RENEWABLE ENERGIES

Abstract: The future of humanity and the planet depends on how we produce energy: a reliable, affordable and decarbonized energy system is essential

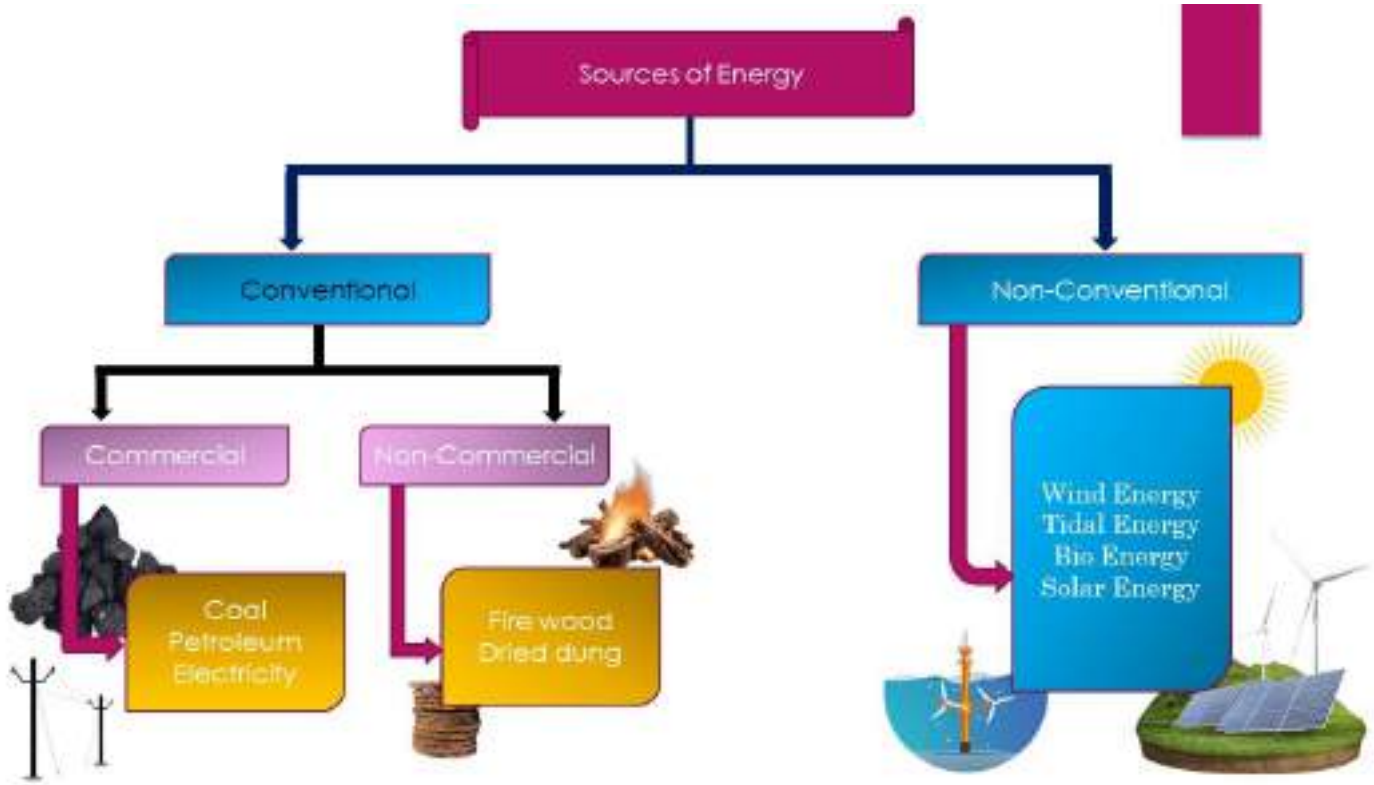
Soyel Majumder
soyelmajumderofficial@gmail.com

Index

Renewable Energy

Renewable energy is energy derived from natural sources that are replenished at a higher rate than they are consumed. Sunlight and wind, for example, are such sources that are constantly being replenished. Renewable energy sources are plentiful and all around us.

1. Energy Sources Chart:



2. Abstract:

The future of humanity and the planet depends on how we produce energy: a reliable, affordable and decarbonized energy system is essential.

3. Introduction:

Energy is the primary and most universal measure of all kinds of work by human beings and nature. Everything what happens in the world is the expression of flow of energy in one of its forms. Most people use the word energy for input to their bodies or to the machines and thus think about crude fuels and electric power. The energy sources available can be divided into three types:

(i) Primary Energy Sources. Primary energy sources can be defined as sources which provide a net supply of energy. Coal, oil, uranium etc. are examples of this type. The energy required to obtain these fuels is much less than what they can produce by combustion or nuclear reaction. Their energy yield ratio is very high. The yield ratio is defined as the energy fed back by the material to the energy received from the environment. The primary fuels only can accelerate growth but their supply is limited. It becomes very essential to use these fuels sparingly. Primary fuels contributes considerably to the energy supply. (ii) Secondary fuels produce no net energy. Though it may be necessary for the economy, these may not yield net energy. Intensive agricultural is an example wherein terms of energy the yield is less than the input. (iii) Supplementary sources are defined as those whose net energy yield is zero and those requiring highest investment in terms of energy Insulation (thermal) is an example for this source.

Coal, natural gas, oil and nuclear energy using breeder reactor are net energy yielders and are primary sources of energy. Secondary sources are like solar energy, wind energy, water energy etc. Solar energy can be used through plants, solar cells and solar heaters. Solar tower is another emerging technology. Solar drying and solar heating are economical applications when passive methods are used. Because of the dilute nature of solar energy it is difficult to classify the source as a primary one. Better sources are wind, tide, wave and hydroelectric applications. Geothermal and ocean thermal are the other sources which may well prove worthwhile. It may be necessary in future to develop the secondary sources like solar, wind etc.

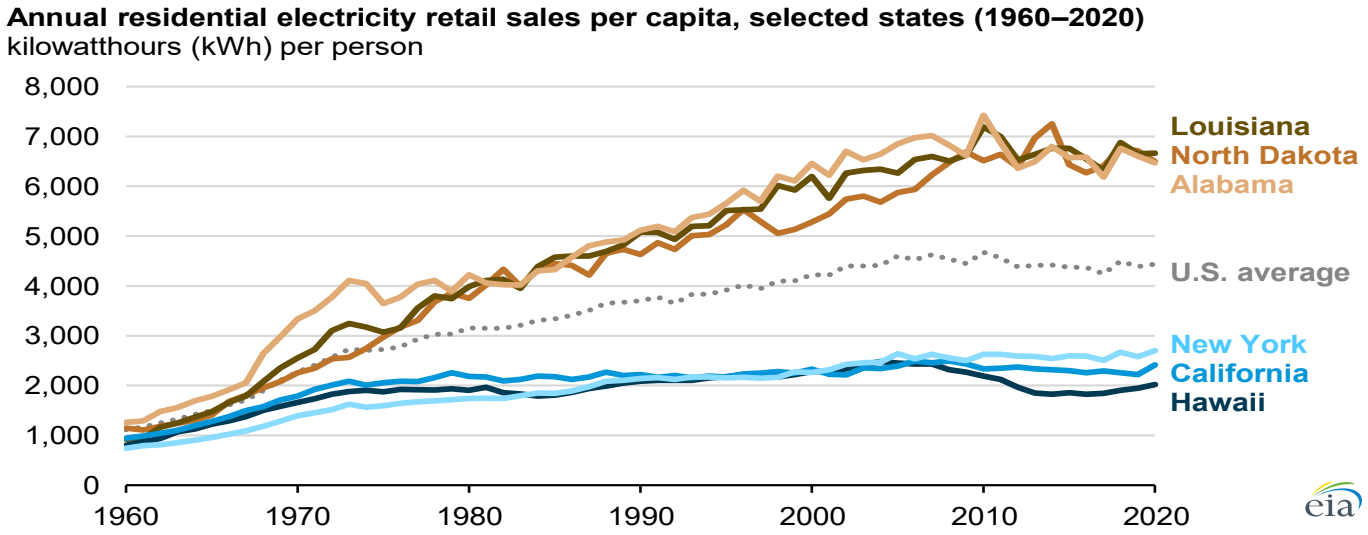
Energy is an important input in all sectors of any country's economy. The standard of living of a given country can be directly related to per capita energy consumption. Energy crisis is due to the two reasons; firstly, that the

population of the world has increased rapidly and secondly the standard of living of human beings has increased. If we take the annual per capita income of various countries and plot them against per head energy consumption.

3.1. Per Capita U.S. residential electricity use:

From 1960 to 2010, per capita U.S. residential electricity use increased by an average of 3% per year. However, that trend reversed over the past decade because of warmer weather and energy efficiency improvements.

Although many people spent more time at home during 2020 in response to the COVID-19 pandemic, retail sales of electricity to the residential sector in the United States, calculated per capita (per person), averaged 4,437 kilowatt-hours (kWh) per person, only 1% more than in 2019. Warmer weather in 2020 (including a significantly warmer winter) increased electricity consumption for air conditioning during the summer but reduced U.S. home electricity consumption for space heating during the winter.

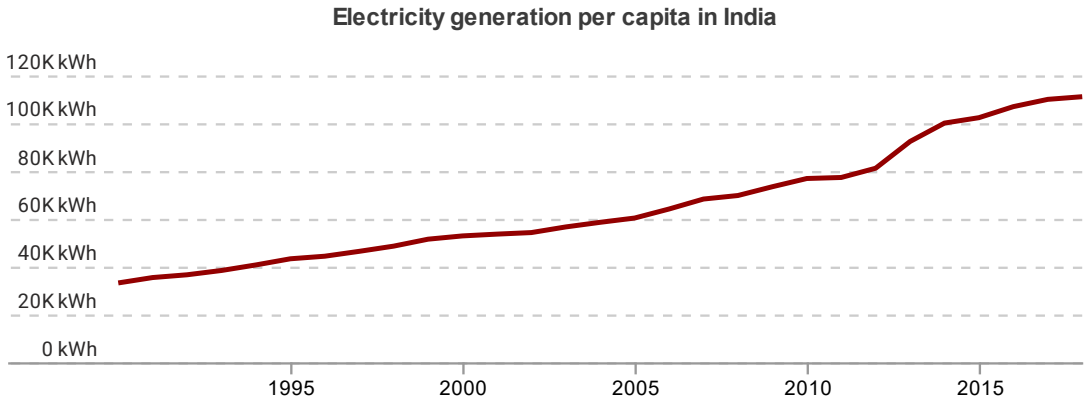


3.2. Per capita India residential electricity use:

India's per capita electricity consumption was 1255 kWh in 2021-22, which is around one-third of the global average of per capita electricity consumption. The Government of India, through Bureau of Energy Efficiency (BEE), has implemented schemes that help in increasing energy efficiency, such as Standards and Label (S&L) Programme, Unnat Jyoti by Affordable LEDs for All (UJALA), Street Lighting National Programme (SLNP), Building Energy Efficiency, Agriculture and Municipal Demand Side Management. As per the Generation Expansion Planning studies carried out by the Central Electricity Authority (CEA) for 2029-30, the share of non-fossil fuel based

generation capacity in the total installed capacity of the Country is likely to increase from around 42% as on Oct, 2022 to more than 64% by 2029-30.

This would reduce the dependence on fossil fuel in electricity generation and promote alternative sources of power like solar and wind.



4. Energy Sources and it's availability:

Today, every country draws its energy needs from a variety of sources. We can broadly categorize these sources as commercial and non-commercial. The commercial sources include the fossil fuels (coal, oil and natural gas), hydroelectric power and nuclear power, while the non-commercial sources include wood, animal waste and agricultural wastes. In an industrialized country like, U.S.A., most of the energy requirements are met from commercial sources, while in an industrially less developed country like India, the use of commercial and non-commercial sources are about equal.

4.1. Commercial or Conventional Energy Sources Major Sources of energy include:

(i) Fossil fuels i.e. solid fuels (mainly coal including anthracite, bituminous, and brown coals lignites and peals), liquid and gaseous fuels including petroleum and its derivatives and natural gas.

(ii) Water power or energy stored in water.

(iii) Energy of nuclear fission.

Minor sources of energy include sun, wind, tides in the sea, geothermal, ocean thermal electric conversion, fuel cells, thermionic, thermoelectric generators etc.

Wood was dominant source of energy in the pre-industrialization era. It gave way to coal and coke. Use of coal reached a peak in the early part of the twentieth century. Oil get introduced at that time and has taken a substantial share from wood and coal. Wood is no more regarded as a conventional source. Hydroelectricity has already grown to a stable level in most of the developed countries. A brief account of the various important sources of energy and their future possibilities is given below.

Coal, oil, gas, uranium and hydro are commonly known as commercial or conventional energy sources. Looking at the percentage distribution one finds that world's energy supply comes mainly from fossil fuels. The heavy dependence on fossil fuels stands out clearly. One of the so most significant aspects of the current energy consumption pattern in many developing countries is that non-commercial sources such as firewood, animal dung and agricultural waste represent a significant 8% of the total energy used in the world. Then constitute about 4 times the energy produced by the hydro and 60 times the energy produced by nuclear sources. In some developing countries non-commercial energy sources are a significant fraction of the total resources. This dependence of the developing countries is likely to continue unless replaced by other alternative sources of energy.

(i) **Coal.** Since the advent of industrialization coal has been the most common source of energy. In the last three decades, the world switched over from coal to oil as a major source of energy because it is simpler and cleaner to obtain useful energy from oil.

Modern steam boilers burn coal in any of its forms as a primary fuel. Coal developed vegetable matter which grew in past geological ages. Trees and plants falling into water decayed and produced peat bogs. Gigantic geological upheavals burried these bogs under layers of silt. Soil pressure, heat and movement of the earth's crust distilled off some of the bog's gaseous matter to form brown coal, or lignite. Continuing subterrane an activity reduces the coal's gaseous content progressively to form different ranks; peat lignite, bituminous and anthracite.

(ii) **Oil.** Almost 40% of the energy needs of the world are fed by oil. The rising prices of oil has brought a considerable strain to the economy of the world more, so in the case of the developing countries that do not possess oil reserves enough for their own consumption. With today's consumption and a

resource amount of 250,000 million tonnes of oil, it would suffice for about 100 years unless more oil is discovered. The question is whether an alternative to oil would then be available, the world must start thinking of a change from a world economy dominated by oil.

(iii) **Gas.** Gas is incompletely utilized at present and huge quantities are burnt off in the oil production process because of the non-availability of ready market. The reason may be the high transportation cost of the gas. To transport gas is costlier than transporting oil. Large reserves are estimated to be located in inaccessible areas.

(iv) **Agriculture and organic wastes**: At present small quantities of Agri-cultural and organic wastes consisting of draw saw dust, bagasse, garbage, animal dung, paddy husk and corn stem accounting a major energy consumption. Most of the remaining material was burnt or left, unused causing considerable environ-mental problems.

a. The waste should be utilised near the source, in order to reduce the transportation cost.

b. Appropriate equipment for burning, or extracting energy from the materials should be developed to suit the local conditions and meet the requirements of the rural areas.

(v) **Water Power:** Water power is developed by allowing water to fall un- der the force of gravity. It is used almost exclusively for electric power generation. In fact, the generation of water power on a large scale became possible around the beginning of the twentieth century only with the development of electrical power transmission. Prior to that, water power plants (Hydroelectric plants) were usually of small capacities usual less than 100 kW.

vi) **Nuclear Power:** According to modern theories of atomic structure, matter consists at minute particles known as atoms. These atoms represent enormous concentration of binding energy. Controlled fission of heavier unstable at- oms such as U235, Th232 and artificial element Pu239, liberate large amount of heat energy. This enormous release of energy from a relatively small mass of nuclear fuels makes this source of energy of great importance. The energy released by the complete fission of one kg of U235, is equal to the heat energy obtained by burning 4500 tonnes of high-grade coal or 2200 tonnes of oil. The heat produced by nuclear fission of the atoms of

fissionable material is utilized in special heat exchangers for the production of steam which is then used to drive turbogenerators as in the conventional power plants.

(vii) **Thermal (burner) and Breeder Reactors:** As stated above, nuclear fission involves splitting the nucleus of heavy atoms, like uranium or plutonium, in a controlled nuclear chain reaction. During fission, heat is released and this can be used to generate high pressure steam to drive turbo-generators and produce electricity. The current generation of 'thermal' or 'burner' nuclear reactors is only able to utilize a tiny fraction of the uranium fuel. The nuclear chain reaction is sustained by uranium-235 which constitutes little more than 0.7% of natural uranium. Thermal reactors also make limited use of the more abundant uranium-238 isotope. During the fission process a small proportion of that present in the fuel is converted (by neutron capture) into fissionable plutonium-239, and some of this fissions to produce heat.

(viii) **The Nuclear option:** One response to the problem of increasing fossil fuel dependency has been to advocate a rapid expansion of nuclear power. However, even if thousands of large nuclear reactors could be built over the comming decades, nuclear power would still only make a small contribution to meeting world energy demand. After more than a quarter of a century of development, nuclear power provides only a few percent of the world's electricity which itself only accounts for a small proportion of the total energy demand. Furthermore, the nuclear path is fraught with dangers. The intractable nature of many of the environmental as well as the social, political and technical problems, and the continued escalation in the costs, have led to widespread disenchantment with nuclear technology.

4.2. New Energy Technologies: Numerous studies are going on around the world in this direction and it would be unwieldly to summarize all of them here. Only a few selected items will be reviewed briefly.

Coal: The first major break through is the application of fluidized bed technology for the coal gasification, carbonization and combustion. Vast improvement in performance and efficiency are achieved. The technology is already commercialized. Presently pressurized fluidised bed technology

is being developed to further improve the performance. The fluidised bed technique has helped to utilise the low rank as well as high ash coals.

4.3. None-Conventional Energy Sources:

i. **Wind Energy:** Energy of wind can be economically used for the generation of electrical energy. Winds are caused from two main factors:

a) Heating and cooling of the atmosphere which generates convection currents. Heating is caused by the absorption of solar energy on the earth's surface and in the atmosphere.

b) The rotation of the earth with respect to atmosphere, and its motion around the sun.

The potential of wind energy as a source of power is large. The energy available in the winds over the earth's surface is estimated to be 1.6 x 107 MW, which is of the same order of magnitude as the present energy consumption on the earth.

ii. **Tidal Energy:** The tidal cycle occurs every 12 hours due to the gravitational force of the moon. The difference in water height from low tide and high tide is potential energy. Similar to traditional hydropower generated from dams, tidal water can be captured in a barrage across an estuary during high tide and forced through a hydro-turbine during low tide. The capital cost for tidal energy power plants is very high due to high civil construction and high power purchase tariff. To capture sufficient power from the tidal energy potential, the height of high tide must be at least five meters (16 feet) greater than low tide. Total identified potential of Tidal Energy is about 12455 MW, with potential locations identified at Khambat & Kutch regions, and large backwaters, where barrage technology could be used.

iii. **Energy from Bio-mass and Bio-gas:** The potential for application of bio-mass as an alternate source of energy in India is very great. We have plenty of agricultural and forest resources for production of biomass. Biomass is produced in nature through photosynthesis achieved by solar energy conversion. As the word clearly signifies, Biomass means organic matter. In simplest form the reaction is the process of photosynthesis in the presence of solar radiation, can be represented as follows

$$H_2O + CO_2 \xrightarrow{Solar\ energy} CH_2O + O_2$$

In the reaction, water and carbon dioxide are converted into organic material i.e., CH_2O, which is the basic molecule of forming carbohydrate stable at low temperature, it breaks at high temperature, releasing an amount of heat equal to 112,000 cal/mole (469 kJ mole).

$$CH_2O + O \longrightarrow CO_2 + H_2O + 112\ kcal/mole.$$

The absorbed energy of photons should be at least equal to this amount. It is therefore, possible to produce large amount of carbohydrate by growing say, algae, under optimum conditions in plastic tubes or in ponds. The algae could be harvested, dried and burned for production of heat that could be converted into electricity by conventional methods. The bio-mass is used directly by burning or is further processed to produce more convenient liquid and gaseous fuels.

5. **Solar Energy:** Solar energy has the greatest potential of all the sources of renewable energy and if only a small amount of this form of energy could be used, it will be one of the most important supplies of energy specially when other sources in the country have depleted.

Energy comes to the earth from the sun. This energy keeps the temperature of the earth above that in colder space, causes current, in the atmosphere and in ocean, causes the water cycle and generate photosynthesis in plants.

The solar power where sun hits atmosphere is 1017 watts, whereas the solar power on earth's surface is 1016 watts. The total world-wide power demand of all needs of civilization is 1013 watts. Therefore, the sun gives us 1000 times more power than we need. If we can use 5% of this energy, it will be 50 times what the world will require. The energy radiated by the sun on a bright sunny day is approximately 1 kW/m^2, attempts have been made to make use of this energy in raising steam which may be used in driving the prime movers for the purpose of generation of electrical energy. However on account of large space required, uncertainty of availability of energy at constant rate, due to clouds, winds, haze etc., there is limited application of this source in the generation of electric power. Now-a-days the drawbacks as pointed out that energy cannot be stored and it is a dilute form of energy, are out dated arguments, since the energy can be stored by producing hydrogen, or by storing in other mechanical or electrical devices, or it can be stored in containers of chemicals called eutectric or phase changing salts. These salts which store large quantities of heat in a relatively small volume, melt when they are heated and release heat later as they cool and crystallize. The energy can be concentrated in solar furnaces, for example which can achieve temperatures in the region of 5000°C. The facts speak in favour of solar energy, as we have seen in analysis of commercial energy sources, that world's reserves of coal, oil and gas will be exhausted within a few decades. Nuclear energy involve considerable hazards and nuclear fusion has not yet overcome all the problems of even fundamental research, compared with these technologies, the feasibility of which is still uncertain and contested, the technical utilization of solar energy can prove very useful. Utilization of solar energy is of great importance to India since it lies in a temperature climate of the region of the world where sun light is abundant for a major part of the year. The basic research in solar energy is being carried in universities and educational and research institutions, public sector institution, Bharat Heavy Electricals Limited and Central Electronic Limited are carrying out a co-ordinated programme of research in solar energy.

The applications of solar energy which are enjoying most success today are:

a) Heating and cooling of residential building.
b) Solar water heating.

c) Solar drying of agricultural and animal products.
d) Solar distillation on a small community scale.
e) Salt production by evaporation of seawater or inland.
f) Solar cookers.
g) Solar engines for water pumping.
h) Food refrigeration.
i) Bio conversion and wind energy, which are indirect source of solar energy.
j) Solar furnaces.
k) Solar electric power generation by-

- Solar ponds.
- Steam generators heated by rotating reflectors (heliostat mirrors), or by tower concept.
- Reflectors with lenses and pipes for fluid circulation (cylindrical parabolic reflectors).

l. Solar photovoltaic cells, which can be used for conversion of solar energy directly into electricity or for water pumping in rural agricultural purposes.

6. Solar Energy for Agriculture:

The demand for electrical energy is far outstripping supply, especially in the agricultural sector. It is also becoming increasingly difficult to meet the exponential growth in demand of Agricultural productivity which is closely associated to direct and indirect energy inputs. Necessary policies are required to consolidate this relationship for the benefit of farmers. If any development in rural areas is to be achieved, proper energy inputs must be made available. This may require special efforts in the country as a whole to develop and utilize renewable energy sources particularly the solar energy. Rural electrification has eluded the most far flung rural areas of the country. It is cost-prohibitive for the Government to extend grid power to remote areas especially to meet agriculture loads. An integrated approach for irrigation and water conservation with scientific agricultural practices, the system of solar energy water pumping assume relevance for optimum exploitation of the ground water resource for the benefit of small/marginal farmers. Inter-sectoral cooperation is necessary and it should include Government, Financial Institutions, Banks, NGOs and the Private sector. It would appear that there is a strong case for the design of institutional mechanisms for encouraging closer cooperation and collaboration between the agricultural and energy sectors.

7. Solar Energy Based Water Lifting And Pumping Systems For Small Irrigation Projects:

Under non-conventional energy source, power generation can be made through Biomass, windmill, small Hydro Electric, Solar Photovoltaic and Solar Thermal systems. Among solar technologies useful in irrigation sector are pumping and water lifting. Water pumping by solar power is a concept which has won widespread interest since the early seventies. Solar energy can be utilized to operate pumps, utilizing either the thermal or light part of solar radiation. With a solar pump, energy is not available on demand. The daily variation in solar power generation necessitates the surplus of water pumped on sunny days and shortage on cloudy days. In view of the fluctuating water demand of any irrigation scheme, solar energy needs to be reserved in the form of either electricity in batteries or lifted water in a storage tank. The suitability of solar power for lifting water to irrigate plants is undeniable because of the complementarities between solar irradiance and water requirements of crops. The more intensively the sun is shining the higher is the power to supply irrigation water while on the other hand on rainy days irrigation is neither possible nor needed. Small scale irrigation is one of the most potential applications of solar power. The main advantage is that solar radiation is intense when the need for irrigation is high. Further, solar power is available at the point of use, making the farmer independent of fuel supplies or electrical transmission lines. The solar pumps have the potential to revolutionize small scale irrigation in the developing countries in the near

future. The technical feasibility of solar (photo voltaic) pumps has been established. The major limiting factor has been the high cost and the lack of familiarity of the technology which require concerted effort in training of technicians and large scale introduction in a region with adequate technical support. However with the incentives and initiatives undertaken by MNES, Government of India and State Government, the scheme may be propagated in rural areas for small irrigation system in far-flung rural areas where electrification is a costly proposition. The model scheme is to introduce solar water pumping and support irrigation schemes to provide a sustainable economic activity to farmers in non-electrified or under electrified rural areas. Various agencies and financial institutions are in place to assist the credit scheme targeted for non-electrified rural areas.

8. Photovoltaic Power Generation:

Photovoltaic cells frequently referred to as solar cells, convert the light part of the solar spectrum (Sunlight) into electricity. They are the most rapidly expanding energy sources in the world. Large scale manufacture of photovoltaic cells, coupled with continued research and development is expected to further make photovoltaic with in the economic framework of rural areas in developing countries.

9. **Solar Cells**:

The solar cell operates on the principle of the photovoltaic effect - the creation of charge carrier with in a material by the absorption of energy from the incident solar radiation. The efficiency of solar cells in converting incident solar energy into electrical energy depends on the illumination spectrum intensity, materials of construction and design of the cell, atmospheric temperature and clearness of the sky. Solar cells used in running DC electric motors have efficiencies ranging from 10 to 12 percent.

Silicon is the most commonly used material for making solar cells. Other materials include cadmium sulfide and gallium arsenate. The fabrication of the solar cell involves a large number of processes. Wafer form followed by junction formation, contact fabrication and anti reflection coating on the active surface of the cell. The outer surface of the panel is protected by a special tempered glass which provides high transmittance of sunlight.

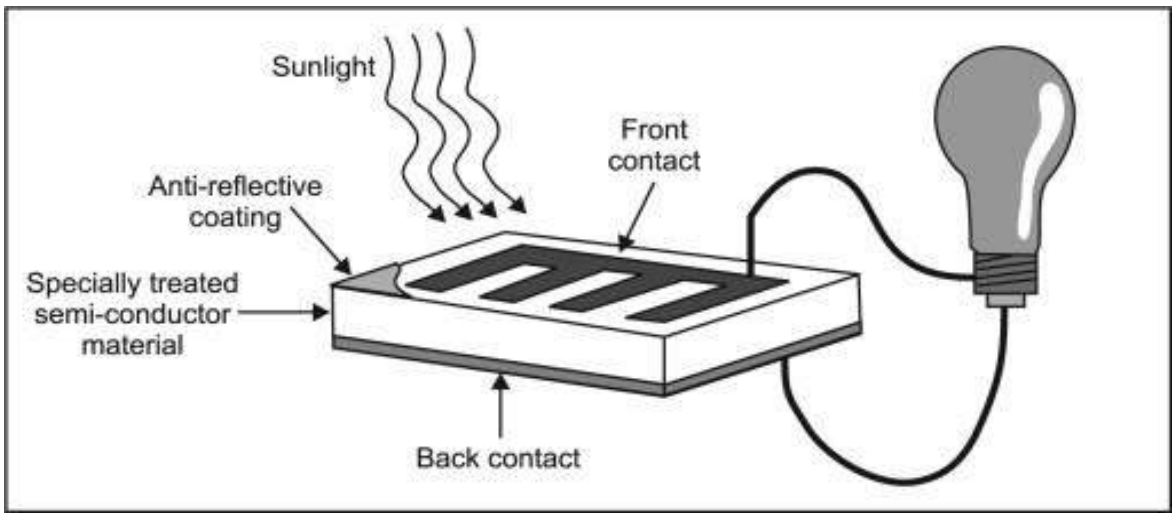
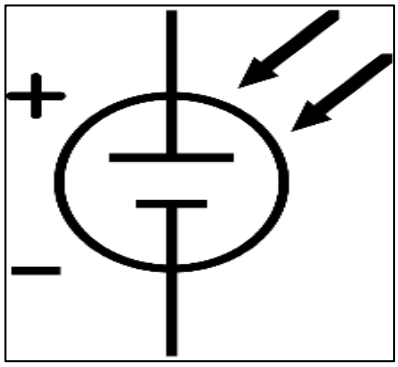


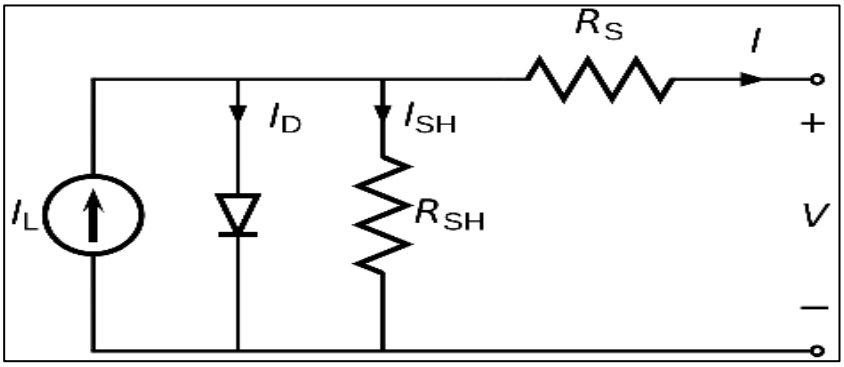
Figure: Solar cells

9.1. Equivalent Circuit of a solar cell:

To understand the electronic behaviour of a solar cell, it is useful to create a model which is electrically equivalent, and is based on discrete ideal electrical components whose behaviour is well defined. An ideal solar cell may be modelled by a current source in parallel with a diode; in practice no solar cell is ideal, so a shunt resistance and a series resistance component are added to the model.[4] The resulting equivalent circuit of a solar cell is shown on the right. Also shown, on the left, is the schematic representation of a solar cell for use in circuit diagrams.



The schematic symbol of solar cell



The equivalent circuit of a solar cell

10. Solar Array:

A solar cell behaves like a low voltage battery whose charge is continuously replenished at a rate proportional to the incident solar radiation. Connecting such cells into series of parallel configuration resulting in photovoltaic modules or solar arrays with high current and voltages. The power developed by a solar array range from 80 to 120 watts per square metre of the panel. The photovoltaic power can be utilized to operate conventional electrical appliances, including DC electric motors. The solar array is mounted on a simple frame which has provision for adjusting the array manually against the position of the sun.

11. Possible Water Sources:

The SPV based pump sets are low head high discharge and may be productively used at sites where water is available at relatively moderate level. The possible water sources for the SPV systems are pits, pen dug wells, medium tube wells, doggies, tanks, farm ponds and surface water from canals and rivers.

12. Pump sets For Photo Voltaic Power:

The solar pump unit consists essentially of a solar array, a direct-current electric motor and a pumping unit. The other components are the electrical control and some mechanism for tracking the array against the sun. Many types of pumping sets are used with photovoltaic systems such as a vertical centrifugal pump coupled to a submersible DC electric motor or an ordinary volute centrifugal pump close coupled to a horizontal DC electric motor. However, the submersible pump unit is most suitable for the photovoltaic system. The arrangement eliminates the suction pipe and foot valve and results in a higher efficiency of the pumping unit. The submersible pump is made leak-proof by a silicon carbide mechanical seal. In case of volute pump, care is taken to limit the pump suction within about 5m to maintain a high level of pump efficiency. The output of the solar array varies with the intensity of the incoming radiation and other factors. Hence, it is necessary to match a variable-speed DC motor with the panel output. At least one make of photovoltaic powered pumping sets utilizes a maximum power-control unit as an integral part of the system, in order to match the load on the pump to the varying power output of the panel. There is considerable commercial interest in manufacturing photovoltaic

powered pumping sets. The power output of the system is directly proportional to the number of solar cells and the surface area of the panel exposed to the sun. The discharge of a solar pump with array area of 2-4m varies from 6-8 lits/s at a head of15- 50 m. This could irrigate about 1.5 - 4 ha of land with crops having moderate irrigation requirements or may provide protective irrigation to even a larger command.

13. Data Collection:

13.1. Field survey:

Farmer Name: Salam Miah, Age: 42years

Address: Vill: Sathbhandari (South), P.O.: Chamta, PS.: Sitai, District: Cooch Behar, West Bengal, Pin: 736167

Daily Run: 10 AM to 3 PM, Area= 0.267 hectare/0.66 Acre/2Bigha

13.2.COST DETAILS:

Sl. No.	Models	Total Cost of system	Cost (Net of subsidy) (Rs.)	Benefit (Incremental incomel) (Rs.)	BCR	IRR (%)
1	Model – I (1800 Wp- 1.5 HP)	308320	184992	39587	1.00	15.04
2	Model –II (2200 Wp- 2 HP)	347200	208320	44833	1.00	15.20
3	Model – III (3000 Wp- 3 HP)	558400	335040	72019	1.00	15.14
4	Model – IV (5000 Wp- 4 HP)	767200	460320	98729	1.00	15.06

13.3.Incentives From Central/State Government:

The Ministry of New and Renewable Energy under JNNSM programme provides subsidy for off grid solar applications (solar water pumping) @ 30% of capital cost. Additional could be provided by State Govt.

14. **Maintenance Of SPV System**:

The supplier provides annual maintenance contract to the beneficiary after initial guarantee period of 5 years. The solar panel is expected to provide about 20 years of satisfactory service under normal conditions, even though the cell itself may last much longer. The only maintenance requirement is occasional washing of the surface to maintain maximum optical transmission through the glass. The panel has to be protected from breakage by external agencies. Some manufacturers cover the cell/array with unbreakable glass. The motor and the pump require the usual periodic maintenance like cleaning, lubrication and replacement of worn parts.

15. Advantages Of SPV Pumping System:

Cost effective: The life cycle and the cost to ultimate beneficiary make the SPV systems cost effective as compared to conventional systems. In addition, the farmer is saved from the capital investment for drawing lines from the grid to his field/farms. The government may save huge resources which otherwise may be uneconomical to network every agriculture field under the state electricity grid.

Reliable : The SPV is more reliable, consistent and predictable power option as compared to conventional power system in rural areas.

Free fuel: Sunlight, the fuel source of SPV system is a widely available, inexhaustible, reliable and free energy source. Hence the SPV system has no monthly fuel bills.

Low maintenance: The system operates on little servicing and no refuelling, making them popular for remote rural areas, hence the operation and maintenance is very low. The suppliers provide maintenance at a very low annual maintenance contract rates.

Local generation of power: The SPV system makes use of local resource-sunlight. This provides greater energy security and control of access to energy.

Easy transportation: As SPV systems are modular in nature they can easily be transported in pieces/components and are easily expandable to enhance the capacity

Energy Conservation: Solar energy is clearly one of the most effective energy conservation programs and provides a means for decentralized PV-generated power in rural areas. Solar pump is energy efficient and a decentralized system avoids any unnecessary expenditure.

Water conservation: The SPV sets are highly economical when combined with water conservation techniques such as drip irrigation & night time distribution of (day time pumped & stored) water. The SPV system leads to optimum exploitation of scarce ground water.

Environmental friendly: The use of sunlight as a source of fuel leads to clean, eco-friendly and decentralised generation of energy which saves the fossil fuel, controls deforestation and prevents environmental pollution.

16. Benefits to Farmers:

- No fuel costs & minimal maintenance costs.
- More economical than diesel pump sets in the long run.
- Enables cultivation of an extra crop,
- Helps in providing the critical protective irrigation in water scarce areas,
- Saves time and labour,
- Improves agriculture productivity,
- Improves general quality of life with higher levels of income,
- Incremental income enables easy repayment loan taken for installing system

17. Extension Services:

Adequate extension services are to be made available by agencies/suppliers in the scheme area. The beneficiaries may adopt modern cultivation practices and adopt crop diversification with an emphasis on cash crop/high remuneration crops. The guidance may be availed from local agriculture extension departments of the state government.

18. Conclusion:

Renewable energy is a vital and sustainable solution for meeting our energy needs while reducing the negative impact on the environment. Its widespread adoption has the potential to significantly decrease greenhouse gas emissions, mitigate climate change, and promote energy independence. The continuous advancements in renewable energy technologies, coupled with supportive policies and public awareness, will drive the transition towards a cleaner and more sustainable future. By embracing renewable energy sources such as solar, wind, hydro, and geothermal, we can create a greener and more resilient energy system that benefits both present and future generations.

19. Reference:

Energy Sources (Non-conventional), G.D. RAI, Khanna Publishers.
Source: Graph by the U.S. Energy Information Administration (EIA), based on EIA's State Energy Data System and Electricity Data Browser and data from the U.S. Census Bureau
https://www.eia.gov/todayinenergy/detail.php?id=49036
Graph:
https://datacommons.org/place/country/IND/?utm_medium=explore&mprop=amount&popt=Consumption&cpv=consumedThing,Energy&hl=en
Data:
https://pib.gov.in/PressReleseDetail.aspx?PRID=1883915#:~:text=India's%20per%20capita%20electricity%20consumption,of%20per%20capita%20electricity%20consumption
Source: https://vikaspedia.in/energy/energy-basics/sources-of-energy
Source: S.C. Bhatia, in Advanced Renewable Energy Systems, 2014 (https://www.sciencedirect.com/topics/chemistry/solar-cell)
Source: https://en.wikipedia.org/wiki/Theory_of_solar_cells#The_p-n_junction
https://agricoop.nic.in/
http://agricoop.gov.in/Documents/SolarPumpsetModel_0.pdf

Under the Guidance of-

Dr. Sulagna Dutta
Assistant Professor
Department of Physics
Mathabhanga College
2009 Received Ph.D from Jadavpur University for the thesis entitled "Theoretical study of the effect of dynamically induced coherence and spontaneously generated coherence on nonlinear processes"
Received DST Women Scientist –A (WOS-A) fellowship in 2011.
(www.mtbcollege.ac.in)

Report Submitted by-

Soyel Majumder
Student of 6th Semester
Department of Physics
Mathabhanga College
Under Cooch Behar
Panchanan Barma University.
Reg.: 2010101160566
Roll.: 2040101160540

ACKNOWLEDGEMENT

I would like to express my deepest gratitude to all those who have supported and contributed to the completion of this dissertation on Renewable Energy. Without their guidance, encouragement and assistance, this work would not have been possible.

First and foremost, I am immensely grateful to my supervisor, Ma'am Dr. Sulagna Dutta, for her invaluable guidance, expertise, and unwavering support through-out this research journey. Her insightful feedback, patience, and mentorship have been instrumental in shaping the direction and quality of this dissertation. I extend my sincere appreciation to the teachers of the Department of Physics of Mathabhanga College, for their academic wisdom, inspiring lectures, and fruitful discussions. Their expertise in the field of electronics and their commitment to knowledge dissemination have greatly enriched my understanding of Renewable Energy. My sincere gratitude goes to the Gram Panchayat Member of my village Hon'ble Mahabbat Miah. With his help I was able to collect information by field survey about solar pumps and family friends, members of family and my friends who have provided support, encouragement, and stimulating discussions throughout the course of this research. Their companionship and camaraderie have made this journey more enjoyable and fulfilling.

Lastly, I would like to express my heartfelt appreciation to all the authors, researchers, and scholars whose work served as a foundation for this dissertation. Their contributions to the Renewable Energy have paved the way for new insights and advancements.

To all those mentioned and the countless others who have contributed in their own ways, I offer my sincerest thanks. Your support and involvement have played a vital role in the completion of this dissertation.

Soyel Majumder
Student of 6th Semester
Department of Physics
Mathabhanga College