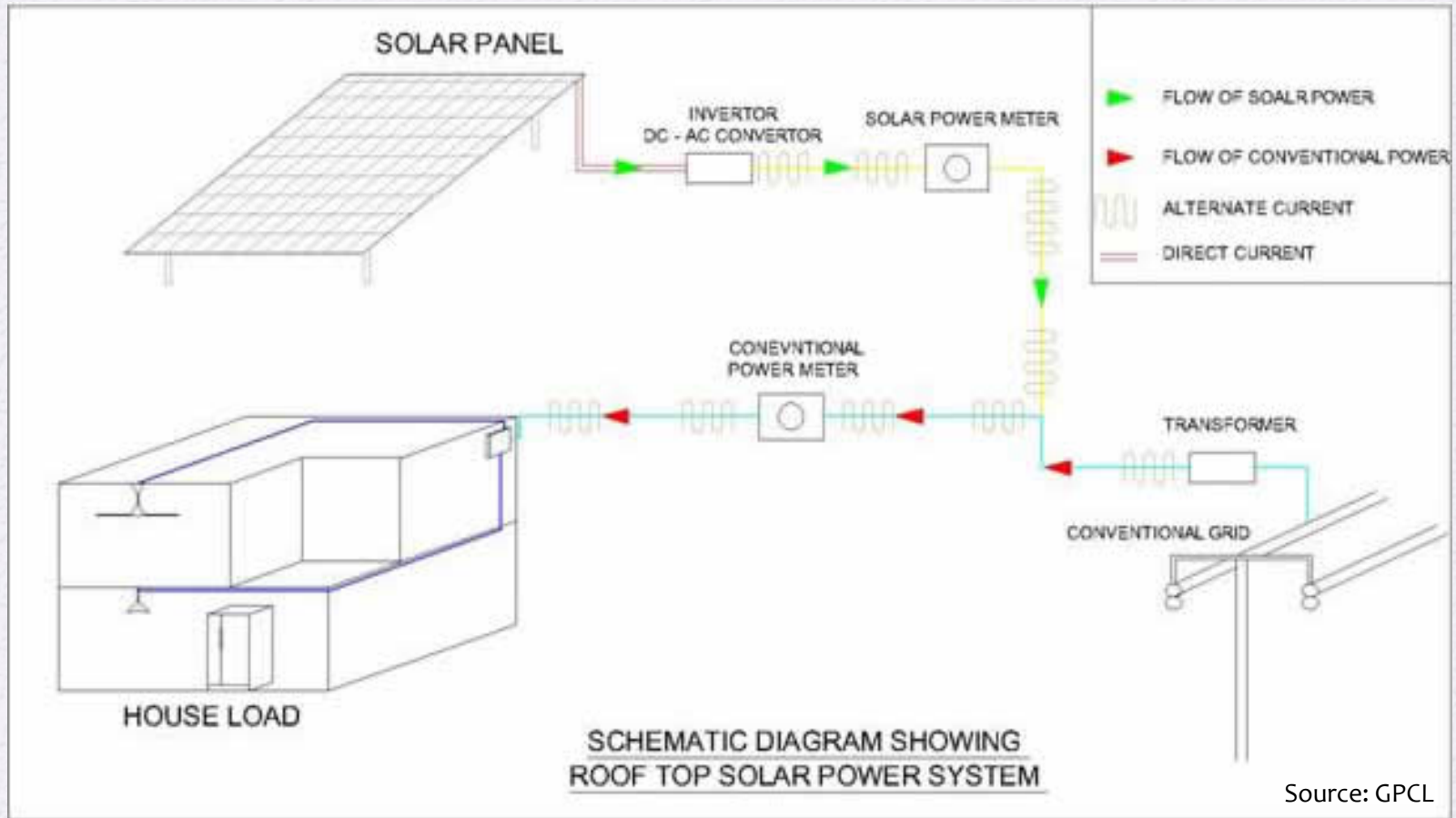- "Come out with **practical solution** to facilitate the process."

Large Scale SPV Power Plant

PV Array

D.C Protection and Switchgears

Inverter

A.C Protection and Switchgears

Distribution/ Transmission Grid

MV/HV Transformer

Rooftop SPV Power Plant

PV → D.C Protection and Switchgears → Inverter → A.C Protection and Switchgears → Main LT Panel → LT Distribution Grid, AC Electrical Loads

Rooftop SPV Power Plant Operation

Source: GPCL

Energy Metering and Feed-in-Tariff

```
PV Array  →  Controller  →  Inverter  →  PV Meter  →  Distribution Panel
                                                             ↕
Grid  ↕  Net Meter  ↕  Distribution Panel  →  Load Meter  →  Loads
```

- PV Array
- Controller
- Inverter
- PV Meter
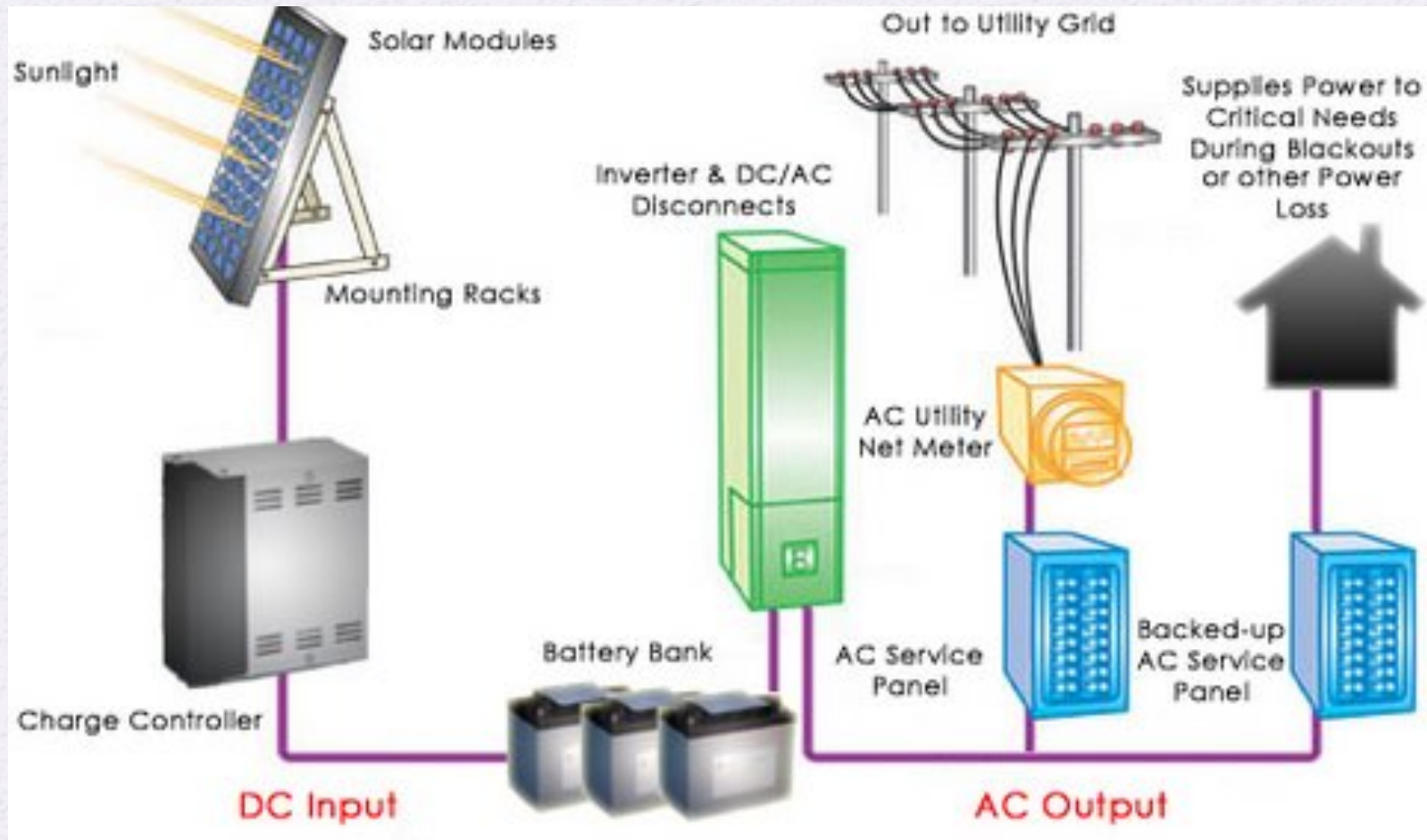- Grid
- Net Meter
- Distribution Panel
- Load Meter
- Loads
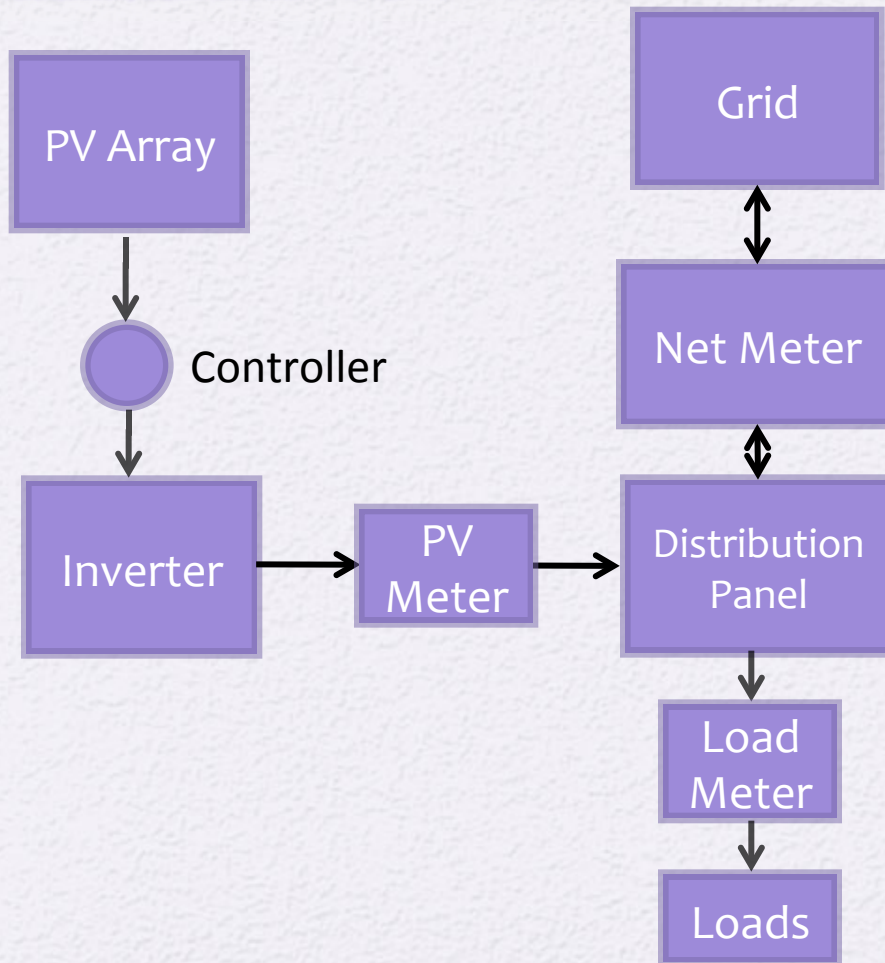
- AC electrical output of inverter consumed by loads or AC current is fed back to grid

- For generation > consumption, PV - Load = Net Export

- For generation < consumption, Load – PV = Net Import

- Feed-in-Tariff (FIT) paid to customer based on Net Export

Islanding Protection

- Islands are small sections of grid network.

- When grid fails, powering of island can pose risk to workers.

- Inverter output can be incompatible with equipment connected to island when grid fails.

- Anti-islanding operation: Inverter output is isolated from grid network in the event grid fails or is unstable.

- This presents a challenge with LV grid in India in terms of PV capacity utilization.

Grid tied System with Battery backup

Sunlight

Solar Modules

Out to Utility Grid

Supplies Power to Critical Needs During Blackouts or other Power Loss

Inverter & DC/AC Disconnects

Mounting Racks

AC Utility Net Meter

Charge Controller

Battery Bank

AC Service Panel

Backed-up AC Service Panel

DC Input
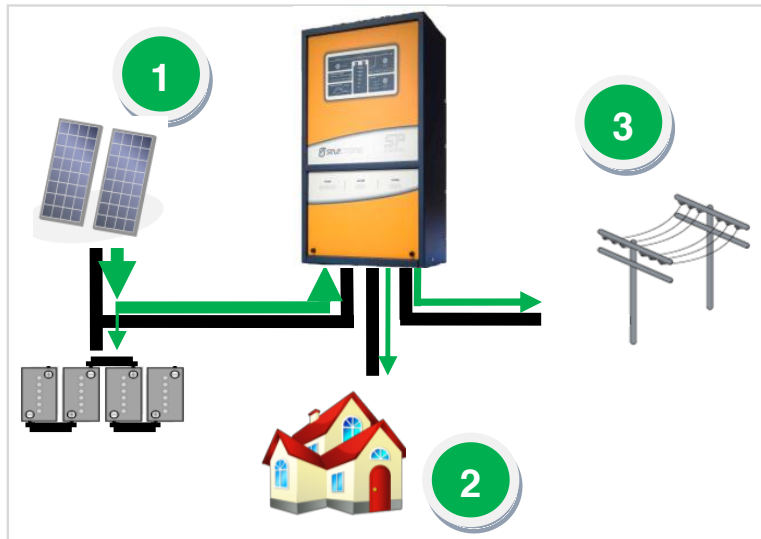
AC Output

Grid tied Battery backup Operation

Figure 1 Normal Grid Operation

1) Solar charges batteries   2) Solar feeds house load, then
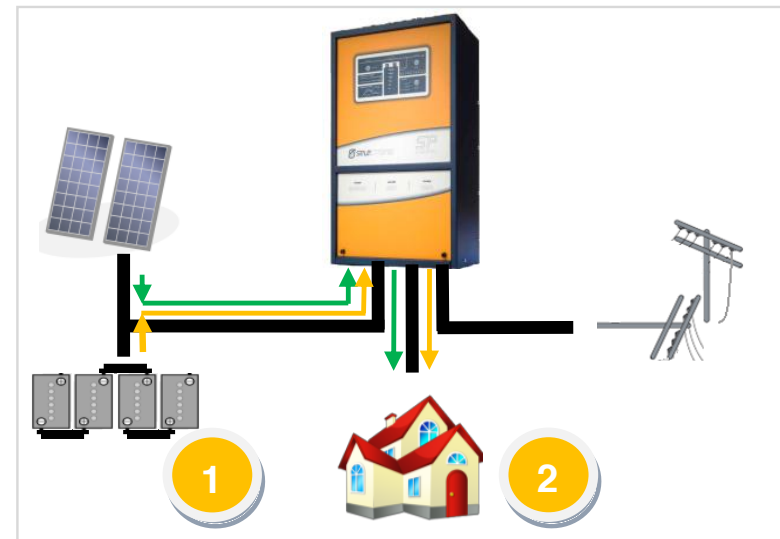3) Solar exports excess to grid

Figure 2 Grid Failure Operation

1) Solar charges batteries
2) Solar and batteries supply house load only

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Utility and User Considerations

- **Power quality of grid** should not be reduced by grid fed solar power.
- **LV grid interface standard** will ensure power quality is maintained.
- **Personnel safety** in the event of mains failure or instability is ensured by anti-islanding operation.
- **Automatic protection device** recognizes grid failures and cut-offs as well as voltage and frequency fluctuations.
- **Manual Switching Devices** sensing grid impedance jumps may be used for LV single phase feed-ins.
- **PV plant feed-ins** to rural grid branch lines **can increase line voltage** and **support weak grid** when **large loads** are present.
- **Load consumption and grid feed-in** need to be **synchronized** during day time by tailoring usage patterns **to avoid excessive increase in line voltage.**

LV Grid Interface Standard

- **G83-1/1 (EN 50438) UK Engineering Recommendation for small embedded generator feeding power to domestic grid.**
  Voltage and Frequency Range: 207-264V, 47-50.5 Hz
  Max. Export: 5.75kW-1 phase, 11kW-3 phase
  Power Quality: Flicker, DC Injection, Harmonics and PF
  Loss of Mains Test:

- **IEC 61727:** *PV Systems Characteristics of the Utility Interface for PV systems <10kW connected to low voltage grid.*

- **IEC 62116:** *Islanding prevention methods*

- **Customize LV grid interface standard for India.**
  Voltage and Frequency Range for synchronization
  Time to connect and disconnect PV generator
  Metering configuration

Germany Rooftop Program

- 20% energy produced by renewable sources.

- 80% of >1GWp PV installations are rooftop in Germany.

- FIT introduced by law and scaled back in phase wise manner to allow market growth.

- Feed-in-tariff: € 0.30-0.40/kWh for 10kWp to 1MWp
  PV size (€ 0.95 in 2005)
  9% digression from 2011.

- Average Electricity Cost approx. 25 Euro Cents/kWh.

Gujarat Rooftop Program

- GPCL has launched 5MWp distributed rooftop PV power plant program in Gandhinagar.

- Build, Own, Operate and Maintain model.

- Rooftop owners to lease rooftop space to project developers.

- Torrent Power to purchase clean electricity from project developers at Rs. 11-12.5/unit. (25 year average)

- Project developers to pay green incentives to rooftop owners based on solar generation.

- Green incentives to cover major % of electricity bills for rooftop owners.

- Solar PV Energy generated by plant will be monitored by separate meter and fed to LV public grid.

Centralized Solar PV Generation

- 12-15% of Solar power generated by large plants is lost in step-up and step-down transformers used in transmission and distribution of power.

- Requires 3-7 Acres land per MWp installation.

- Large solar arrays are complex, need matched PV modules and are prone to string and MPPT losses.

- Automated monitoring is mandatory.

- Cost effective: Rs. 8-10 Cr/MW.

- MV/HV grid interface is reliable.

Distributed Solar PV Generation

- Use available roof/terrace space.

- Overall performance ratio to point of utility is 10-15% higher due to reduced transformer and cable losses.

- Feed local load and meet peak day time demand.

- Potential to improve local power quality.

- Reduce additional investment and on-going maintenance for DG sets, Batteries and UPS.

- Higher installation cost of Rs. 10-12 Cr/MW.

- LV grid interface is a challenge.

Rooftop Program Implementation Challenges

- Requires LV grid interface standard.

- Large Voltage and Frequency range of operation.

- Power quality issues: PF, DC Injection, Harmonics, EMI, Surge Currents, Voltage Dips.

- Anti-islanding Operation and capacity utilization.

- Battery Operation when grid is not available.

- Dual Mode Inverter is complex and adds to cost.

- Requires solar energy meter in addition to load energy meter.

- Net Metering/ABT (Availability Based Tariff) Meter infrastructure is complex and expensive.

Rooftop Program Recommendations

- High efficiency C-Si technology for limited space on rooftop to enhance local manufacturing.

- Distributed PV architecture for improved performance.

- Customized LV grid interface standard for India.

- Grid interactive battery backup operation to improve plant availability.

- Standardize support structures for rooftop power plants to reduce cost and time to install.

- Develop low cost dual inverter and net energy meter.

- Develop means to harness thermal energy and enhance PV output.

- Large scale manufacturing of plug and play AC modules for direct grid interface.

Thank You!

Are you?