RENEWABLE ENERGY IN INDIA

ISSUES, CHALLENGES & OPPORTUNITIES

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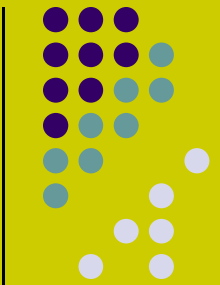
ISSUES & OBJECTIVES



- To grow power generation capacity in line with future demand.
- To reduce dependence on fossil fuel, mainly coal and diesel.
- To control cost of generation on long term basis.
- To resolve/avoid environmental problems associated with coal/diesel power generation.

WHY RENEWABLE?

- Limited Stock of fossil fuel.
- Developments will meet more per capita power consumption.
- Stops fast depletion of fossil fuel stock.
- Reduces carbon emission .
- Fights Global warming.
- Solves Green House Gas effect.

Renewable Energy Options :

- Wind Power
- Small Hydropower
- Bio-mass Energy
- Co-generation from Waste
- Solar Photovoltaic
- Solar Thermal

New Technologies

- Fuel Cells
- Hydrogen Energy
- Geo-Thermal
- Tidal Energy

STATUS OF RENEWABLE ENERGY - AS ON 01 FEB 2012

Category	Grid Inter-active		Off Grid/Stand Alone	
	Target	Achieved	Target	Achieved
(All figures in MW)	2011-12	end Jan	2011-12	end Jan
Wind Turbines	2400	2023	15	27
Mini/Micro Hydro	350	257	-	-
Bio –mass	465	145	93	63
Waste Co-generation	25	1	15	27
Solar Photovoltaic	200	445	20	11

Solar photovoltaic has already exceeded the target set for full year.

THUMB RULE COMPARISON

1.. Windpower started years back and has been popular in coastal areas and south. The main limitation is locational – there are vast areas where wind turbines can not work.

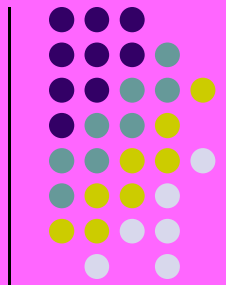
2.. Mini hydel, similarly is limited locationally, even more than wind.

3.. Bio mass & waste co-generation have scale problems.

4.. New technologies are not yet commercialized.

3.. Solar photovoltaic is possible almost in the entire country, but works only in daylight hours.

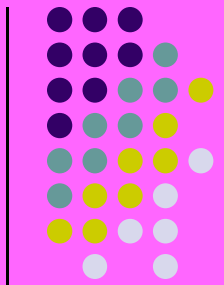
NEHRU SOLAR MISSION



The targets for Solar Energy are set as below :

	Phase 1	Phase 2	Phase 3
	2010-13	2013-17	2017-22
Grid-connect (MW)	1000	10000	20000
Off grid (MW)	200	1000	2000
Thermal Heating (Million sq mtrs)	7	15	20

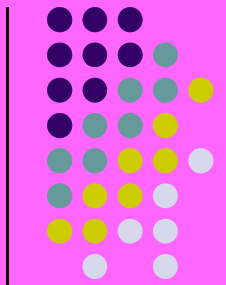
METHODOLOGY OF NEHRU SOLAR MISSION



Off Grid/Stand Alone

- Private sector or even individuals to set up.
- Sell power (if required) through RESCOs.
- Operation basis : BOO.
- Selection criteria – wide based.
- Entry barrriers – Credentials, Financial.
- Sale assistance - Indirect only.
- Incentives – Capital Financial Subsidy.
- Available – MNRE & State Incentives, Soft loans,

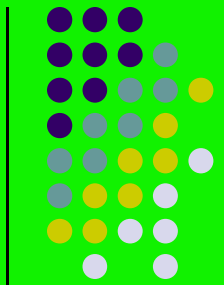
METHODOLOGY OF NEHRU SOLAR MISSION



Grid – Connect :

- Private/Public sector or State to set up.
- Sell power (mandatory) to grid.
- Operation basis : BOO.
- Selection criteria – By tenders - Highest discount on benchmark tariff of CERC
- Entry barriers – Credentials, Financial, Technical
- Sale assistance - Power Purchase Agreement
- Incentives – Generation based
- Available – Other MNRE & State Incentives, Soft loans, Accelerated depreciation, etc.

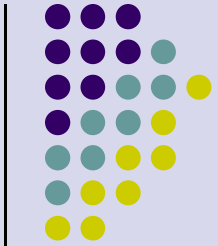
PV SOLAR POWER SYSTEM



Photovoltaic Solar Power System consists of :

- Photovoltaic Solar Panel
- Inverter (plus Charge Controller) System
- Balance Of System .
- Control, Monitoring and Protection System
- Connection System to load and/or grid.

Types of Photovoltaic Cells



The three general types of silicon photovoltaic cells are:

- Single-crystal silicon.
- Polycrystal silicon (also known as multicrystal silicon).
- Amorphous silicon (abbreviated as "aSi," also known as thin film silicon).

Polycrystal Silicon

- Polycrystalline silicon devices are most common as these are less expensive to produce.
- The polycrystalline silicon can be produced by casting molten silicon directly into a mold and allowing it to solidify into an ingot.
- The starting material can be a refined lower-grade silicon.
- The mold is usually square, producing an ingot that can be cut and sliced into square cells that fit more compactly into a PV module.

Governing specfn : IEC 61215.

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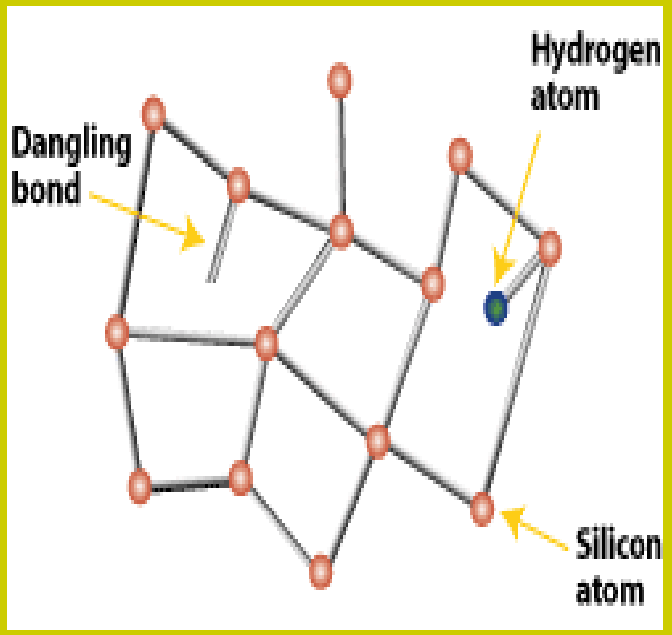
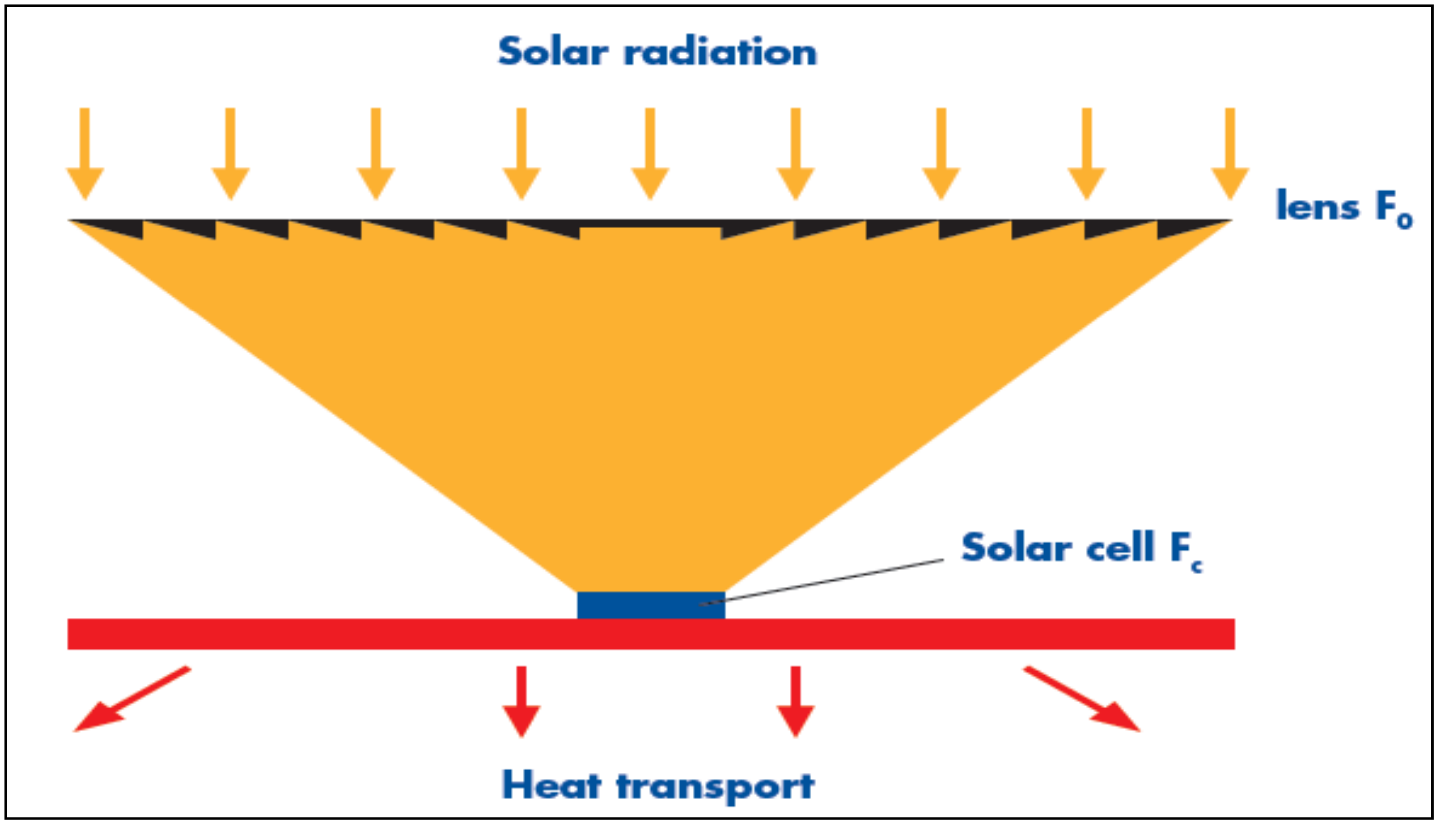
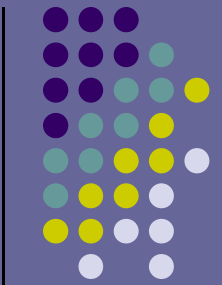
- Amorphous silicon may not have the structural uniformity of single- or multicrystalline silicon but have its own use..
- In early stages, small deviations in this material resulted in "dangling bonds," where atoms lacked a neighbor to which they can bond.
- Now amorphous silicon is deposited along with a small amount of hydrogen, in a process called "hydrogenation," so that hydrogen atoms combine chemically with many of the dangling bonds, essentially removing them and permitting electrons to move through.
- Governing Specfn : IEC 61215



Principle Arrangement of PV Concentrator

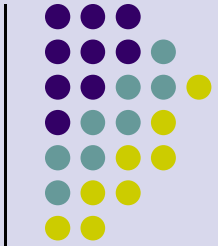


EFFICIENCY OF MODULES



- Efficiency consists of and is sum total of :
  - Reflectance / quantum efficiency,
  - Thermodynamic efficiency,
  - Charge carrier separation efficiency, etc.
- Efficiency is monitored by :
  - V o C ratio
  - Fill factor

RECENT DEVELOPMENTS

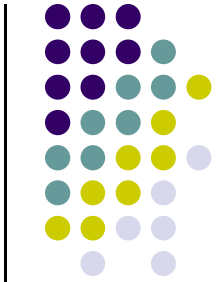


- Many types of more expensive materials have been tried, main being :
- Cadmium Telluride Cd Te
- Gallium Arsenide Ga As
- Copper Indium Gallium Selenide CIGS

These are adopted with Thin Film Technology.

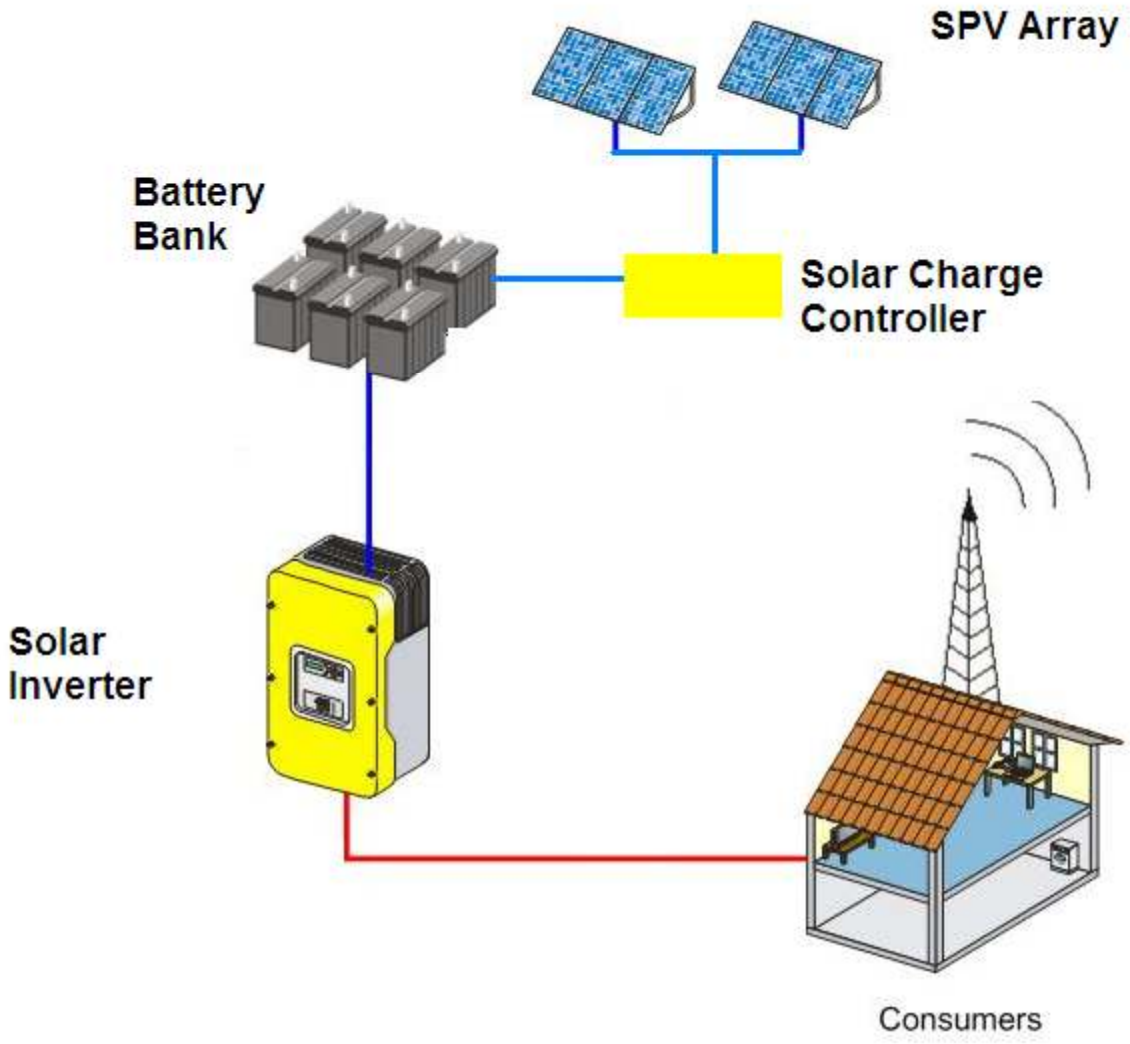
Governing Specfn : IEC 61646

AC Power From Solar

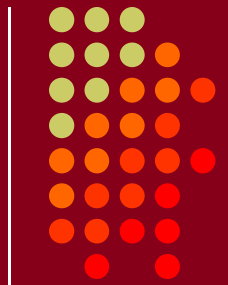


SA	• Stand Alone Solar Power Plant
GI	• Grid Interactive Solar Power Plant
AG	• Creation of Alternate Grid

Stand Alone Solar Power Plant

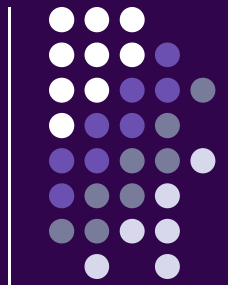


Application Areas



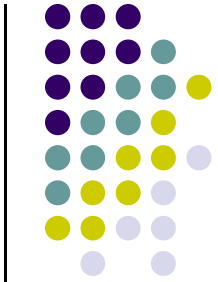
- Rural Electrification or Areas where there is no power
- Stand Alone Applications Like Street Lighting and Community Lighting
- Needs battery support to provide power during dark (night) hours.

Theory Of Operation



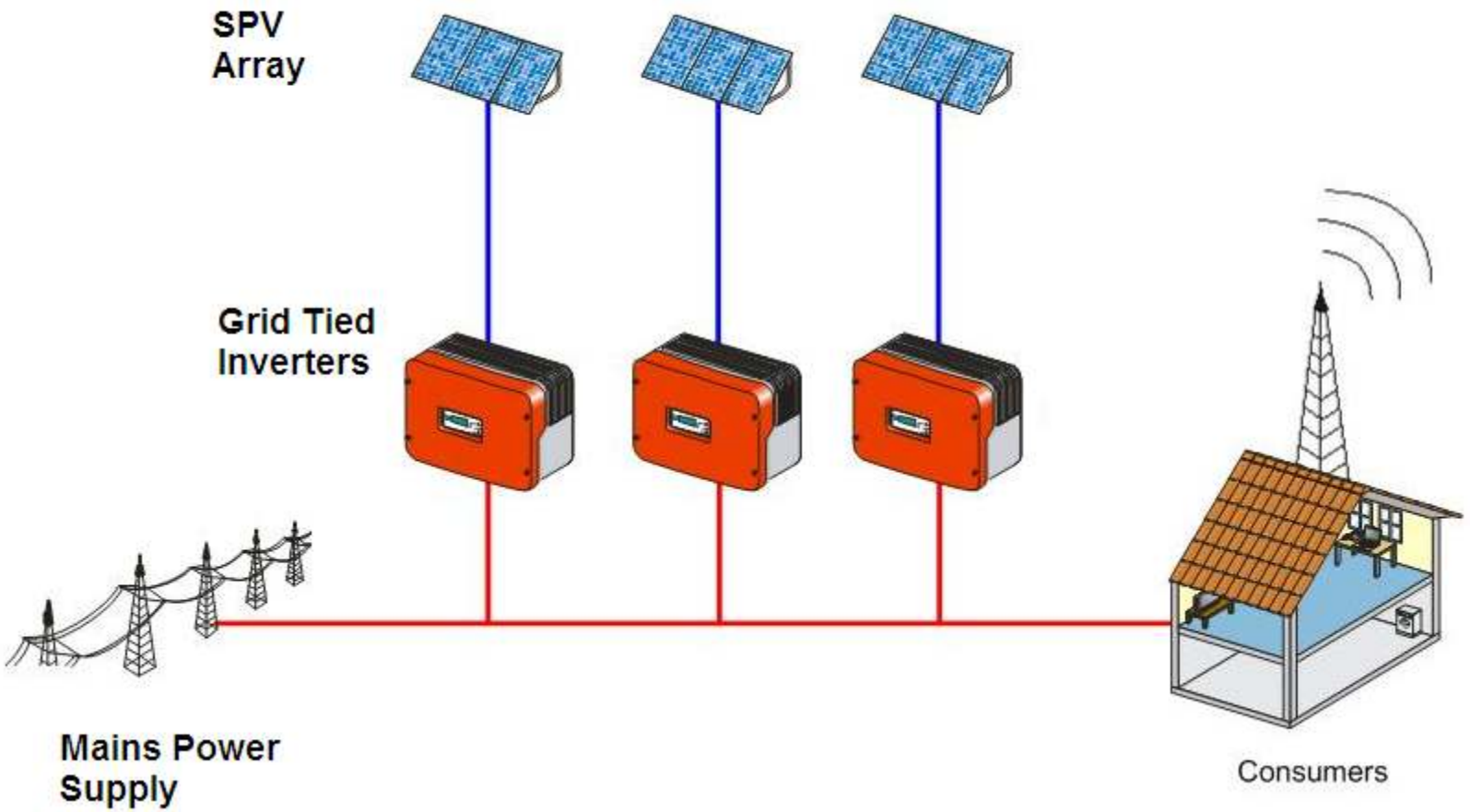
- Collects power from sun during charging (daylight) hours.
- Also feeds power load simultaneously if that is the intention.
- Stores power simultaneously in battery bank for dark (night) hours usage.
- Capacity should be suficient for both alternative usages – (a) only dark hours or (b) both charging and dark hours.

Grid Interactive Systems

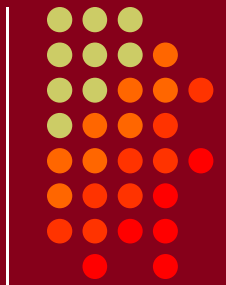


Grid Interactive Systems	
Grid Export Systems	Grid Support Systems

Grid Export Systems

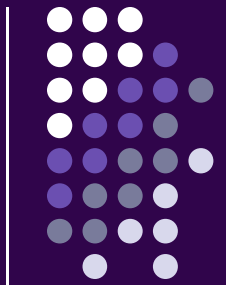


Application Areas



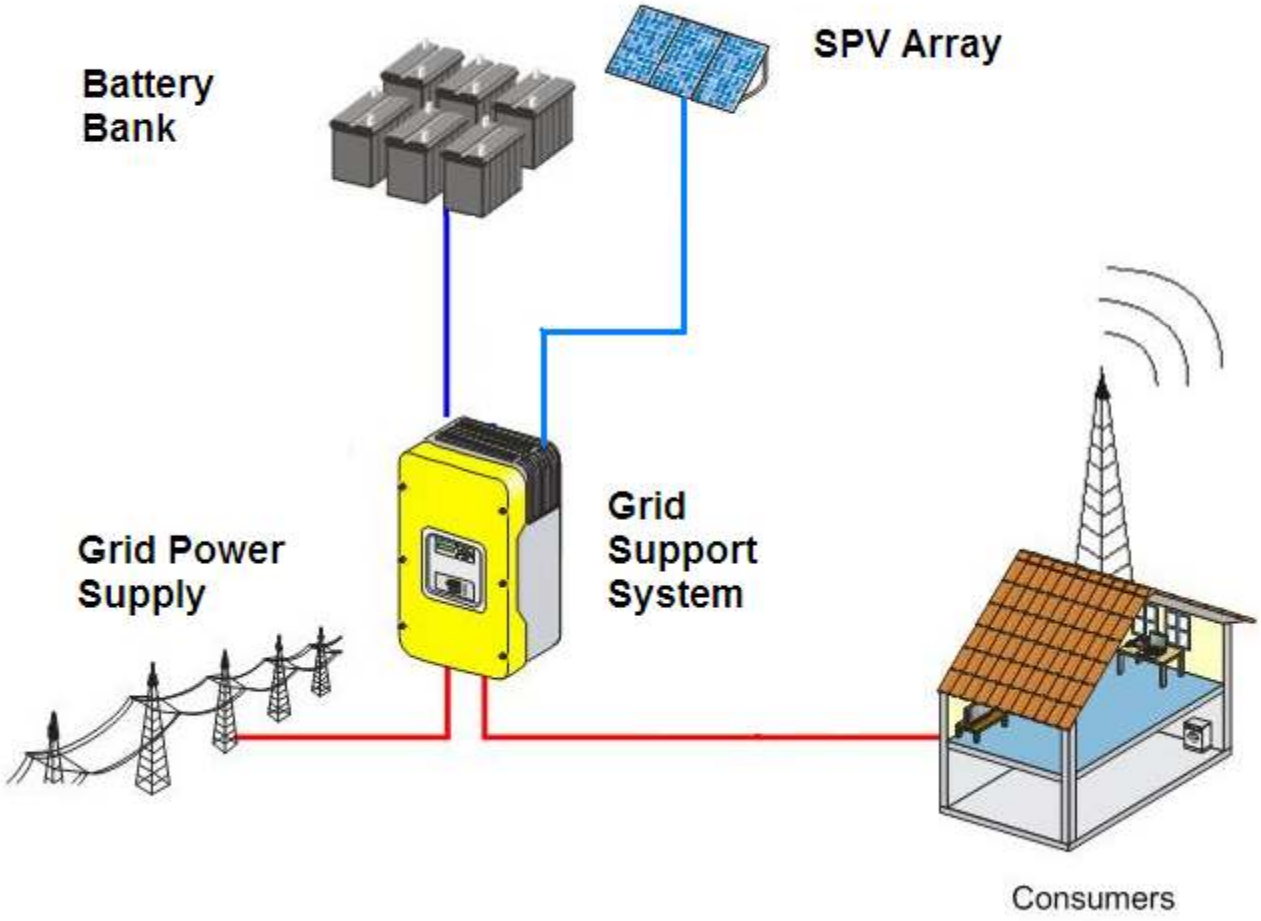
- Now being promoted by Government as the profitable way to generate Solar Power, through special power purchase tariff and other incentives.
- Direct Feeding to grid allows for minimum cost and hazards of distribution

Theory Of Operation

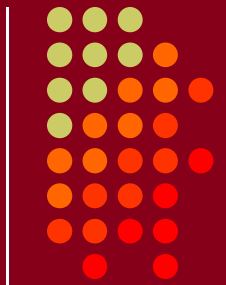


- Entire solar power generated is exported to utility grid supply.
- An MPPT extracts maximum available power from the Solar Array.
- If Grid voltage/frequency deviates from pre-set range, Inverter will automatically get disconnected from Grid, and will reconnect only when grid characteristics are back in range.

Grid Support Systems



Theory Of Operation

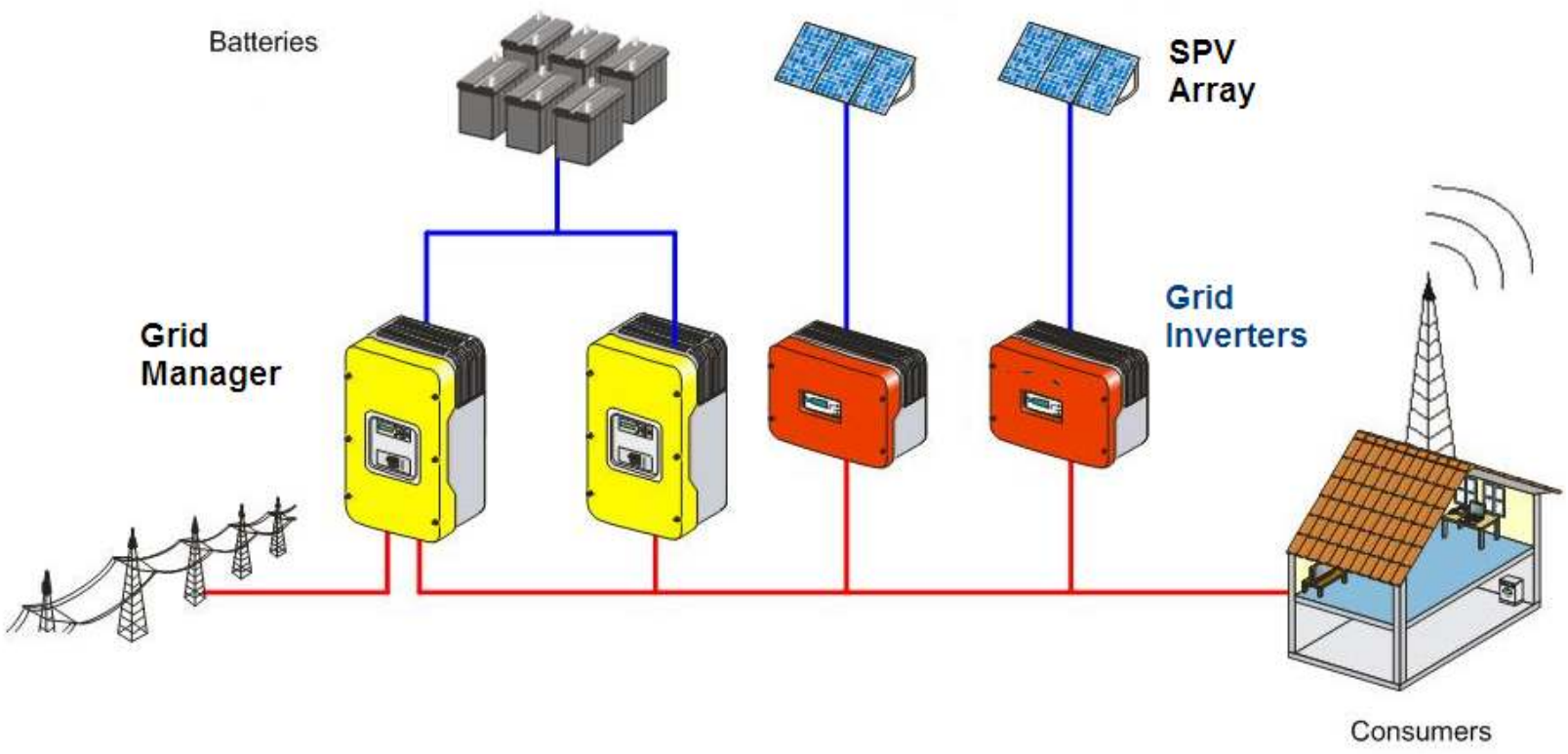


- Inverter operates in parallel with utility supply, and Diesel Generators / Wind Turbines, as required.
- Inverter supports high peak short duration loads while utility maintains base load.
- Starting/synchronization of various power sources controlled centrally.

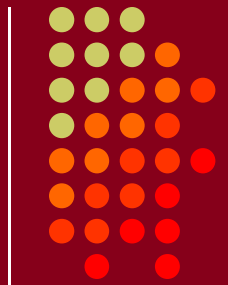
Application Areas

- Urban Areas where mains power is available
- Mains Power Utilized only when solar power is not sufficient
- Where PV array size may be less than total requirement

Hybrid Systems

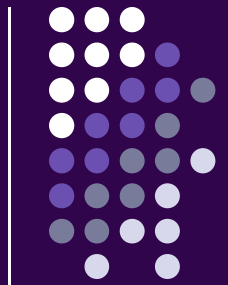


Application Areas



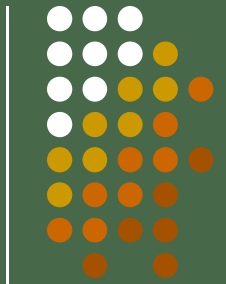
- Suitable for Both Urban and Rural Applications
- Has Provision for Both AC and DC Coupling hence very useful for
  - Connecting Other Renewable Energy Sources
  - Diesel Generators
  - Suitable for Expansion in Phases

Theory Of Operation



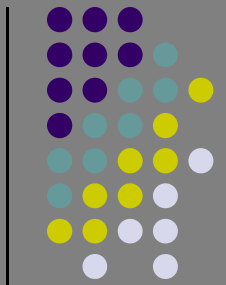
- Accomodates Solar, Wind, Gridpower as parallel input sources.
- Flexible operation capacity – source can be selected to suit operating load and conditions.
- Can be used with or without battery support.

S M D Systems



- A popular variant of the Hybrid System.
- Input includes Solar, Mains and Diesel options.
- Usually runs on Mains (Grid supply). If Grid fails, Solar takes over during day and diesel during night.
- Very common for small factories, shopping malls, Institutions/Offices, etc.

INVERTER PROTECTION SYSTEM



- Power Inverters are provided with protection system as below as per site requirement :
- Inverter continuous overload
- Inverter peak current (short circuit)
- Heat sink overheating
- Over/under grid A C voltage
- Over/under grid frequency mismatch
- Anti islanding