International Journal of Electrical, Electronics and Computer Engineering 5(1): 138-146(2016)

ISSN No. (Online): 2277-2626

# A Survey: Renewable Energy Based Modeling and Control Strategy

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*(Received 29 June, 2016 Accepted 12 August 2016)*
*(Published by Research Trend, Website: www.researchtrend.net)*

**ABSTRACT: The extraction of energy from renewable sources is quickly developing. The present pace of innovative improvement makes it financially suitable to bridle energy from sun, wind, geothermal and numerous other renewable sources. On account of the negative effects of the surroundings, the economy, ordinary energy sources like natural gas, crude petroleum and coal are going under political and financial anxiety. Along these lines, they require a superior blend of energy sources with a higher rate of renewable energy sources. On the other hand, there is an expanding apprehension over renewable energy sources in power framework because of its exceedingly irregular nature. This may bring about issues, for example, dependability, voltage direction and other power quality issues. This paper presents, a survey on different techniques used to address the above issues associated to renewable energy generation and integration.**

**Keywords:** Natural Gas, Optimization, Renewable Energy, Wind Energy

## I. INTRODUCTION

The world is confronted with various difficulties identified with energy maintainability and security. If not instantly tended to, these can prompt financial and political unsteadiness. The consumption of fossil fuel holds and in addition the natural effect of smoldering these energizes have prompted expanded enthusiasm for creating alternative and more reasonable energy sources. Renewable energy assets like sunlight based photovoltaic (PV), sun oriented warm (a.k.a. concentrated sunlight based power, CSP), geothermal, tsunamis, wind power, and biomass have been becoming quickly in energy advertise [1]. Numerous nations and organizations are looking to expand their energy blend by expanding the share of renewable. In routine energy era prepare, energy creation relies on upon the energy request from the clients, and the security of the power lattice depends on the balance of energy request and supply. At the point when the energy request outperforms the energy supply, it destabilizes the power matrix and results in power quality debasement and/or power outages in a few sections of the matrix. At the point when the request is lower than the supply, energy is lost bringing about high pointless expenses due to wastage. Creating the appropriate measure of energy at the perfect time is vital both for the smooth running of the matrix and for higher financial benefits.

To keep up this dependability, much research has concentrated on energy free market activity estimating to foresee the measure of energy that will be required. This will then guarantee that there will be sufficient ability to meet these prerequisites, additionally that abundance limit and thus energy squandered will be minimized.

Renewable energy assets like sun based light, sunlight based warmth and wind are profoundly variable and the subsequent fluctuations in the era limit can bring about in- security in the power matrix. This is on account of the energy/control yield of these plants is defined by the natural components, for example, wind speed, the force of sun powered radiation, overcast cover and different elements. Another imperative impediment of renewable energy control plants is that they are liable to checked day by day and yearly cycles (e.g., sun oriented energy is just accessible amid the day). Therefore, it is important to create control when assets are accessible and store it for some other time utilize while utilizing a specific parcel of the produced control in the meantime. Wind also, sun based PV energy is costly to store, consequently watchful administration of energy era is required. At the point when the era limit of characteristic assets are inadequate to take care of demand, ordinary sources, for example, gas control plants are normally used to cover the power shortage.

Then again, it is likewise important to gauge the energy yield from renewable energy control plants themselves, since the energy yield from these control plants relies on upon numerous ecological elements that can't be controlled. This thusly requires the expectation of these ecological components, for example, wind speed, bearing and sun oriented radiation in the region of the power plant.

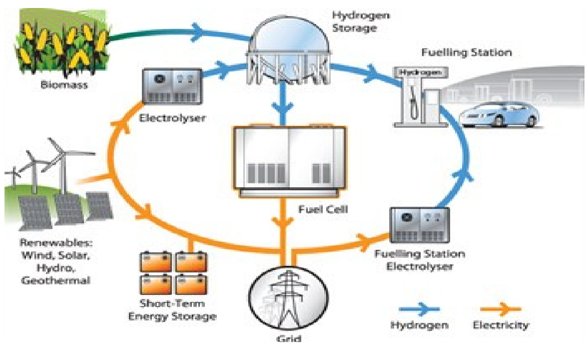


**Fig. 1.** Renewable Energy System.

Various research papers related with modeling and control technique are available in literature. In this paper, renewable energy based half models and control system is thought about. Besides, issues related to mutt showing are moreover tended to. It has been found that the specialists have endeavored to accomplish two far reaching comes about as determined earlier. This paper is dealt with as follows:

In section 2, we describe the different sources of renewable energy and the control strategy and approaches is discussed in section 3. The overall conclusion of the paper is presented in section 4.

## II. RENEWABLE ENERGY SOURCE

Renewable energy sources also called non-conventional energy are sources that are continuously replenished by natural processes**.** For example, solar energy, wind energy, bio-energy - bio-fuels grown sustain ably), hydropower etc., are some of the examples of renewable energy sources.

A renewable energy system converts the energy found in sunlight, wind, falling-water, sea-waves, geothermal heat, or biomass into a form, we can use such as heat or electricity. Most of the renewable energy comes either directly or indirectly from sun and wind and can never be exhausted, and therefore they are called renewable.

However, most of the world's energy sources are derived from conventional sources-fossil fuels such as coal, oil, and natural gases. These fuels are often termed non-renewable energy sources. Although, the available quantity of these fuels are extremely large, they are nevertheless finite and so will in principle 'run out' at some time in the future .

Renewable energy sources are essentially *flows* of energy, whereas the fossil and nuclear fuels are, in essence, *stocks* of energy

**Various forms of renewable energy [2-3]:**

**A.** Solar energy
B. Wind energy
C. Bio energy
D. Hydro energy
*E. Tidal and Ocean Energy*
*F. Ocean Energy*

*A. Solar Energy*

Solar energy is the most readily available and free source of energy since prehistoric times. It is estimated that solar energy equivalent to over 15,000 times the world's annual commercial energy consumption reaches the earth every year. India receives solar energy in the region of 5 to 7 kWh/m2 for 300 to 330 days in a year. This energy is sufficient to set up 20 MW solar power plants per square kilometre land area. Solar energy can be utilized through two different routes, as solar thermal route and solar electric (solar photovoltaic) routes. Solar thermal route uses the sun's heat to produce hot water or air, cook food, drying materials etc. Solar photovoltaic uses sun's heat to produce electricity for lighting home and building, running motors, pumps, electric appliances, and lighting.

**Fig. 2.** Solar Energy.

**Solar Thermal Energy Application**

In solar thermal route, solar energy can be converted into thermal energy with the help of solar collectors and receivers known as solar thermal devices. The Solar-Thermal devices can be classified into three categories:

(i) Low-Grade Heating Devices - up to the temperature of 100°C.

(ii) Medium-Grade Heating Devices -up to the temperature of 100°-300°C

(iii) High-Grade Heating Devices -above temperature of 300°C

Low-grade solar thermal devices are used in solar water heaters, air-heaters, solar cookers and solar dryers for domestic and industrial applications.

**Solar water heaters**. Most solar water heating systems have two main parts: a solar collector and a storage tank. The most common collector is called a *flat-plate collector (*Fig. 3). It consists of a thin, flat, rectangular box with a transparent cover that faces the sun, mounted on the roof of building or home. Small tubes run through the box and carry the fluid – either water or other fluid, such as an antifreeze solution – to be heated. The tubes are attached to an absorber plate, which is painted with special coatings to absorb the heat. The heat builds up in the collector, which is passed to the fluid passing through the tubes.

**Fig. 3.** Solar Flat plate collector/

An insulated storage tank holds the hot water. It is similar to water heater, but larger is size. In case of systems that use fluids, heat is passed from hot fluid to the water stored in the tank through a coil of tubes.

Solar water heating systems can be either active or passive systems. The active systems, which are most common, rely on pumps to move the liquid between the collector and the storage tank. The passive systems rely on gravity and the tendency for water to naturally circulate as it is heated. A few industrial application of solar water heaters are listed below:

(i) Hotels: Bathing, kitchen, washing, laundry applications

(ii) Dairies: Ghee (clarified butter) production, cleaning and sterilizing, pasteurization

(iii) Textiles: Bleaching, boiling, printing, dyeing, curing, ageing and finishing

(iv) Breweries & Distilleries: Bottle washing, wort preparation, boiler feed heating

(v) Chemical /Bulk drugs units: Fermentation of mixes, boiler feed applications

(vi) Electroplating/galvanizing units: Heating of plating baths, cleaning, degreasing applications

(vii) Pulp and paper industries: Boiler feed applications, soaking of pulp.

**Solar Cooker.** Solar cooker is a device, which uses solar energy for cooking, and thus saving fossil fuels, fuel wood and electrical energy to a large extent. However, it can only supplement the cooking fuel, and not replace it totally. It is a simple cooking unit, ideal for domestic cooking during most of the year except during the monsoon season, cloudy days and winter months

**Fig. 4.** Solar Cooker.

***Parabolic concentrating solar cooker:***

A parabolic solar concentrator comprises of sturdy Fiber Reinforced Plastic (FRP) shell lined with Stainless Steel (SS) reflector foil or aluminized polyester film. It can accommodate a cooking vessel at its focal point. This cooker is designed to direct the solar heat to a secondary reflector inside the kitchen, which focuses the heat to the bottom of a cooking pot. It is also possible to actually fry, bake and roast food. This system generates 500 kg of steam, which is enough to cook two meals for 500 people (see Figure 4). This cooker costs upward of Rs.50,000.

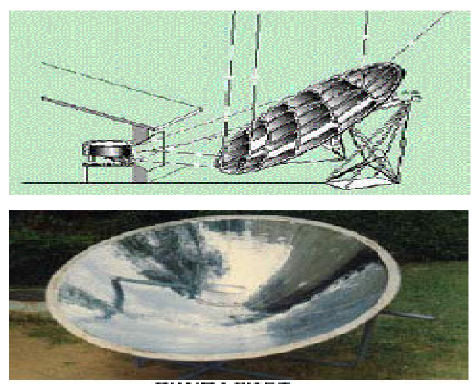


**Fig. 5.** Parabolic Collector.

**Positioning of solar panels or collectors** can greatly influence the system output, efficiency and payback. Tilting mechanisms provided to the collectors need to be adjusted according to seasons (summer and winter) to maximize the collector efficiency. The period four to five hours in late morning and early afternoon (between 9 am to 3pm) is commonly called the "Solar Window". During this time, 80% of the total collectable energy for the day falls on a solar collector.

Therefore, the collector should be free from shade during this solar window throughout the year - Shading, may arise from buildings or trees to the south of the location.

**Solar Electricity Generation**

***Solar Photovoltaic (PV):*** Photovoltaic is the technical term for *solar electric*. Photo means "light" and voltaic means "electric". PV cells are usually made of silicon, an element that naturally releases electrons when exposed to light. Amount of electrons released from silicon cells depend upon intensity of light incident on it. The silicon cell is covered with a grid of metal that directs the electrons to flow in a path to create an electric current. This current is

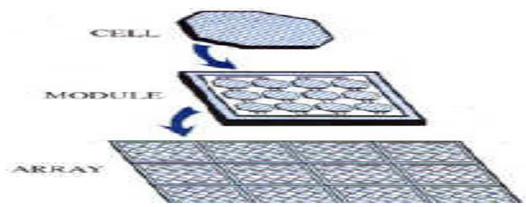


**Fig. 6.** Solar Photovoltaic Array.

guided into a wire that is connected to a battery or DC appliance. Typically, one cell produces about 1.5 watts of power. Individual cells are connected together to form a solar *panel* or *module*, capable of producing 3 to 110 Watts power. Panels can be connected together in series and parallel to make a solar *array* (see Figure 6), which can produce any amount of Wattage as space will allow. Modules are usually designed to supply electricity at 12 Volts. PV modules are rated by their peak Watt output at solar noon on a clear day. Some applications for PV systems are lighting for commercial buildings, outdoor (street) lighting, rural and village lighting etc. Solar electric power systems can offer independence from the utility grid and offer protection during extended power failures. Solar PV systems are found to be economical especially in the hilly and far flung areas where conventional grid power supply will be expensive to reach.

PV tracking systems is an alternative to the fixed, stationary PV panels. PV tracking systems are mounted and provided with tracking mechanisms to follow the sun as it moves through the sky. These tracking systems run entirely on their own power and can increase output by 40%.

Back-up systems are necessary since PV systems only generate electricity when the sun is shining. The two most common methods of backing up solar electric systems are connecting the system to the utility grid or storing excess electricity in batteries for use at night or on cloudy days.

**Performance.** The performance of a solar cell is measured in terms of its efficiency at converting sunlight into electricity. Only sunlight of certain energy will work efficiently to create electricity, and much of it is reflected or absorbed by the materials that make up the cell. Because of this, a typical commercial solar cell has an efficiency of 15%—only about one-sixth of the sunlight striking the cell generates electricity. Low efficiencies mean that larger arrays are needed, and higher investment costs. It should be noted that the first solar cells, built in the 1950s, had efficiencies of less than 4%.

**Solar Water Pumps.** In solar water pumping system, the pump is driven by motor run by solar electricity instead of conventional electricity drawn from utility grid. A SPV water pumping system consists of a photovoltaic array mounted on a stand and a motor-pump set compatible with the photovoltaic array. It converts the solar energy into electricity, which is used for running the motor pump set. The pumping system draws water from the open well, bore well, stream, pond, canal etc.

*B. Wind Energy*

Wind energy is basically harnessing of wind power to produce electricity. The kinetic energy of the wind is converted to electrical energy. When solar radiation enters the earth's atmosphere, different regions of the atmosphere are heated to different degrees because of earth curvature. This heating is higher at the equator and lowest at the poles. Since air tends to flow from warmer to cooler regions, this causes what we call winds, and it is these airflows that are harnessed in windmills and wind turbines to produce power.

Wind power is not a new development as this power, in the form of traditional windmills -for grinding corn, pumping water, sailing ships – have been used for centuries. Now wind power is harnessed to generate electricity in a larger scale with better technology.

**Fig. 7.** Wind Energy.

**Wind Energy Technology**

The basic wind energy conversion device is the wind turbine. Although various designs and configurations exist, these turbines are generally grouped into two types:

1. **Vertical-axis wind turbines**, in which the axis of rotation is vertical with respect to the ground (and roughly perpendicular to the wind stream),

2. **Horizontal-axis turbines**, in which the axis of rotation is horizontal with respect to the ground (and roughly parallel to the wind stream.)

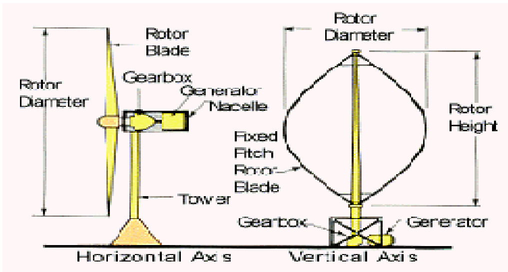


**Fig. 8.** Wind Turbine Configuration.

The Fig. 7 illustrates the two types of turbines and typical subsystems for an electricity generation application. The subsystems include a blade or rotor, which converts the energy in the wind to rotational shaft energy; a drive train, usually including a gearbox and a generator, a tower that supports the rotor and drive train, and other equipment, including controls, electrical cables, ground support equipment, and interconnection equipment.

**Wind electric generators (WEG)**

Wind electric generator converts kinetic energy available in wind to electrical energy by using rotor, gear box and generator. There are a large number of manufacturers for wind electric generators in India who have foreign collaboration with different manufacturers of Denmark, Germany, Netherlands, Belgium, USA, Austria, Sweden, Spain, and U.K. etc. At present, WEGs of rating ranging from 225 kW to 1000 kW are being installed in our country.

**Evaluating Wind Mill Performance**

Wind turbines are rated at a certain wind speed and annual energy output

**Annual Energy Output = Power × Time**

Example: For a 100 kW turbine producing 20 kW at an average wind speed of 25 km/h, the calculation would be:

100 kW x 0.20 (CF) = 20 kW x 8760 hours = 175,200 kWh

The Capacity Factor (CF) is simply the wind turbines actual energy output for the year divided by the energy output if the machine operated at its rated power output for the entire year. A reasonable capacity factor would be 0.25 to 0.30 and a very good capacity factor would be around 0.40. It is important to select a site with good capacity factor, as economic viability of wind power projects is extremely sensitive to the capacity factor.

**Wind Potential.** In order for a wind energy system to be feasible there must be an adequate wind supply. A wind energy system usually requires an average annual wind speed of at least 15 km/h. The following table represents a guideline of different wind speeds and their potential in producing electricity.

A wind generator will produce lesser power in summer than in winter at the same wind speed as air has lower density in summer than in winter. Similarly, a wind generator will produce lesser power in higher altitudes - as air pressure as well as density is lower -than at lower altitudes.

The wind speed is the most important factor influencing the amount of energy a wind turbine can produce. Increasing wind velocity increases the amount of air passing the rotor, which increases the output of the wind system. In order for a wind system to be effective, a relatively consistent wind flow is required. Obstructions such as trees or hills can interfere with the wind supply to the rotors. To avoid this, rotors are placed on top of towers to take advantage of the strong winds available high above the ground. The towers are generally placed 100 meters away from the nearest obstacle. The middle of the rotor is placed 10 meters above any obstacle that is within 100 meters.

*C. Bio Energy*

Biomass is a renewable energy resource derived from the carbonaceous waste of various human and natural activities. It is derived from numerous sources, including the by-products from the wood industry, agricultural crops, raw material from the forest, household wastes etc.

Biomass does not add carbon dioxide to the atmosphere as it absorbs the same amount of carbon in growing as it releases when consumed as a fuel. Its advantage is that it can be used to generate electricity with the same equipment that is now being used for burning fossil fuels. Biomass is an important source of energy and the most important fuel worldwide after coal, oil and natural gas. Bio-energy, in the form of biogas, which is derived from biomass, is expected to become one of the key energy resources for global sustainable development. Biomass offers higher energy efficiency through form of Biogas than by direct burning.

**Fig. 9.** Bio Gas.

Biogas is a clean and efficient fuel, generated from cow-dung, human waste or any kind of biological materials derived through anaerobic fermentation process. The biogas consists of 60% methane with rest mainly carbon-di-oxide. Biogas is a safe fuel for cooking and lighting. By-product is usable as high-grade manure.

**A typical biogas plant has the following components:** A digester in which the slurry (dung mixed with water) is fermented, an inlet tank - for mixing the feed and letting it into the digester, gas holder/dome in which the generated gas is collected, outlet tank to remove the spent slurry, distribution pipeline(s) to transport the gas into the kitchen, and a manure pit, where the spent slurry is stored.

Biomass fuels account for about one-third of the total fuel used in the country. It is the most important fuel used in over 90% of the rural households and about 15% of the urban households. Using only local resources, namely cattle waste and other organic wastes, energy and manure are derived. Thus the biogas plants are the cheap sources of energy in rural areas. The types of biogas plant designs popular are: floating drum type, fixed dome-type and bag-type portable digester.

*D. Hydro Energy*

The potential energy of falling water, captured and converted to mechanical energy by waterwheels, powered the start of the industrial revolution.

Wherever sufficient head, or change in elevation, could be found, rivers and streams were dammed and mills were built. Water under pressure flows through a turbine causing it to spin. The Turbine is connected to a generator, which produces electricity. In order to produce enough electricity, a hydroelectric system requires a location with the following features:

Change in elevation or head: 20 feet @ 100 gal/min = 200 Watts. 100 feet head @ 20 gal/min gives the same output.

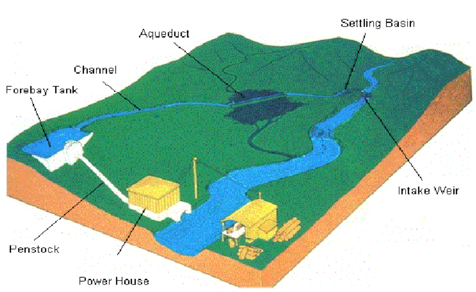


**Fig. 10.** Hydro Power Plant.

In India the potential of small hydro power is estimated about 10,000 MW. A total of 183.45 MW small Hydro project have been installed in India by the end of March 1999. Small Hydro Power projects of 3 MW capacity have been also installed individually and 148 MW project is under construction.

**Small Hydro.** Small Hydro Power is a reliable, mature and proven technology. It is non-polluting, and does not involve setting up of large dams or problems of deforestation, submergence and rehabilitation. India has an estimated potential of 10,000 MW

**Micro Hydel.** Hilly regions of India, particularly the Himalayan belts, are endowed with rich hydel resources with tremendous potential. The MNES has launched a promotional scheme for portable micro hydel sets for these areas. These sets are small, compact and light weight. They have almost zero maintenance cost and can provide electricity/power to small cluster of villages. They are ideal substitutes for diesel sets run in those areas at high generation cost.

Micro (upto 100kW) mini hydro (101-1000 kW) schemes can provide power for farms, hotels, schools and rural communities, and help create local industry.

*E. Tidal and Ocean Energy*

**Tidal Energy.** Tidal electricity generation involves the construction of a barrage across an estuary to block the incoming and outgoing tide. The head of water is then used to drive turbines to generate electricity from the elevated water in the basin as in hydroelectric dams.

Barrages can be designed to generate electricity on the ebb side, or flood side, or both. Tidal range may vary over a wide range (4.5-12.4 m) from site to site. A tidal range of at least 7 m is required for economical operation and for sufficient head of water for the turbines.

**Fig. 11.** Tidal Energy.

*F. Ocean Energy*

Oceans cover more than 70% of Earth's surface, making them the world's largest solar collectors. Ocean energy draws on the energy of ocean waves, tides, or on the thermal energy (heat) stored in the ocean. The sun warms the surface water a lot more than the deep ocean water, and this temperature difference stores thermal energy.

The ocean contains two types of energy: thermal energy from the sun's heat, and mechanical energy from the tides and waves.

Ocean thermal energy is used for many applications, including electricity generation. There are three types of electricity conversion systems: closed-cycle, open cycle, and hybrid. Closed cycle systems use the ocean's warm surface water to vaporize a working fluid, which has a low boiling point, such as ammonia. The vapour expands and turns a turbine. The turbine then activates a generator to produce electricity. Open-cycle systems actually boil the seawater by operating at low pressures. This produces steam that passes through a turbine / generator. The hybrid systems combine both closed-cycle and open-cycle systems.

Ocean mechanical energy is quite different from ocean thermal energy. Even though the sun affects all ocean activity, tides are driven primarily by the gravitational pull of the moon, and waves are driven primarily by the winds. A barrage (dam) is typically used to convert tidal energy into electricity by forcing the water through turbines, activating a generator.

India has the World's largest programmes for renewable energy. Several renewable energy technologies have been developed and deployed in villages and cities of India. A Ministry of Non-Conventional Energy Sources (MNES) created in 1992 for all matters relating to Non-Conventional / Renewable Energy. Government of India also created Renewable Energy Development Agency Limited (IREDA) to assist and provide financial assistance in the form of subsidy and low interest loan for renewable energy projects.

IREDA covers a wide spectrum of financing activities including those that are connected to energy conservation and energy efficiency. At present, IREDA's lending is mainly in the following areas: -

- Solar energy technologies, utilization of solar thermal and solar photo voltaic systems
- Wind energy setting up grid connected Wind farm projects
- Small hydro setting up small, mini and micro hydel projects
- Bio-energy technologies, biomass based co-generation projects, biomass gasification, energy from waste and briquetting projects
- Hybrid systems
- Energy efficiency and conservation

The estimated potential of various Renewable Energy technologies in India by IREDA are given below.

**Energy source estimated potential**

Solar Energy 20 MW / sq. km
Wind Energy 20,000 MW
Small Hydro 10,000 MW
Ocean Thermal Power 50,000 MW
Sea Wave Power 20,000 MW
Tidal Power 10,000 MW
Bio energy 17,000 MW
Draught Animal Power 30,000 MW
Energy from MSW 1,000 MW
Biogas Plants 12 Million Plants
Improved Wood Burning Stoves 120 Million Stoves
Bagasse-based cogeneration 3500 MW

**Cumulative achievements in renewable energy sector (As on 31.03.2000)**

Sources / Technologies Unit Upto31.03.2000
Wind Power MW1167
Small Hydro MW217
Biomass Power & Co-generation MW 222
Solar PV Power MW / Sq. km 42
Urban & MSW MW 15.21
Solar Heater $m^2$. Area 480000
Solar Cookers No. 481112
Biogas Plants Nos. in Million 2.95
Biomas Gasifier MW 34
Improved Chulhas Nos. in Million 31.9

## III. CONTROL STRATEGY & OPTIMIZATION

In this section, renewable energy based hybrid models and control strategies are taken into consideration. In addition, various issues related to hybrid modeling are also addressed. It has been found that the researchers have worked to achieve two broad results as mentioned above. As discusses earlier, the researchers worked under two broad optimization objectives. One such category is the design of an optimal sizing of hybrid energy sources. This includes the selection of proper renewable energy sources with proper sizing, so that an optimized hybrid energy system could be developed, depending on the availability and feasibility of renewable energy power required of each source. Some of the key methodologies and approaches adopted are as follows:

*A. Using Simulation Programs*

Optimum sizing is necessary to obtain economical power output from an efficient renewable energy based system thereby reducing the investment with full utilization of the system component [4].

It has been found that simulation programs are the most common tools used for optimization of hybrid systems, among which, Hybrid Optimization Model for Electric Renewable (HOMER) has been used extensively [NREL: HOMER]. Later, researchers developed HYBRID2, with very precise simulation, as it can define time intervals ranging from 10 min to 1 hour. Similarly, HOGA is developed incorporating an optimization program by means of Genetic Algorithms. It is seen that all these simulation programs can only simulate one configuration at a time, but not designed to provide an optimized configuration.

*B. Graphical Approach*

Various graphical optimization techniques have been reported in the literature. Graphical construction technique to calculate the optimum combination has been presented using long-term data [5]. Another graphical technique is used to optimally design a hybrid solar–wind power generation system by considering the monthly-average solar and wind energy values. However, in both graphical methods, only two parameters are included in the optimization process, while some important factors are completely neglected.

*C. Probabilistic Approach*

Probabilistic approaches have also been opted for sizing hybrid system, as it accounted for the effect of renewable sources variability in the system design. Sizing method treating storage energy variation as a random walk and the probability density for daily increment or decrement of storage level approximated by a two-event probability distribution is presented [6]. The method is further extended to account for the effect of correlation between day to day radiations values, then modified, in whose works, the storage energy transitions were approximated by three-event probabilistic approach to overcome the limitations of conventional two-event approach in matching the actual distribution of the energy generated by hybrid systems. Probabilistic approach is based on the convolution technique to incorporate the fluctuating nature of the resources and the load, thus eliminating the need for time-series data, to assess the long-term performance of a hybrid solar wind system for both stand-alone and grid-connected applications. It has been noticed that the major limitation of this probabilistic approach is that it cannot represent the dynamic changing performance of the hybrid system.

*D. Artificial Intelligence Approach*

Artificial intelligence methods such as Genetic Algorithms, Artificial Neural Networks and Fuzzy Logic, have also been widely used to optimize a hybrid system. In such cases, Genetic Algorithm has been widely used as compared to other artificial intelligence techniques because of their capability to handle complex problems with linear or non-linear cost functions [7]. Genetic Algorithms address the problems of uncertain renewable energy supplies, load demand and the non-linear characteristics of some components by incorporating past and future demand. GA is also widely used in conjunction with artificial neural networks.

New design variables/constraints including cost minimization, and both reliability and CO2 emission are taken as constraints. Markov-based GA is introduced for the determination of optimal sizes of renewable energy sources units. It is found that Markov-based GA can help to reduce CPU time greatly and provide competitive cost.

*E. Operating Point Control*

Effort has also been done in controlling the operating point of the system keeping the system to work at maximum power point. A cost-effective control technique for maximum power point tracking from the photovoltaic array and wind turbine under varying climatic conditions without measuring the irradiance of the photovoltaic or the wind speed has been developed. Predictive control has also been used to compute the operating points of the wind subsystem and of the solar subsystem together to generate enough energy to satisfy the load demand. In addition to this, supervisory controls have also been used to optimize the operating points so as to reduce the peak value of surge currents. Predictive control has also been extensively used by other researchers [8]. It is shown that the temperature profile can be predicted as a function of the cooling strategy for a solar-module. It is found that the I–V electrical characteristic of the whole module can be derived from this information, thereby identifying those average parameters that mainly affect the solar-module behaviour, thus facilitating the prediction on the current and voltage levels that can be sustained by the solar panel as well as the maximum sup pliable power. All of these aspects are a key to the proper design of the electronic control interface that tracks the maximum power point. Such control techniques have been applied to control different types of hybrid systems to maintain constant voltage, constant frequency, MPT, neutral-current compensation, harmonics elimination, load balancing and the highest efficiency optimization.

*F. Hybrid Energy Storage System Control*

Power quality can be increased by the proper selection and control of Hybrid Energy Storage System. A miniature flywheel energy storage system for energy storage with a pair of hybrid magnetic bearings (HMBs); consisting of both superconducting magnetic bearings (SMBs) and active magnetic bearings (AMBs) applied with H-infinity control method and zero bias method has also been developed. It is seen that by using the HMBs the radial displacement of the rotor is much smaller than that with SMBs thus improving the dynamics of the ESS. Hybrid power sources that combine advanced batteries with ultra capacitors can be operated for longer times. Peak power can be greatly enhanced, internal losses can be considerably reduced, and that discharge life of the battery is extended using ultra capacitors [9]. The greatest benefits can be seen when the load pulse rate is higher than the system eigen-frequency and when the pulse duty is small. Ultra capacitors are also increasing interest because of their high-energy density (compared to conventional capacitors) and high-power density (compared to batteries and fuel cells). The use of ultra capacitor in power distribution and in utility electronic apparatus has shown improvements in power quality, uninterrupted power supply, and memory backup.

Also, superconducting magnetic energy storage (SMES) has been utilized for better power quality by many researchers. With the appropriate topology of the power conditioning system (PCS) and its control system design, the SMES unit has been found capable of simultaneously performing both instantaneous active and reactive power flow control. Fuzzy control scheme has also been used for the optimized performance of a hybrid energy storage system composed of a superconducting magnet Due to the emergent technology of fuel cells, much amount of research has also been focused on it. PEMFC control strategy has been developed to produce the power, minimize the fuel consumption and also provide a regulated dc bus voltage to the load. This is done by controlling the voltage of air pump of FC for the control of fuel cell current through a dc/dc switching converter. The control results, fuel consumption, and fuel cell protect against oxygen starvation phenomenon. To incorporate some non linear structures, the development of an ANN based fuel-cell model within the hybrid model of a FC stack not only improves accuracy but also allows the model to adapt itself to operating conditions; giving a good estimate of the relationship between current and temperature and making the system work on maximum power condition . Other types of fuel cells have also been suggested in HESS for the minimization of hydrogen rate using the output dc current of the SOFC or the current magnitude of the ac load. The topology of ESS is also suggested by the researchers for better power quality. A two level ESS has been proposed, where the battery is paired with a fast-acting low-power -capacity ESS. The controller minimizes dump load, limits the intra-hour diesel ramp rates, and maximizes ESS utilization. In addition, the operation of charging and discharging of ESS can be managed by controlling the bidirectional converter operated under buck boost or shut down mode according to the operation condition of the fuel cell and battery. Fatness properties for a FC/super capacitor could also be used in designing a better control law.

## V. CONCLUSION

Because of the consumption of routine energy sources like natural gas, unrefined petroleum also, coal and to moderate the natural impacts of the smoldering of fossil powers, governments and organizations are concentrating progressively on creating renewable energy sources. In this paper, we present the classification and control strategy for renewable energy source. The control system has the subsequent benefits such as quicker voltage control, low charge/discharge current rates of battery, diminishes current push levels on battery, enhanced life extent of battery and diminished computational weight. The good example of renewable source is hydro power which is efficiently used from past decades. The wind and solar energy source is that which can be utilized for next subsequent years.

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