Hybrid Renewable Energy and its Power Applications

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Abstract

Renewable energy resources are becoming popular in today's world due to advances in renewable technology, rise in fossil fuel prices and their fast depleting sources. Renewable energy sources are sufficiently promising to include them in power generation but each source has some limitations and hence cannot cope up with the needs so we need to combine two or three resources to make a continuous supply. This can be done by using hybrid renewable technology. The paper describes HRES design and its energy and economic evaluation. The issues related to the penetration of energy system in the present network are highlighted. Research and development efforts in solar, wind, hydro and biomass are required for improving their performances, establishing technologies for predicting their output, making them reliable and their integration with other sources.

MAIN TEXT

In today's world everything is working/running on energy and on the other hand a major portion of this energy is produced by conventional resources which are costly, depleting on a faster scale and polluting in nature.

So now there is a need to find some alternatives to the conventional sources which are non-polluting, cost effective, and available easily and the alternative is renewable energy sources which get replenished on human time scale such as solar, wind, hydro, biomass etc. These resources can be used to replace the conventional resources.

Advantages of these sources over conventional sources are many; such as cheaper, easily available, non-polluting, spread over a wide geographical area and promising. Then why is renewable energy not being brought in use, why we still prefer to get 78-80% of our requirement from conventional sources. Does renewable energy have some drawbacks? Yes, as every coin has two sides these sources to have some disadvantages.

Now let's see both the sides of the coin,

SOLAR ENERGY

This is the radiant light coming from the sun. The solar energy is being used since ancient times for drying and heating purposes. But today since the technology has developed we harness the same energy with modern equipment's such as photo-voltaic cell, solar water heaters, cookers, chargers, etc. On an average the Earth receives approx.174 Peta-watt of solar energy. From this 30% gets reflected back to the space; rest is available on the Earth and can be used to generate a huge amount of energy. This energy is widely available, free, non-polluting, and can be used to power low energy consuming devices.

The disadvantages of solar energy are that the energy is available only during daytime and sunny weather, and the solar collectors, panels and cells are relatively expensive to manufacture. Cloudy skies reduce its effectiveness and also large areas of land are required to capture the suns energy. Batteries are used in the night time but these batteries are large and heavy and need lots of storage space. They also need replacing from time to time.

WIND ENERGY

It may be said that it is the energy extracted from the blowing wind by using devices such as windmills, wind turbines, wind pumps and sails for the purpose of electricity generation, water pumping and propulsion. This energy was used in ancient times for pumping water from the rivers to the fields and for the propulsion of ships and yachts. But today this energy resource is mostly used for electricity generation. The energy supplies were around 4% of worldwide electricity usage. The wind energy is available throughout the day and takes up only a small plot of land. Remote areas that are not connected to the electricity power grid can use wind turbines to produce their own supply and wind farms enhance the landscape of a given area.

The disadvantages of the wind energy are that the strength of the wind is not constant and keeps on varying. Wind turbines are noisy, and the offshore wind speeds are 90% greater than the land speeds. Large wind farms are needed to provide entire communities with enough electricity and there are some cases where people have reported that wind farms produce a visual pollution.

HYDRO POWER

Hydro power is the power derived from the flowing or falling water and hence also known as water power. Since ancient times it has been used for watermills, sawmills, and for irrigation. But today with modern techniques we have built turbines to convert the water power to electricity and hence the term hydroelectric power has come up. This source of energy provides huge power approx. 10 gigawatts per plant for e.g. the THREE GORGES DAM in China is the leading producer generating almost 22,500 Megawatts of energy. Normally dams are built on the riverbeds for this purpose. The advantages are that once a dam is constructed, electricity can be produced at a constant rate. If electricity is not needed, the gates can be shut, stopping electricity generation, the water can be saved for other use. Dams are designed to last many decades and so can contribute to the generation of electricity for many years. The lake that is formed behind the dam becomes a tourist attraction. The stored water can be used for irrigation purposes, electricity produced by a dam does not produce greenhouse gases and do not pollute the atmosphere.

The disadvantages of this energy are that dams are extremely expensive to build and must be built to a very high standard. The flooding of large areas of land means that the natural environment and that particular ecosystem is destroyed. People living in villages and towns that are in the valley to be flooded, must be moved out. This means that they lose their farms and businesses. In some countries, people are forcibly removed so that hydro-power schemes can go ahead. Building of large dams can cause serious geological damage. For example, the building of the Hoover Dam in the USA triggered a number of earth quakes and has depressed the earth's surface at its location. Dams built block the progress of a river in one state usually meaning that the water supply from the same river in the following state is affected and out of their control. This can lead to serious problems between neighboring states. Breakage of the dam due to water force may cause heavy damage and the dams can only be built on the course of a river so this renewable energy is confined to a geographical location.

BIOENERGY

Bioenergy is a renewable energy made available from materials derived from biological resources.

We have used biomass energy or bioenergy - the energy from organic matter - for thousands of years, ever since people started burning wood to cook food or to keep warm. And today, wood is still our largest biomass energy resource. But many other sources of biomass can now be used, including plants, residues from agriculture or forestry, and the organic component of municipal and industrial wastes. Even the fumes from landfills can be used as a biomass energy source. Biomass Energy technology applications are**:**

Biofuels- Converting biomass into liquid fuels for transportation.

Bio power- Burning biomass directly, or converting it into a gaseous fuel or oil, to generate electricity.

Bio products-Converting biomass into chemicals for making products that typically are made from petroleum.

This biomass is used for the generation of biogas. Biogas typically refers to a mixture of different gases produced by the breakdown of organic matter (biomass) in the absence of oxygen. Biogas can be produced from raw materials such as agricultural waste, manure, municipal waste, plant material, sewage, green waste or food waste. It is a renewable energy source and in many cases exerts a very small carbon footprint. Biogas can be used for any heating purpose, such as cooking. It can also be used in a gas engine to convert the energy in the gas into electricity and heat. Biogas is estimated to have the potential to replace around 17% of vehicle fuel.

The advantages of biogas generated from the biomass are that biogas is considered to be a renewable source of energy as it is produced from materials which form waste. The production of biogas is non-polluting in nature; it reduces the landfills as it uses the waste, the technology is a cheaper technology and it has very little investment.

The disadvantages of the biogas are the process of using biogas is not viable as it is less attractive to the people. It may lead to explosion if the methane leaks and it needs refinement for its industrial use.

Now above we have seen that renewable energy have both advantages as well as disadvantages. But the disadvantages are less as compared to the advantages. The main problem of the renewable energies is that they are seasonal and their generation varies throughout the year like solar generation drops during rainy and cloudy seasons, wind generation falls when the wind speed is not achieved, biogas requires manning of the plant and hydro power requires continuous flow of water.

We require a continuous and constant energy flow and any one renewable energy source cannot provide this so why don't we combine two or three renewable energy sources to gain a continuous output? This is known as hybrid renewable energy.

Hybrid renewable energy systems (HRES) are becoming popular for remote area power generation applications due to advances in renewable energy technologies and subsequent rise in prices of petroleum products. A hybrid energy system usually consists of two or more renewable energy sources used together to provide increased system efficiency as well as greater balance in energy supply. So if all the three are combined into one hybrid power generating system the drawbacks can be avoided partially or completely, depending on the control units. One or more drawbacks can be overcome by the other, eg. in the northern hemisphere it is generally seen that on windy days, the solar power is limited and vice versa and in the summer and rainy seasons the biomass plant can operate in a full-fledged manner so the power generation can be maintained in the above stated conditions.

Now as a case study I have taken the campus of my college and I have studied the total consumption of my college and on the basis of which I have designed a hybrid power system to power the college campus

which will replace the MSEB supply for good. Now the advantages of my campus are that it has a wide open area suitable for solar panel installations. There is a river flowing along the campus which is suitable for generation of hydroelectric energy and a huge amount of waste is generated daily which can be used for the generation of biogas.

MANET CASE STUDY

Average Total consumption of the campus is 2, 50,000 units (kW-hr)

And the bill amount is Rs. 25, 00,000/- that means approx. Rs. 10/- per unit

Hence per day the campus requires about 8333 units of electricity.

Now as per the time over device concept by MSEB it specifies different consumptions in different times:-

Zone A- 0000hours to 0600hours & 2200hours to 2400hours.

Zone B- 0600hours to 0900hours & 1200hours to 1800hours.

Zone C- 0900hours to 1200hours.

Zone D- 1800hours to 2200hours.

And as per the bill, consumption during zone B and zone C is 1, 34,710 units and during zone A and zone D is 1, 15,240 units.

SOLAR POWER

The time period during which generation by means of solar power can take place is 0600hours to 1800hours. This time period is in the zones B & C. For making use of solar energy available there are two arrangements possible:

A. Mounting solar panels and making use of batteries to make power available throughout the day.

B. Mounting solar panels and directly supplying generated power to the load. But this can take years to complete. This increases the generation cost by 40%. Hence this arrangement is not economically viable. Also this arrangement is used without considering the cost where energy needs to be supplied and there is no other alternative.

Our consumption during the day time is 1, 34,710 units per day. During the daytime we require almost 4,465 units from 0600-1800 hours.

Per year 4465*365=16, 29,725 units per year.

Now, as per the information provided by TATA SOLAR POWER 1kw-hr solar system generates about 1,500 units per year.

So, annual consumption /generation per year = 1629725/1500 = 1,084 kW system. This means that an approximate requirement is of 1 MW capacity.

The requirements for the plant are as follows:

A. **Land availability** - 4 acres of area is required. The land can be available in breakups or single piece of land.

B. **The total investment** - This may go up to 7 crores; including everything. The mountings can be made on ground or at a raised height as suitable to us.

The solar system is like a fixed deposit……. we will reap our returns only after the maturity date!!!!

For our campus,

Total investment = starting investment + maintenance

This goes to 8 crores for 1 MW system.

Generation per year from the system= 16, 29,725 units

Currently our campus pays approximately Rs. 10/- per unit to MSEB.

So the cost saved per year with this installation is 16, 29,725*10= 1, 62, 97,250

Which is almost 1.62 crores.

So, the time period after which we will start getting energy for free is

= total investment/savings per year.

=7crore/1.62crore =4.3 years.

So, after 4.3 years the campus starts to get almost 16, 29,725 units of electricity for free. This means almost Rs. 1.62 crores will be saved per year. This can be used for providing other facilities such as better infrastructure and more modern teaching aid.

Thus solar energy will be supplying almost 53.8% of our total power demand.

HYDRO-ELECTRIC ENERGY

Through the campus, river Mula-Mutha flows and a weir has been constructed on the flow channel. The height of the weir (wall) is almost 4-4.5 meter and water flows over the wall for most of the year. The wall has 7 big openings in it which are almost 4 feet in length and 4 feet in height. Discharge through these openings is large. If a turbine could be fitted on these openings it could be a source of electricity generation. The turbine can be coupled to a suitable alternator to generate the electricity which can be provided continuously as long as the water is flowing.

These type of projects are known as small head projects and generally a propeller turbine is used.

CALCULATION OF GENERATION POSSIBLE -

Area of opening = 1.44 sq. meter, assuming only 80% of area is effective.

Velocity of water flow = Square Root of 2*g*h,

Where,

g = gravitational acceleration,

h = height of water in Pitot tube.

So velocity comes to 2.5 meter/second (height of water in Pitot tube was measured at the opening)

And according to the general formula for shaft power,

Power = n*g*Q*H*ρ,

Where, ρ = density of water

G = gravitational acceleration

H = height of wall

Q = discharge of water

Hence, Power = 113.011 kW.

As there are some losses always present at alternator and transmission assuming 30% power is lost. Therefore we are left with 80 kW.

So if the alternator runs for 1 hour with 80kw of power it will be generating 80 units per hour. So in a day, 1,920 units and in a month = 57,600 units for one opening in the wall.

Thus hydro power supplies almost 23.04% of our power demand.

The investment required for the turbine and alternator may differ with the further consideration and may require more deep study.

BIOMASS ENERGY (Biogas)

In our campus we have a dining mess which provides food for cadets and there are lawns which need to be maintained so they are the source of organic waste for biogas plants (Generally biogas plant needs cooked waste for better generation)

The design of the biogas plant depends upon the amount and type of waste available. Basically, if the waste generated is around 40-50kg then a basic module of 10 cu.meter digester volume, which is capable of absorbing 30-50 kg of mixed waste per day. Installation of multiple units is possible if the waste generated is higher. A certain amount of physical work is also needed to be done.

Now as per the information provided by the mess staff approximately 100 -110 kg of waste is generated per day. So, it will be advised to install 3 units of biogas plant each having a capacity of 10 cu.meter. A food pulverizer must be provided with the plant for maceration of the food waste. The Biogas generated may be used for heating water, cooking or as a fuel for stationary IC engine. With mixed food waste of

40-50kg it is possible to generate 7-10kg of biogas which is equivalent to 3-4 kg of LPG and if used for running an IC engine energy of about 15-20 kW-hr can be generated.

So for waste of 110 kg on a daily basis it is possible to generate about 60 units.

For a month 60*30=1800 units

Surely this is a very small quantity but this may be used for small purposes such as powering street lights or heating the water.

So, from a total consumption of 2,50,000 units, approx. 1,34,710 units will be provided by a solar plant, approx. 57,600 units by a hydro power plant and approx. 1,800 units by a biogas plant. Still we will be short by 55,890 units.

Now to make the campus completely independent from the MSEB supply some changes must be made in the original design so that we will conserve energy.

1.) **Replacing the conventional tubes with LED tubes**:

At present we are using the conventional tubes and sodium vapor lamps whose running hours and total consumption is given below in a tabular form-

Device	Wattage	Running hours	Quantity	Consumption units (per day)
Tube light	40	10	2500	1000 units
Bulb	10	8	1000	80 units
Streetlight	150	12	30	54 units
Streetlight	70	12	40	34 units

Hence total consumption per day = 1,168 units

So, **for every month= 1,168*30= 35,040 units**

If these are replaced with LED fittings giving the same luminance for same running hours their consumption will be as follows:-

Device	Wattage	Running hours	Quantity	Consumption (per day) units
LED Tube light	16	10	2500	400 units
LED Bulb	3	8	1000	24 units
LED Streetlight	65	12	30	24 units

LED Streetlight	36	12	40	18 units

Total consumption per day after replacement with LED = 466 units,

For **every month= 466*30=13,980 units**.

Hence, **total savings per month 35,040-13,980 = 21,060 units.** This will be the savings.

2.) **Fitting the buildings with the light dimmer circuits** -

There circuits are available in the market. They can help us to adjust the intensity of light just as we adjust the speed of a fan with a regulator. LDR sensors are available which sense the outside natural light and adjust the intensity of light. This saves a lot of electricity.

3.) **Motion sensors**-

On several occasions, we just walkout of some places forgetting to switch off lights and fans and unnecessarily wasting electricity. Motion sensors can be installed in the parking, common room and corridors. They will sense the human movement and accordingly control the supply to that particular place.

Now,

Total consumption= 2, 50,000 units

Total generation= 1, 34,710+57,600+1,800+21,060=2, 15,710 units

So, we have to depend on MSEB for remaining 34,830 units.

The campus can be made completely campus free but needs research and more development

The advantages of the hybrid renewable energy are same as that of individual renewable energy

There are many advantages of renewable energy and some of them are listed below

1.) **Lower surrounding temperatures**- As most of the sun's radiant heat is absorbed by the solar panels mounted on the roofs it helps to keep the building and surrounding at a lower temperature.

This saves the extra cost of ventilation needed to cool the buildings. Roofs of parking shade are covered solar panels which in turn provide electricity to the lamps there.

2.) **Smart investment**- Investment in solar is considered to be a smart investment as it gives the profits by reducing your electricity bills.

3.) **Carbon footprint reduction**- For each unit of the renewable energy 0.864 pounds of carbon footprint is saved.

4.) **Independent power**- We do not need to depend on MSEB for the power supply. We generate our own and use our own electricity.

5.) **Green campus**- On successful installation of the hybrid power system in our campus our campus will be known as green campus and we can move ahead with the aim of zero emission campus.

6.) **Solution to the organic waste**- The waste generated in this campus is usually filled in landfills or is burnt in the vicinity. This is saved with the use of biogas plant plus it gives us the useful biogas.

7.) **Jobs and other economic benefits**- Compared with fossil fuel technologies, which are typically mechanized and capital intensive, the renewable energy industry is more labour- intensive. This means that, on an average, more jobs are created for each unit of electricity generated from renewable sources than from fossil fuels.

8.) **Stable energy prices-** If calculated properly, the per unit price of renewable energy is less than that of energy from fossil fuel. Solar energy= 7-8 Rs. per unit whereas at present our campus pays approximately 10Rs. per unit. The cost of renewable energy have declined and are projected to drop even more.

9.) **The penalty is saved**- The penalty for late payment of electricity bill which is up to 10% of bill is saved in case of delay.

CHALLENGES FOR HYBRID RENEWABLE ENERGY

1.) Reliability of Supply- One shortcoming is that renewable energy relies heavily upon the weather for sources of supply: rain, wind, and sunshine. In the event of weather that doesn't produce these kinds of climate conditions renewable energy sources lack the capacity to make energy. Since it may be difficult to generate the necessary energy due to the unpredictable weather patterns, we may need to reduce the amount of energy we use.

2.) Large Capital Cost- Initial investments are quite high in case of building renewable energy plants. These plants require upfront investments to build, have maintenance expenses and require careful planning and implementation. The huge cost of installation must be tackled some way for bringing it up to common people.

3.) Large Tracts of Land Required- To meet up with the large quantities of electricity produced by fossil fuels, large amount of solar panels and wind farms need to be set up. For this, large tracts of land is required to produce energy quantities competitive with fossil fuel burning.

4.) The **water in the hydro power** must be clean for efficient working of turbine and for which the river must be kept clean. Rivers which are dirty and contaminated on a large scale are barriers in energy generation.

5.) **Labour work in biogas plant** – There is some labour work with biogas plant which needs to be done regularly for efficient working of the system. This may include adding the feed and removing effluent.

6.) The biogas output is dependent on ambient temperature and may drop down in winter season.

The above given design and calculation of the hybrid renewable energy was done on the approximate cases and for designing and for actual implementation a deep study and intensive research will be required. My basic aim of the paper was to explain to the people this interesting concept of hybrid renewable energy and its advantages.

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REFERENCES

Google

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WIKIPEDIA