- The realization of the enormous need to electrify and energize remote, rural areas
- They are adequately available and have lesser impact on the environment and ecology
- They are ideally suited for decentralized variety of applications
- The future of fossil fuels is limited time, that is, it is estimated that it could about 70 to 100 years.
- Renewable energy is well-suited for inaccessible areas and hilly terrain

Individual and community power generation

A look at wind and hybrid power systems

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Introduction

In the present day energy scenario, many efforts have come into focus, for meeting the ever-increasing energy demand, with a view to develop new generation technologies. The major goals of these approaches are: to have reduced environmental damages, conservation of energy and exhaustible sources, and increased safety. In this context, during the past few years, renewable energy sources have received greater attention and considerable inputs have been given to develop efficient energy conversion and utilization techniques. Majority of the population in our country resides in the rural areas and a large number of the villages are still not served by the national grid due to the cost involved for laying of the transmission line.

Conventional sources of energy have a long generation period, draw heavily on exhaustible deposits, and adversely affect ecological balance. New and renewable sources of energy are not only economically viable but also do not suffer from any of the above disadvantages.

Developing new generation technologies and renewable energy sources

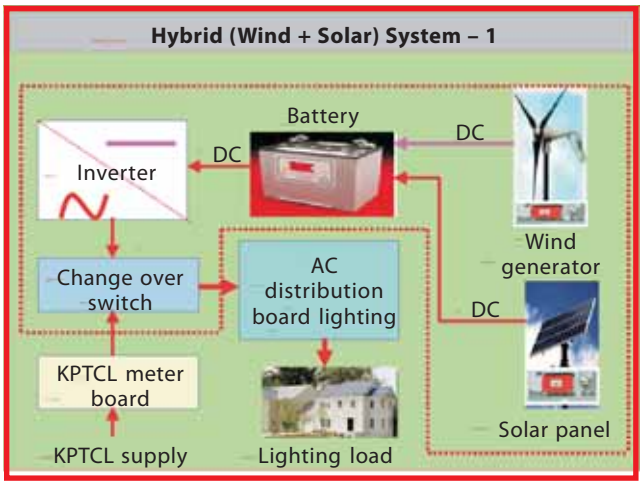
There are many reasons for developing new generation technologies.

- Ever-increasing energy demand
- Reduced environmental damages and increased safety
- Conversion of energy and inexhaustible sources
- Greater attention to developing efficient energy conversion and utilization techniques
- The cost of generation goes on decreasing with time

Hybrid systems (wind–solar)

A hybrid plant combines wind, solar, and hybrid power conditioning unit with a battery (Figure 1) to supply electricity to remote areas. Locations that relied on conventional fuel can now take advantage of natural energy.

A stand-alone wind system with a SPV (solar photovoltaic system) is the best hybrid combination of all renewable energy systems and is suitable for most of the applications, taking care of seasonal changes. They also compliment each other during lean periods, for example, additional



energy production through wind during monsoon months compensates the less output generated by solar. Similarly, during winter when the wind is dull, SPV takes over. The ground space required for wind generator is hardly 4 x 4 square feet. It can be easily erected on towers of 9 metres up to 18 metres with foldover mechanism on the ground. It can also be mounted on roofs of tall buildings. The low inertia comes in handy to start generating wind speeds as low as 2.5 metres per second. The energy generated can be easily combined with that of SPV through an integrated controller, which will ensure continuity of energy transfer into the battery bank system. This DC stored energy can be converted by power conditioning unit to AC single-phase 230V/50Hz—power that can be used for lighting load.

Solar and solar photovoltaic modules

Solar energy is a very large, inexhaustible source. The power from the sun intercepted by the earth is approximately 2.9 x 10^{15} MW, which is many thousands of times larger than the present consumption rate on the earth of all commercial energy source. Thus, in principal, solar energy could supply all the present and future energy needs of the world as a continuous basis. This makes it one of the most promising of the unconventional energy sources.

The solar modules generate DC electricity whenever sunlight falls on solar cells. The solar modules should be tilted at an optimum angle for that particular location, face due south, and should not be shaded at any time of the day.

Advantages/disadvantages of photovoltaic systems

Advantages

- Direct room temperature conversion of light to electricity through simple solid-state devices
- Absence of moving parts
- Ability to function unattended for long periods as evidence in space program
- Power levels: voltage/current can be achieved by more integration
- Maintenance cost is low, as they are easy to operate
- They do not create pollution
- They have a long effective life
- They consume no fuel to operate, as the sun's energy is free
- Rapid response in output to input radiation
- Wider power handling capabilities
- Easy to fabricate
- Amenable to on-site installation
- They can be used with or without sun tracking, making possible wide range of applications
- It is an environmentally clean source of energy.
- Available in adequate quantities in almost all parts of the world.

Disadvantages

- The solar radian flux availability is a low value: 1 kW / m^2 for technological utilization
- Large collecting area is required and the cost is more
- Its availability varies with time
- In many applications, energy storage is required because of insolation at night
- It has relatively poor conversion efficiency

Aero wind generator

Wind energy is a clean, renewable energy source, cheaper to maintain, saves fuel, and can give decentralized energy all through the day. This is one of the main components in this system and converts kinetic energy of wind into electrical energy in the wind into mechanical energy. An electric generator is coupled to the propeller shaft directly. This propeller in turn rotates the rotor of the electric generator and generates DC electricity. The output from the wind generator varies as per the wind speed. Wind electricity for decentralized system or hybrid generation of electricity using other energy sources as complementary to wind energy has now been given some attention and this could be suitable in low wind regimes for localized small off-grid

systems or battery charging for low wind speed. Wind pumps could also be a viable option. This needs strengthening of necessary data and manpower base, setting up some more demonstration plants at appropriate locations, and carrying out research and studies for improvements in technology. The energy generated can be easily combined with that of SPV through an integrated controller, which will ensure continuity of energy transfer into battery bank system. This DC stored energy can be converted by power conditioning unit to AC single-phase 230v/50 Hz, power which can be used for lighting load.

Features of aero wind generator

- 20 years' equipment life
- Microprocessor-based smart internal regulator with peak power tracking safety protection electronics controls voltage and rotor RPM.
- Maintenance-free: only two moving parts, exclusive auto-brake feature that slows the system to a silent spin when the batteries are charged thus extending bearing life and reducing noise.
- Sophisticated internal charge controller: externally adjustable for any type of battery.
- Low cost, low maintenance cost, no fuel cost
- No pollution, easy installation
- Designed to be used in combination with PV modules to balance system energy output during times of seasonal fluctuations.

Advantages/salient features of hybrid systems

- Eliminate expensive mains cable installation costs
- Eliminate any associated electricity bills
- Increase public safety aids by providing a safe working environment in areas where mains power is difficult to access
- Fully automatic operation; easy to operate and maintain
- High quality construction and components
- Designed for easy servicing and maintenance where required
- Most eco-friendly and clean source of power
- No pollution and no recurring fuel costs
- Highly reliable and consistent power supply. Very good quality power output with steady voltage and frequency
- Long life span for SPV modules and modular design
- Simple installation
- Very few moving parts: negligible maintenance required
- Lower total system cost, contribution of solar and cost-effective electric power for remote application. Wind is beneficial even on low-wind sites and smoothens out seasonal weather fluctuations
- Environmental pollution is controlled thus improving health
- Laying of expensive grid line, and transmission and distribution losses, can be avoided
- Can generate DC power as long as sun and wind are available

Major components of a hybrid system

Hybrid power-conditioning unit

A hybrid power-conditioning unit is used to combine SPV array and wind generator. This unit prevents the overcharging and the deep discharging of the battery bank. It is the brain of the whole set up. When batteries are fully charged then it stops the further charging of the batteries and when the batteries are deep discharged then it disconnects the load and allows the battery to charge. The output from batteries is in DC form. To supply power to loads such as CFLs (compact fluorescent lamps), street lights, and television, this DC power needs to be converted to AC. Power conditioning is an electronic device in which an in-built inverter, converts DC power to AC with the help of IGBTs. The advantage of using AC is that we can use energy-efficient lights such as CFLs (for example, 11-W CFL gives same lumen output as that of 60-W ordinary bulb). The overall system size can be optimized, thereby saving in the initial higher investments.

Battery

Once the power output from solar and wind is converted to DC, it is supplied to batteries and the

batteries get charged. Depending upon the load requirement and the number of hours of operation of loads the adequate battery size is calculated.

Applications of hybrid systems

- Ideal for cell phone recipient stations
- Farm houses, guesthouses, hospitals, hotels, laboratories, primary health care centres, police communications centres, literacy centres, tribal hostels, and R&D centres
- Remote and rural village electrification
- Residential colonies and apartments for general lighting
- Street lighting
- Transmissions and communication tower and many more applications.
- High output, making it ideal for virtually any remote battery charging application

MNRE guidelines

The rated capacity of individual aero generator unit covered under the MNRE programme will be to a maximum of 30 kW.

- Stand-alone system based on combination of various renewable energy sources, that is, wind, solar, and biomass
- Warranty for a minimum of 2 years on the entire system from the date of installation of the system.
- SPV modules used in the hybrid system will be warranted for a period of at least 10 years from the date of installation of the system.
- The selected site should be free from any obstacles (for example, tall trees, high buildings, electricity transmission lines, and so on) within the radius of about 100 metres.
- Installation of an aero generator should be preferred for a site, which has the annual average wind speed of 4.17 metres/ second or above.
- Aero generator of capacity more than 500 W should not be installed on the roof of a building.
- The minimum height of the tower should be 18 m from the ground level.

Daily load consumption: for domestic applications

	550W = 400 W Wind+ 150 W Solar		
Connected load details	*Total Nos*	*No. of hours*	*Total load* (watt)
CFL - 11 W	8	5	440
Radio/tape recorder– 50 W	1	2	100
TV – 80W	1	6	480
Ceiling fan/table fan – 40 W	1	6	240
TOTAL			**1260**

Daily load consumption: for community street light applications

	550W = 400 W Wind+ 150 W Solar		
Connected load details	*Total nos.*	*No. of hours*	*Total load* (watt)
CFL- 18 W	10	12	2160

Sizing of equipment

Name of the equipment	*Units*	*475*	*550*
Wind aero generator	W	400	400
Solar PV module	W	75	150
12 -V battery	Ah	200	400
Solar PV module: charger	A	10	15
Hybrid power conditioning: (inverter and charge controller systems)	VA	500	500

Energy generation details

- The energy generated from the wind aero generator is considered 1 kwh/day
- The energy generated from the solar module by considering a working of 6 hours/day
- For 75 W × 6 hours = 450 W hours and for 150 W × 6 hours = 900 Whours
- *Energy generation* Hybrid system: 550 W = 400 W wind + 150 W solar; Power generated (kilowatt-hour per day): 1.9; Power generated (kilowatt-hour per month): 57; Power generated (kilowatt-hour per annum): 684.

Conclusion

- Stand-alone wind with SPV is known as the best hybrid combination of all renewable energy systems and is suitable for most of the applications taking care of seasonal changes.
- Hybrid wind and solar systems provide more consistent year-round performance and reduce the need for back-up generation.
- The major advantage of solar–wind hybrid system is that when solar and wind power production are used together, the reliability of the system is enhanced. Additionally, the size of battery storage can be reduced, as there is less reliance on one method of power production.