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REPORT

IND

2015

RENEWABLES FOR LIFESTYLE SHIFT

A User-Friendly Booklet on Renewable Energy Applications in India

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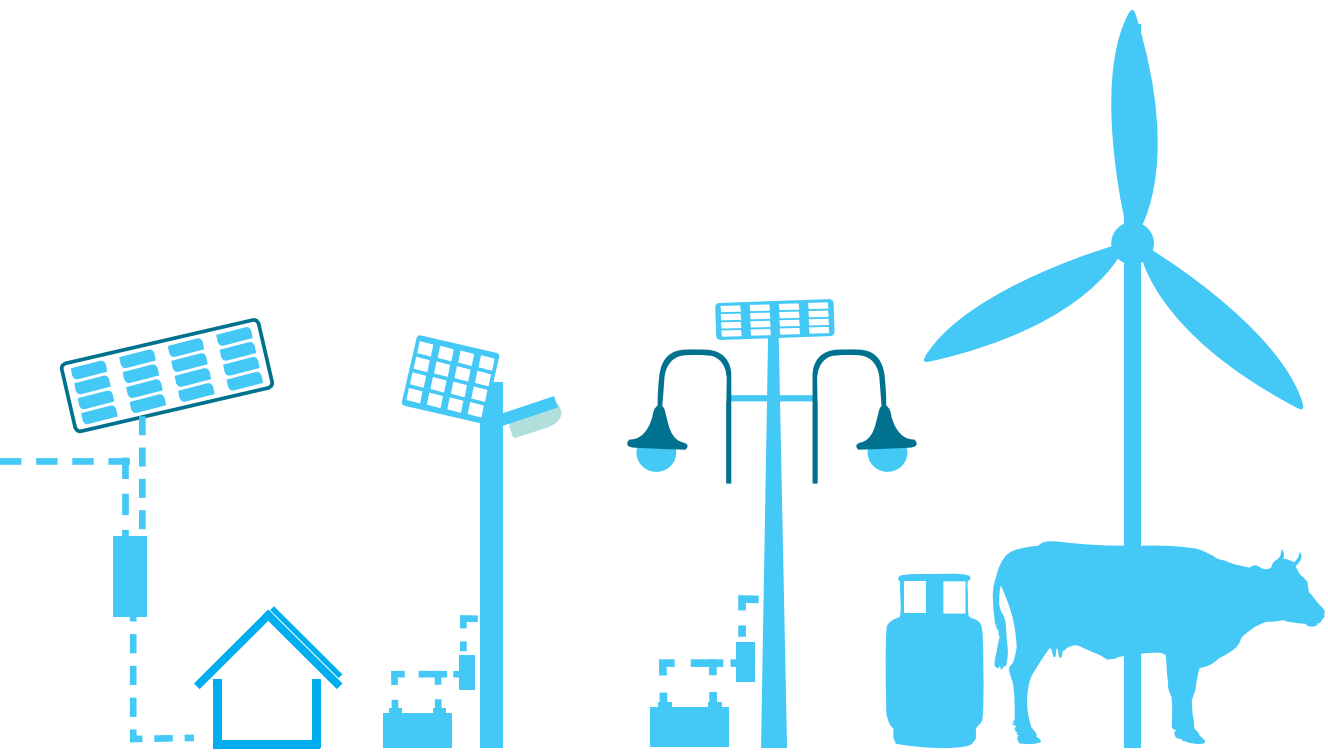
RENEWABLES FOR LIFESTYLE SHIFT

A User-Friendly Booklet on Renewable Energy Applications in India



Do you wish to install a renewable energy (RE) technology at your home, office, institution or elsewhere

Here's a booklet on renewable energy that will enable you to shift to a clean energy lifestyle.

This handy booklet compiles basic information on all that you need to know about installing and using RE applications.

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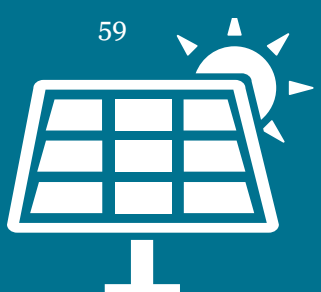

सत्यमेव जयते
उपेन्द्र त्रिपाठी
Upendra Tripathy

सचिव
भारत सरकार
नवीन और नवीकरणीय ऊर्जा मंत्रालय
SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF NEW AND RENEWABLE ENERGY

05th January, 2015

MESSAGE

The need for secure, affordable, and environmentally sustainable energy has become one of the principal economic and development challenges for the country. As far back as 1982, Indian leadership could envision the promise of renewable energy and this foresight that resulted in the creation of a separate administrative set-up for promoting the development and deployment of renewable energy in the country.

Renewable energy has already become a key component of the energy mix and is likely to play an increasingly important role. Renewable power, excluding hydro above 25 MW installed capacity, has reached over 33 GW, contributing over 13% of the country's electric installed capacity and around 7% in the electricity mix. In addition, decentralized distributed energy supply solutions play a catalytic role in development of rural areas and renewable energy instrumental to building up rural energy capacity. The National Action Plan on Climate Change mandates increasing share of renewable power in the electricity mix to 15% by the year 2020. Further, Ministry has plans to scale up renewable energy deployment to reach a cumulative installed capacity of around 165 GW by 2022 that includes 100 GW solar power capacity.

I am happy to learn that the WWF–India is bringing out a booklet **"Renewable Energy for Lifestyle Shift"**. I have found the booklet user friendly and written in lucid style. It provides basic information that the common user requires about installing and using renewable energy systems and devices. I congratulate WWF–India for this positive contribution towards renewable energy transition.

(Upendra Tripathy)

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FOREWORD

India is one of the most vulnerable countries to the impacts of climate change. With fossil fuels contributing to a large per cent of our energy needs, the situation becomes all the more precarious. 70 per cent of our electricity is being generated by coal based power plants, and the existing supply falls 10 per cent short during peak hours. In such a scenario, it is expected that there will be continued pressure on supply sources as well as the fiscal situation in the coming years. The fact that we have a large dependence on imported oil, and also coal imports in recent years, has implications on our energy security. Another major challenge is in terms of energy access–300 million people in India are still without access to electricity. This is where renewable energy has to step in and create solutions that can provide access to energy in a clean and sustainable manner. Accordingly, "renewables as the new normal" has become the new mantra of WWF-India.

Considering the increase in urbanization levels projected in India, it is important that renewable energy and energy efficiency measures are taken up in a major way, and replicable & scalable models are created. Besides the government, all stakeholders including the industry, NGOs as well as common citizens have to play a proactive role in this endeavour.

This booklet attempts to demystify renewable energy based technologies, and brings it a step closer to the general masses from a practical perspective. It provides handy and useful information on applications of renewable energy that range from solar PV rooftop to wind solar hybrid systems, solar water heater to geothermal cooling systems, and biogas plants to biomass gasifier systems. We are hopeful that such initiatives for creating increased awareness would eventually lead to higher adoption of renewable energy.

Ravi Singh
Secretary General and CEO
WWF-India

SOLAR PHOTOVOLTAIC (PV) ROOFTOP SYSTEMS

Definition

Solar PV rooftop is a roof-mounted system where solar panels are mounted on the roof of a building complex. The major components of a solar PV rooftop system are:

1. PV Panels
2. Mounting Structure
3. Junction Box
4. Charge Controller
5. Battery Bank
6. Inverter
7. Cables and other electrical accessories

A typical solar PV rooftop installation can be any one of the following types: grid-connected, grid-connected with storage or off-grid.

Technology Description

When the charged particles of sunlight called photons fall on the solar cells in the solar panel, they energize the electrons in the solar cell thereby producing electricity. This phenomenon is called photoelectric effect. The electricity so produced is in the form of Direct Current (DC). The DC charges a battery, which is connected with the solar rooftop system. The DC current can either be used directly to run DC appliances or can be converted into Alternating Current (AC) by using a solar inverter or a solar power conditioning unit. The AC produced from the solar rooftop system can be used to run household appliances.

Space Requirement

The area requirement for solar PV rooftop varies depending upon the capacity of the installation. The area must be free of any shade so as to allow maximum solar insolation on the rooftop system. A typical capacity of 1kWp (kilowatt peak) system would require an approximate shade free area of 80ft^2 (around 8m^2) if placed in a single row. The space requirement for 1kWp system would be about 120ft^2 (around 12m^2), if panels are placed in multiple rows. This increase in space requirement is to avoid shadow of one row from falling over the other.

It is advised to install the solar panel in south facing direction so that the panel absorbs maximum solar radiation and the system is more efficient. Solar PV rooftop systems are also available with tracking mechanism, wherein a solar tracker device orients the PV panel(s) according to the movement of the sun throughout the day, thereby significantly increasing absorption of solar radiation power output from the PV panel(s). The size of the system is fixed depending upon the load and space availability.

BENEFITS

Optimum utilization of space since the unused space at the rooftop is used for setting up the equipment.

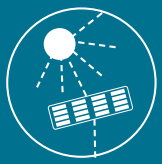
Saving of additional electricity cost

Pollution free

Requires very little maintenance and produces no noise.

A typical solar PV powered system of 1kWp capacity can generate around 1,650 kWh/year.

Electricity that is generated can be utilized at source, hence no transmission and distribution losses entail in the system.



Fast speed of deployment, i.e., projects can be executed in less time.

The system can be integrated with conventional electrical grid, using net metering mechanism, feeding surplus electrical units, if any, to the grid.

Associated Limitations

- Intermittent nature of solar energy generation due to diurnal and seasonal variations.
- Off grid system require a battery to store the additional electricity that is generated by the rooftop solar PV system. This leads to an additional set-up cost.
- The area required by the PV panels is large.

Cost of the Technology

The cost of a typical 1kWp off grid (with battery backup) solar PV rooftop system would be in the range of Rs 1.3 lakhs to Rs 1.5 lakhs depending on technology, user requirements etc.

Cost Analysis

More than 50 per cent of the cost of rooftop PV system is taken up by the solar panel. The inverter takes up more than 20 per cent of the total cost. The wiring, charge controller, mounting auxiliaries, etc., are called the balance of system components. These components take up more than 15 per cent of the total cost. The remaining percentage of the total cost is taken up by the installation of the entire system.

The battery efficiency and electricity backup period add up heavily to the cost of the system. Batteries add to the initial cost, recurring maintenance and replacement expenditure. A battery backup would add upto 12.5 per cent to the total cost of the system.

Application Market/Potential and Current Status

Residential buildings such as houses can install PV modules on their rooftops. It is preferred for the building to have a sturdy roof so that the structure may not collapse due to the weight of the mounting structure. Commercial complexes such as institutions, offices, hospitals, malls, hotels and resorts can have roof-mounted systems installed for meeting their power backup requirements that would otherwise be fulfilled by diesel generators. Constant power is available during the day to meet the peak load requirements.

Potential Users

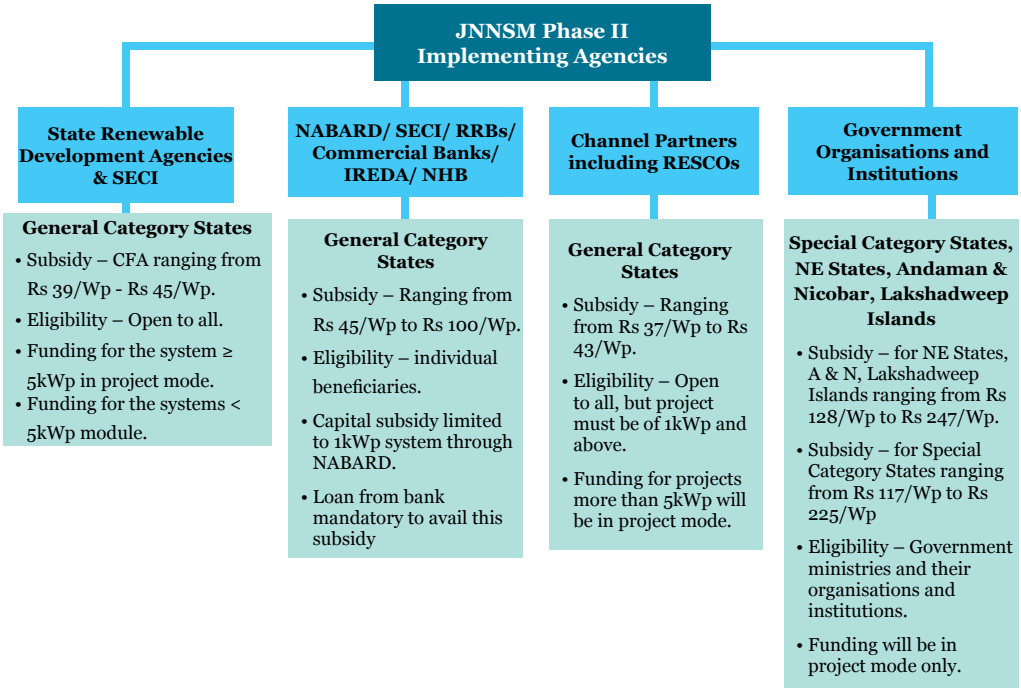
Users of residential complexes, commercial and industrial units, and institutional buildings.

Manufacturers / Suppliers

See Annexures I and II.

Applicable Subsidies

Central Subsidies*



**As per MNRE sanction order for re-fixing/revising the Central Financial Assistance (CFA) for "Off-grid and Decentralized Solar Applications Programme" for the year 2014-15 dated 3rd November 2014*

State Subsidies

ANDHRA PRADESH[1]

- All solar power projects will be exempted from paying electricity duty for captive consumption and third party sale within the state.
- Promotes off-grid applications on stand-alone basis.
- Net metering provided for which Rs 3.50 per unit will be paid on exported power for seven years.

DELHI[2]

- Net Metering Regulations announced. This allows a user with a minimum system capacity of 1kWp to install a net meter.
- Solar Policy on rooftop systems to focus on government buildings.

GUJARAT[3]

- Subsidy – MNRE subsidies and incentives are followed along with JNNSM guidelines.
- Electricity generated from PV plants and used for self-consumption is exempted from electricity duty.
- Energy generated from a solar power project shall be sold to distribution licensees at levelized fixed tariff per unit for a period of 25 years.

KARNATAKA[4]

- The state will follow MNRE guidelines and subsidies.
- No performance guarantee or bid security is required for rooftop projects ranging from 5–50kWp and from >50kW to 1MWp.
- Net metering policy is in the draft phase.

JAMMU & KASHMIR[5]

- Subsidy–90 per cent for the government sector and 30 per cent for others is available from MNRE. All schemes of MNRE are applicable.

KERALA[6]

- MNRE subsidies, incentives and guidelines are followed.
- The state has a special scheme for development of solar PV rooftop which has stopped for the time being till further notice.
- Net metering policy is in the draft phase.

PUNJAB[7]

- Subsidy –30 per cent capital subsidy for rooftop standalone systems as stated by MNRE.
- Solar Rooftop Programme for domestic, industrial and commercial sectors, grid connected and using net metering is in the draft phase.

MADHYA PRADESH[8]

- MNRE subsidies and incentives are available and the guidelines of JNNSM are followed.

TAMIL NADU[9]

- For grid connected domestic rooftop, GBI is Rs.2 per unit for first 2 years, and subsequently Re. 1 per unit for the next 2 years and Re. 0.5 per unit for the subsequent 2 years (for rooftops installations before 31 March 2014).
- All new government or local bodies should necessarily have solar PV rooftop.
- Net metering will be allowed in individual homes and commercial establishments.

UTTARAKHAND[10]

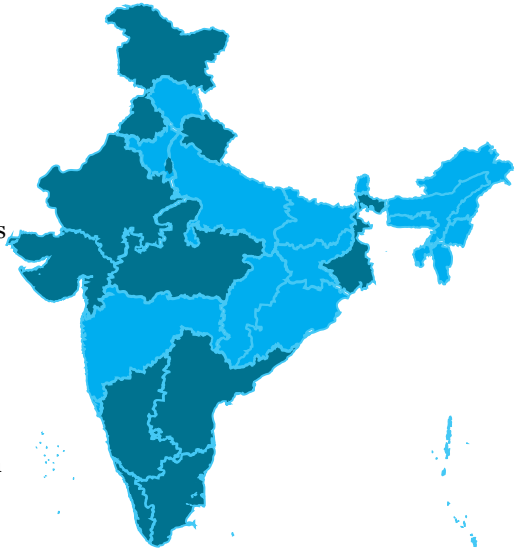
- Subsidy–All MNRE subsidies available.
- Net metering is available as:
- Project capacity with battery backup must be 300W to 100kW.
- Project capacity without battery backup upto 55kW.
- Scheme for Grid Interacted Rooftop and SPV is available.

RAJASTHAN[11]

- Incentives by MNRE are followed for promotion of off grid and decentralized solar applications for replacement of diesel generators. The Government of Rajasthan will also consider own incentives.
- Grid connected solar rooftop PV connected to LT/11kV grid under RPSSGP is promoted.

WEST BENGAL[12]

- Capital subsidy at the rate of Rs 90 per Wp or 30 per cent of the project cost whichever is less for government/ government aided institutions and individuals. Range of power plants–201kWp to 500kWp.
- Subsidy at the rate of Rs 70 per Wp for private/ commercial organizations.
- Net metering to projects from 2 to 200kW.



SOLAR LIGHTING SYSTEMS

SOLAR HOME LIGHTING SYSTEM

Definition

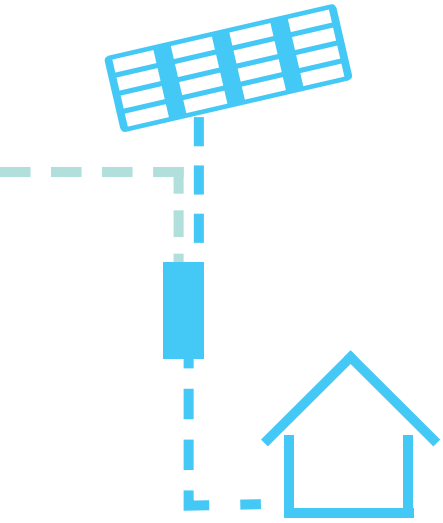
A solar home lighting system mainly provides electricity for indoor lighting purposes. This system can effectively provide light in one or more rooms of a house. System with higher capacity can also be used to run small fans or television.

Technology Description

Home lighting system is powered by solar energy using solar cells that convert solar energy directly to electricity. The electricity is stored in batteries, which are placed inside the house and used for the purpose of lighting whenever required. A charge controller prevents overcharging and deep discharge of the battery.[13]

Benefits

- Light can be provided to households that do not have grid connectivity and are difficult to reach.
- A typical 60Wp solar home lighting system saves around 100 litres of kerosene oil per system per year.[14]
- In addition to providing lighting needs, solar home lighting system can also run equipment like a fan or television.
    - Bank loan schemes are available for such systems.



Associated Limitations

- The system performance deteriorates during rainy or cloudy weather.
- The system is not designed to withstand heavy loads.
- Help of an expert is required to install the solar panel.
- Initial upfront cost is high because of the batteries.

Cost of the Technology

The cost varies depending upon the system capacity, battery backup, user requirement and other technical specifications. The indicative cost of a typical solar home lighting system which includes solar panels, batteries, charge controllers, electronics,

luminaries and other loads as well as installation cost and 1 year of servicing is in the range of Rs 6,000 to Rs 45,000 for system capacity between 10W to 100W.

Applicable Subsidy

MNRE provides Central Financial Assistance (CFA) in General Category, NE States, Andaman & Nicobar, Lakshadweep Islands and Special Category States.

A subsidy of Rs 100/Wp (CFL-based system) and Rs 160/Wp (LED-based system) is provided by NABARD on home lighting systems. MNRE provides subsidies for solar PV lights and small capacity PV systems from 10Wp to 1kWp including both CFL and LED based systems. To obtain the subsidy, the product has to match the minimum technical requirements set by the ministry. [15]

Cost Analysis

Payback period is almost two years.

Application Market/Potential and Current Status

Solar home lighting systems are ideally suited for remote un-electrified villages where grid electricity cannot reach due to price constraints. Solar home lighting system is also suited for adventure camps which are seasonally operational.

Under the Off-grid and Decentralized Solar Application Scheme, a total 10,01,890 solar home lights have been installed in the country, including in rural and ST dominated areas.[16]

Potential Users

Individuals and users of residential complexes.

Manufacturers/ Suppliers

See Annexures I and II.

SOLAR STREET LIGHTING SYSTEM

Definition

Solar street lights are standalone systems utilizing solar energy. It gives an immediate lighting solution. These get charged during the day by the sun on the working principle of solar PV. The timers fitted onto them help in identifying dusk and get switched on from dusk till dawn. The power with which solar street lights operate might range from 20 to 200W that can be served by lead acid storage batteries.

Space Requirements

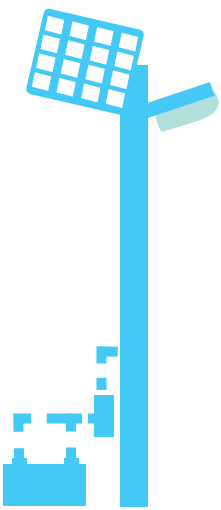
The solar street light requires very less space as the light and panel are mounted on a pillar. Hence, the area occupied is as less as the diameter of the base of the pillar on the ground.

Benefits

- The peak demand of lighting on streets in the evening can be met by these solar lights.
- Since it is a standalone system, it is easy to install as there are no cables required to be connected to the power source.

Associated Limitations

- Solar street lights are expensive in comparison to the conventional street lights.
- The performance of the system goes down in winters (due to fog) and in monsoons (due to cloud cover), as the system is not able to charge fully.



Cost of the Technology

The cost varies depending upon the system capacity, battery backup, user requirement and other technical specifications. Solar street light systems available in market commonly have capacity range between 35Wp to 150Wp. The indicative cost of a typical 75Wp capacity solar street light system which includes solar panels, batteries, charge controller, electronics and luminaries is in the range of Rs 22,000 to Rs 24,000.

Applicable Subsidy

MNRE provides Central Financial Assistance (CFA) in General Category, NE States, Andaman & Nicobar, Lakshadweep Islands and Special

Category States. A subsidy of Rs 100/Wp (CFL-based system) and Rs 160/Wp (LED-based system) by NABARD is provided for solar street lighting systems.[17]

To obtain the subsidy, the product has to match the minimum technical requirements set by the ministry.

Cost Analysis

The operation and maintenance cost is very less. As compared to other street light system, they save power to a large extent.

Application Market/Potential and Current Status

Solar street lights can be installed in remote villages where grid connectivity has not reached so far or in poorly electrified villages where electricity is available for only 5–8 hours. These are extremely useful for educational institutions and hospitals that have a larger area that need lighting. These are also suitable for gardens and parks, for landscaping and better aesthetics.

According to MNRE, a total of 2,74,679 solar street lights have been installed in various locations around the country.[18]

Potential Users

Residential societies, municipalities, institutions and panchayats.

Manufacturers/Suppliers

See Annexures I and II.

SOLAR GARDEN LIGHTING SYSTEM

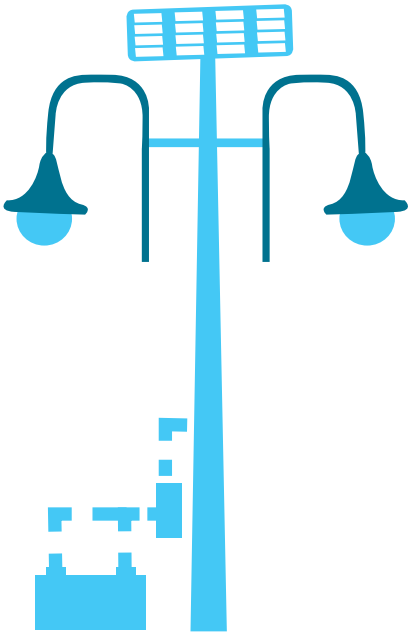
Definition

Solar garden light comprises an LED lamp, a solar panel to convert solar energy to electrical energy and a battery to store the additional electricity thus generated.

The solar garden lights come in various forms such as:

- Hanging solar lighting system
- Ground stake solar garden lighting fixture
- Solar landscape lighting equipment fixture
- Solar garden spot lights system/flood light
- Solar deck, patio and step lights equipment
- Solar lamp post

Solar garden lights can be used to improve the aesthetics of a garden, to light up a fence, a deck or a patio. These lights also come with motion sensors. The motion sensor lights can be used for security purposes.



Technology Description

Solar garden lights are standalone, cordless LED lights powered by a built in battery that charges during the daytime. When the sun light is incident on the solar panel mounted on the garden light, the panel converts sun light into electricity using PV principle. This electricity charges the inbuilt battery system. The automatic light sensor turns the garden lights on after sunset.

Benefits

- Cost-effective, as compared to the conventional garden lighting arrangement.
- These are much easier to install. Installation does not require a skilled technician, all one has to do is to install the garden light at a place that receives optimum sun light and is not in shade.
- The garden lights use minimal area.

Associated Limitations

- They are expensive in comparison to the conventional garden lights.
- The working of the system comes down in winters (due to fog) and in monsoons (due to cloud cover), as the system is not able to charge fully.

Cost of the Technology

The stake mounted system goes as low as Rs 285 per piece to as high as Rs 1,000 (approx.) per piece.[19] The lower priced systems have a stainless steel body whereas the higher priced systems have a carbon fibre or plastic body.

Cost Analysis

The pricing of solar garden lights varies depending upon the requirements of the user. These are a cheaper alternative to the wire mounted garden lighting system requiring only the initial cost. The operation and maintenance of the garden light is minimal. Since the system is standalone, all of its components are built within the light structure.

Potential Users

Users of residential complexes and commercial units.

Manufacturers/ Suppliers

See Annexures I and II.

SOLAR LANTERN

Definition

A solar lantern is a portable lighting device consisting of a PV module, battery, lamp and electronics. Battery, lamp and electronics are placed in a suitable housing, made of metal or plastic or fibre glass.[20] Some lanterns have an in-built PV module, while others are designed to be plugged into a PV module, which can then be detached for use. The solar lantern is suitable for both indoor and outdoor lighting.

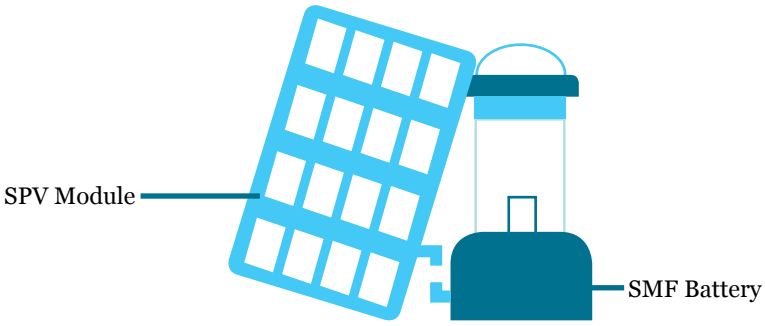
The popular solar lanterns are of two types, viz., compact fluorescent lamp (CFL) based solar lantern and white LED (W-LED) based solar lantern.

Technology Description

The operation of a solar lantern involves the conversion of solar energy to electrical energy by the solar PV panel. This energy is then stored in a sealed maintenance-free battery for later use during the night hours. A single charge can operate the lamp for about 4–5 hours.[21]

Benefits

- By replacing a kerosene lantern, a solar lantern can save about 50 litres of kerosene in a year.[22]
- No cost involved to run the solar lanterns.
- Solar lanterns require very low maintenance and are economical.
- Solar lanterns provide better quality lighting as compared to kerosene based devices.
- Being a portable light, it can be used both indoor as well as outdoor.
- Solar lantern is pollution free and environment friendly.



Associated Limitations

- Number of hours of use is limited.
- Higher upfront cost of the lantern can be a barrier for adoption in rural households.

Cost of the Technology

The cost varies depending upon battery backup, user requirement and technical specifications including the type of luminaries. Typically the cost of a solar lantern available in market is in the range of Rs 500 to Rs 4,000 which includes solar panels, batteries, electronics and luminaries.

Applicable Subsidy

MNRE provides Central Financial Assistance (CFA) in General Category States, NE States, Andaman & Nicobar, Lakshadweep Islands and Special Category States. A subsidy of Rs 100/Wp (CFL-based system, upto 74Wp) and Rs 160/Wp (LED-based system, upto 40Wp) by NABARD is provided for solar lanterns.[23] To obtain the subsidy, the product has to match the minimum technical requirements set by the ministry.

Application Market/Potential and Current Status

Under the Off-Grid and Decentralized Solar Application Scheme of MNRE, around 9,40,000 solar lanterns have been installed in the country.[24] A project on "One Million Solar Study Lamps (CFL/LED)" for empowering populations in underserved communities by IIT-Bombay is also under progress.[25]

Potential Users

Users of residential units and complexes, and people residing in remote rural villages.

Manufacturers/ Suppliers

See Annexures I and II. These are also available on various online shopping portals.

SOLAR FAN

Definition

A solar fan is a mechanical fan powered by solar panels. The solar panels are either mounted on rooftops or are installed independently. Solar fans mostly do not require secondary power sources other than solar power, as most of them are used for cooling purposes.

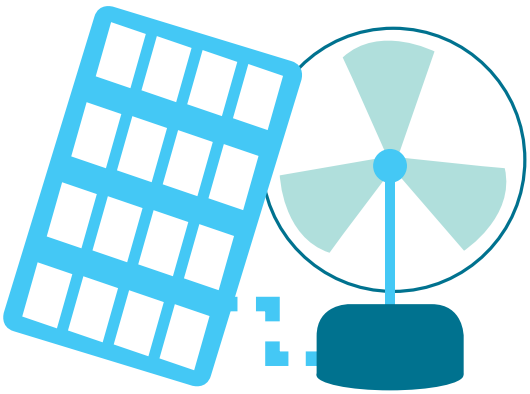
Technology Description

A solar powered fan has a working principle similar to that of conventional electric fans. The unique characteristic of the solar powered fans is that unlike conventional electric fan which run on grid electricity, these are powered using solar energy. The solar energy is captured through usage of solar panel(s).

Solar fans are primarily DC operated fans, which can be used for a variety of purposes. These are available in different varieties like table top fan, ceiling fan etc. AC operated fans can also be operated using solar energy but will require a solar inverter/power conditioning unit for necessary power conversion (from DC to AC). Diurnal intermittency of solar fans can be mitigated by using a battery storage device.

Benefits

- Solar powered fans use no extra energy.
- Electric motors of solar powered fans are virtually silent and they need no extra wiring or additional circuit breakers for installation.
- There are no hidden costs with installation or during operation.



Associated Limitations

- System required to store the energy for use may involve extra cost.
- Not suitable for shade installations, in which case the panels must be installed independently.

Cost of the Technology

The cost of a solar fan ranges between Rs 3,000 - 5,000.[26] The pricing for solar fans would vary depending on its capacity. The overall system cost would also include cost of the associated equipment such as solar PV panel and storage battery.

Potential Users

Users of residential complexes, and commercial and institutional buildings.

Manufacturers/ Suppliers

See Annexures I and II. Also available on various online shopping portals.

SOLAR CHARGER

Definition

A solar charger essentially uses solar energy to charge gadgets, equipments and devices. They are an alternative to conventional electrical chargers and in some cases can also be plugged into an electrical outlet.[27]

Technology Description

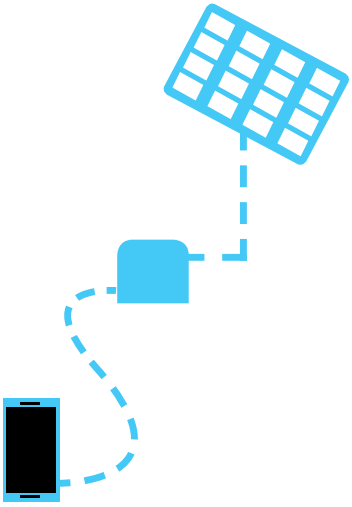
A solar charger converts solar energy into electricity through an electro-chemical process. The embedded solar panel gathers and stores energy to the solar charger's internal battery.[28] The stored energy can then be used to charge different devices, when required.

Benefits

- Portable and hence can be easily carried to different places in order to charge various devices.
- Battery life is more as high voltages are not developed.
- Solar chargers can also be used many times for charging purposes without having to pay for the extra power.

Associated Limitations

System required to store the energy for use involves extra cost.



Cost of the Technology

Solar Mobile Chargers – Rs 500–5,000[29]

Solar Laptop Chargers – Rs 7,000–18,000[30]

The pricing for solar chargers would vary depending on its capacity. In addition, the overall system cost would also include cost of the associated equipments such as solar PV panel and storage battery.

Potential Users

Individuals.

Manufacturers/ Suppliers

See Annexure I and II. Also available on various online shopping portals.

SOLAR INVERTER

Definition

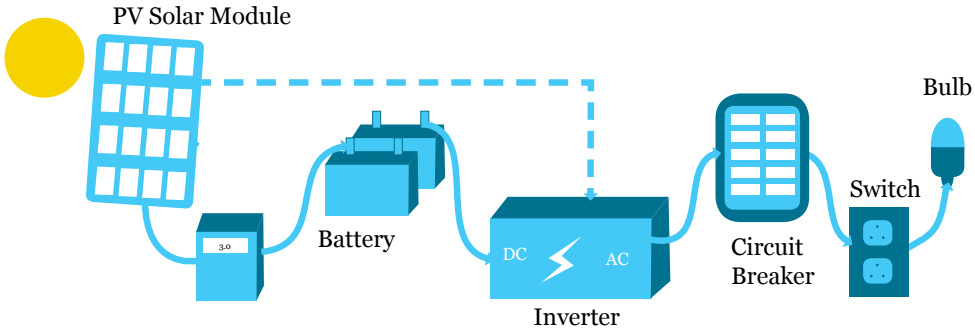
Electricity that flows from the utility grids to our home is alternating current (AC). When solar panels are used to generate electricity, direct current (DC) is produced. Therefore, this DC current must be converted to AC current, which will then be connected directly to the commercial grid or to a local off-grid electrical network. The device that helps in this conversion is called 'solar inverter'.

Technology Description

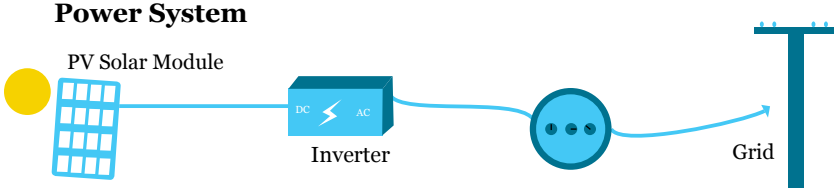
A home UPS or home inverter takes the DC power from the batteries and converts it to AC, for use of appliances. The function of a solar inverter is also the same, if it is an 'off-grid' solar power system. In case of 'grid connected' system, the DC power generated from the solar panels is converted to AC and is then connected to the grid.

Working of a solar inverter in Off-Grid Connected Solar Power System

An off-grid solar powered system consists of solar panels, charge controller, batteries and inverter as shown in the image below. The solar panels help in charging the batteries and the inverter performs the function of converting DC power to AC power. This system can also be automated if grid is not supplying power that can change the power source of the connected home from grid to batteries. Depending on the need, the system can be designed to either completely rely on solar power or charge the batteries from solar power when sun is available and switch to the grid when sun is not available to charge the PV modules.



Working of a solar inverter in Grid Connected Solar Power System



The main function of a grid-connected solar power system is to supply excess electricity to the grid. The system performs the basic role of converting DC power (generated from solar panel) to AC power. However, the system additionally needs an MPPT (maximum power point tracking) or PWM (pulse width modulation) feature to be built in it, as the voltage generated by the solar panel may vary depending on the temperature and availability of the sun. MPPT enables solar inverters to draw maximum power from the solar panels. The solar inverter used for grid-connected solution also includes an anti-islanding functionality to prevent risks to grid in case there is power failure in the grid.[31]

Benefits

- Greater efficiency and reliability.
- Outstanding energy harvest in a small modular design.
- Ease of installation to save time and money.

Cost of the Technology

The pricing for solar inverters would vary depending on its capacity. In addition, the overall system cost would also include cost of the associated equipments such as solar PV panel and storage battery.

Applicable Subsidy

To promote commercial marketing of solar accessories, MNRE had launched the Jawaharlal Nehru National Solar Mission (JNNSM) with subsidy for solar lighting and small capacity PV systems, which would be routed through NABARD. NABARD will provide 40 per cent subsidy for purchasing solar inverters.

Potential Users

Individuals, users of residential complexes and commercial buildings.

Manufacturers/ Suppliers

See Annexures II and III.

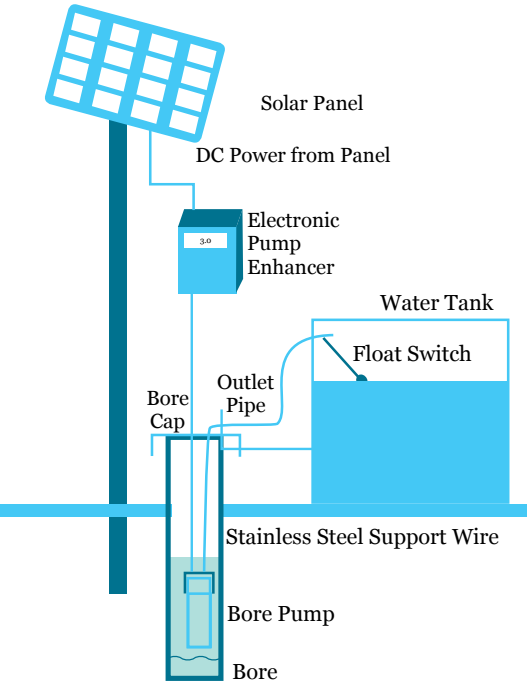
SOLAR PV WATER PUMP

Definition

A solar PV water pumping system is defined as an electric pump running on electricity generated by a solar PV array. A solar PV water pump mainly consists of a PV array which is mounted on a stand, and connected to a motor pump set which is compatible with the PV array. As the sun's rays fall on the solar modules, DC electricity is generated and is used to run a DC motor pump set or an AC motor pump set. AC motor pump set requires an inverter.[32]

Technology Description

Some of the important components of a solar PV water pumping system include: solar PV array (set of PV modules connected in a series and the strings of the modules connected in parallel), controller (the electronic device that matches the PV power to the motor) and a pump set (consists of motor to drive the pump that helps in moving the water under pressure). The main solar water pump technologies are:



- **Centrifugal Pump:** Centrifugal pumps use high-speed rotation to suck in water through the middle of the pump. Most AC pumps use such a centrifugal impeller.
- **Positive Displacement Pump:** Many DC powered pumps use centrifugal force or positive displacement to move fluids. The positive displacement pump is currently being used in many solar water pumps. The pump transfers water into a chamber and then forces it out using a piston or helical screw.[33]

Types of Pump

- **Surface Pump:** Placed beside the water source (lake, well, etc.).
- **Submersible Pump:** Placed in the water source.
- **Floating pump:** Placed on top of the water source.

Surface pumps are less expensive than submersible pumps but they are not well suited for suction and can only draw water from about 6.5 vertical meters.[34] Yet they are excellent for pushing water over long distances.

Benefits

- Solar water pumps do not require fuel or constant maintenance.
- These pumps can also be designed for portability to cater to water demand or change of season.
- Operational cost of these pumps are less as compared to diesel pumps.
- Solar water pumps offer clean solutions with no danger of borehole contamination.

Associated Limitations

- High capital costs.
- Water storage is required for cloudy periods.
- Repairs often require skilled technicians.
- The water yield of the solar pump varies according to the sunlight. It is highest around noon and least in the early morning and evening.

Applicable Subsidy

MNRE provides Central Financial Assistance (CFA) for General Category States, NE States, Andaman & Nicobar, Lakshadweep Islands and Special Category States. A maximum subsidy (per HP) ranging from Rs 57,600 (upto 2HP) to Rs 54,000 (from >2HP to 5HP) for DC pumps is provided by NABARD. For AC solar pumps, NABARD provides subsidy of Rs 50,400 (upto 2HP), Rs 43,200 (from >2HP to 5HP) and Rs 38,880 (from >5HP to 10HP). For pumps >5HP-10HP, subsidy amount is fixed at Rs 194,400/- per pump. To obtain the subsidy, the product has to match the minimum technical requirements set by the ministry.[35]

In addition to the central subsidy, few state governments also provide additional incentive to the farmers:

Rajasthan	The government of Rajasthan would provide 56 per cent subsidy in addition to central subsidy to farmers. For the FY 2013-14, the government of Rajasthan had planned to install 10,000 solar water pumps across the state, for which the state government is expected to receive Rs 148 crore from the National Clean Energy Fund (NCEF).
Andhra Pradesh	The government of Andhra Pradesh would provide 20 per cent subsidy in addition to the central subsidy to the farmers.
Gujarat	The government of Gujarat would provide 80 per cent subsidy (to a maximum of Rs 3.2 lakh) to install 500 systems for farmers in the Saurashtra region.

Punjab	The government of Punjab plans to provide 40 per cent subsidy (to a maximum of Rs 1 lakh) in addition to MNRE subsidy for 500 solar irrigation systems in FY 2013–14.
Tamil Nadu	The government of Tamil Nadu plans to provide 80 per cent subsidy (to a maximum of Rs 4 lakh) for 2,000 systems during FY 2013–14.

Cost of the Technology

The upfront costs of solar water pumping solution vary with respect to different capacities: 1HP (Rs 2–2.5 lakhs), 2HP (Rs 3–3.5 lakh), 3HP (Rs 4.25–4.75 lakhs) and 5HP (Rs 7.25–7.75 lakhs).

Cost Analysis

After taking into account certain assumptions, studies clearly show that when compared to diesel (Rs 17 to 20 per unit of electricity), the cost of per unit from a solar water pumping solution (Rs 10 to 13 per unit of electricity) is comparatively less.

In addition, the cost of water pumping from diesel gensets varies from Rs 100 to 160/hour. This may reduce to Rs 60 to 80/hour in case of solar pumpsets. If used for 1,250 hours annually, a solar pumpset without an MNRE subsidy may have a payback period of six to eight years and it can further reduce to four to six years with an MNRE subsidy.[36]

Application Market/Potential and Current Status

According to the recent budget announcement 2014–15, Rs 400 crores have been allocated for installing one lakh solar power driven agricultural pump sets and water pumping stations.

The system has a wide ranging applications, as listed below:

- Water supply (in villages, schools, hospitals, home, animal farms and poultry, housing societies and apartments).
- Irrigation (in fields, farms and greenhouses, also used for sprinklers and drip irrigation for agro-based industries).

Currently, a total of 11,626 solar pumps have already been installed in various parts of the country.[37] The technology has huge potential of diffusion to large parts of the country.

Manufacturers/ Suppliers

See Annexures II and III.

SOLAR COOKER

Definition

Solar cookers use solar energy to generate heat for cooking food. The solar cooker application is a safe, clean and economically viable and healthy cooking technology, which can be a promising alternative for conventional fuels like LPG, kerosene and fire wood.[38]

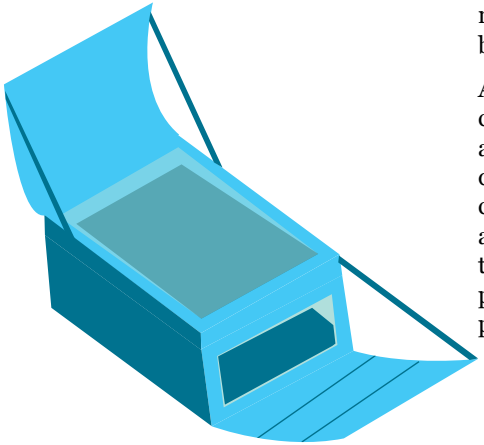
The major types of solar cookers are:

1. **Panel cookers**
2. **Box cookers** also called solar ovens
3. **Concentrating solar cookers:** Different types of concentrating solar cookers used in India are:
   a. **Small and medium sized dish cookers:** These are used for domestic cooking as well as for small communities.
   b. **Scheffler indoor solar cooker:** These are used for community cooking.
   c. **Large sized dish, fresnel and trough concentrators:** These are used for large community cooking.

Technology Description

A solar panel cooker is the cheapest and simplest solar cooker where a reflecting panel diverts solar radiation towards the pot which is kept inside a plastic bag. Plastic bag works as a greenhouse and the trapped heat is used for cooking.

A solar box cooker works on the principle of a heat-trapping enclosure. The enclosure is made of an insulating material with glass cover. Glass cover traps heat with greenhouse effect principle inside the box. The cooker has single or multiple reflectors. This trapped solar radiation raises the temperature for cooking the food inside the box to around 110–120°C.



A concentrating parabolic dish shaped cooker is constructed using multiple reflective metal sheets assembled on a rigid frame. The principle of this device is to concentrate solar rays on a point, in this case its bottom and side of the cooking pot. The aperture of these types of cookers is usually more than 1m^2 and the bottom temperature of the cooking pot can reach around 100°C to 300°C. Shapes of the paraboloid dish can be circular or square.

To cater to the cooking needs of 50 to 100 people, community level solar dish cookers are available in the same dish design. These are generally available in 4m² aperture area. There are 'Scheffler concentrators' available for indoor cooking. These systems are oblique sections of paraboloid and look elliptical in shape. Solar primary reflector/ concentrator with minimum 7 and 16m² aperture area focuses sunrays on a secondary reflector through a small window in the north wall of kitchen. The temperature achievement in this system is around 400°C.

Lastly, solar concentrators like large paraboloidal dishes, fresnel dishes and troughs are used to generate steam or hot thermic oil. This is then used to deliver necessary heat to cook food through elaborate system of piping and special cooking vessels. These systems are usually designed to cater to large-scale community and institutional cooking needs.[39]

Benefits

- A solar dish cooker can save up to five to eight LPG cylinders per year at domestic level. A community dish solar cooker can save 10–35 LPG cylinders per year in community kitchens and small establishments. Scheffler concentrator of 16m² can save even up to 100 LPG cylinders per year and big community cooking systems can save huge amount of fuel depending on the size.
- Reduction in deforestation and indoor air pollution.
- Food cooked in a typical solar system is more nutritious as it has better retention of Thiamine, Riboflavin, Vitamin C, etc., due to its low temperature and slow cooking process.

Associated Limitations

Cooking hours need to match sun availability. To overcome this, few companies have recently come up with heat storage solutions for large community cooking systems.

Cost of the Technology

- Cost of a box type solar cooker ranges between Rs 2,500 to 4,500.[40]
- A dish solar cooker of smaller size costs around Rs 6,000 to 11,000.[41]
- Community dish cookers cost around Rs 8,000/m² while Scheffler indoor cooking system costs Rs 20,000/m².[42]
- Dish cookers of a bigger size cost Rs 30,000.[43]

Applicable Subsidy

MNRE provides a capital subsidy of up to 30 per cent of the capital cost, subject to some benchmarks for all solar cooking systems. Subsidies depend on the policies and projects at the time of execution.

In case of special category states, the capital subsidy is doubled to maximum 60 per cent of the project cost.[44]

Application Market/Potential and Current Status

A total of approximately 639,000 box type solar cookers and dish cooker units of about 10,200 have been installed in India till the end of the Eleventh Plan (2007–11). Total of about 80 solar energy based steam generating systems have been installed in India till 2013.

There is an overall target of deployment of 50,000 solar cookers with at least 100 institutions and around 25,000 installations for solar cooking applications in schools for mid-day meals under Phase II of JNNSM.[45]

The physical target for solar cookers (Box type + Dish type) is estimated at 3.5 million in the Twelfth Plan and that of CST-based systems for community cooking is set at 50,000m^2.[46]

Potential Users

Residential colonies, community institutions such as old age homes and anganwadis, commercial establishments, schools serving mid-day meals to children, and industrial units serving food to workers.

Manufacturers / Suppliers

See Annexure III.

SOLAR WATER HEATING SYSTEM

Definition

A solar water heater (SWH) provides hot water for bathing, washing, cleaning, etc., using solar energy. It is generally installed at the terrace or where sunlight is available to heat water during daytime, which is stored in an insulated storage tank for use when required.[47]

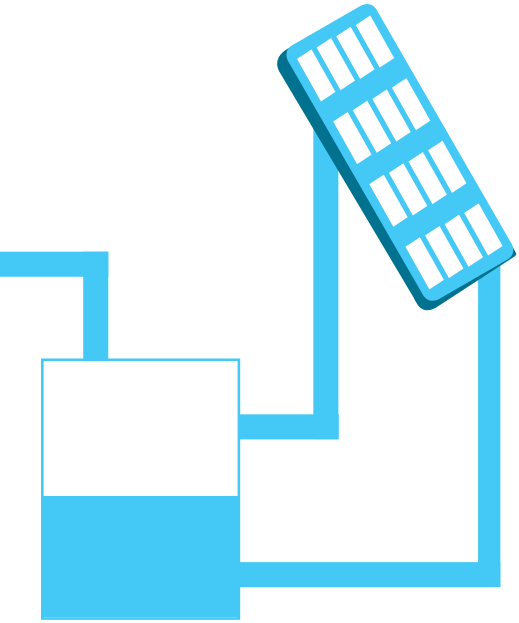
Two types of solar water heaters are:

- Flat Plate Collector (FPC) based systems.
- Evacuated Tube Collector (ETC) based systems.

Technology Description

Domestic solar water heaters work on the principle of thermosyphon action, i.e., without any mechanical process. Water circulates through the system by virtue of density difference between hot and cold streams. No electricity is required for circulation of water or for any other operation in smaller systems. For bigger systems, recirculation pumps are provided.

These are also available with or without heat exchanger. The system is generally installed on the terrace and requires minimum maintenance. It works automatically and one does not have to operate any part of the system. Typically, a surface area of 2m^2 shadow free area is required to install a typical 100lpd (litre per day) SWH system.



Lastly, solar concentrators like large paraboloidal dishes, fresnel dishes and troughs are used to generate steam or hot thermic oil. This is then used to deliver necessary heat to cook food through elaborate system of piping and special cooking vessels. These systems are usually designed to cater to large-scale community and institutional cooking needs.[48]

Benefits

- A 100lpd solar system can reduce carbon dioxide emission by over one tonne annually.
- It has a potential to replace a 2kW electric geyser for 2.5 hours, saving five units of electricity.[49]
- Quick payback.
- Operation and maintenance free system.

Associated Limitations

- Hard water may create issues of scale deposition in the tubes.
- Will underperform in cloudy climate.

Cost of the Technology

Rs 15,000 to 22,000 for 100 lpd domestic system in plains depending on the type of system. In hilly and north-eastern region, the cost may be 15 to 20 per cent more.[50]

Applicable Subsidy

As per the latest directive from MNRE, no subsidy is provided on solar water heaters from 1 October 2014.

Cost Analysis

It can pay back the cost in three to five years time, depending on the electricity tariff and hot water usage in a year.[51]

Application Market/Potential and Current Status

Presently, over 7.27 million m^2 collector area is installed in India.[52] It is estimated that India has a potential of 35–40 million m^2 of collector area and the country aims to deploy 15 million m^2 collector area by 2017 and 20 million m^2 by the end of the National Solar Mission in 2022.

Potential Users

Users of residential colonies, and commercial and industrial buildings.

Manufacturers/Suppliers

See Annexures II and III.

SOLAR AIR-CONDITIONING SYSTEM

Definition

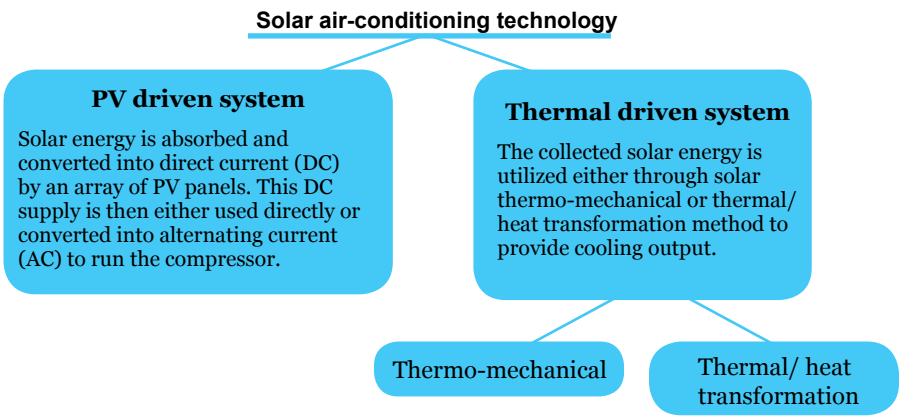
Solar air-conditioning system utilizes solar energy to generate electricity/ thermal energy, which in turn is used to meet cooling demand.

Air-conditioning systems are the most energy intensive systems around the world. With increasing population and higher economic growth, coupled with rising demand for housing and commercial spaces, the demand for cooling systems in India is bound to increase.

A majority of the cooling systems, from small scale (residential ACs) to large scale (heating, ventilation and air conditioning (HVAC) systems in commercial and industrial sectors), run on grid-provided electricity. In India, cooling (fans, evaporative cooling and air conditioners) accounts for 45 per cent of the total energy consumption in the residential building sector, whereas HVAC consumes 55 per cent of the total energy utilized in the commercial building sector.[53]

In such a scenario, solar air-conditioning system can help meet the cooling requirements in a sustainable manner.

Technology Description



Small systems are solar PV based while large systems are solar thermal based.

Benefits

- Lower demand for grid electricity.
- Lower operational costs.
- Reduced environmental impacts, like GHG emissions, etc.
- Solar air-conditioning systems work more efficiently during hot summer season, thereby reducing electrical peak loads linked to conventional grid electricity based cooling systems and giving a good seasonal match.
- Reduced capital expenditure associated with transmission and distribution.
- Added benefit in places where the demand for cooling is not annual– these systems can provide hot water for utilization in other systems and processes.

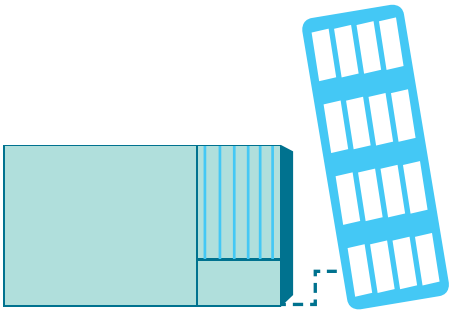
Associated Limitations

Technical barriers

- Lack of units with small capacities.
- Absence of commercially available package-solutions for residential and small commercial applications.
- Low thermal efficiency (COP) thus low cooling output.
- Lack of skilled manpower or professionals.
- Limited demonstration and replication projects.

Cost Barriers

- Initial investment cost is high.
- Limited avenue for finance accessibility.
- Lack of financial support-based system performance.



Cost of the Technology

Cost of technology for solar PV is around Rs 1.5 lakh to 2.5 lakh per TR while for solar thermal cooling system the cost is about Rs 3 lakh to Rs 5 lakh per TR (Variation in cost of solar air-conditioning depends on solar radiation in different regions and to some extent on choice of technologies).

Applicable Subsidy

MNRE under the JNNSM, provides incentives and capital subsidies for solar component of the air-conditioning system.

For CST-based systems, MNRE provides 30 per cent of system benchmark cost as capital subsidy in general category states. Additionally, a benefit of 80 per cent accelerated depreciation is given to profit-making bodies from MNRE for installations.

Higher subsidy (60 per cent of cost) in special category states, including hilly states, islands, and border districts, except commercial establishments.[54]

Cost Analysis

A typical system of 30TR capacity for commercial complexes and institutions require about 250–300m^2 of CST area depending on the type of technology used, which may cost around Rs 60–70 lakh. This system should be able to save 18,000–22,000 litre of diesel per year depending on the solar radiation available at the place of installation. Assuming the price of diesel at Rs 55, it should be recover its cost in five to six years.[55]

Application Market/Potential and Current Status

A market analysis by KPMG estimates the potential for solar cooling segment in India to be about 0.13 million m^2 of collector area (approx. Rs 2 billion).[56] According to a recent estimate, it is possible to achieve solar cooling capacity of about 25,000TR in India by 2022.[57]

In India, currently 10 solar thermal-based systems have been installed with cumulative capacity of 816TR of solar cooling.

Potential Users

Users of residential colonies, and commercial and industrial buildings.

Manufacturers/ Suppliers

See Annexure III.

AEROGENERATORS AND WIND-SOLAR HYBRID SYSTEM

Definition

In windy areas of the country, small wind energy systems viz. aerogenerators and wind-solar hybrid systems are useful for meeting water pumping and small power requirements.

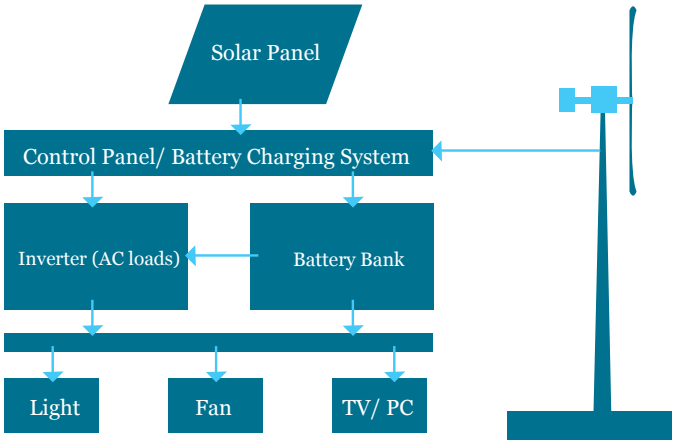
A hybrid system combines a wind turbine with solar PV technologies. An aerogenerator is a small wind electric generator having a capacity of up to 100kW.[58] Aerogenerators are either installed in standalone mode or along with solar PV systems to form a wind-solar hybrid for decentralized power generation.

Hybridizing solar and wind power sources together with storage batteries covers the period of time without sun or wind, hence providing a practical option for power generation. The system creates a stand-alone energy source that is both dependable and consistent.[59]

Technology Description

Technology Description of Wind-Solar Hybrid Systems

The hybrid solar wind turbine generator uses solar panels that collect light and convert it into energy along with wind turbines that collect energy from the wind. Solar wind composite power inverter contains the required DC to AC transformer to supply charge to batteries from AC generators. Hence, the power from the solar panels and wind turbine is stored in the battery bank.



Technology Description of Aerogenerators

The small wind turbines comprises the following components: a propeller (also termed as windmill) made out of aerodynamically shaped rotating blades mounted on a shaft, an alternator or generator for producing electricity when the shaft is rotated, a tail or vane at the back of the wind turbine, which is used to steer it into or out of the wind automatically and a well-anchored, robust and tall tower for mounting the propeller blades along with the alternator/generator and tail.

The windmill extracts energy from the moving air by slowing down the wind, and transferring this harvested energy into a spinning shaft, which usually turns an alternator or generator to produce electricity. The power available in the wind that can be harvested depends on two factors, i.e., wind speed and the area swept by the propeller blades.[60]

Space Requirement

- The site should be free from obstacles like tall trees, high buildings, electric transmission lines etc., within the radius of about 100 metres.
- Wind and solar resources should preferably be complementary.
- The foundations should be designed and constructed taking into consideration the soil bearing capacity of the site.
- Wind solar hybrid system may be installed in areas having annual average wind speed of about 15kmph (4.17m/s) at 20m height.[61]
- The wind component of the hybrid system has to be at least 60 per cent of the total capacity. This generates a maximum of 5 units of usable energy per day. During monsoons, when solar energy is practically zero, the energy from wind offsets the shortfall to a great extent.[62]

Benefits

- Power generated by wind and solar energy is stored in the battery bank for future use.
- Since two sources of energy are being utilized, the reliability of the system is more.
- Both the windmill and solar panel need not be located adjacent to one another. Either of the systems can be situated in the most appropriate location.[63]
- Wind turbines need only periodic service (rotational inspection and lubrication of moving parts), while solar panels require very little maintenance (cleaning when necessary).[64]

Associated Limitations

- Hybrid solutions are not feasible in non-windy locations. Besides, hybrid solar-wind solutions are mainly applied to electricity production. In applications such as water heating (where solar is widely used), hybrid solutions do not come into direct use.[65]
- The initial investment in case of hybrid systems is higher.

Cost of the Technology

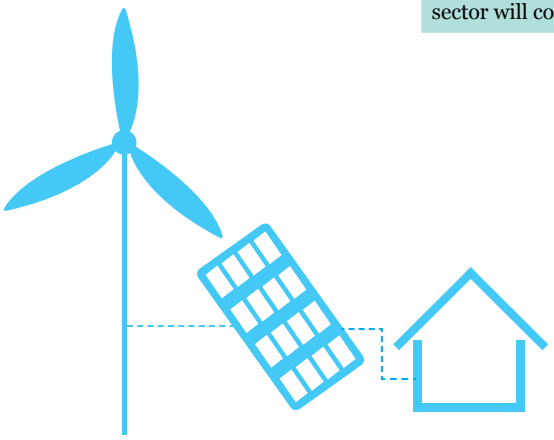
The cost of the wind-solar hybrid system varies from Rs 1.50 lakh to Rs 2 lakh per kW depending on the ratio of wind and solar components. The approximate cost of the installation, including civil works, is about Rs 20,000–30,000 per kW. Repair and maintenance cost is about Rs 3,000 per kW per annum.[66]

Aerogenerators cost about Rs 1-1.25 lakh per kW. In addition, the cost of installation including civil works is estimated at Rs 10,000–15,000 per kW. The repair and maintenance cost is about Rs 2,000 per kW per annum.[67]

Applicable Subsidy

(a) MNRE support for aerogenerators/wind-solar hybrid systems is provided on per kW basis. The subsidy is on the basis of type of users. Following two slabs of CFA will be available:

Govt./ Public/ Charitable, R&D, academic and other non-profit making institutions.	Rs 1.50 lakh per kW
Other beneficiaries not covered above (Individuals and private/ corporate sector will come under the category).	Rs 1.00 lakh per kW



(b) The remaining cost of the system and all other expenditure related to packing & forwarding, transportation, installation and commissioning is part of the system and is met by the beneficiary.

(c) In case of installation of the system to be done through State Nodal Agencies (SNAs), an administrative charge of 2 per cent of CFA is provided to SNAs at the time of final release.[68]

Potential Users

Individuals, organizations and people residing in residential units/ complexes.

Manufacturers/ Suppliers

See Annexure III.

IMPROVED BIOMASS COOK STOVE

Definition

Improved biomass cook stoves are fundamentally a combustion apparatus which burn biomass-based fuel more efficiently with reduced consumption of fuel and indoor emissions.

Improved biomass cook stoves are able to deliver higher thermal efficiency (due to better heat generation, transfer and reduced wastage of heat to the ambient environment) compared to traditional cook stoves or chullas due to design improvements.

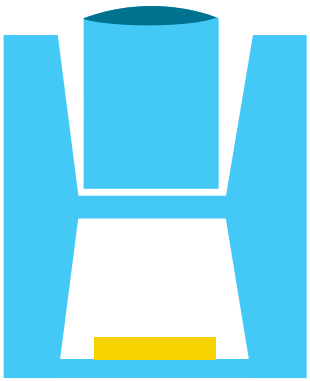
Technology Description

As per MNRE classification, biomass cook stoves are classified as fixed type and portable type based on their portability.[69] Also, based on air delivery mechanism, portable biomass cookstoves can be further classified into two types: natural draft and forced draft cookstoves.[70]

Comparatively, thermal efficiency and heat output rating of forced draft improved biomass cookstoves is more than to the natural draft cookstoves. Forced draft gives higher performance due to better air inlet control resulting in improved air fuel ratio and increased flame temperature that facilitate complete combustion and decreased emissions.[71]

Presently, improved biomass cook stoves are being used at the domestic level as well as for community cooking. The fuel used in these stoves can be traditional biomass or processed biomass pellets/briquettes.

In India, as per MNRE guidelines, the thermal efficiency of natural draft type Portable (Metallic) Solid Biomass Chulha is more than 25 per cent[72] and it ranges between 35 to 40 per cent for the forced draft cookstoves.[73]



Benefits

- Using improved cook stoves with greater fuel combustion efficiency can reduce the emissions of PICs (products of incomplete combustion) including nitrous oxide (N_2O), carbon monoxide (CO) and black carbon, with a high global warming potential (GWP).[74]
- Biomass fuel supply chain also provides farmers with additional income and locals with job opportunities, such as in pellet manufacturing, biomass transportation etc.
- Negative health impacts on women and children due to indoor air pollution are reduced.
- Fuel and time savings due to reduced fuel wood requirement.

Associated Limitations

- Supply and distribution chain is a barrier to penetration, widespread acceptability and scaling up of improved cookstoves.
- Uncertainties pertaining to the system (especially related to post-sale servicing and maintenance of stoves).
- Availability of cheaper alternative stoves and fuel.
- Financial constraints in terms of higher upfront cost.
- Lack of user awareness.

Cost of the Technology

Single pot cook stove costs around Rs 2,000 and double pot cook stove around Rs 4,000.

Applicable Subsidy

The support from MNRE under the National Biomass Cookstoves Programme (NBCP) will be limited to 50 per cent of the cost of cookstoves with ceiling of Rs 400 per cookstove for natural draft type and Rs 800 for forced draft type cookstoves for the year 2013–15.

The support from MNRE under the NBCP will be limited to 40 per cent of the cost of cookstoves with ceiling of Rs 300 per cookstove for natural draft type and Rs 600 for forced draft type cookstoves for the year 2015–17.

Similarly, the support in the case of larger size cookstoves, the support will be limited to 50 per cent of the cost of the cookstove with ceiling of Rs 2,500 per cookstove for natural draft type and Rs 5,000 for forced draft type community cookstoves for the year 2013–15 and 50 per cent of the cost of the cookstoves with ceiling of Rs 200 per cookstove for natural draft type and Rs 4,000 for forced draft type community cookstoves for the year 2015–17.[75]

Application Market/Potential and Current Status

Based on the study done by Global Alliance for Clean Cook Stoves, the overall market size in India is approx 235 million households.[76]

According to estimates of the Global Alliance for Clean Cook Stoves, as of July 2013, around 0.25 per cent of the total Indian households were using an improved cook stove.[77]

Potential Users

Individuals, communities and institutions.

Manufacturers/ Suppliers

See Annexure III.

BIOGAS PLANT

Definition

Biogas is a clean and efficient fuel, containing about 65 per cent methane, 34 per cent carbon dioxide and traces of other gases, such as hydrogen sulphide and ammonia. Biogas digester takes organic material such as animal dung and kitchen waste into an air-tight tank, where bacteria break down the material and produce biogas. The biogas can be burned as a fuel, for cooking and the solid residue can be used as organic compost.

It can also be used for other purposes like power generation and transportation (using biogas engines and compressed biogas).

Different types of biogas plant have been officially recognised by the MNRE. These include:[78]

1. **Fixed Dome Biogas Plants:**
   - i) Deenbandhu fixed dome model with brick masonry construction.
   - ii) Deenbandhu ferro-cement model with in-situ technique.
   - iii) Prefabricated RCC fixed dome model.
2. **Floating Dome Design Biogas Plants:**
   - i) KVIC floating steel metal dome with brick masonry digester.
   - ii) KVIC floating type plant with ferro-cement digester and FRP gas holder.
   - iii) Pragati Model Biogas Plants.
3. **Prefabricated Model Biogas Plants:**
   - i) Prefabricated Reinforced Cement Concrete (RCC) digester with KVIC floating drum.
4. **Bag Type Biogas Plants (flexi model).**[79]

Technology Description

A basic biogas digester consists of a tank in which the organic material is digested, combined with a system to collect and store the biogas produced. The digesters can be quite simple, and the details vary depending on available materials and the needs of the community. As biogas is produced, the inner tank fills with gas and rises, telescoping out of the outer tank. As biogas is removed for use, the inner gas storage tank sinks back into the larger outer tank. In this system, the

inner tank act both as storage, and as a lid for the digester tank. The gap between the tank walls is narrow enough to prevent significant quantities of oxygen from entering the digester, which would kill the anaerobic bacteria that produce the methane. The amount of biogas lost though the gap is negligible.[80]

Benefits

- Regular usage of 1m^3 of biogas for cooking every day can roughly save 1.25 tonnes of fuelwood per year.
- Biogas plant also contributes to reducing indoor air pollution and health impacts associated with it.
- O&M of the plant also provides employment to the local technicians. Installation of one 2m^3 biogas plant (brick masonry construction) generates about 30 man days of employment for skilled, semi-skilled and unskilled workers.

Associated Limitations

- High initial investment cost of installing a biogas plant.
- Raw materials (cow dung) are not consistently available locally.
- Low performance in winter season and in low temperature areas.

Cost of the Technology

1m^3 family-sized biogas plant costs Rs 12,080. A 2m^3 biogas plant costs around Rs 20,000–25,000 and MNRE provides subsidy in the range of Rs 8,000–14,700 depending on the location.[81] Also based on conservative estimates, a typical 1,000m^3 Biogas-Fertilizer Plants (BGFP) requires a total investment of Rs 15 million. With the annual income generation from biogas and organic slurry, the plant can fully recover the cost within three years.[82]

Applicable Subsidy

The central subsidy is given in fixed amounts for different categories of areas/ states/ regions. It varies from Rs 4,000 to Rs 8,000 as per the general category states and Rs 14,700 per plant for North Eastern states including Sikkim, but excluding plain areas of Assam.

Cost Analysis

A 1m^3 family sized plant provides 24 metric tonnes per year of organic fertilizer and generates biogas equivalent to 126kg of LPG. The simple payback period for the original investment is around two years.

For large scale biogas plants used at commercial level, such as for a typical 1,000m^3 BGFP, a total investment of Rs 15 million is required. The plant can fully recover the cost within three years.[83]

Application Market/ Potential and Current Status in India

A total of 4.54 million family type biogas plants have been installed in India till 31 March 2013,[84] and under Twelfth Plan, nearly 0.7 million biogas plants are to be installed.[85]

Potential Users

Users of residential complexes, and commercial and industrial units.

Manufacturers/Suppliers

See Annexure III.

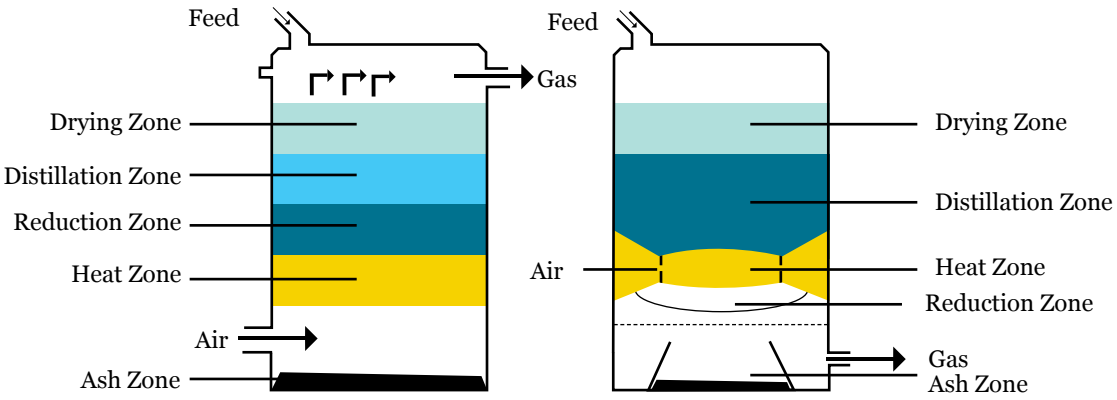
BIOMASS GASIFIER

Definition

Biomass gasifier is a device that converts solid biomass fuel into convenient-to-use gaseous fuel (commonly called producer gas) by a series of thermo-chemical processes (called gasification) in a closed reactor. Gasification is a thermo-chemical process that converts organic or fossil-based carbonaceous materials into mixture of combustible gases such as carbon monoxide, hydrogen, methane and carbon dioxide. This is normally achieved by using air as gasifying agent, reacting material at high temperatures of 700–900°C, under reducing environment, with a controlled amount of oxygen (sometimes steam is also used along with air during gasification to increase hydrogen content in the gas). The resultant combustible gas mixture produced is called producer gas, which in turn can be used as a fuel either for process heat applications or for generating power using gas engines. If the biomass used in the gasifier is from sustainable resource (such as agro-residue by product or energy plantation), the energy derived through gasification and combustion of the resultant gas is considered to be a source of renewable energy.

Remote, non-accessible villages where laying of transmission lines is not economical and where sufficient biomass is available locally, electrification can be made possible through biomass gasifier based power generation systems.

Typically, 1kg of biomass produces 2.5–3Nm^3 of producer gas having calorific value of 1,000–2,000kcal/Nm^3 and approximately 1–1.5kg of biomass can produce 1 unit of electricity. In case of thermal application, approximately 3–4kg of biomass is required to obtain equivalent thermal energy generated from 1kg of furnace oil or diesel.



Updraft Gasifier

In an updraft gasifier, the biomass moves downwards from the top of the gasifier. The producer gas being light moves upwards within the gasifier, hence it is also called a counter-current gasifier (see above figure). An updraft gasifier has distinctly defined zones for partial combustion, reduction and distillation/ devolatilization. The gas produced in the reduction zone leaves the gasifier reactor together with the pyrolysis products and the steam from the drying zone. The resulting combustible producer gas is rich in hydrocarbons (tars) and, therefore, has a relatively higher calorific value. Therefore, the updraft gasifier is more suitable for thermal applications, such as direct heating in industrial furnaces, as it gives higher operating thermal efficiency. As a special case it can also be used under natural draft mode without need of blower, for application where electricity is not available and the need of constant heat input rates. If it is to be used for electricity generation by internal combustion engines, it has to be cleaned thoroughly.

Downdraft Gasifier

This is the most common gasifier, also known as co-current gasifier, as here the biomass moves down from the top of the gasifier and the resultant producer gas also moves downward within the gasifier (see above figure). The gas quality is relatively much better since producer gas passes through a hot charcoal bed under reducing atmosphere resulting in tar cracking and so is preferred for engine applications.[86]

Technology Description

A biomass gasifier for heat application is simple in construction. It consists of a biomass gasifier, a blower, and a burner with a furnace. The producer gas released from the gasifier can be efficiently used with a good degree of control to meet heat demands in ovens/burners, boilers or kilns for thermal applications.

A biomass gasifier based power system consists of the following components: gasifier, heat exchanger, cyclone, venturi scrubber, chillers, fabric filter, paper filter and engine.

Benefits

- Provides clean products of combustion during thermal applications and reliable power for rural electrification and captive power backup (institutional/industrial) use.
- The technology provides compact burning equipment and a good degree of control and is available in a wide range of capacities.
- Biomass gasifier yields high thermal efficiency and provides energy security.

- It also generates local employment in rural sector.
- Gasifier systems offer definite economic advantages in locations where biomass is already available at reasonably low prices (e.g., rice mills) or in industries using fuel wood.
- Biomass gasification technology is also environment friendly, because of the fossil fuel savings through use of renewable biomass, which is CO_2 neutral (as unlike fossil fuels like diesel, biomass does not result in net CO_2 emissions if harvested sustainably).

Associated Limitations

- The gasification process is quite complex and sensitive.
- Fuel is bulky and frequent refuelling is often required for continuous running of the system.
- Handling residues such as ash, tarry condensates is time consuming.

Cost of the Technology

The approximate cost of a biomass gasifier for thermal application is Rs 30,000/kW and for electricity generation the cost is Rs 1–1.5 lakh/kW.[87]

Applicable Subsidy

Central Financial Assistance for off- grid power programme for rural areas and biomass gasifier based grid connected power programme:

- Rs 15,000 per kW for distributed/off grid power projects in rural areas and grid connected power projects with 100 per cent producer gas engines or biomass based combustion projects.
- Rs 1.50 lakh per 50kW for ensuring regular availability of biomass, provision of collection, processing and storage and operation & maintenance including compulsory AMC for five years after the guarantee period.
- Financial support limited to a maximum of 3km, i.e., Rs 3 lakh per project (@ Rs 1 lakh per km) for support towards lighting devices and distribution network.

Central Financial Assistance in the form of capital subsidy to biomass gasifier projects in industries.

- Central finance assistance in form of capital subsidy is provided for biomass gasifiers for thermal and electrical applications which are: Rs 2 lakh/300kWth for thermal applications; Rs 2.5 lakh/100kWe for electrical applications through dual fuel engines; Rs 10

lakh/100kWe for 100 per cent producer gas engines with gasifier system and Rs 8 lakh/100kWe for 100 per cent producer gas engine alone.

- Capital subsidy for deployment of biomass gasifiers with 100 per cent producer gas engines in institutions for captive use is Rs 15 lakh/100kWe for 100 per cent producer gas engines with gasifier system and Rs 10 lakh/100kWe for 100 per cent producer gas engines alone.
- Incentives/service charges at the rate of Rs 1 lakh/MWe (or its equivalent) would be provided to SNAs on pro-rata basis, subject to a ceiling of Rs 5 lakh per project, for their active involvement in promoting biomass power projects.
- CFA would be limited to a maximum capacity of 5MW, irrespective of the installed capacity of the project. In case of Special Category States,[88] 20 per cent higher capital subsidy than that of the General Category States would be provided.[89]

Cost Analysis

The investment cost for biomass-based power generation is Rs 44.5 million/MW.[90] The O&M cost of this is about 6 per cent of the investment cost.[91]

Application Market/ Potential and Current Status in India

In India, more than 2,000MW power is established from biomass resources. Projects of up to 800MW are under implementation, with 100MW installed for thermal applications in industries.[92]

Potential Users

Users of residential complexes, and commercial and industrial units.

Manufacturers/ Suppliers

See Annexure III.

GEOTHERMAL COOLING SYSTEM

Definition

Conventional air-conditioning expels building heat into the atmosphere using either an air-cooled or water-cooled heat exchanger pump. The outside temperature heavily influences the efficiencies of the air-conditioning systems, because under high external temperatures, air conditioning efficiency decreases and vice versa.[93] Alternatively, a geothermal cooling system uses the earth as a heat sink instead of outside atmosphere. The earth temperatures are lower than atmospheric temperatures thereby increasing the efficiency of the geothermal heat sink system.[94]

Technology Description

A geothermal cooling system works on the principle that the earth temperature remains constant at certain depth and thus is used as a heat sink to absorb heat from above ground structures. Geothermal cooling technology uses this principle to build a geothermal interface to provide a constant temperature environment to the air-conditioning system. This reduces the work to be done by the compressor to provide cooling in the building as it is interfacing with a temperature zone that is much cooler than the ambient environment temperature, thereby saving electrical energy. This geothermal interface is created using geo sinks and these can measure around 6 to 8 inch in diameter and each geo sink could be designed for a capacity ranging from 10TR to 40TR.

A geothermal cooling system when coupled with traditional air-conditioning systems can enhance the system's efficiency by 50–70 per cent. For example, traditional air-conditioning equipment could consume 0.9–1.0 Input kW/TR (IkW/TR) and this consumption can be reduced to 0.4–0.5IkW/TR when coupled with the geothermal system.[95]

Benefits

- Improvement in efficiency of the air-conditioning system by 50–70 per cent thereby reducing the operational costs.[96]
- Since they do not need additional space for installing, it reduces the need for space/land.
- Significant GHG emission reduction, i.e., a typical 1TR geothermal cooling system can mitigate 1.6tCO_2 eq. per year.[97]

Associated Limitations

- Lack of skilled manpower or professionals.
- Lack of an organized technology ecosystem.
- Limited demonstration and replication projects.
- Higher initial investment costs.
- Limited avenue for finance accessibility.
- Public perception of geothermal cooling being a complex and auxiliary system.

Cost of the Technology

The cost of the system would depend on system size and geological conditions of the project site like soil-heat capacity and moisture content etc.[98] However, the indicative cost of an 200TR capacity system installed at Apollo Cancer Hospital, Hyderabad is INR 1.7 crore.

Applicable Subsidy

No subsidy available.

Cost Analysis

A geothermal system coupled with conventional system (costing Rs 50,000–1,00,000/TR), would have an additional cost in the range of Rs 35,000–60,000/TR.

Typically, savings per annum range from Rs 40,000–70,000 per TR making the payback in the range of six to eighteen months.[99]

Application Market/Potential and Current Status

At present, few installations have been done in India such as at ISB Mohali by GIBSS and Apollo hospitals in Chennai and Hyderabad by Geothermal India.[100] However, considering the increasing cooling demand in the building sector, geothermal cooling systems have good potential in India.

Potential Users

Users of commercial buildings and the industrial sector.

Manufacturers / Suppliers

See Annexure III.

CASE STUDIES

SUCCESS STORIES OF SOME APPLICATIONS FROM ACROSS INDIA

Solar PV Rooftop Programme in Gandhinagar, Gujarat

To promote rooftop solar system installations in the state, the government of Gujarat initiated the Gandhinagar (Solar) Photovoltaic Rooftop Programme. The programme aims at installation of 5MW (4MW on government offices and 1MW on private home rooftops) of solar rooftop systems in Gandhinagar on a Public-Private Partnership (PPP) model. This 5MW rooftop system has a potential to reduce around 6,000 tonnes of CO_2 eq per year. Under the aegis of this programme, two project developers, viz., Azure Power and SunEdison were selected for 2.5MW capacities each. As of now, 312 installations with a cumulative capacity of 4,688kWp have been executed.[101] The 2.5MW capacity system to be executed by Azure Power has been awarded the FIT (Feed-In Tariff) of Rs 11.21 and is likely to generate 4.61 million units per year.[102]

Solar Cooking System at Shirdi, Maharashtra

A solar steam cooking system was commissioned in July 2009 at Sri Saibaba Sansthan Trust at Shirdi, a popular pilgrimage shrine in Maharashtra. This system cooks food for pilgrims twice a day and caters to about 20,000 people per day. The system comprises 73 fixed focus single axis automatically tracked elliptical dishes, each of 16m^2 area, that generates about 3,500kg steam per day. The Sansthan has been involved in the development and installation of the system from the design stage. A saving of around 263kg of LPG/day (18–20 cylinders) has been reported by the Shirdi Sansthan on a clear sunny day. This system has been reported as the world's largest solar system for cooking.[103]

Solar Water Pumps in Nalanda, Bihar

In order to convert existing diesel pump operated bore wells into solar water pumps, the Minor Water Resources Department of Bihar launched an initiative in 2012 to operate 34 existing tube wells in 20 villages of Nalanda district in Bihar with solar power. The systems were commissioned by Claro Energy Pvt Ltd with 7.5HP pumps (discharge capacity of 70,000 litres per hour) and an 8.5kWp solar system (six arrays with six panels of 235W capacity). The cost of a 7.5HP solar water

pump was around Rs 12,50,000 and with government subsidy, the simple payback period is less than 4 years. These 34 solar water pumps have the potential to reduce around 511 tonnes of CO_2 emission per annum and at the same time, have created over 45 direct and 80 indirect jobs in the region.

Wind Solar Hybrid System at Vagator Beach, Goa

One notable project is a 5kW capacity wind-solar hybrid system installed on Vagator beach in Goa, which has become a destination point for tourists. The system illuminates 60 CFLs (compact fluorescent lamps) of 18W rating each. These CFLs are the only source of illumination on the beach.[104]

Aerogenerator at Manashakti Research Centre, Lonawala, Maharashtra

A number of aerogenerators have been installed by the Maharashtra Energy Development Agency(MEDA), and are working satisfactorily. An aerogenerator of 3.2kW capacity, installed at the Manashakti Research Centre, Lonawala, is supplying electricity to illuminate 22 streetlights on the road connecting the centre's hostel to the highway. The aerogenerator is visible from the Mumbai-Pune highway.[105]

Biogas Plant at Wipro, Bangalore, Karnataka

A 50m^3 biogas plant was installed at the Wipro corporate office in Bangalore in 2010 with technical support from the Nuclear Agriculture and Bio-technology Division (NA&BD) of BARC (Bhabha Atomic Research Centre). The gas can cook 1,000–1,500 meals per day or alternatively can generate electricity of 32MWh per annum. Prior to the installation, food wastage in the canteen was estimated at 600–1,000kg per day. The gas produced by the installed plant is now used by four burners to cook food continuously for five hours in the canteen that helps in saving three LPG cylinders per day. The installation has also resulted in GHG reduction of about 50–65 tonnes per annum.[106]

SUCCESS STORIES FROM WWF'S CLIMATE SOLVER AWARDEES

Aspiration Energy – Climate Solver Awardee 2013 under GHG Reduction

Solar Water Heating System

Aspiration Energy, a Solar Energy Services Company based in Chennai, has installed a rooftop 630kWth Capacity Evacuated Tube Collector (ETC) based Solar Thermal System in the factory premises of Wheels India Ltd, Chennai. The system involves a total of 105 ETC modules (each ETC module having 6kW thermal rating capacity with 13m^2 aperture area). Aspiration Energy has made use of solar collectors that were fitted on trussed factory rooftops, the space that would otherwise be unused and wasted. The system provides hot water with temperatures more than 100°C for their components' wash and coat application. Prior to the installation of Aspiration's system, furnace oil based thermopack (thermic fluid heater - 200°C) was used for heating the solutions to the required temperature. The system has been able to save 48,60,000 litres of fuel oil per year, resulting in annual carbon abatement of 280 tonnes. The project cost was about Rs 1.65 crore and along with fuel savings, the simple payback period for this system is 1.3 years.

Clique Developments Ltd – Climate Solver Awardee 2013 under GHG Reduction

Solar Air-Conditioning System

Clique Developments Ltd, a Mumbai based solar thermal technology provider, installed a 50TR solar air-conditioning system at NTPC Energy Technology Research Alliance (NETRA), Greater Noida in 2012. The solar air-conditioning system installed at NETRA consists of two ARUN 160 solar concentrator dishes. The system provides dry saturated steam at 180°C to a 50TR (i.e., about 175kW of cooling) double effect Vapour Absorption Machine. Steam from ARUN dish is supplied at 8 bar pressure. Cold storage tank with 500m^3 capacity has been installed to store up chilled water for two days of chilling. The cost of the solar component for this system was Rs 1.4 crores and the simple payback period is around 8-10 yrs.

Envirofit India Pvt Ltd – Climate Solver Awardee 2013 under Energy Access

Improved Biomass Cook Stoves

Envirofit India Pvt Ltd has developed and disseminated more than 4,00,000 improved biomass cook stoves across communities in India, Nepal and Bhutan through multiple retail and non-retail distribution channels since 2008.

The cook stoves, with their higher efficiency, address issues of fuel wood consumption, indoor air pollution and greenhouse gas (GHG) emissions, providing a clean and affordable cooking option for rural households. The improved cook stoves use the Enviroflame Combustion Technology which helps in retaining the heat and also directing most of it towards the pot. In addition, insulation between the inner chamber and outer body of the cook stoves reduces the wastage of heat. Through the use of these cook stoves, there has been reduction in smoke and toxic emissions up to 80 per cent, fuel wood consumption up to 60 per cent and cooking time up to 50 per cent.

Green India Building Systems & Services (GIBSS) Pvt Ltd – Climate Solver Awardee 2012 under GHG Reduction

Geothermal Cooling System

Geothermal cooling system was installed by Green India Building Systems & Services (GIBSS) Pvt Ltd at the Mohali Campus of Indian School of Business, a premier business and management institute in India. The system has a capacity of 234TR out of the total air-conditioning capacity of 900TR. The system design uses production and diffusion sinks involving 12 geo sinks, each having diameters of eight inch, spread across three different parts of the facility. In comparison to the already installed conventional air-conditioning system, GIBSS' geothermal system is able to deliver three types of savings at the campus, i.e., energy savings (181MWh per year) as a result of lower condenser water temperature, water savings by avoiding the water loss due to evaporation and chemical savings by avoiding the usage of hazardous chemicals which are otherwise required for treating the cooling towers. The payback period for this system is 2.25 years.

ANNEXURE I

List of Solar PV System and Solar Lighting Systems manufacturers:

- List of Manufacturers empanelled under "Capital Subsidy Scheme" implemented through NABARD as on 13 March 2014–http://mnre.gov.in/file-manager/UserFiles/list_manufacturers_SPV_NABARD-part-I.pdf.
- List of Manufacturers empanelled under "Capital Subsidy Scheme" implemented through NABARD as on 20 March 2014–http://mnre.gov.in/file-manager/UserFiles/list_manufacturers_SPV_NABARD-part-II.pdf.
- List of channel partners accredited by MNRE for "Off-Grid and Decentralized Solar Applications under JNNSM" as on 11 March 2014 (Not for NABARD programme); Solar Photovoltaic-System Integrator–http://mnre.gov.in/file-manager/UserFiles/list_channelpartners_sp_jnnsm.pdf.
- List of channel partners accredited by MNRE for "Off-Grid and Decentralized Solar Applications under JNNSM" as on 11 March 2014. The listed Channel Partners are not eligible for direct access of CFA from MNRE but they are on equivalence with other channel partners to participate in any tenders–http://mnre.gov.in/file-manager/UserFiles/list_channelpartners_sp_jnnsm-not-eligible-for-cfa.pdf.

List of Solar Inverters manufacturers:

- Battery and inverter manufacturers empanelled by MNRE under "Off-Grid and Decentralized Solar Applications" as on 4 April 2014–http://mnre.gov.in/file-manager/UserFiles/Empanelment-of-Battery-and-Inverter-offgrid-decentralized-solar.pdf.
- Battery and inverter manufacturers empanelled by MNRE under "Off-Grid and Decentralized Solar Applications" as on 4 April 2014–http://mnre.gov.in/file-manager/UserFiles/Additional-list-of-empaneled-%20Battery-and-Inverter-manufacturers.pdf.

ANNEXURE II

1. State-wise & district-wise list of functional Akshay Urja/ Aditya Solar Shops in India–http://mnre.gov.in/file-manager/UserFiles/urjashops.pdf.
2. State Governments accredited Channel Partners for Solar PV System and Solar Lighting Systems.

- **Andhra Pradesh**
  - List of registered SPV System Suppliers for Seemandhra/Andhra Pradesh Districts–http://nedcap.gov.in/PDFs/SPV_SYSTEMS_SUPPLIERS_AP_as_on_06_08_2014.pdf.
  - List of empanelled suppliers for 1 kWp grid connected solar roof top PV system–http://nedcap.gov.in/PDFs/Solar_Net_Metring/List_of_empannelled_suppliers_09_04_2014.pdf.
- **Gujarat, Karnataka, Kerala and Punjab**
  - Gujarat, Karnataka, Kerala and Punjab governments recognize the channel partners of MNRE that are not empanelled under the NABARD scheme–http://mnre.gov.in/file-manager/UserFiles/list_channelpartners_sp_jnnsm.pdf.
  - In addition to the above list, Kerala government lists down the following channel partners for its 10,000 Rooftop Scheme–http://anert.gov.in/images/stories/spvprogramme/2012-13/updated%20list%20of%20empanelled%20agencies17032014.pdf.
- **Tamil Nadu**
  - List of vendors empanelled with Tamil Nadu Government for SPV system–http://www.teda.in/pdf/manufacturer_list_new_2013.pdf.
  - List of vendors empanelled for the Chief Minister's Solar Rooftop Capital Incentive Scheme–http://www.teda.in/pdf/CIS_INSTALLERS.pdf.
- **Telangana**
  - List of registered SPV Systems Suppliers for Telangana Districts–http://nedcap.gov.in/PDFs/SPV_SYSTEMS_SUPPLIERS_TG_as_on_06_08_2014.pdf.
- **Uttarakhand**
  - List of manufacturers and suppliers of various solar systems: http://www.ureda.uk.gov.in/files/EC%20Reports/SRNotifiedEquipmentsUK.pdf.
- **West Bengal**
  - List of manufacturers of various solar systems–http://www.wbreda.org/all-manufacturing-list/.

ANNEXURE III

1. List of BIS certified box type solar cookers & other known box type solar cooker manufacturers–http://mnre.gov.in/file-manager/UserFiles/list_solar_box_cooker_manufacturer.htm.
2. List of Manufacturers of Evacuated Tube Collector Based Solar Water Heating Systems–http://mnre.gov.in/file-manager/UserFiles/list_etc_m.pdf.
3. List of Manufacturers of Solar Air-Conditioners:
   - Sharada Inventions, SuryaShakti Pvt Ltd
   - Arka technologies, First Esco (India) Pvt Ltd
   - VSM Solar Pvt Ltd
   - Thermax Ltd
   - Clique Solar
   - Mamta Energy
   - Energetic Consulting Pvt Ltd
   - SLT Energy Ltd
   - Taylormade Solar Solutions (TSS) Pvt Ltd
4. List of Manufacturers of Solar PV Water Pumps–http://mnre.gov.in/file-manager/UserFiles/sec-manufacturer-spv-water-pumping-system.pdf.

   List of empanelled manufacturers for solar pumping programme to be implemented through NABARD–http://mnre.gov.in/file-manager/UserFiles/manufactures_nabard_pump.pdf.
5. Manufacturers of Aerogenerators–http://goo.gl/GJwm0H.
6. Manufacturers of Wind-Solar hybrid system and aerogenerators–http://goo.gl/sVsyb1.
7. List of Manufacturers of various types of Improved Biomass Cook Stoves (ICS): Basic ICS: Appropriate Rural Technology Institute (ARTI), Pune; Sustaintech, Madurai; Vikram Stoves, Osmanabad, TARA, New Delhi.

   Intermediate ICS: Envirofit India, Pune; Greenway Grameen Infra, Mumbai; Prakti, Puducherry.

   Advanced ICS: Servals, Biolite, Philips, First Energy, Technology Informatics Design Endeavour (TIDE), Nishant Bioenergy.

   List & details of other ICS manufacturers–http://mnre.gov.in/file-manager/UserFiles/improvedbiomass_cookstoves_manu.htm.
8. List of Biogas Plant Manufacturers: Installation of biogas plants can be done by State Nodal Departments / State Nodal Agencies, Khadi and Village Industries Commission (KVIC) and Biogas Development and Training Centres (BDTCs), recognized and registered Biogas Turn Key

Workers (BTKW) / Rural or Renewable Energy Technicians (RETs), Self Help Groups (SHGs) and other experienced and recognized organizations having knowledge in the biogas technology development and implementation. List of Biogas Development & Training Institutes are available–http://www.mnre.gov.in/file-manager/dec-biogas/biogasscheme.pdf.

9. List of Biogas Gasifier Manufacturers–http://mnre.gov.in/file-manager/UserFiles/biomass_gasifier_manu.htm.
10. List of Geothermal Cooling System Manufacturers–Green India Building Systems & Services (GIBSS) Pvt Ltd, Mumbai; Geothermal India, Gurgaon, NCR.

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ABOUT WWF-INDIA

WWF-India is one of the largest conservation organizations in the country dealing with nature conservation, environment protection and development related issues. Established as a Charitable Trust in 1969, it has an experience of over four decades in the field. Its mission is to stop the degradation of the planet's natural environment, which it addresses through its work in biodiversity conservation and reduction of humanity's ecological footprint.

WWF-India works across different geographical regions in the country to implement focused conservation strategies on issues like conservation of key wildlife species, protection of habitats, management of rivers, wetlands and their ecosystems, climate change mitigation, enhancing energy access, sustainable livelihood alternatives for local communities, water and carbon footprint reduction in industries, and combating illegal wildlife trade. WWF-India is actively engaged in promoting renewable energy uptake, enabling energy access, demonstrating renewable energy projects in critical landscapes, and overall promoting clean energy solutions. WWF-India has been working on issues related to biodiversity conservation, sustainable livelihoods and governance, and climate change.

The Climate Change and Energy programme of WWF-India is working towards a climate resilient future for people, places and species that support pathways for sustainable and equitable economic growth. Low carbon development and renewable energy at scale are the thrust areas of climate change and energy programme.

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To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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