بسم الله الرحمن الرحيم

Solar Home Power Supply Unit: Perspective- Bangladesh

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF BACHELOR OF SCIENCE IN TECHNICAL EDUCATION IN ELECTRICAL & ELECTRONICS ENGINEERING

Prepared by:

MOHAMMAD TAIBUR RAHMAN

MD. NURUL ISLAM

Under the Supervision of

Kazi Obaidul Awal

Part Time Teacher, EEE Department and

Former Chief Engineer, Bangladesh Atomic Energy Commission

DEPARTMENT OF ELECTRICAL &ELECTRONIC ENGINEERING (EEE)

ISLAMIC UNIVERSITY OF TECHNOLOGY, Gazipur, BANGLADESH

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FROM

Islamic University of Technology (IUT)

The Organization of the Islamic Cooperation (OIC

Submitted by:

MOHAMMAD TAIBUR RAHMAN (103407)

MD. NURUL ISLAM (093426)

UNDER THE SUPERVISION

OF

Mr. Kazi Obaidul Awal

Part Time Teacher & Ex –Chief Engineer

Bangladesh Atomic Energy Commission

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September, 2012

This Study is dedicated to our Teachers

Declaration

We do hereby declare that this thesis has not been submitted elsewhere for obtaining any degree or diploma or certificate or for publication.

Signature

Mohammad Taibur Rahman -103407

Md. Nurul Islam. -093426

Countersigned

Kazi Obaidul Awal

(Project Supervisor), Department of EEE, IUT

Approved by

Prof. Dr. Md. ShahidUllah

Head, Department of EEE, IUT.

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Mohammad Taibur Rahman

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September 2012 Md. Nurul Islam

Preface

Adequate and uninterrupted supply of different forms of energy particularly electricity is essential for quality living as well as for the development of a country. Electricity is the most preferred form of energy. It is one of the indicators of development of a country, like, per capita GDP or GNP. The article 16.1 of Bangladesh Constitution recognizes the right of electricity as one of the basic needs of even rural population. Nonetheless majority (60%) of the people of Bangladesh do not have the access to electricity. This is also true for most of the least developed and developing OIC Member States.

Per capita energy consumption of energy, accordingly, in all countries particularly in developing countries has been continuously increasing. The bulk portion of the primary energy is met by fossil fuels. Renewable energy like solar, wind can of course help to make electricity accessible to the isolated rural people as well as for low power demand. Bangladesh Government is currently giving incentives and in some cases forcing users to use solar PV. The utility of such decision may be subject to proper economic and social analysis. The policy decisions should be based on cost, utility and risks.

The geological location and socio-economic situation of Bangladesh also demands due consideration for the appropriate use of photovoltaic within an optimum and comprehensive program of energy mix for the country. Solar photovoltaic (PV) systems are now profitably and increasingly used for meeting the needs of electricity in remote and difficult areas in developed countries as well as in many developing countries.

During our research work we visited and had discussions with many intellectuals, both government and private officials. This thesis paper is an outcome of their valuable comments and also from our search and reading of many articles and journals related with solar photovoltaic systems particularly home supply units.

Abbreviations

BPDB:	Bangladesh Power Development Board
BSS :	British Standard Specifications
BRU:	British Thermal Unit
BUET:	Bangladesh University of Engineering and Technology
CFL:	Compact Fluorescent Lamp
DESCO:	Dhaka Electric Supply Company Authority
DPDC	Dhaka Power Distribution Company Limited
GHG:	Greenhouse Gas
IUT:	Islamic University of Technology
NPP:	Nuclear Power Plant
PV:	Photovoltaic
REB:	Rural Electrification Board
UNDP:	United Nations Development Program
UNO:	United Nations Organizations
USA:	United States of America
WEC:	World Energy Council
WB:	World Bank
SOC:	State of Charge
SHS:	Solar Home Supply

Contents

CHAPTER-1

Introduction

1.1 Objective

The need and importance of use of energy-particularly electricity at increasingly higher quantities and rates can hardly be overemphasized in order to accelerate the growth of socioeconomic development. Electricity is mostly, generated in power plant by burning conventional fuels: coal, oil, gas, biomass or using hydro potential or in the nuclear power plant through nuclear fission. The conventional sources are finite and their prices fluctuate. The sources pollute environment and cause global warming up. Renewable and environment friendly energy sources like: photovoltaic(PV), wind, tide etc., therefore, drawing attentions of the technologists and the policy makers to meet ever-increasing demand of electricity and at the same the keep the consequent environment degradation to an acceptable level. Among all the renewable sources solar is more appropriate for Bangladesh.

a) To distribute electricity in every villages.

b) To develop social activities in every villages.

c) To distribute electricity in school, colleges, business centre, health sector in every villages without any load shedding.

1.1 Solar Home Power Unit

Solar power units for your home can include solar panels or roof tiles. Both are excellent for delivering solar energy to your home and because of recent sleek designs they fit discreetly on your roof, especially roof shingles which are laid on top of existing shingles and look natural and flawless.

Portable solar power units are perfect for powering campers, cookers, or other items that may be away from mainstream electricity. It’s convenient and you never have to worry about loosing power and being stuck in the middle of nowhere. Other portable solar power units can be used to power cell phones, laptops, and MP3 players. It’s perfect for traveling.

No matter what type of solar power units you use, one thing is for sure; solar energy provides clean power at no cost. It’s dependable, affordable and eco-friendly

1.2 **Brief Overview**

Solar photovoltaic modules, called ―photovoltaic‖ or ―PV‖ , are solid-state semiconductor devices with no moving parts that convert sunlight into direct-current electricity. Although based on science that began with Alexander Edmond Becquerel‘s discovery of light-induced voltage in electrolytic cells over 150 years ago, significant development really began following Bell Labs‘ invention of the silicon solar cell in 1954. PV‘s first major application was to power man-made earth satellites in the late 1950s, an application where simplicity and reliability were paramount and cost was nearly ignored. Enormous progress in PV performance and cost reduction, driven at first by the U.S. space program‘s needs, has been made over the last 40-plus years. Since the early 1970s, private/public sector collaborative efforts in the U.S., Europe, and Japan have been the primary technology drivers. Today, annual global module production is over100 MW, which roughly translates into a $1billion/year business. In addition to PV‘s ongoing use in space, its present-day cost and performance also make it suitable for many grid-isolated applications in both developed and developing parts of the world, and the technology stands on the threshold of major energy-significant applications worldwide.

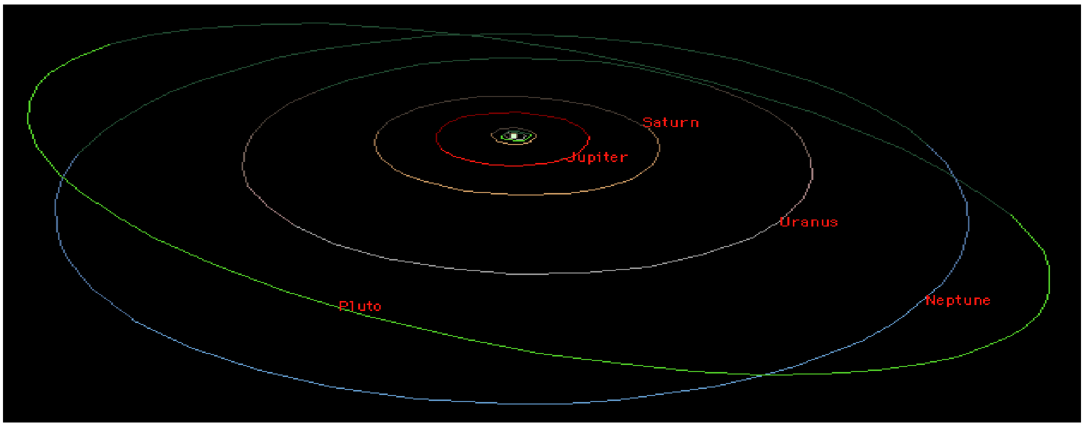


Fig: 1.1 Brief Overview of Solar photovoltaic modules

CHAPTER-2

Key Terminologies

Energy: energy is defined as the capacity of a physical system to do work. Work can not be done without the expense of energy. It is expressed in joules or kilowatt hours (KWh).

Energy sources: are generally defined as anything that can be used as a source of energy to provide heat, light and power. Some important energy resources are oil, natural gas and coal.

Energy Conversion: it is the process of conversion of naturally occurring energy to other useful form of energy. Some loss is associated with it as well. So energy conversion is never 100%.

Electrical energy: refers to the flow of power or flow of charges along a conductor to create energy.

Sustainable Energy: means environmentally sound, safe, reliable, affordable energy, in other worlds, energy that supports sustainable development in all its economic, environmental, and social and security dimension.

Energy security: may be defined as the national policy actions assuring thee availability of all energy forms at affordable prices and in sufficient quantities for a reasonable future period (30 to 50 years, depending on many factors).

Energy efficiency: It is the ratio between electrical energy outputs to electrical energy input.

Climate change: a long-term change in the statistical distribution of weather patterns over periods of time that range from decades to millions of years. It may be change in the average weather conditions or a change in the distribution of weather events with respect to an average, for example, greater or fewer extreme weather events.

Carbon tax: a levy exacted by a government on the use of carbon containing fuel for the purpose of influencing human behavior (specially economic behavior) to use less fossil fuels (and thus limit green house gas emission).

Theoretical Potential: Projected ability of a system without taking into consideration the practical implications.

Technical Potential: Projected ability of a system by taking the practical implications (real life scenario) into account.

Economical Potential: Projected ability of a system measured in terms of financial loss or gain.

Solar Photovoltaic: Photovoltaic (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect.

Demand Factor: It is the ratio between maximum demand to the connected load. Demand Factor (<1).

CHAPTER- 3

Electricity and Human Development Link

3.1 Electricity and Human Development

Electricity Access Produced by the SASI group (Sheffield) and Mark Newman (Michigan) This map shows where people who have electricity supplied to their homes live. Electricity access includes that sourced from a publicly used grid and self-generated electricity (possibly from solar, wind or hydroelectric sources). This map shows access, not the quantities of electricity used. The percentage of people with access to electricity in their own homes is over 97% in Eastern Asia, Eastern Europe, North America, Western Europe and Japan. 7 of the 10 territories with the lowest access to electricity are in Southeastern Africa. Electricity in homes can be used to power lighting, heating, cooking, radios, televisions, computers, washing machines, and other appliances. Territory size shows the proportion of all people with some electrical power in their homes living there. LOWEST ACCESS TO ELECTRICITY ACCESS % of people with access to electricity in 2000 100 Rank Territory Value Rank Territory Value Western Europe Japan Northern Africa Eastern Asia North America 90 Eastern Europe Asia Pacific 171 Dem People's Republic Korea 20.0 191 Madagascar 8.0 80 South America 171 Cameroon 20.0 192 Kenya 7.9 Middle East Southern Asia 178 Eritrea 17.0 193 Mozambique 7.2 70 Southeastern Africa 179 Cambodia 15.8 194 Democratic Republic of Congo 6.7 60 Land area 180 Nepal 15.4 195 Myanmar 5.0 50 181 Burkina Faso 13.0 195 Malawi 5.0 Central Africa Technical notes 40

• Data are sourced from the World Resources Institute's 2005 Earth Trends. 182 Angola 12.0 195 Lesotho 5.0 30

• *Territories for which data have been estimated 182 Zambia 12.0 198 Ethiopia 4.7 20 are not shown in the table.

• See website for further information. 184 United Republic of Tanzania 10.5 199 Uganda 3.7 10 190 Togo 9.0 200 Afghanistan 2.0 0 percentage of population with electricity access in 2002* "Have you ever thought about what you would have to give up or how much work and effort you would have to dedicate to daily activities if electricity did not help you?" PrazkáEnergetika, 2005 www.worldmapper.org © Copyright 2006 SASI Group (University of Sheffield) and Mark Newman (University of Michigan) Map 346

3.2 Bulk Power and Isolated Low Power

Bulk Power

Pioneer’s Modular PFC Product Series can also be used in applications where 400VDC non-isolated single output bulk power converter is required. With PFC, output power can be maintained with a 30% reduction in RMS line current. Other advantages include improved hold-up performance, reduced line harmonics (for 1φ input only), and insensitivity to voltage and frequency variations. Because they effectively eliminate harmonic currents, the converters are ideal for applications where neutral wire current exceeds recommended ratings due to waveform distortion caused by the typical off-line units.

Additional benefit of the bulk power converter is that it eliminates the need for switches and jumpers to adapt the supply for 110VAC or 220VAC operation, creating a “Universal Input” power unit. The input voltage on the bulk PFC converter is boosted to provide a nominal 400VDC output for conventional pulse width modulated (PWM) power supplies or distributed DC bus network. It meets the most stringent international safety and EMI standards, including the IEC555-2 which limits line current harmonic content to less than 5% (for 1φ input only).

Isolated power

The IL41050TA is a galvanic ally isolated, CAN (Controller Area Network) transceiver, designed as the interface between the CAN protocol controller and the physical bus. Quiescent and dynamic supply current is significantly lower than NVE’s higher speed CAN (Controller Area Network) transceivers. The IL41050 family provides isolated differential transmit capability to the bus and isolated differential receive capability to the CAN controller via NVE’s patented* Isoloopspintronic Giant Magneto resistance (GMR) technology. Advanced features facilitate reliable bus operation. Unpowered nodes do not disturb the bus, and a unique non-volatile programmable power-up feature prevents unstable nodes. The devices also have a hardware-selectable silent mode that disables the transmitter. Designed for harsh CAN and Device Net environments, IL41050TA transceivers have transmit data dominant time-out, bus pin transient protection, a rugged Charged Device Model ESD rating, thermal shutdown protection, and short-circuit protection. Unique edgetriggered inputs improve noise performance. Unlike opt couplers or other isolation technologies, Iso Loop isolators have virtually indefinite barrier life**.**

3.3 Renewable Sources

<u>Introduction</u>

Renewable energy is a term used to describe energy that is derived from naturally occurring resources such as sunlight, wind, tides, rain, and geothermal heat that are continually available to some degree or other all over the world. These sources of energy never run out as it continuously renews itself in a small time period, unlike the conventional energy sources such as oil, coal, natural gas etc. The source is not dependent on the rate of consumption. These types of energies are environmentally friendlier and termed as ―Green Energy‖ . Usage of these types of energies supports sustainable development by reducing carbon emissions. This contributes to increasing energy and climate security for many communities across the world

A renewable resource is a natural resource with the ability to reproduce through biological or natural processes and replenished with the passage of time. Renewable resources are part of our natural environment and form our eco-system. Renewable resources are endangered by industrial developments and growth. They must be carefully managed to avoid exceeding the natural world's capacity to replenish them. A life cycle assessment provides a systematic means of evaluating renewability. This is a matter of sustainability in the natural environment. Solar radiation, tides, winds, geothermal, biomass and other natural elements are renewable resources of energy now called renewable energies. Gasoline, coal, natural gas, diesel and other commodities derived from fossil fuels, as well as minerals like copper and others are non-renewable resources without a sustainable yield.

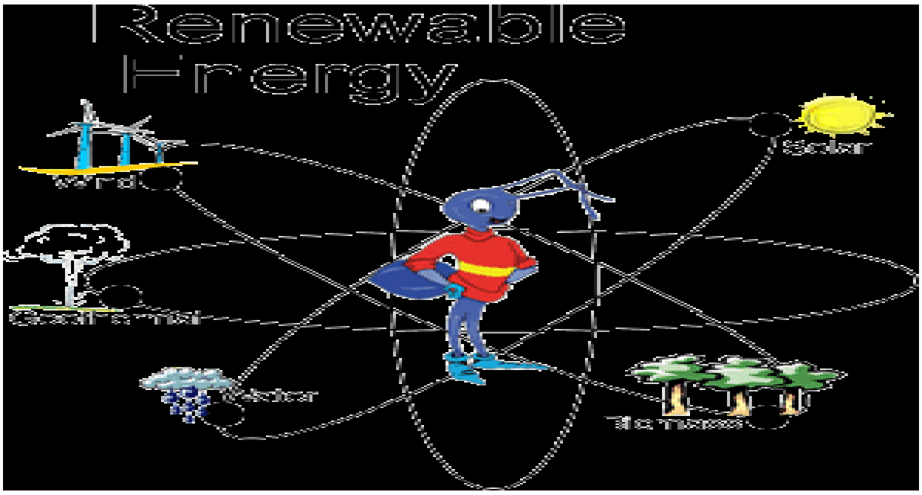


Fig: 3.1(a) Renewable Sources in Solar System

Fig: 3.2(b) Renewable Sources in Solar System

Major Renewable Energy sources are:

a. Hydro Power

b. Wind Power

c. Solar Power

d. Geothermal power

e. Biomass power

A. .**Hydropower**

Hydropower refers to using water to generate electricity. Water is the most common renewable source of energy in the United States today.

Many hydroelectric power plants use a dam on a river to store water. Water released from behind the dam flows through a turbine, spinning it, which then turns a generator to produce electricity. Electricity generated this way is known as hydroelectricity, and it accounts for about 7% of the electricity used by the nation. Hydroelectric power doesn't necessarily require a large dam – some hydroelectric power plants just use a small canal to channel the river water through a turbine. A small or micro-hydroelectric power system can produce enough electricity for a home, farm, or ranch.

Fig: 3.3 Renewable Energy sources of Hydro Power

B. Wind Power

For hundreds of years, humans have used wind to pump water or grind grain, usually with small windmills. Large, modern wind turbines are used to generate electricity, either for individual use or for contribution to a utility power grid. Wind turbines usually have two or three blades and, because winds above the ground tend to be faster and less turbulent than those near the surface, the turbines are mounted on tall towers to capture the most energy. As the blades turn, the central shaft spins a generator to make electricity.

Fig: 3.4 Renewable Energy sources of Wind Power

C. Solar Power

Solar technologies use the sun's energy to provide heat, light, hot water, electricity, and even cooling, for homes, businesses, and industry. Despite sunlight's significant potential for supplying energy, solar power provides less than 1% of U.S. energy needs. This percentage is expected to increase with the development of new and more efficient solar technologies.

Fig: 3.5 Renewable Energy sources of Solar Power

D. Geothermal Power

Geothermal power uses the natural sources of heat inside the Earth to produce heat or electricity. Currently, most geothermal power is generated using steam or hot water from underground. Geothermal power generation produces few emissions and the power source is continuously available. There are three geothermal technologies currently in use in the United States: direct-use systems, use of deep reservoirs to generate electricity, and geothermal heat pumps.

Fig: 3.6 Renewable Energy sources of Geothermal Power

E. Biomass power

Biomass power is power obtained from the energy in plants and plant-derived materials, such as food crops, grassy and woody plants, residues from agriculture or forestry, and the organic component of municipal and industrial wastes. Biomass power provides two valuable services: it is the second most important source of renewable energy in the United States and it is an important part of our waste management infrastructure. In the future, farms cultivating high-yielding energy crops (such as trees and grasses) will significantly expand our supply of biomass. These energy crops, coupled with high-efficiency conversion technologies, can supplement our consumption of fossil fuels and help us respond to global climate change concerns

Fig:: 3.7 Renewable Energy sources of Biomass Power

3.4 Global Power Trend

Trading has become more competitive in today's global economy. To compete and obtain the financial independence that you want, you need something better than basic trading skills. Chuck Hughes, seven times World Trading Champion, reveals his Global Power Trend System, or GPS, consisting of global trading secrets to help you stay ahead of everyone.

The #1 rule for this to work—don't take your competition head on. Fly under the radar and trade funds that few people know of. For more than a decade, there has been a series of funds traded by investors who were able to identify the potential for record profits at a controlled risk. Everyone has access to these funds, the key is to

- Spot the opportunity

- Learn the simple Global Power Trend System

- Keep and grow your trading profits

Power plays a great role wherever man lives and works. The living standard and prosperity of a nation vary directly with the increase in the use of power. The electricity requirement of the world is increasing at an alarming rate due to industrial growth, increased and extensive use of electrical gadgets. According to world energy report, we get around 80% of our energy from conventional fossil fuels like oil (36%), natural gas (21%) and coal (23%). It is well known that the time is not so far when all these sources will be completely exhausted. Nuclear energy is a comparatively clean source of energy. However, safe handling of nuclear energy reactor is a sophisticated task and only around 7% of the world's total energy requirement is being satisfied by it today.

CHAPTER- 4

Solar Home Power System

4.1 Solar Energy

Solar power is energy from the sun and without its presence all life on earth would end. Solar energy has been looked upon as a serious source of energy for many years because of the vast amounts of energy that are made freely available, if harnessed by modern technology.

The tropical climate of Bangladesh is an advantage to the utilization of solar energy resources to meet various energy needs. Though sun drying of fruits, fish, vegetables and spices in the open air is one popular use of solar energy, solar drying is also disseminated in Bangladesh through various agencies. Solar photovoltaic (PV) systems are gaining acceptance as a technology for electricity generation in remote and rural areas. Bangladesh Atomic Energy Commission (BAEC) ran the first PV pilot project at Sandwip Island in 1988. This project installed a solar-powered beacon light on top of a watch-tower, solar-powered refrigerators in a hospital for storing life-saving vaccines, and a solar light and a microphone in the local mosque. However, these were all destroyed during the 1991 cyclone. There have been two substantial interventions in Bangladesh in the field of rural electrification through solar PV. These are the solar PV project by Grameen Shakti (GS) and Narshingdi pilot project by the Rural Electrification Board (REB). These projects attempted to provide basic needs such as electric lighting and power for TV or radio. Up to June 1998, GS had sold 376 solar panels with an installed capacity of 15,229 Wp. GS sells the PV systems on credit to rural households; it also trains the customers and maintains the systems. With assistance from the French Government, REB has implemented a solar PV electrification project for rural households and commercial enterprises at a remote island in Narshingdi district. This pilot project serves about 700 households of the island community. The total installed capacity is 62 kW, divided among three battery charging stations (29.4 kWp total installed capacity) (Figure 3) and stand-alone solar home systems (total capacity of 32.6 kWp). The PV systems are owned by REB and the users pay a monthly fee. Other applications of PV include water pumping and power for cyclone shelters, hospitals, mosques, institutions and offices. PV systems are also effectively used in income-generating enterprises such as grocery shops, tailoring shops, clinics, restaurants, sawmills, rice mills, cellular phone services, barber shops, bazaars and micro-utilities which sell electricity to customers in the neighborhood.

This is one way of using the suns energy, but flames are dangerous and difficult to control. A much safer and practical way of harnessing the suns energy is to use the suns power to heat up water.

A magnifying glass can be used to heat up a small amount of water. A short piece of copper tube is sealed at one end and filled with water. A magnifying glass is then used to warm up the pipe. Using more than one magnifying glass will increase the temperature more rapidly. After a relatively short time the temperature of the water increases. Continuing to heat the water will cause water vapor to appear at the top of the tube. In theory, with enough patience, several magnifying glasses and very strong sun light enough heat should be generated to boil the water, producing steam. This is one way of harnessing solar power.

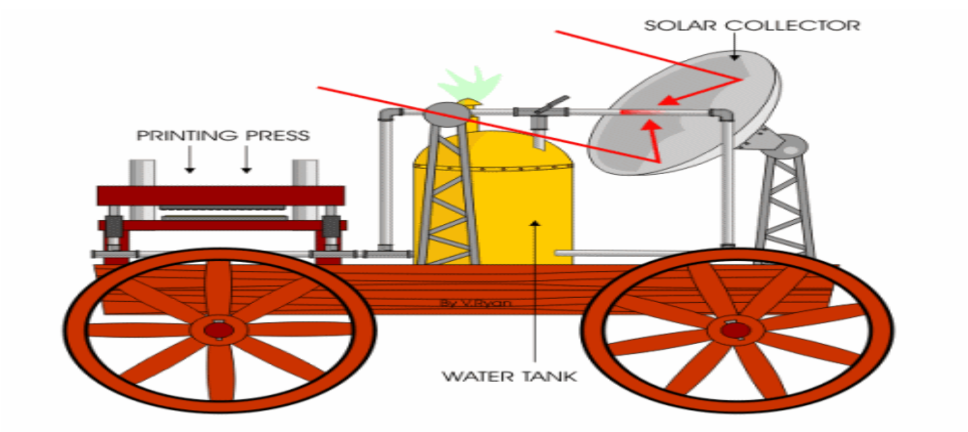


Fig: 4.1 (a) Solar Energy

The principle of heating water to boiling point was used by the French in 1888. They developed a solar powered printing press. It used the energy of the sun to boil water, producing steam. The steam was used to drive a steam engine which provided the power to drive the mechanical printing press. The machine was unreliable and very expensive to manufacture. Modern solar panels are a combination of magnifying glasses and fluid filled .pipes. The solar panel seen

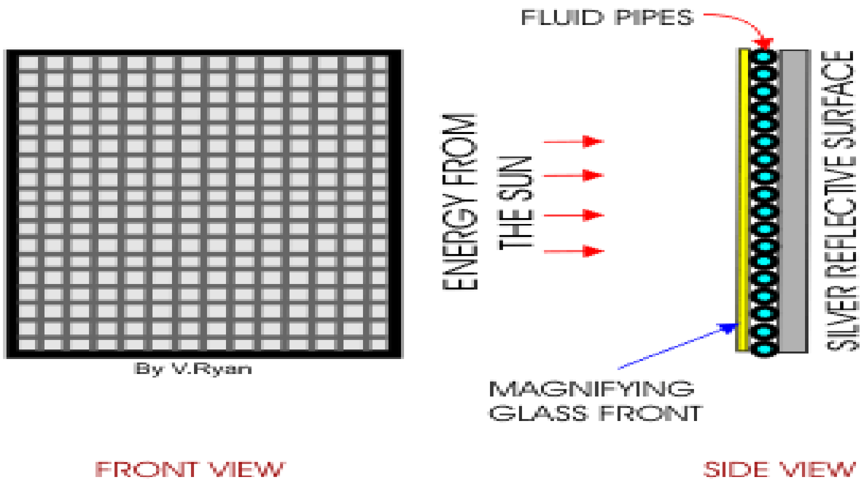


Fig: 4.2(b) Solar Energy

Opposite has a glass front which is specially made to focus the power of the sun on pipes behind it. The solar panel seen

The pipes carry a special fluid that heats up rapidly. They are painted black to absorb the heat from the sun. The silver reflective surface behind the pipes reflects sun light back, further heating the pipes and the fluid they contain. The reflective surface also protects anything behind the solar panel (such as a roof).The heat produced in the pipes is then used to heat a tank of water. This saves using electricity or gas to heat up the water tank.

4.2 Photovoltaic System

Electricity is produced by sunlight through a process called solar photovoltaic. Photovoltaic cells are made of semi-conducting materials, so when the sunlight strikes, it is converted into electricity. Even if the sky is overcast, PV still produces electricity Buying a Photovoltaic Solar Electric System: A Consumer Guide discusses the basic technical, economic and regulatory formation you should know before buying a photovoltaic (PV) solar electric generation system .This Guide is not a comprehend siveechnical or economic guide on photovoltaic systems. For than formation, see the “Getting Help”ection or consult an experienced photovoltaic system designer, retailer replier .Unlike a solar hot water system that uses the sun’s energy to heat water, solar electric or photovoltaic Technology uses the sun’s energy to make electricity. Learning from the word self, the prefix “photo “means “produced by light, “and the suffix “voltaic” refers to “electricity produced by a chemical reaction.” PV technology produces electricity directly from the electrons reed by the interaction of sunlight with certain semiconductor materials, such silicon, in the PV module. The electrons are collected to form a direct current(DC) of electricity. The basic building block of Technology is the solar “cell.” Many cells may be wired together to produce pave “module,” and many modules are linked together to form a PV “array.” Modules sold commercially range in power output from about 10 watts to 300watts, and produce a direct current like that from a car’s battery.

A complete PV system usually consists of one or more modules connected to an inverter that changes the PV's DC electricity to alternating current (AC)electricity to power your electrical devices and to be compatible with the electric grid.1 Batteries are sometimes included in a system to provide back-up power in case of utility power outages. PV cells can be made from several processes or technologies. They all do the same job — produce electricity from sunlight.

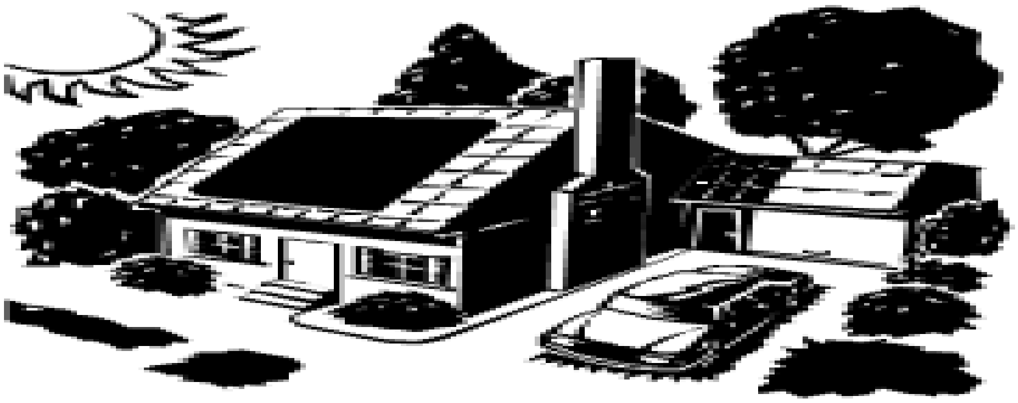


Fig: 4.3 Photovoltaic Systems

4.3 Solar Home Power Supply Units:

Details of Major Different Unit of Solar Home Power Supply

- Photo electricity
- Irradiation
- Photovoltaic effect
- Photovoltaic cells
- Photovoltaic modules
- PV Longevity & Degradation
- Photovoltaic systems
- Solar Charge controller
- Tilt Angle
- Batteries
- Inverters

1. Photo electricity

The energy from the sun can serve many purposes. One of them is to generate electricity. This is what we call solar electricity. Using solar panels, the sunlight is directly converted into electricity. This process is called the photovoltaic effect (abbreviated as PV; See Photovoltaic effect).

PV is short for photovoltaic (photo=light, voltaic=electricity). PV is a semiconductor-based technology used to convert light energy into direct current (dc) electricity, using no moving parts, consuming no conventional fuels, and creating no pollution.

The use of solar electricity has many advantages. It is a clean, quiet and reliable energy source.

2. Irradiation

The sun is continuously emitting enormous amounts of energy. A fraction of that energy reaches the earth. The fraction of the energy from the sun that reaches the earth in just one day is still more than enough to cover the energy use of the world in a whole year. However, not all the energy of the sun that reaches the earth can be used effectively. Part of the sunlight is absorbed in the earth's atmosphere or reflected back into space.

The intensity of the sunlight that reaches the earth varies with time of the day and year, location, and the weather conditions. The total energy on a daily or annual basis is called irradiation and indicates the strength of the sunshine. Irradiation is expressed in Wh/m2 per day or for instance kWh/m2 per day

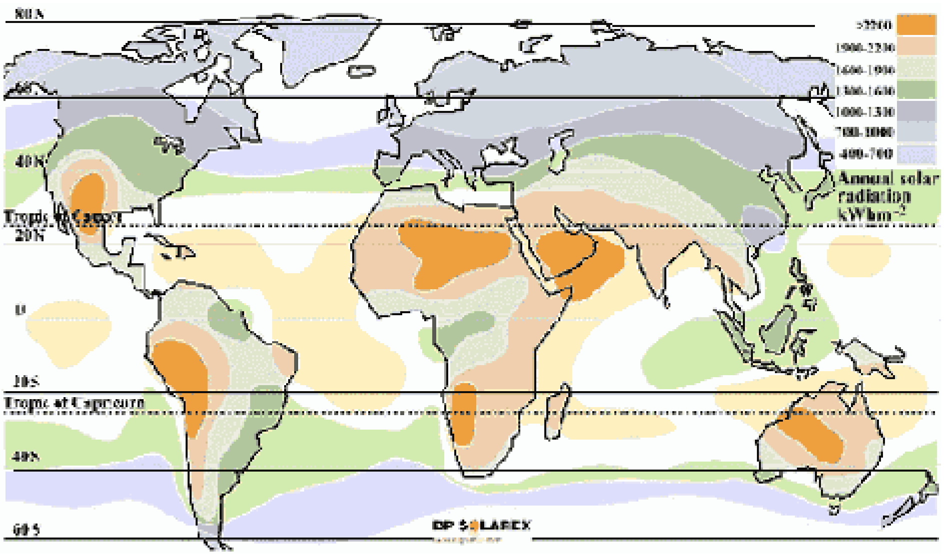


Fig: 4.4 Irradiation of Solar Home Power Supply

3. Photovoltaic effect

For solar electricity you need a solar panel that consists of one or more solar cells. When sunlight falls onto a solar cell, the solar cell material absorbs some of the light particles (so called photons). Each photon contains a small amount of energy. When a photon is absorbed it starts a process of freeing an electron in the material of the solar cell. Because both sides of a solar cell are electrically connected with a wire, a current will flow when the photon is absorbed. The solar cell now produces electricity, which can be used instantly or stored in a battery.

The principle of solar electricity.

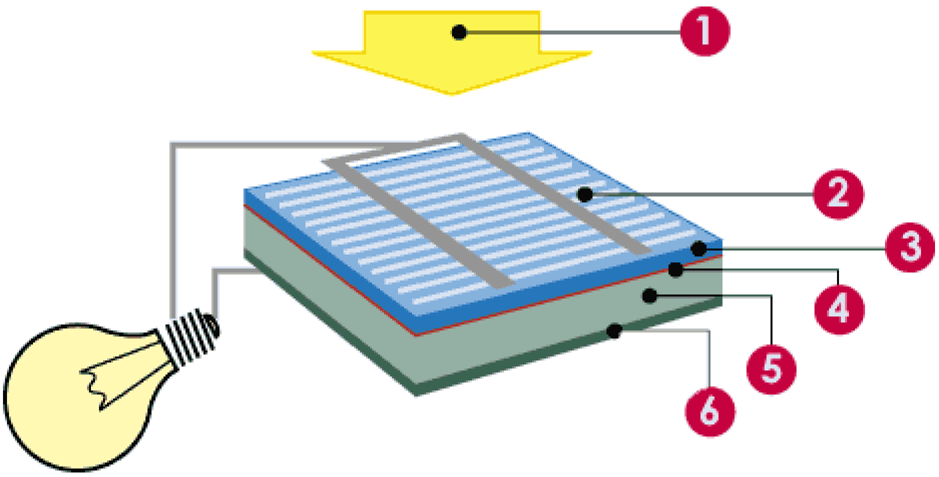


Fig: 4.5 Photovoltaic effect of Solar Home Power Supply

1.Light (photons) 2. Front contact 3. Negative layer 4. Diversion layer 5. Positive layer 6. back contact

As long as the solar cells are exposed to light this process of creating free electrons continues and electricity is produced. Materials that possess this photovoltaic effect are some semiconductors. In a special production process solar cells are made out of this semiconductor material.

A solar panel can produce clean electricity for 20 years or more. Wear is mainly due to exposure to the environment. A well-mounted solar panel will be a reliable, silent and clean source of energy for many years.

4. Photovoltaic cells

Solar cells are made of materials that directly convert light into electricity. Most of the todays commercially used solar cells are made of silicon (chemical symbol Si). Silicon is a so-called semiconductor. Silicon is found all over the world as sand, which is silicon dioxide (SiO_2) also named quartzite. Another application of the semiconductor silicon is found in the microelectronics industry where silicon is used as the base material for chips.

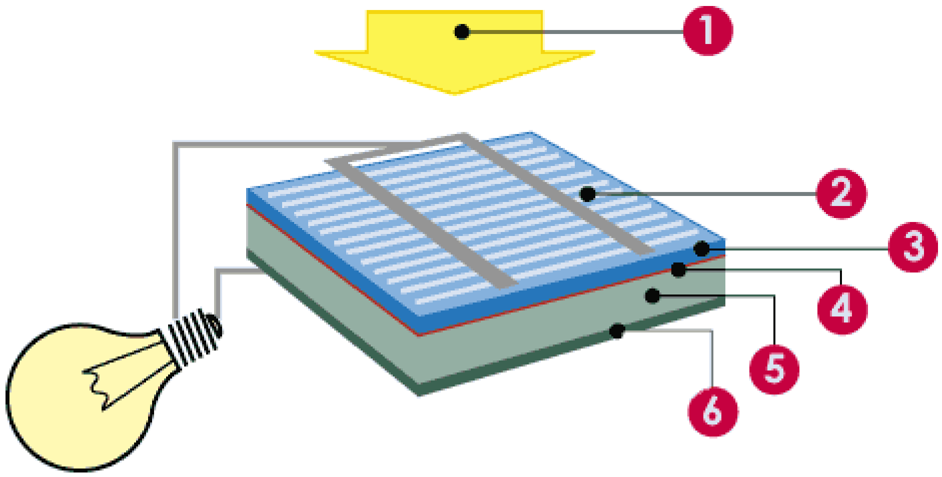


Fig: 4.6Photovoltaic cells of Solar Home Power Supply

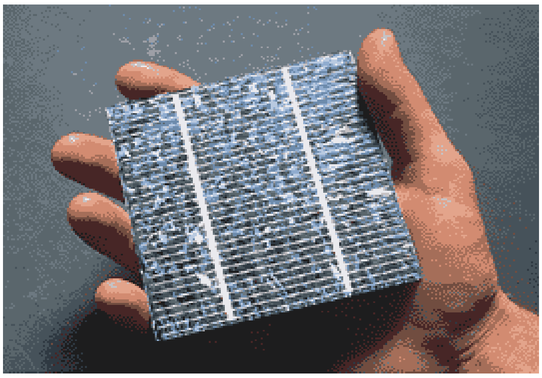
1.Light (fotons)	4.	Diversion layer
2.Front contact	5.	Positive layer
3.Negative layer	6.	Back contact

5. Photovoltaic panels

Solar panels consist of solar cells. As one single solar cell does not produce sufficient energy for most purposes, solar cells are put together in solar panels so that they produce more electricity jointly.

Solar panels (also called Photo Voltaic or PV modules) are produced in many types and sizes. The most common ones are 50 Wp (Watt peak, producing a maximum of 50 Watts of solar electricity in bright sunlight) and consist of Silicon solar cells. Such panels are about 0,5 m2. However, a wide range of smaller and larger panels is commercially available. Solar panels can be interconnected to generate more solar electricity (two interconnected 50 Wp solar panels equal one 100 Wp panel).
The efficiency of the solar panels that are commercially available varies from 5-15%. This means that 5-15% of the energy of all sunlight that reaches the cell will actually be transformed into electricity. Research laboratories all over the world are developing new materials with higher efficiencies (up to 30%). Production costs are evenly important. Some new technologies (such as thin film) allow labor extensive large scale production which would decrease the cost significantly.

Solar panels mounted on a tilted roof.



Multi crystalline solar cell.

Fig: 4.7 Photovoltaic panels of Solar Home Power Supply

6. PV Longevity & Degradation

I have been wondering lately about the life span of solar-electric (photovoltaic; PV) modules. They are usually warranted for 20 or 25 years, but what actually goes bad, and when? Do they really have an infinite theoretical life span, but develop corrosion in the metal parts? Do they run out of electrons? Yours in anticipation, Anton Berteaux • winters, California

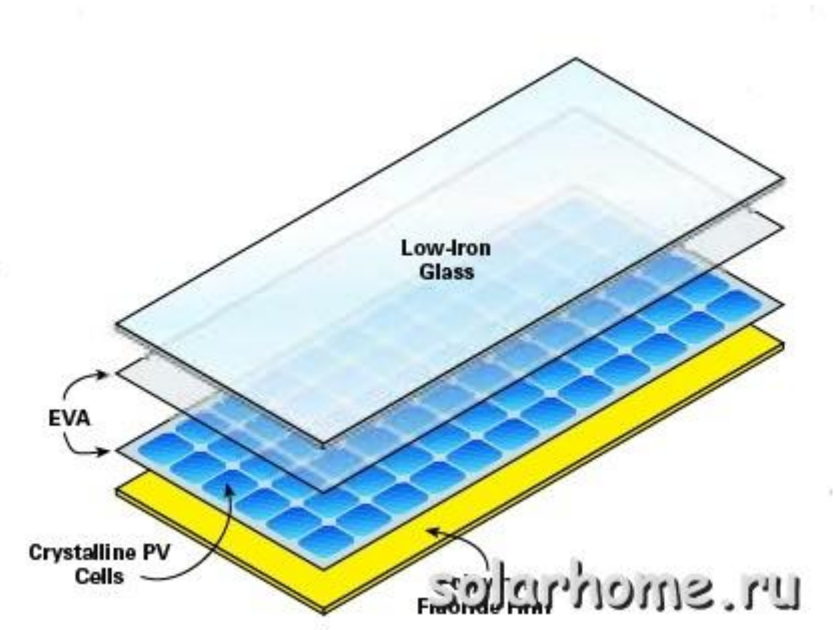


Fig: 4.8 PV Longevity & Degradation of Solar Home Power Supply

Although several types of photovoltaic modules exist, laminated crystalline modules are by far the most common and have the longest history in the field, dating from the 1950s, with mass-production beginning in the late 1970s. The information here relates to this type of module.

Crystalline modules are typically designed for a 30-year operational lifetime. Manufacturers perform accelerated life-cycle testing during the design phase to predict module longevity in the field. The actual silicon cells used in modules have an infinite life span and show no degradation after decades of use. However, module output can decrease over time. This performance degradation is the result of two main factors—the slow breakdown of a module’s encapsulate (typically ethylene vinyl acetate; EVA) and back sheet (typically polyvinyl fluoride films), as well as the gradual obscuration of the EVA layer between the module’s front glass and the cells themselves.

7. **Photovoltaic systems**

To use solar panels as a safe and reliable energy source, additional components are needed: cables, a support structure and depending on the type of system (grid connected, stand-alone or back-up), an electronic inverter or a charge controller + batteries. The whole system is called the solar electricity system.

There are three types of solar electricity systems that can be distinguished:

- Stand-alone solar electricity or Solar Home Systems (SHS)
- Grid-connected solar electricity systems
- Back-up systems

Stand-alone solar electricity or Solar Home Systems (SHS)

Stand-alone solar electricity systems or solar home systems (SHS) are used when no electricity grid is available. A battery is needed to ensure the availability of electricity at night or at periods with little bright sunlight. Solar Home Systems are often used to cover the electricity needs of a household. Small systems (commercially available as a SHS kit) cover the most basic needs (lighting and sometimes TV or radio), larger systems can also power a water pump, wireless phone, refrigerator, electric tools (drill, sewing machine, etc) and a VCR. The system consists of a solar panel, a control unit, battery storage, cables, the electric load and a support structure.

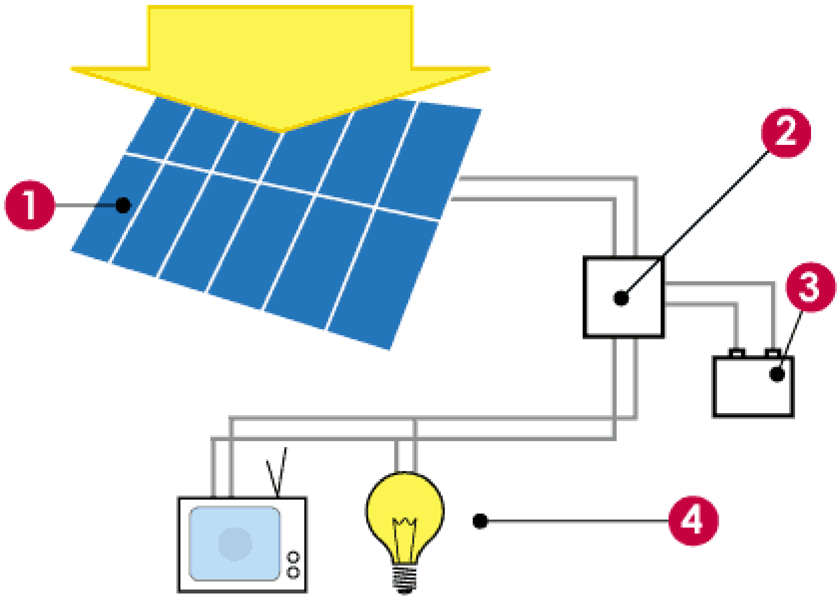


Fig: 4.9 Photovoltaic systems of Solar Home Power Supply

1. Solar panels 2. Controller
3. Battery 4.appliance

8. Solar Charge controller

Charge controllers are used in stand-alone solar electricity systems or SHS to protect the battery from deep discharge (too empty, too much energy used) or overcharging (too full, too much energy coming from the solar panel).

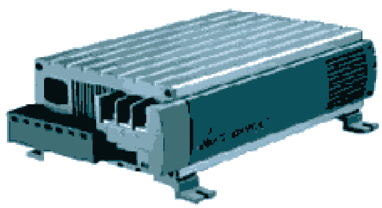


Fig: 4.10 Solar Charge controller of Solar Home Power Supply

- The use of a charge controller is highly recommended. It switches off loads when the battery is almost empty. All standard Solar Home System kits come with a charge controller.

- Observe your charge controller to check the state of charge of the battery (how full it is); usually there is a red light that will come on when the battery is empty and a green lamp when it is full. Try to keep the green lamp on as much as possible. This will extend the life of the battery.
- Never by-pass the charge controller to get the last bit of energy from the battery: doing so will ruin your battery

9. Tilt Angle

The sun moves across the sky from east to west. Solar panels are most effective when they are positioned facing the sun at a perpendicular angle at noon. Solar panels are usually placed on a roof or a frame and have a fixed position and cannot follow the movement of the sun along the sky. Therefore they will not face the sun with an optimal (90 degrees) angle all day. The angle between the horizontal plane and the solar panel is called the tilt angle.

Due to motion of the earth round the sun there are also seasonal variations. In the winter the sun will not reach the same angle as in summer. Ideally, in the summer solar panels should be placed somewhat more horizontal, to benefit most from the sun high in the sky. However these panels will then not be placed optimally for the winter sun. To achieve the best year round performance solar panels should be installed at a fixed angle, which lies somewhere between the optimum angle for summer and for winter. For each latitude there is an optimum tilt angle. Only near to the equator the solar panels should be placed horizontally.

Optimum tilt angle in winter and summer time

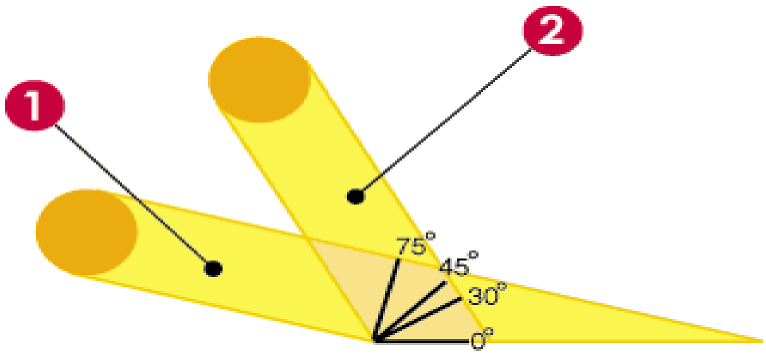


Fig: 4.11 Tilt Angle of Solar Home Power Supply

1.winter sun 2. summer sun

10.Batteries

Most off-grid PV systems use batteries to store power for use during periods of low or no sunlight. Certain specialized applications (e.g. some pumping and ventilation systems and calculators) do not require storage because power is needed only during periods of light. Some pumping applications use pumped water as the storage medium rather than electricity. However, most PV systems in Canada use batteries.

Fig: 4.12 Batteries of Solar Home Power Supply

Your choice of battery size and type is an important design consideration, particularly for systems that have no backup power source. The batteries alone can represent 25 to 50 percent of total system cost, so it is essential to select the right type. You can use different types of rechargeable batteries, depending on the system's requirements. Batteries with a long expected life have higher initial costs but should cost less in the long run. Several batteries on the market are designed for use with renewable energy systems, such as PV and wind systems. Deep-discharge marine, golf cart or recreational vehicle (RV) batteries may also be suitable and are generally more affordable up front. An experienced PV dealer can advise on what type of battery is best for your needs.

Most PV systems use lead-acid batteries such as deep-discharge lead-calcium or lead-antimony batteries. Do not use car batteries as they are not designed for repeated deep discharges. Nickel-cadmium (Ni-Cd) batteries are rarely used in residential applications. Although they can be deeply discharged many times without harm and are less affected by temperature changes than lead-acid batteries, Ni-Cd batteries are more expensive and very expensive to recycle. As a result, their use is primarily restricted to applications where their increased reliability and low maintenance are worth the premium price.

Battery storage capacity is generally rated in ampere-hours (Ah). This is the amount of current that a battery will deliver over a given number of hours at its normal voltage and at a temperature of 25°C. The rated capacity of any battery drops with temperature. The size of battery you require is determined by the total anticipated drain on the battery. You can calculate this if you know the following information: the voltage of the battery, the wattage of the load, the length of time the load is operated and the ambient temperature of the batteries.

11. Inverters

Inverters are used to change Direct Current (DC) from the battery into Alternating Current (AC) from the grid: Most solar panels produce DC. Some solar panels have an inverter integrated in the back of the panel (so called AC modules)

Fig: 4.13 Inverters of Solar Home Power Supply

4.4 PHOTOVOLTAIIC HOME POWER SYSTEM CONFIGURATION AND OPERATION

The solar (PV) home power system (Figure 1) consists of the following:

 PV module Inverters are used to change Direct Current (DC) from the battery into Alternating Current (AC) from the grid:

- In grid connected systems to adapt the solar electricity from the solar panel so that it can be fed into the grid. Most solar panels produce DC. Some solar panels have a inverter integrated in the back of the panel (so called AC modules).
- In stand-alone solar electric systems to adapt electricity from the solar panel and the battery for electric appliances that cannot run directly from the battery.
- In backup systems to provide AC for appliances that are normally using electricity from the grid.

Inverters are available in many sizes and types. Some inverters have very high efficiencies, which is to be preferred. If you plan to have the inverter on stand-by most of the time, make sure that you buy one with low stand by power consumption. If you plan to have the inverter operational most of the time, choose one with a high efficiency (ask your supplier).

- Battery
- Bi-directional Power Converter
- Controller unit
- DG set as a standby source

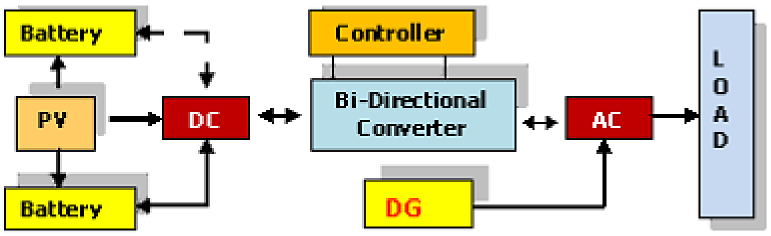


Fig: 4.14 Block schematic of a solar power converter with a standby DG Set

The primary source of power supply to rural houses is the PV power. Load power is managed either by PV system or stand by alternative DG source. The power converter unit of the PV system takes the low 12V DC voltage input from PV energy source, stored in battery, as shown in Figure 2 and convert it into usable 220VAC, 50Hz output with the help of a centre tapped transformer (Tr) based push-pull configured BJT/MOSFET bi- directional converter(inverter) circuit. The controller circuit generates PWM pulses to activate transistors T1 and T2 alternatively, producing AC voltage across the load. DG set is connected to load only when the battery reaches a discharge level of 10.4V and remain on till battery become fully /sufficiently recharged at a level in the range of 12.8V to 13.8V. The intelligent, adaptive control action of the controller performs load power and energy management and thus monitor and manage to deliver continuous power to load. The charging operation is performed by PV source and /or DG Source through converter circuit comprising of diodes D1 and D2 while transistor T1 and T2 remain off. Due to this bi- directional feature AC power is transferred to DC power which charges the battery under low charged condition.

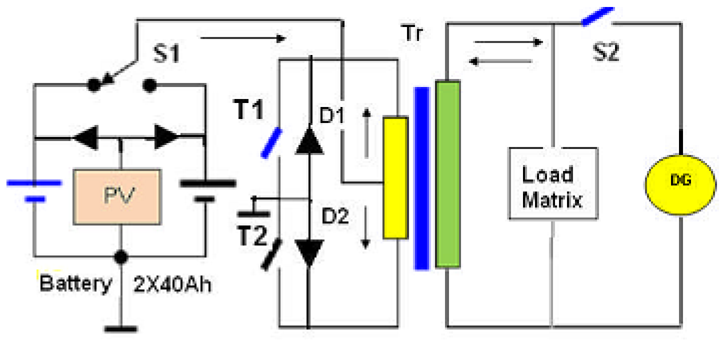


Fig: 4.15 Circuit diagram of PV System integrated with DG Set

4.5 Capital cost

The cost of fuel consumption was evaluated for a period of one year (Table 3) and compared with cost of PV system. It is apparent from the table that the payback period the PV system introduced in the schemes less than two years only as against the fuel consumption and maintenance of DG sets.

DG Fuel Consumption and Maintenance Cost		Cost of PV System	
Fuel Cost X Month Rs 1000 X 8 = Rs 8000 Rs 1500 X 4 = Rs 6000	Rs 14000	PV 4 X 75Wp	Rs 30000
		Inverter 300VA	Rs 5000
		Battery 2 X 80Ah	Rs 10000
Operational Maintenance Rs 1000 X 12 = Rs 12000	Rs 12000	Maintenance	Rs 500
		Misc. Expenses	Rs 4000
Total	**Rs 26,000**	Total	**Rs 49,500**

Table: 4.1. Cost evaluation of PV system and comparison with cost of fuel consumption and operational maintenance of DG set Pay back Period = Total Cost of PV system / (Fuel consumption +Maintenance)

= 2 years (Maximum)

4.6 Mode of System Operation

4.6.1 during Day Time

In Figure 4 (a), solar is the first choice and only source of energy while the generator is off. Solar (PV)DC power, sharing with one of the pre stored charged battery, is converted into AC power by converter for the load (s) and simultaneously charges the other battery.

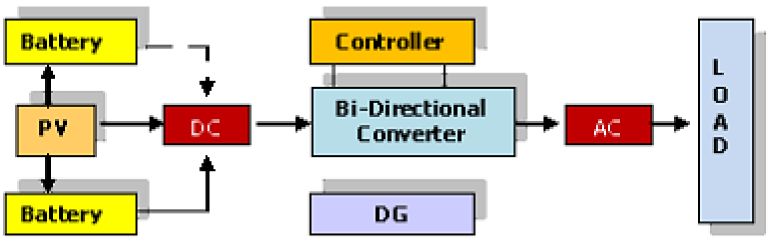


Fig: 4 .16 Operation of System during daytime

4.6.2 during Night Time

In Figure 4 (b), solar energy stored during daytime in battery is the only source of energy while the generator is off. The converter converts DC power, selecting either pre stored charged battery or the day stored battery, to AC power for the load. The battery will supply the load to its maximum discharge level.

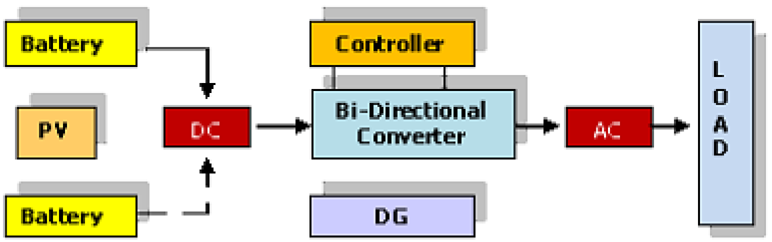


Fig: 4 .17 Operation of System during night time

4.6.3 During Shortfall period

Shortfall can occur on any low sun - radiation day or on excess load demand resulting in low charging of battery and thus system may encounter a problem during end of day or night period to meet the balance load power requirement of the day. During shortfall, the battery reaches its maximum discharge level and therefore, the generator is made on, as shown in Figure 4 (c). During this period DG set serves the load as well as charges both the batteries , one at a time or simultaneously , till they resume full /sufficient voltage in the range of 12.8V - 13.4V.

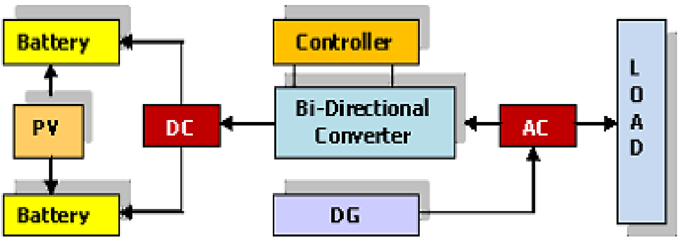


Fig: 4 .18 Operation of System during shortfall

The battery charge rate (i.e. Trickle/Boost (C4/C8/C10)) is adjusted to maintain the generator at full output. The operations, which activate or deactivate Gen-set and charging or discharging battery are managed and done by controller unit. The built in DC and AC switching module of controller unit monitors and manages the load demand and energy supplied.

4.7 Economic Compatibility

Empirical progress in manufacturing processes is frequently displayed by means of a "learning"‖ or "experience" curve. Conventionally, such curves are plotted using logarithmic axes, to show per-unit cost versus cumulative production volume. Most often, such a plot will produce a straight line over a very large range of actual production volumes and unit costs. The slope of that line, expressed as the percent of cost remaining after each doubling in volume, is called the progress ratio.‖ (Since a progress ratio of 100% would represent no learning —i.e., zero cost reduction—it would perhaps be better called a lack-of-progress ratio.‖) Most manufactured goods are found to yield progress ratios between 70% and 90%, but there appears to be no generally applicable rule for assigning a priori expectations of progress ratios for a given process. Figure shows the experience curve over the past 20-some years for PV module prices versus total sales. Price and total sales are used as proxies for cost and manufactured volume because the actual cost and production information for the entire industry is not available. Note that, although the plotted data comprise a number of technologies, the dominant technology crystalline silicon—has set the pace for the price-volume relation. Therefore, this figure most closely represents an experience curve for crystalline silicon PV, and this curve was used within the Technology Characterization for Residential PV systems. The 82% value falls within the range typical for manufactured goods, and the projections of crystalline-silicon module sales and prices provided within that TC are further supported by a bottom up‖ analysis of the industry.

CHAPTER- 5

Bangladesh Status

5.1 Bangladesh Background

Bangladesh is endowed with plentiful supply of renewable sources of energy. Out of various renewable sources solar, biomass, peat, and hydro-power can be effectively used in Bangladesh (Government of Bangladesh, 1991).

Many government departments, academic institutions, non-government organizations and private companies are involved in renewable energy technologies. Bangladesh Atomic

Energy Commission (BAEC), Dhaka University (DU), Bangladesh Institute of Technology (BIT),Bangladesh University of Engineering and Technology (BUET), Rural Electrification Board (REB), Power Cell of the Ministry of Energy and Mineral Resources and Grameen Shakti (GS) have been carrying out various activities related to photovoltaic technology for a long time. Bangladesh Council of Scientific and Industrial Research (BCSIR) and Local Government Engineering Department (LGED) are primarily involved with biogas technology. Bangladesh Rice Research Institute (BRRI) and BIT have some research interests in biomass briquetting technologies.

Renewable energy practices in Bangladesh are

· Solar Energy

· Wind Energy

· Biomass Energy

· Hydro-power energy

Solar Energy

The tropical climate of Bangladesh is an advantage to the utilization of solar energy resources to meet various energy needs. Though sun drying of fruits, fish, vegetables and spices in the open air is one popular use of solar energy, solar drying is also disseminated in Bangladesh through various agencies.

Solar photovoltaic (PV) systems are gaining acceptance as a technology for electricity generation in remote and rural areas. Bangladesh Atomic Energy Commission (BAEC) ran the first PV pilot project at standup Island in 1988. This project installed a solar-powered beacon light on top of a watch-tower, solar-powered refrigerators in a hospital for storing life-saving vaccines, and a solar light and a microphone in the local mosque. However, these were all destroyed during the 1991 cyclone.

There have been two substantial interventions in Bangladesh in the field of rural electrification through solar PV. These are the solar PV project by Grameen Shakti (GS) and Narshingdi pilot project by the Rural Electrification Board (REB). These projects attempted to provide basic needs such as electric lighting and power for TV or radio. Up to June 1998, GS had sold 376 solar panels with an installed capacity of 15,229 Wp. GS sells the PV systems on credit to rural households; it also trains the customers and maintains the systems. With assistance from the French Government, REB has implemented a solar PV electrification project for rural households and commercial enterprises at a remote island in Narshingdi district. This pilot project serves about 700 households of the island community. The total installed capacity is 62 kW, divided among three battery charging stations (29.4 kWp total installed capacity) (Figure 3) and stand-alone solar home systems (total capacity of 32.6 kWp). The PV systems are owned by REB and the users pay a monthly fee.

Other applications of PV include water pumping and power for cyclone shelters, hospitals, mosques, institutions and offices. PV systems are also effectively used in income-generating enterprises such as grocery shops, tailoring shops, clinics, restaurants, sawmills, rice mills, cellular phone services, barber shops, bazaars and micro-utilities which sell electricity to customers in the neighborhood.

Wind Energy

Of the several available option of renewable energy, wind systems have captured interest for a long time. The modern development of wind turbines was started from 1973 and the main achievement of this development lies in the improvement of aerodynamic efficiency and reliability, leading to lower costs per kWh generated. A great deal of information has been gathered in the last few years on the wind energy potential along coastal Bangladesh. The potential of wind energy in the coastal areas of Bangladesh is very high but this cannot be determined accurately until sufficient good quality data on wind speeds over at least twelve months of the year are available in different location.

The data obtained by meteorological department have been assessed by Bangladesh University of Engineering and Technology (BUET). The data show a prospective source of wind energy in many places in Bangladesh. The wind speed in some regions of Bangladesh is satisfactory for operation pumps and for generation of electricity. The wind turbines may also be useful to drive hand pumps used in irrigation agricultural land. It was found that the wind speed in Chittagong is 2.57 m/sec or more for 4000 hours a year. At this available speed a wind plant can be operated both for generation of electricity and for driving pumps. Grameen Shakti has been assessing the wind resource at Chicora, Cox‘s Bazar as well. Till now, the activities regarding wind energy are related to wind resource assessment only.

Biomass

Biomass energy is the important source of energy in many countries of the world. It is oldest type of fuel which men used for centuries after discovery of fire itself. The increase in population has forced larger numbers of rural poor to use the forests unsustainably for fuel-wood, bamboo, fodder, game meat, medicines, herbs and roof materials. Deforestation will upset the natural recycling system as well as increase the cost of fuel wood required, both in time and money, creating a vicious circle and further deforestation. Forest in many developing countries is disappearing at a high rate. Major problems are facing Bangladesh are food and fuel. In Bangladesh, commonly known Biomass fuels are: fuel wood, agricultural residues and animal dung. The country has naturally high potential for production of Biomass resources; but because of high growth rate of population (2.4%) forest cover is being reduced in an alarming proportion. In Bangladesh, while looking at over all energy consumption over the past 15 years, Biomass energy contributed 83% in 1980-81, 73% in 1989-90, and 67% in 1994-95. With the growth of GDP, consumption of commercial fuel increased more rapidly than that of Biomass fuel.

Hydro Power

Hydro-electricity accounts for 3% of the total electricity consumption in the country. The potential of hydropower sources has not yet been assessed (EIA, 1999). The first hydro power plant of Bangladesh was Kaptai with a capacity of 2 x 40MW=80MW commissioned in 1960. At present Kaptai on Karnafuli river generating 230MW of power (reservoir size 777 sq. km), which is 4.19% of total power. More than 22,000 hectares of arable land and 18,000 houses were flooded to make room for its reservoir. As Bangladesh is flat terrain, it has very limited potential of hydro power. Other potential rivers for hydro power plant are Matamuhuri and Sangu.

5.2 Constitution

Solar PV System: Rural electrification Board (REB), Atomic Energy Commission (AEC), Local Government Engineering Department (LGED), and Grameen Shakti (GS) have installed (are in the process of installation of) a number of solar PV systems in different parts of the country. REB has undertaken a pilot project for supply of solar electricity in some islands of one main river (Meghna) in Narshingdi district. Five types of PV systems are delivered to 1370 consumers as shown in Table below**:**

Type	System I Lantern	System II	System III	System IV	System V
Units Supplied	400	380	275	190	125
Module (Watt peak)	6	Charged at PV charging station	Charged at PV charging station	46	2x46
Battery (no. X volts x amp hours)	6v x 3.2AH	12V x 60AH	2x12x60AH	12Vx60AH	2x12Vx100AH
8 W Fluorescent	1	2	2	2	1
3 W incandescent	1	-	-	-	-

13 W Fluorescent	-	-	1	1	2
Fan	-	-	1	1	1
Socket	-	1	1	1	1
CIF Cost (Tk.)	3,894	24,352	46,478	31,509	51,559
CIF Cost ($)	93	580	1,107	750	1,228

Table 5:1: PV Systems in the REB Pilot Project.

Under this project, PV systems have been installed at one rural health clinic for running fans, lights and refrigerators. Same systems are being set up in another clinic. The first solar module was installed on 3rd August 1996 and since then till 10-05-97 a total households have been provided with different types of systems as shown in Table

Progress of Solar PV installation

System type	No. Of units supplied	Watt Peak
I	Nil	Nil
Ii	233	Charging station
Iii	27	Charging station
Iv	113	5,198
V	115	10,588
Total of Household systems	188	
Charging station	3	29,440
Health clinic	1	828
		46,054

Table 5:2 Progress of Solar PV installations

More than 500 potential consumers have been trained on the operation and maintenance of the entire PV system. This was conducted by BCAS and CMES experts. AEC initiated solar PV program (SPV) in 1985. The systems installed over the period 1985-1994 are 9790 watt peak. Most of the systems are not functional at present because of the lack of fund for spare parts, maintenance and back-up service.

Grameen Shakti at a Glance May, 2012

Created with a vision to empower the Rural People with Renewable Energy Technologies

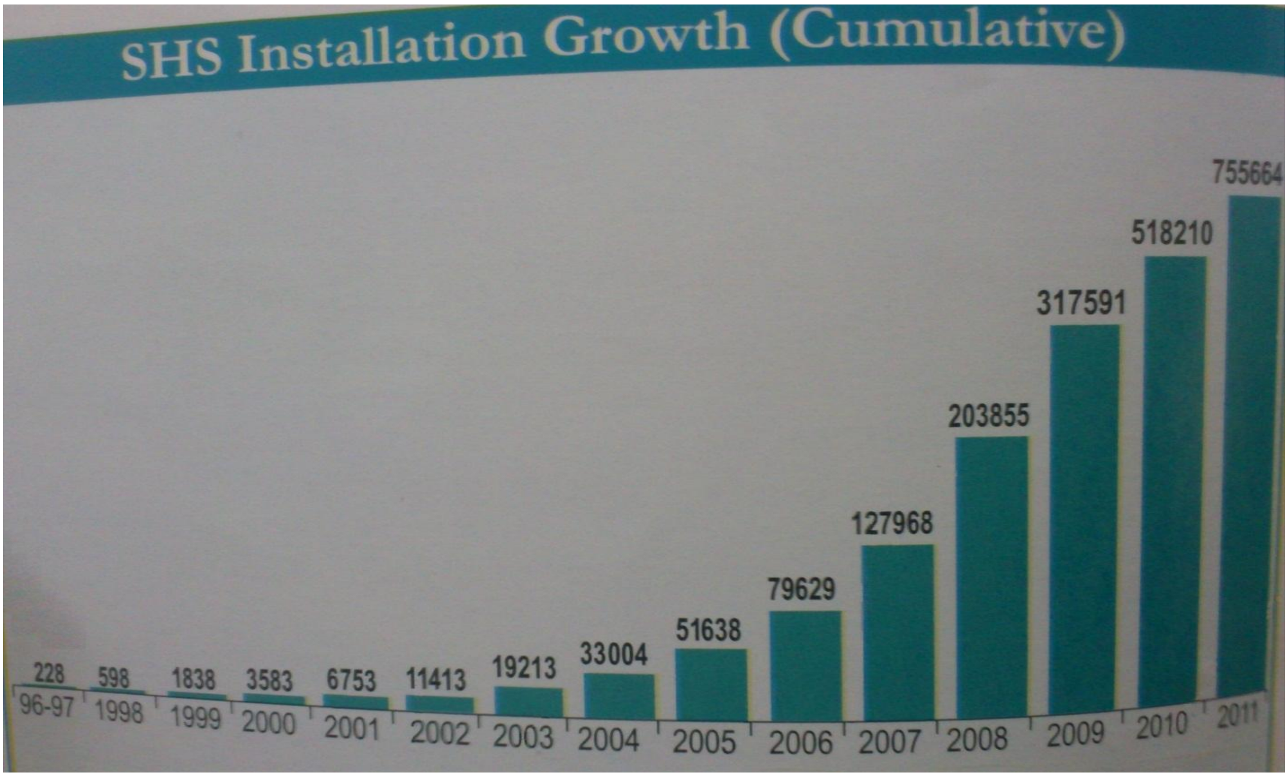
Grameen Shakti was established as a not-for-profit company in 1996 to promote affordable, clean, modern, and sustainable renewable energy technology for the rural people of Bangladesh to improve their living standard and to protect the environment they are living in.

Sl/no	Items	Quantity
01	Total installation of SolarHome Systems(SHS)	8,64,149
02	Total baneficiarie	Around 7.0 million people
03	Installation rate	Over 22,000 SHSs / month
04	Grameen Technology Centre	46
05	Number of districts Covered	64 out of 64 districts
06	Number of upazilas Covered	504 Upazilas
07	Number of villages Covered	50,000 villages

Table 5:3 Grameen Shakti At a Glance2May,2012

Successfully Reaching Rural People

Solar Home Systems have become popular among the rural people because of the innovative and sustainable approach Grameen Shakti has developed.



OFF-GRID SOLAR HOME SYSTEM PACKAGE PRICE

s/l	System capacity(watt)	Loads can be Used	Equipment's supplied by GS	Package price
01	10	2/3 LED light or 5 watt CFL	A 10watt panel 2/3 LED light or 5 watt CFL a18AH battery, a charge controller, a frame And cables	9,800/=
02	20/21	2*5watt CFL or5 watt CFL and a tube light	A 20/21 watt panel, 2*5watt CFL or5 watt CFL , a tube light a 30AH battery, a charge controller, a frame and cables	13,100/=
03	40/42	3*7watt tube light and a14"TV	A 40/42watt panel 3*7watt tube light a 55/60AH battery, a charge controller, a frame and cables	23,000/=
04	50	4*7 watt tube light and a 17"TV	A 50 watt panel3*7watt CFL, a 80AH battery, a charge controller, a frame and cables	29,500/=
05	60	5*7 watt tube light and a 17"TV	A 60 watt panel 5*7 watt CFL,a 80 AH battery, a charge controller, a frame and cables	34,400/=

Table: OFF-GRID SOLAR HOME SYSTEM PACKAGE PRICE

5.3 Power Development Organizations

Electricity is the major source of power for country's most of the economic activities. Bangladesh's installed electric generation capacity was 4.7 GW in2009; only three-fourth of which is considered to be ‘available’. Only 40% of the population has access to electricity with a per capita availability of 136kWh per annum. Problems in the Bangladesh's electric power sector include corruption in administration, high system losses, and delays in completion of new plants, low plant efficiencies, erratic power supply, electricity theft, blackouts, and shortages of funds for power plant maintenance. Overall, the country's generation plants have been unable to meet system demand over the past decade. In generating and distributing electricity, the failure to adequately manage the load leads to extensive load shedding which results in severe disruption in the industrial production and other economic activities. A recent survey reveals that power outages result in a loss of industrial output worth $1billion a year which reduces the GDP growth by about half a percentage point in Bangladesh. A major hurdle in efficiently delivering power is caused by the inefficient distribution system. It is estimated that the total transmission and distribution losses in Bangladesh amount to one-third of the total generation, the value of which is equal to US $247 million per year.

Company Profile: (Bangladesh Power Development Board)

Bangladesh Power Development Board (BPDB), established in 1972, is the authority for planning, construction and operation of power generation and transmission facilities throughout Bangladesh and for distribution in urban areas except metropolitan city of Dhaka and its adjoining area. In the recent past a number of Generation and Distribution companies have been created under the reform programmed. Ashuganj Power Station Company Ltd. (APSCL), Electricity Generation Company of Bangladesh (EGCB), North West Power Generation Company Ltd.(NWPGCL) and West Zone Power Distribution Company Ltd. (WZPDCL) have already started functioning as company under BPDB.

The BPDB is responsible for major portion of generation and distribution of electricity mainly in urban areas of the country. The Board is now under the power Division of the ministry of power, Energy and Mineral Resources. With the aim to provide quality and reliable electricity to the people of Bangladesh for desired economic and social development, the power system has been expanded to keep pace with the fast growing demand.

History of BPDB:

At the time of partition of Indo-pak sub-continent, in the year 1947 when the British colonial rulers left, power generation and distribution of this part of the country were in the hands of some private companies. The power supply to then 17 provincial districts was within the township in a limited way. The generation voltage was 400 volts. Power used to be supplied to most of the districts during nighttime only. Only exception was Dhaka City where power used to be supplied by two 1500 kW generators and the generation voltage was 6600 volts and this was the highest supply voltage. There were no long distance transmission lines. Besides power used to be generated by some industries (tea, sugar and textiles) and railway workshops Dhakeswari Cotton Mills, Pahartali Railway workshop, Saidpur Railway workshop and Sugar Mills were amongst them. In aggregate the generation capacity of the country was 21 MW. The generation capacity of the power utility companies together was only 7 (seven) MW and there was no transmission system.

In 1948, Electricity Directorate was created in order to plan and improve power supply situation. In 1959, Water and Power Development Authority (WAPDA) was created and the power sector really started working satisfactorily. In 1960, Electricity Directorate was merged with WAPDA. The basic philosophy was to give more autonomy to an organization for development of this basic infrastructure. At that time relatively higher capacity plants were built at Siddhirganj, Chittagong and Khulna (highest plant size was only 10 MW Steam Turbine at Siddirganj). At the same timeKaptai dam was under construction under Irrigation department. Unit size of Kaptai was 40 MW, which for that time was considered to be a large power plant. Side by side construction of Dhaka-Chittagong 132 KV transmission line was in progress. Construction of Kaptai dam and commissioning of Dhaka-Chittagong 132 KV transmission line in the year 1962 may be taken as milestone of power development of this country. In 1972, after the emergence of Bangladesh through a bloody War of Liberation as an independent state, Bangladesh Power Development Board (BPDB) was created as a public sector organization to boost the power sector. During mid-1970s government emphasized on the rural electrification for achieving a desirable social up liftman in the country. A different approach and a new

Model was considered for undertaking a comprehensive scheme. Thus the Government created Rural Electrification Board (REB) in October 1977. Later in 1991 Dhaka Electric Supply Authority (DESA) now DPDC was created basically to operate and develop distribution system in and around Dhaka (including the metropolitan city) and bring about improvement of customer service, collection of revenue and lessen the administrative burden of BPDB. Public investments and state ownership have been the traditional means to exercise control over the electricity sector. Government regulated the natural monopoly of power supply primarily to protect the consumer's interest. The situation is fast changing. Structural changes are taking place and new corporate characters are emerging. The gradual expansion of the infrastructure has also been justified by the need for realizing social goods relating to rural electrification and low. As on June-2010, in FY 2009-2010, BPDB has total installed capacity of 5823MW at 88 units (BPDB 3719 MW at 50 Unit and IPP, SIPP& Rental at 38 units)of Power Plants located at different parts of the country. The main fuel used for power generation is indigenous gas. Total 17,079 Gwh gross energy was generated in the public sector power plant under BPDB. In addition, total11,327 Gwh of energy was purchased by BPDB from Independent Power Producers (IPP, SIPP & Rental) in the private sector. The maximum demand served during peak hours is 4698.5 MW in August 20, 2010. The transmission network is 8465 ckt km long comprising 230, 132 and 66 KV lines. The total numbers of grid sub-stations are 108 and the total capacity is 16,749 MVA as on June-2010 . In FY 2010-11, BPDB had about 12,516 employees of which 2,362 were of supervisory level (holding positions of sub-assistant engineer or higher equivalent) as on 05/05/2011.

Vision Statement

BPDB's vision is to provide quality and reliable electricity to the people of Bangladesh for desired economic, social and human development of the country undertaking institutional and structural reforms leading to the creation of a holding company.

Mission Statement:

a)To deliver quality electricity at reasonable and affordable prices with professional service excellence.

b) To make electricity available to all citizens on demand by the year2020

c) To provide specialized skilled services in Operation and Maintenance with outstanding performance in Generation, Transmission and

d) Distribution for promoting competition among various power sector entities.

e) To follow international standard and adopt modem technology and practices in power generation activities.

f) To ensure improved and satisfactory services to the consumers.

g) To develop new mindset for all of its employees congruent with the corporate culture.

h) To reach self sufficiency by increasing of its income and reduction of expenditure.

5.4 Rural Electrification Board

The Government of Bangladesh and the Rural Electrification Board continue to apply the ‘area coverage ‘concept in expanding grid access to rural areas. This has worked well in the past and has the potential to yield good results, provided three constraints can be addressed – (i) rising costs of grid extension as load densities decline; (ii) shortage of power supply from BPDB to the rural grid; and (iii) ensuring financial sustainability of the PBSs.

Government is also promoting the rationalization of distribution networks by handing over power systems in secondary towns previously electrified by BPDB to reduce overall costs of electrification. Furthermore, REB is introducing greater prudence in selection of lines and revisiting revenue and cost assumptions that have governed the area coverage program thus far. In order to address the shortage of adequate bulk power supply, REB and the Government have introduced a policy to promote localized power generation through small privately operated plants, supplying directly to PBSs. Three 10-MW power generation plants have already been awarded to various private sector companies and contract evaluations for eight more such plants in various rural locations is underway. In addition, programs aimed at expanding productive uses of electricity are also being pursued to improve the impact of electrification and the finances of PBSs.

At another level, the REB has undertaken to work within the envelop of resources and financing terms from Government to examine various financial restructuring options for the poorly performing PBSs. The latter constitute about a third of all the PBSs, and are in need of immediate attention with respect to (i) revenue enhancing measures such as actions to transfer of pocket areas and critical load centers from BPDB; (ii) possible debt restructuring in the form of increased grace periods or adjustment of debt against grants; and (iii) selective investments that could enhance revenue and performance profiles. Government has indicated its support for such a strategy to operate under REB’s supervision.

The Government is actively promoting off-grid options, both through PBSs and through NGOs and MFIs. A signal in this regard was the elimination of import duty on solar home systems in April 2000. The Government strategy calls for introducing such technologies in areas that are unsuitable for grid expansion or where there is a preponderance of low intensity household consumption alone, rendering high cost grid service non-viable. In parallel, Government has introduced a policy to attract the private sector into establishing mini-grids in unsaved or poorly served areas. These grids, referred to as ‘Remote Area Power Supply

Systems' or RAPSS would be established by the private sector under a concession arrangement with the concerned utility – BPDB or REB. The Government has reached an agreement with IFC to earmark 3-4 PBS and non-PBS areas for establishment of privately owned and operated integrated mini-grids. These projects would be developed with IFC's assistance, with IFC playing the role of a project promoter and possibly providing an equity stake as well.

The track record from prior RE projects leads us to believe that the Government would continue to build on its hitherto successful strategy of expanding rural electricity coverage by playing an active policy and coordination role, especially with regard to facilitating enabling agreements between REB and BPDB on issues like area rationalization, transfer of lines and bulk supply tariffs .

Table 4. *Pricing Options of SHS*

Scale of SHS (Wp)	Cash package price (BDT*)	Down payment (BDT)	Loan amount (BDT)	Monthly installment amount (36 installments)	Monthly installment amount (24 installments)	Monthly installment amount (12 installments)
75	34,500	5,865	28,635	1,034	1,432	2,625
50	22,000	3,740	18,260	660	913	1674
40	17,300	2,941	14,359	519	718	1317
30	12,500	2,125	10,375	375	519	951

*BDT is the abbreviation for the Bangladeshi currency, the taka. Seventy taka is approximately equivalent to one U.S. dollar.

Barriers to development of SHS programs and possible solutions

Social and Information Barriers:	
Lack of knowledge of consumers about SHS. Many people have never heard about the technology and are not aware of its possibility as an alternative source of electricity.	Wider awareness programs and motivation for consumers through : Newspaper advertisements Radio/TV advertisements Leaflets, posters, permanent sign boards Motivation programs conducted by NGOs and local community
Lack of knowledge of electricity providers about SHS	Awareness program and business development programs for the PBSs, private providers and NGOs

Lack of information with the PBSs on the socio-economic characteristics of the rural consumers	PBSs should maintain a record of the socio-economic characteristics of their grid and off-grid consumers, in order to identify the most suitable conditions for SHS utilization and its impact on livelihood.
Information about possibility of using solar lighting for purposes other than home lighting is not available	Installation of SHSs in educational institutions, hospitals, clinics, mosques, community buildings has to be arranged to demonstrate their usefulness
Fear that, if solar systems are installed, grid electricity will never come to the locality.	PBSs should use their trained staff to explain the pre-electrification concept to the public, and develop policies to handle the transition from solar to grid.
Lack of information about availability, maintenance and warranty of solar system components	Demonstration and awareness program for PBSs, private providers and NGOs. REB may take this responsibility and make suitable arrangements for the national level program
Community level interchange of idea to promote solar lighting has not taken place. This could have increased the momentum needed for success of a program.	Involvement of PBS area directors, teachers, village mosques, UP members NGO officials and the elite should take leading roles in informing the local people and mobilizing support for solar electrification.

Table 5:4Social and Information Barriers

Financial and Economic Barriers:	
Barriers to development of SHS programs	**Possible solutions**
High initial cost of solar systems	Introduction of suitable financing mechanisms by the government and financial institutions to bring the cost of SHS within the affordable range of the rural population. Motivation of the consumers to bear partial costs of the systems.
High cost of solar module	Long term financing of solar modules

Import items of solar systems requiring foreign currency High cost of batteries High cost of suitable lamps Physical vulnerability of batteries and lamps	Simplify import procedures. Arranging appropriate credit programs for purchase of batteries. Introduce locally manufactured lamps with Proper training and motivation of consumers on proper use and maintenance of system.
Technical:	
Limited capability of solar systems	Selection of the best system for each customer taking into accounts their economic condition, load requirement and ability to pay, so that unrealistic expectations can be avoided.
Dependence on climatic conditions	Incorporate reasonable levels of autonomy in the system design. Train users in estimating energy supply & demand, conservation and use of best practices in operation of solar systems

Table 5:5 Financial and Economic Barriers

Management Barriers:	
Barriers to development of SHS programs	**Possible solutions**
Governments programs for SHS are not available for all locations	Motivation and awareness building of PBS officials to adopt SHS projects for inaccessible areas and unqualified households.

Lack of technicians trained in the installation and operation of SHS	Training courses should be organized in a coordinated manner for all levels of practitioners to develop local capability in each project area. Directorate of Training of REB can serve as the main coordinator.
PBSs are not familiar with the special requirements of solar photovoltaic	Build awareness among all persons related to SHS project development, planning and installation
Policy for implementation of SHS are not in place	REB should develop a policy for SHS implementation covering legal, operations, recruitment, training, and all other issues in implementing SHS program.

Table 5:6Management Barriers of SHS programs Possible& solutions

Areas of Solar Home Systems in Bangladesh

Figure 1. Areas of solar home systems in Bangladesh.

Fig: 5:1Areas of Solar Home Systems in Bangladesh

5.5 Weaknesses

For closed environment and open environment indoor setup as light source a halogen lamp was used whose spectrum was not matching with sun’s spectrum. Although we tried to carry our experiment with standard test conditions such as 25C, it was not always possible to maintain a constant temperature during measurement because the light source was radiating heat. The heat problem can be solved by water bed of test cells. Also the Problem with the test lamp can be solved by using high pressure mercury arc lamp. Both of these cases weren’t solved because of financial crisis.

CHAPTER- 6

Conclusions

Solar (PV) power system has a great potential in future as one of renewable energy technologies for off-grid power generation. The hybrid technology, integrating PV with DG, offers solution to off-grid power generation. The easy installation and maintenance free operational feature of the hybrid system created more popularity among the rural masses. The successful implementation of system has following outcomes:

- Generating electricity and meeting load(s) demand of a rural house in a grid deprived area by reducing consumption of fuel etc in DG set
- Reducing CO2emission and noise due to minimum use of DG and thus preserving the environment from being polluted
- Cost effective (i.e. the minimum running hours of DG set also reduces the maintenance cost of a diesel generator).

Solar home power system is also a good idea to use PV in rural areas instead of extending the

Grid line. In the future if the cost of PV components becomes less and the efficiency of the panel is increased, we can use it in large scale as well.

References

1. www.spheral solar.com /solar power solar. Units .him

2. http://www.chuckhughesonline.com/inner-circle-trading-systems/global-powertrend-system

3. http://www.technologystudent.com/energy1/solar1.htm

4. http://www.pvsystems.com/

5. http://www.energy.ca.gov/reports/2003-03-11_500-03-014F.PDF

6. www.slides hare, net/- -/access _ to electricity-is-particulars-crucial-to-h..

7. www.pioneermag.com

8. www.ccs.neu,@du/hom/feneric/

Bibliography

1. *Shakti: Energy Website of Bangladesh*, http://shakti.hypermart.net.

2. *Market Assessment Survey of Solar PV Application in Bangladesh - Final Report*, World Bank, Dhaka, Bangladesh, July 1998.

3. *Feasibility Study for a Solar Home Systems Project within the Context of Alternative Options for Rural Electrification -Final Report*, World Bank, Dhaka, Bangladesh, 2000.

4. *Schofield, N., et al. Hybrid energy sources for electric and fuel cell vehicle propulsion*, IEEE Vehicle Power and Propulsion Conference (VPPC)- Chicago, IL, 2005.

5. *Implementation, Completion and Results Report on a Credit in the amount of US$ 120 million to the People's Republic of Bangladesh for a Power Sector Development Policy 2009*, World Bank.

6. *Modal, M.A.H. and Danish, M. Assessment of Renewable Energy Resources Potential for Electricity Generation in Bangladesh*. Renewable Sustainable Energy Reviews,2010. 14(8): p. 2401-2413.

7. *EPIA, Solar Photovoltaic Electricity: A mainstream power source in Europe* by 2020. 2009 European Photovoltaic Industry Association.

8. *Stafford, A. and S. Irvine, UK Photovoltaic Solar Energy Road Map*. 2009 OpTICTechnium/Glyndwr University.

9. *UNDP, Energy and Climate Change: Strategic Programmer* Framework 2006-2010. 2008.

10. *Mondale, M.A.H., L.M. Kamp and N.I. Pachova, Drivers, barriers, and strategies for implementation of renewable energy technologies in rural areas in Bangladesh*-An innovation system analysis. Energy Policy, 2010. 38(8): p. 4626-4634.

11. *MPEMR, Renewable Energy Policy of Bangladesh, E.a.M.R. Ministry of Power, Government of the People's Republic of Bangladesh*, Editor. 2008.

12. *Rahmatullah, B.D., N. Norris, and J. Richards, A New Mandate for the Rural Electrification Board*. Centre for Policy Research, 2008.

13. *CIA. CIA The World Factbook: Bangladesh*. 2011 [cited 2011 26/01/2011]; Available from: www.cia.gov/library/publications/the-world-factbook/geos/bg.html.

14. *Annan, R.H., ―Solar 2000: Office of Solar Energy Conversion Strategy,‖* Proceedings of the 22nd IEEE PV Specialist Conf., Las Vegas, NV (1991).

15. *Shugar, D.S., ―Photovoltaic in the Utility Distribution System: The Evaluation of System and Distribute d Benefits,‖* Proceedings of the 21st IEEE PV Specialist Conference, Kissimmee, Fl (1990).

16. *Iannucci, J.J., and D.S. Shugar, ―Structural Evolution of Utility Systems and Its Implications for Photovoltaic Applications,‖* Proceedings of the 23rd IEEE PV Specialist Conference, Louisville, KY (1993).

17. *Wegner, H., et al., ―Niche Markets for Grid-connected Photovoltaics,‖* Proceedings of the 25th IEEE P V Specialist Conference, Washington, D.C. (1996).

18. *Shugar, D.S., M.G. Real, and P. Aschenbrenner,* ―Comparison of Selected Economics Factors for Large Ground-Mounted Photovoltaic Systems with Roof-Mounted Photovoltaic

Systems in Switzerland and the USA, ‖ Proceedings of the 11th E.C. Photo. Solar Energy Conf (1992).

19. *Osborn, D.E., and D.E. Collier, ―Utility Grid-connected Photovoltaic Distributed Power Systems*,‖ Proceedings of the National Solar Energy Conf., ASES Solar 96, Asheville, NC (April 1996).

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