Role of Solar System Technology in Domestic and Agriculture work

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***Abstract* - Solar energy is genesis for all forms of energy. This energy can be made use of in two ways the thermal route i.e. using heat for drying, heating, cooking or generation of electricity or through the Photovoltaic route which converts solar energy in to electricity that can be used for a myriad purposes such as lighting, pumping and generation of electricity. With its pollution free nature, virtually inexhaustible supply and global distribution solar energy is very attractive energy resource. Solar energy is widely being adopted in residential, commercial and industrial sectors and it has huge potential to benefit the agriculture sector.**

***keywords* - Solar photovoltaic, Solar thermal, On-grid, Off-grid, Hybrid, Economy analysis**

1. Introduction

Solar energy is produced when sunlight strikes solar panels, which then turn solar power into usable electricity. This photovoltaic transformation is the way solar energy is generated. The process of creating power from sunlight starts with the biggest part of a solar installation i.e. the solar panels. A typical solar panel is made from either monocrystalline or polycrystalline silicon housed in a metal panel frame with a glass casing. When sunlight strikes the thin layer of silicon on the top of a solar panel, it knocks electrons off the silicon atoms. Electrons are negatively charged, which means they are attracted to one side of the silicon cell. This creates an electric current that is captured by the wiring in a solar panel. Known as the "photovoltaic effect", flowing electrons that have been knocked free by sunlight are the basis of the electricity generated from solar panels. The more sun that strikes your solar panels, the more electrons will be knocked free, so it is important to consider factors like shade and local cloud cover when designing a solar energy system. Different solar panels produce electricity at different rates depending on their efficiency and quality. High quality solar panels will often cost slightly more money up front, but in the long term will save you money because they produce electricity more efficiently.

Once loose electrons have been collected at individual panels, the resulting current is known as direct current, or DC. The electricity we use to power devices, charge electric vehicles and turn on our lights is alternating current or AC. Electricity generated by loose silicon electrons is DC electricity and needs to be converted to AC electricity for before we can use it. This conversion is done by important devices called inverters. Inverters can be configured as string inverters, micro inverters or power optimizers, but each setup performs the same general function of turning DC electricity to AC electricity. Once the electricity passes through inverters and is changed to AC electricity, it flows to your electric panel and meter. Finally, it can be dispersed throughout your home or into the electric grid.

India being a tropical country receives adequate solar radiation for 300 days, amounting to 3,000 hours of sunshine equivalent to over 5,000 trillion kWh. Almost all the regions receive 4-7 kWh of solar radiation per sq meters with about 2,300–3,200 sunshine hours/year, depending upon the location. Potential areas for setting up solar power plant can be analyzed using solar irradiation map of India [1],[2].

2. Solar Panel Technologies

The PV effect was observed as early as 1839 by Alexandre Edmund Becquerel, and was the subject of scientific inquiry through the early twentieth century. In 1954, Bell Labs in the U.S. introduced the first solar PV device that produced a useable amount of electricity and by 1958, solar cells were being used in a variety of small scale scientific and commercial applications. The energy crisis of the 1970s saw the beginning of major interest in using solar cells to produce electricity in homes and businesses but prohibitive prices, nearly 30 times higher than the current price, made large-scale applications impractical. Industry developments and research in the recent years made PV devices more feasible and a cycle of increasing production and decreasing costs began which continues even today [1],[2],[7].

Most solar panels available are made from crystalline silicon, but there are a few other types of solar panels that produce electricity from the sun.

(i) Cadmium Telluride (CdTe) Solar Panels

CdTe panels use a different material than silicon to produce electricity. While they don't have very high efficiency ratings, CdTe panels can capture energy at shorter wavelengths than silicon panels. Additionally, manufacturing costs are low [3].

(ii) Copper Gallium Indium Diselenide (CIGS) Solar Panels

With higher efficiencies than CdTe panels, CIGS panels are a promising panel option. Unfortunately, high production costs have prevented CIGS panels from making it to the mainstream. CIGS panels use a different, copper based material to generate electricity [4].

(iii) Organic Photovoltaic Cells (OPV)

Instead of using an inorganic material like silicon or copper, OPV cells use thin layers of organic vapor or solution to generate an electrical current from sunlight. OPV cells have yet to see widespread adoption due to both low efficiencies and short life spans when compared to other panel technologies. These solar technologies all fall under the umbrella of thin film panels and are a very small part of the overall solar market. This is mainly because they are not cost effective at this time. In the future these unique options may be the dominant solar technologies, but for now silicon panels dominate the industry [5].

3.Solar Photovoltaic Cells and Solar Thermal Power systems

3.1 Solar Photovoltaic Cells

Solar photovoltaic (SPV) cells convert solar radiation (sunlight) into electricity. A solar cell is a semi-conducting device made of silicon and/or other materials, which, when exposed to sunlight, generates electricity. Solar cells are connected in series and parallel combinations to form modules that provide the required power.

(i) Crystalline Silicon solar cells (C-Si): Monocrystalline and Polycrystalline

(ii) Thin-film solar cells: Amorphous Silicon Solar cells (A-Si), CIGS, CdTe

PV modules are manufactured by assembling the solar cells after stringing, tabbing and providing other interconnections [8],[9].

3.2 Solar Thermal

Solar Thermal Power systems, also known as Concentrating Solar Power systems, use concentrated solar radiation as a high temperature energy source to produce electricity using thermal route. High temperature solar energy collectors are basically of three types:

(i)Parabolic trough system: at the receiver can reach 400° C and produce steam for generating electricity.

(ii)Power tower system: The reflected rays of the sun are always aimed at the receiver, where temperatures well above 1000° C can be reached.

(iii)Parabolic dish systems: Parabolic dish systems can reach 1000° C at the receiver and achieve the highest efficiencies for converting solar energy to electricity [9],[10].

4. On Grid, Off Grid and Hydrid Solar System

4.1 Solar for grid connected electricity

Grid interactive solar energy is derived from solar photovoltaic cells and concentrated solar power (CSP) plants on a large scale. Figure: 1 shows setup of solar system for grid connected electricity. The grid connection is useful due to following reasons [6],[16].

(i)Solar Energy is available throughout the day which is the peak load demand time

(ii)Solar energy conversion equipments have longer life and need lesser maintenance and hence provide higher energy infrastructure security

(iii)Low running costs & grid tie-up capital returns to utility grid

(iv)Unlike conventional thermal power generation from coal, they do not cause pollution and generate clean power

(v)Abundance of free solar energy throughout all parts of world, which although gradually decreasing from equatorial, tropical, sub-tropical and polar regions. Can be utilized almost everywhere.

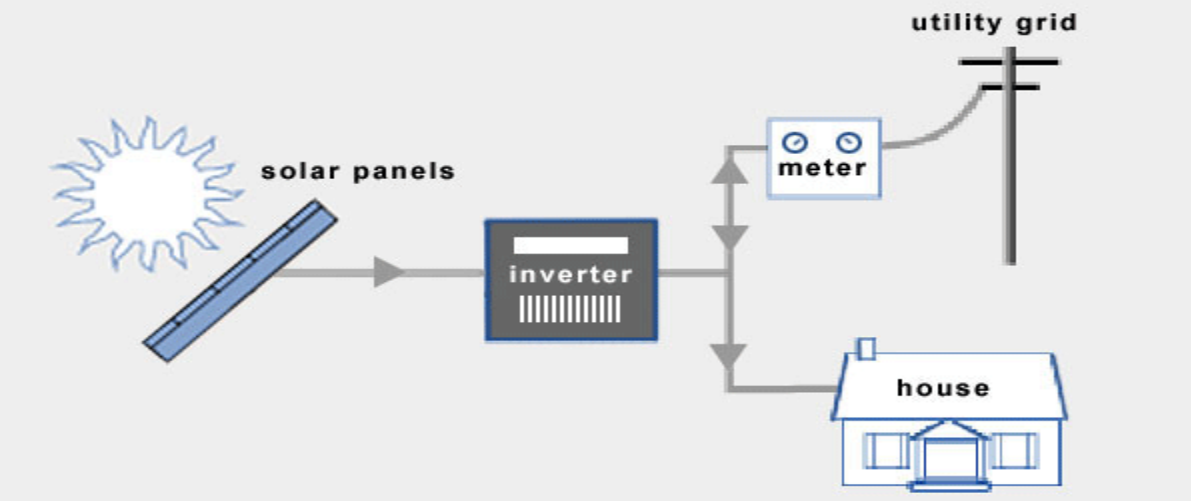

Figure: 1 Solar system for grid connected electricity

4.2 Solar for off-grid solutions

The areas with easier grid access are utilizing grid connectivity, the places where utility power is scant or too expensive to bring, have no choice but to opt for their own generation. They generate power from a diverse range of small local generators using fossil fuels likes diesel, gas and locally available renewable energy technologies like solar PV with its own storage. This is known as off-grid electricity. Figure: 2 shows setup of solar system for off grid connected electricity [6],[16]. Remote power systems are installed for the following reasons:

(i) Use renewable energy like solar for environmentally safe, pollution free
(ii)Combining various generating options available- hybrid power generation
(iii)Desire for independence from the unreliable, fault prone and interrupted grid connection
(iv)Available storage and back-up options
(v)No overhead wires- no transmission loss
(vi)Used for various purpose like Lighting, Communication Systems, Cooking, Heating, Pumping

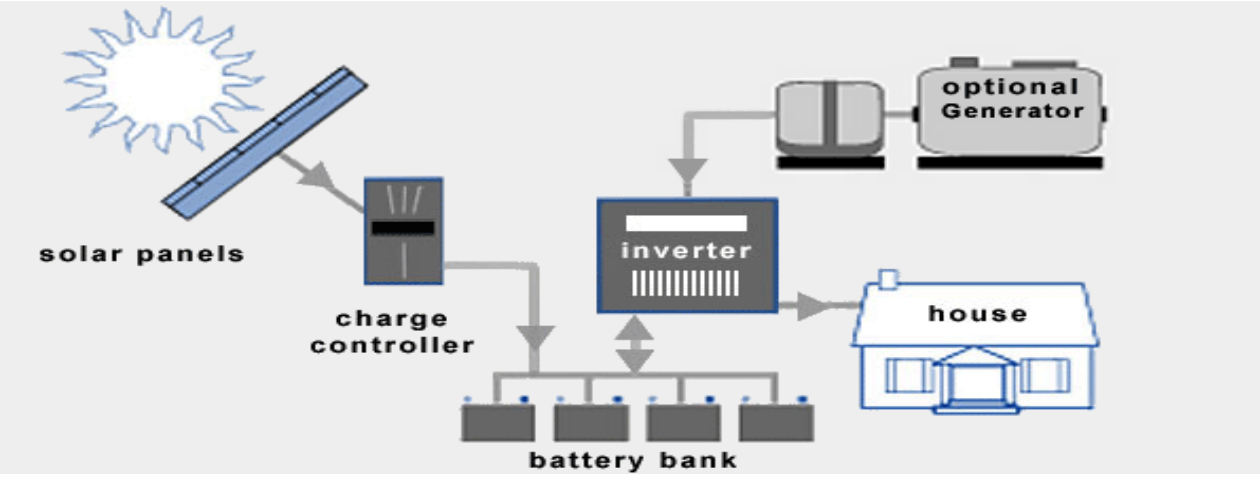

Figure: 2 Solar system for off grid connected electricity

4.3 Hydrid Solar System

Hybrid solar systems combine the best from grid-tied and off-grid solar systems. These systems can either be described as off-grid solar with utility backup power or grid-tied solar with extra battery storage. Figure: 3 shows hybrid solar system.

A hybrid solar power system is combination of on grid solar system and off grid solar system. It has battery backup in it to store power and it also have the ability to feed surplus electricity into main grid. It means that even during a power cut your system will work, you still have electricity. Hybrid system is a combination of solar energy storage with grid connection. This system provide the flexibility of being able to store the power into batteries that your solar system generated during the day time instead of feeding it back into electricity grid. The same energy can be used in the evening or night instead of buying from government grid at a higher price [6],[15].

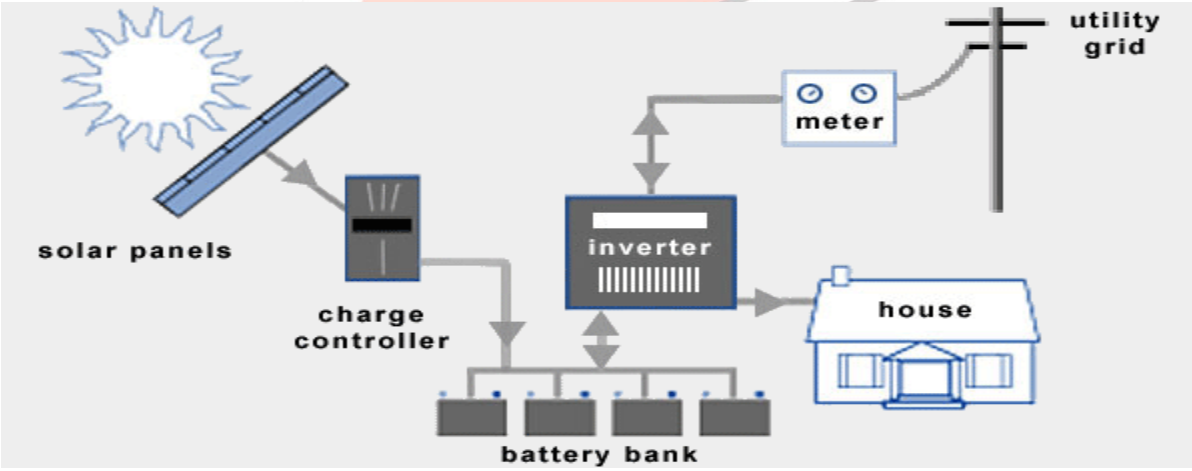

Figure: 3 Hybrid solar systems

5. Solar energy in domestic and agricultural work

About 700 million people in India live in households that cook every day with simple chulha using locally gathered biomass for fuel. This result in substantial air pollution estimated to be responsible for more than 25% of the country's outdoor air pollution. These exposures are estimate to result in the premature death of more than 8 lakh Indians each year, with the greatest risk for women and young children. In addition, gathering biomass fuel often requires many hours per week that could be put to more productive activities. LPG is commercially available but issues of affordability and distribution limit use in rural areas. It is possible to keep the chulha all time inside the kitchen for cooking purposes, similar to traditional commercially available cook stoves which work on LPG or other fuels. Solar chulha can provide solution for half of the world that cooks on biomass cook stoves and looking for affordable, accessible, appropriate and better cooking option. The solar chulha works on solar energy which is Non-polluting, renewable and free available energy. Alternate cooking technology to LPG. Can save precious money spent on buying LPG, kerosene from other countries. Woman can saves 3-5 hours a day from kitchen and fuel collection. Woman safety from going in to jungle to collect firewood. Smokeless cooking, save lives, healthy people, greener community places.

Due to cheapest, today solar energy is widely used in home kitchen, home electricity and agricultural related work [11],[12],[13]. Figure: 4 shows various solar based energy equipments.

(a)Solar Cooker

(b)Parabolic Solar Cooker

(c)Solar Induction Cooker

(d) Solar Water Pump

(e) Solar Water Pump

(f) Crop Harvesting

Figure: 4 Various solar energy based domestic and agricultural Equipments

6. Cost Benefit Analysis of Hybrid Solar System

Solar Hybrid System is an On-grid system with a battery connected to store Power. It combines Solar Modules, AC utility and battery power source to supply continuous power. This is suitable in case of situations where a user is using On-grid systems but facing a lot power cuts during night times. Using a Hybrid Solar PV system comes in handy during these times since there is battery backup to provide power in case of power cuts. Power generated from the Solar Panels is supplied to the load and in case of surplus power, it is stored in batteries. After the batteries are fully charged any excess power is supplied to the Grid. Similarly in case of power needed by the load and there is no solar power, if there is grid availability then power is supplied from the grid. In case of no grid power then power is taken from the charged batteries. The main feature of the inverter being its ability to feedback the excess generated power to the utility grid in case of no usage. This is not possible from a standard Off-Grid system.

Hybrid PV solar system price range starts from Rs.1.5 Lakh for 1 kW solar system to Rs. 12 Lakh for 20 kW solar system for home and business purpose in India. Following table: 1 shows the approximate price of hybrid solar system in India, year 2020 . Table: 2 shows 5 kW solar Hybrid system and Table: 3 shows 10 kW solar hybrid system setup requirements [14],[15],[16].

Table 1 : Hybrid Solar System approximate Price

Solar System Model	Selling Price	Price per watt
1kW Hybrid system	Rs. 1,50,000	Rs. 150
2kW Hybrid system	Rs.2,40,000	Rs. 120
3kW Hybrid system	Rs. 3,00,000	Rs. 100
5kW Hybrid system	Rs. 4,50,000	Rs. 90
10kW Hybrid system	Rs. 8,40,000	Rs. 84
15kW Hybrid system	Rs.9,50,000	Rs. 63
20kW Hybrid system	Rs. 12,00,000	Rs. 60

(i) 5kW Solar Hybrid System

A 5KW hybrid system can generate up to 20 units per day and 600 units per month as an average. You will get all its accessories along with it. Detailed description regarding 5 KW solar hybrid systems is mentioned below.

Table 2 : 5kW Solar Hybrid System requirement

Particular	Description
Solar System	5 kW
Solar Panel	335 watt
Solar Panel Qty.	15 Nos.

Hybrid Solar Inverter	5 kW
Solar Battery	8 Nos.
Space Required	30 squire meter
Solar Panel Structure	GI Chanel
Warranty	5 years for complete system
Delivery and installation	10 days from the date of payment
Price	**Rs. 4,50,000**

Recommended Load:
1.5 Ton AC + 12 Fan + 1 Computer + 35 LED Lights + 3 LED TV + 1 Refrigerator
Backup Time:
Approximate 4-6 Hours for 3500W Load.

(ii) 10kW Solar Hybrid System

The average power generating capacity of 10 KW solar hybrid system is 40 units per day and 1200 units per month. 10 KW solar system is best to run heavy load. The specifications of 10 KW hybrid solar system is given below.

Table 3 : 10 kW Solar Hybrid System requirement

Particular	**Description**
Solar System	10 kW
Solar Panel	335 watt
Panel Qty.	30 Nos.
Hybrid Solar Inverter	10 kW
Solar Battery	10 Nos.
Space Required	60 squire meter
Panel Structure	GI Chanel
Warranty	5 years for complete system
Delivery and installation	10 days from the date of payment
Price	Rs.8,40,000

Recommended Load:
2 AC of 1.5 Ton + 60 LED Lights + 30 Fans + 2 Coolers + 6 LED TVs + 1 Refrigerator.
Backup Time:
Approximate 4-6 Hours for 7000W Load.

7. Conclusions

Solar energy today becomes a good and cheaper source of electricity for kitchen, home and agricultural related work. Cooking is a prime necessity for all people across the world. About 75% of people living in rural India fulfill their cooking energy needs from non commercial fuels like wood from the forest which contributes to deforestation and greenhouse effect. On the other hand LPG in India, which is another major source of energy for cooking has to be imported from other countries and its prices, is constantly rising. Due to this cooking by using renewable energy sources is a burning issue. Fortunately, India is blessed with ample amount of solar radiation. Currently two type solar chulha are available. One solar chulha use PV system while other uses solar concentrator to charge a thermal battery. The Solar chulha stores sun energy in heat form which provides cooking solution that works indoor, cooks all dishes for 24x365, provides convenience & conventional cooking experience. Solar chulha makes it possible to keep the chulha all time inside the kitchen for cooking purposes i.e. including frying, baking and chapatti making, similar to traditional commercially available cook stoves which work on LPG or other fuels. Electricity produce by solar energy can be used in AC, LED Lights, Fans, Coolers, TV and Refrigerator etc.

Solar energy can be used in agriculture in a number of ways, saving money, increasing self reliance and reducing pollution. From above study we found that solar hybrid system technology is better than other available technology. Solar energy can cut a farm's electricity and heating bills. Solar heat collectors can be used to dry crops and warm homes, livestock buildings and greenhouses. Solar water heaters can provide hot water for dairy operations, pen cleaning and homes. Photovoltaic's i.e. solar electric panels can power farm operations and remote water pumps, lights and electric fences. Buildings and barns can be renovated to capture natural daylight, instead of using electric lights. Solar power is often less expensive than extending power lines.

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