Chapter 2
Planning Methodologies of Hybrid Energy System

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Abstract A hybrid system consists of conventional and nonconventional energy systems for the achievement of reliable operation to keep the balance between energy supply and load demand. Various methods have been employed for planning and sizing of the hybrid energy system to get optimal location. Due to weather conditions, some renewable energy sources such as solar and wind energy may be unable to provide continuous supply. In addition, stability is an important issue. This may be voltage stability, frequency stability, and rotor angle stability. Different optimization techniques have been developed for optimizing the parameters of the hybrid energy system. This manuscript deals with a review of different hybrid energy systems with optimization techniques to achieve their best optimal location and sizing. Some planning methods have been reviewed with in this manuscript and focused on the development of a new hybrid energy system with advanced techniques.

Keywords Renewable energy system · Solar system · Wind power · Particle swarm optimization · Genetic algorithm · Artificial bee colony algorithm

Abbreviations

PV	Photovoltaic
NPC	Net percent cost
RES	Renewable energy sources
MPPT	Maximum power point technique
PSO	Particle swarm optimization
HVAC	High voltage alternating current
ACO	Ant colony optimization
HVDC	High voltage direct current
GA	Genetic algorithm

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DCMG Direct current microgrid

2.1 Introduction

In the last decades, renewable energy source has increased unprecedented growth with globalized manner by using different energy sources such as solar PV cell, wind energy, hydropower, geothermal, biomass, etc. As per U.S. energy report, the energy consumption falls by 4% in the previous year of 2021 and will increase by 1.4% in year 2021. The report says that India will be the largest contributor in the field of renewable energy production by 2021 and overall total production throughout the world will be a double contributor as compared to 2020. These variable energy sources are different in various aspects than conventional energy sources. These renewable energy sources are required to produce electricity with increasing energy demand and with suitable efficieny. In comparison to conventional energy sources, various major aspects such as the small size of generators, location constrained, non-synchronous type generators, low-run cost fall under the category of renewable energy sources. Hence, these characteristics produce challenges in existing power systems. These challenges may include capacity of transmission grid and sufficiency of electricity generation. Renewable energy sources have taken considerable attraction throughout the world. All these things come due to insufficient amounts of fuels and discontinuity of supply. By using fossil fuels, energy consumption is low and overall efficiency is low due to large generation of gas emissions. In year 2019, overall consumption of energy by using fossil fuels was 82% by using 12 billion tons of fossil fuels.

Apart from this, numerous renewable energy sources have been implemented in different countries. Bioenergy production is carried out by using biomass to be used to generate renewable electricity and thermal electricity. All energy production goes under different processes like pyrolysis, hydrothermal liquefaction and gasification (Ali et al. 2020). In addition to energy production having intermittent availability of alternate energy sources such as wind and solar photovoltaic cells, sometimes we also need energy storage devices. The amalgamation of alternate energy sources depends upon weather conditions which impact on the reliability, stability and quality. After all few nonconventional energy generators have been coupled with transmission line systems with keeping superiority of similar generators interconnected with distributed generation systems. Through new regulation act, it requires renewable energy sources to perform similar to conventional energy sources and play a vital role in enhancing voltage and frequency stability. There are numerous renewable energy sources as classified below (Fig. 2.1).

From the diagram, renewable or nonconventional energy sources are such as wind power, biomass, solar energy, hydropower, and geothermal. Further, these sources have been classified into different types depending upon different modes of operation. For example, wind energy performs on ON-Shore and OFF-Shore mode and solar

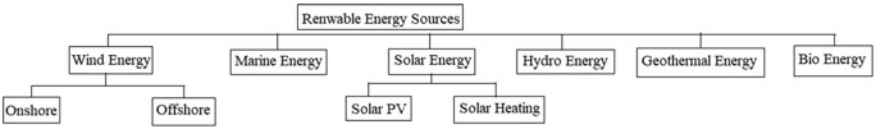

Fig. 2.1 Classification of renewable energy sources

energy can be performed as solar PV and solar thermal. Renewable energy sources have been considered as clean energy and critically important due to ecofriendly environmental parameters. These renewable energy sources cover domestic applications and provide energy service at the customer end with zero gas emission problems. Most of the researchers have deployed results in renewable energy sources and have focused on policy, financial challenges, and technical issues (Quazi et al. 2019).

Hence, the overall net capacity of renewable energy sources will be kept by 10% in years 2020 and 2021. The capacity of renewable energy can be increased by a new installation of energy sources with 85% net of all newly installed limits by the year 2017 from the energy report. Fossil fuel contributes around 74% for the production of electricity in the year 2017–18 and renewable energy sources have a contribution of 27% in electricity production (Report and IEA 2020).

This chapter includes the following sections:

- Section 2.1 describes introduction and classification of renewable energy sources.
- Section 2.2 describes about hybrid energy system.
- Section 2.3 describes the types of hybrid energy systems.
- Section 2.4 describes various technologies for hybrid energy system.
- Section 2.5 describes the planning methodologies of hybrid energy system.
- Section 2.6 describes different optimization techniques for obtaining an optimal location of energy system with the development of hybrid energy system using new techniques.

2.2 Hybrid Energy System

As per increasing energy demands, there is a need for environmental protection and secure electricity, then a new energy system has been introduced named as hybrid energy system. Hybrid energy system is an amalgamation of conventional and nonconventional energy sources through which electricity can be transferred to the customer side at an efficient cost. These sources perform well under all environmental conditions keeping all climate parameters as per requirement in establishing a hybrid energy system. Utilization of nonconventional energy sources reduce the cost of fossil fuels and draw more attraction. The energy report represents the use of RES and power production around 15% in the year 2020 (Guo et al. 2018). Sometimes, renewable energy sources may have a problem of low energy density and the energy production is low due to the use of only one source. To overcome all these problems, amalgamation of nonconventional energy sources has been introduced. Most of the research work has been done in the area of hybrid systems in distant areas applications. The installation of hybrid systems has been executed in different countries for the last few years. Overall hybrid systems have curtailed the total maintenance cost of standalone energy in different conditions.

Extensively, hybrid system consists of a standalone system which incorporates the features of traditional and alternate energy sources with having cells, controller, and power conditioning unit. The controller and power conditioning unit are used to maintain the power quality of the grid. Research work has been centralized on the performance of the system and the evolution of power converters (Nema et al. 2009). Hybridization of energy sources can increase reliability, however, there is an essential aspect of designing for such systems for achieving efficient performance. The hybrid energy system performs effectively by supplying electric load in case of OFF grid applications. These systems have an advantage in designing by taking one or more than one nonconventional energy sources with or without using traditional energy sources improve the system performance and provide reliability. However, there are many remote areas in which they are performing by using ordinary energy sources such as diesel, gas, etc., based generators to fulfill energy demand at the customer side.

For the implementation of alternate energy sources economically, it is required for designing an optimal model which is positioned on forecasting alternate energy sources by employing convenient methods. The modeling of hybrid energy system is a mosaic one which has the need of mathematical models of the alternate energy systems and then optimized. Many of the renewable energy sources have been characterized which involve a variation of output power. In addition to this, energy storage is also used to ensure the durability of power supply to load through amending power reliability (Anounea et al. 2018). As per government report, total renewable energy production is about to be 450 GW up to year 2030.

There are various advantages by using a hybrid energy system:

- Better utilization of renewable energy sources
- Low generation variability
- Better utilization of land for renewable energy sources
- Conclusive generation profile
- Enhancement of overall efficiency of system.

There are various schemes proposed by the Indian government such as installation of solar and other renewable energy sources with a capacity of 25,750 MW by the year 2022 and national solar mission up to 2022 with a production of 20GW. Many researchers have focused on developing hybrid energy systems by utilizing renewable energy sources into the grid. Hence through the contribution of energy storage systems, power-sharing regulation is required for the accomplishment of characteristics of energy sources (Babu et al. 2020).

2.3 Types of Hybrid System

There are discrete types of hybrid systems which consist numerous conventional and nonconventional energy sources. Depending upon environmental parameters, hybrid energy system performs under all considerations and provides reliable operation.

2.3.1 Solar Gas Turbine

A typical solar gas turbine structure consists of several components such as solar collector, solar receiver, combustion chamber, expander, and prime mover. The design of this hybrid system consisting of a solar tower associated with a gas turbine provides consistent energy with varying solar irradiance. The solar tower transforms solar energy into electricity. This system contains two types which focus sunlight into a single point having collectors such as heliostats and dish type. There is a system-integrated heat storage unit which performs in coordination with the steam line. Initially, storage chamber is to be considered empty when the size reaches up to 110 percent compressor outlet temperature (Kulor et al. 2021). This hybrid system has the advantage of solar panel fields and towers with combination of energy storage systems (Grangea et al. 2014).

2.3.2 Fuel Cell Gas Turbine

In this system, turbine avails fuel cells, for example, solid oxide fuel cell exhaust to generate compressed power. The gas turbine is used to extract thermal energy with high temperature for driving compressor in addition to provide pressurized air to the fuel cell. This hybrid system provides efficiency of fuel cell and power density for reliable operation. This system captures and oxidizes anode off-gas to excursion turbine machine and generate electricity. This method provides the requirement of airflow and heat to drive the turbine for the production of electricity (McLarty et al. 2014).

2.3.3 Solar Biomass Energy

In a solar biomass energy hybrid system, there are various components such as heliostats, parabolic troughs, solar PV panels, and hyperboloid reflectors. First, the condensed water is to be preheated by using bled steam from a turbine at a pressure of 0.5 MPa. After that, hot water flows into the heat exchanger and acquires heat energy from the solar PTC system when sunlight is available. Then runs a boiler of biomass where it is used to generate superheat at a pressure of 6 MPa and temperature of 772 K (Zhang et al. 2019). Then, superheated steam is used to build up electricity in turbine where sunlight is available. During the daytime, biomass boiler runs with low capacity and at nighttime, it runs with full load capacity. So due to this hybrid energy system, it is not only supplying but also generating clean energy and having the capacity to avoid unnecessary waste which can further be used for agricultural purposes. By using two-stage gasifier solar biomass, it will be better efficient utilization of energy produced (Bai et al. 2016).

2.3.4 Solar Geothermal Energy

This hybrid system is very clean and energy-saving to produce electricity by using solar or geothermal energy systems. In many countries, commercial solar and geothermal energy system has been established. The hybridization of solar and geothermal system consists of geothermal with organic rankine cycle, solar heating comprises of superheater, solar collector, and solar pump. The running fluid ORC is burnt by an evaporator, then superheated and moved to the turbine for electricity production. The exhausted steam from the turbine is condensed by using a condenser and run into a preheater. An evaporator completes the entire process for the generation of electricity. The overall cost of such type of hybrid system may be 1.5–3.5% than normal cost.

2.3.5 Solar Wind Energy

By using solar wind hybrid system in which wind energy is transformed into electricity by using wind turbine and for solar energy system, sunlight is transformed into electrical energy with the help of photovoltaic system. Hybrid solar-wind energy system combines solar PV array, wind turbine, controller, inverter, battery, generator, and another appliance. The charge controller and inverter are used to adjust output power as per load demand. This hybridization system performs for ON grid and OFF grid, both modes with their intermittent nature. Grid-connected systems are more economical rather than OFF grid mode connected system, since they do not require a battery bank. The suitable optimization method can be preferred for the measurement of net present value that helps to reduce future cost (González et al. 2015).

2.4 Technologies/Tools for Hybrid Energy System

There are various emerging technologies/tools for hybrid energy system operation which are highlighted on proper designing with the integration of multiple energy sources. It is also required for reducing the overall cost of system designing hence it can be met with using different software tools. Below, the description of different software applications for hybrid energy system have been described:

RET Screen: This simulation tool is excel-based clean management tool which incorporates in determining economical and technical viability. This is the most used simulation tool for reliability and feasibility studies in renewable energy sources and is free to download. It uses C language and was released in year 1988. It is attainable with higher number than 30 languages and have variants such as RET Screen 4 and RET Screen plus. RET screen plus includes monitoring the system performance with the integration of solar radiation data.

HOMER: HOMER tool is user-friendly and developed by National Renewable Energy Laboratory (NREL), USA. This application tool is used for designing and evaluating the performance for ON grid and OFF grid systems. In this simulation, virtual C++ language is required. It also represents the tables and charts for the comparison of different configuration and analyzes their performance by Net Percent Cost (NPC).

HYBRID2: It was developed by Renewable Energy Research Laboratory (RESL), USA in the year 1996. This tool can simulate both AC & DC distribution systems, renewable energy sources, energy storage, and converters. HYBRID 1 simulation tool was developed in the year 1994. It comprises of four major segments such as Simulation Module, Graphical User Interface, Graphical results Interface, and Economics Module which permit users to design projects and maintain all records.

HySim: It prefers to hydrological simulation tool and was developed by Sandia National Laboratory (SNL), 1987. It employs amalgamation system that combines solar photovoltaic, wind energy turbine, generator, and energy storages for a standalone system. This tool is having an economic analysis consisting of cost of fuel, energy, operational. and maintenance cost.

HybSim: This simulator tool was developed by Sandia National laboratories for the purpose of economic analysis of remote areas where energy demand is fulfilled by using renewable energy sources along with conventional energy sources. It requires a datasheet of load demand, solar irradiation, wind speed, etc.

TRNSYS: TRNSYS tool is developed by the University of Wisconsin and the University of Colorado, 1975. Initially, this tool was used only for thermal systems but after sometime, it was promoted for solar PV applications, diesel generator, and wind energy. It uses FORTRAN language which does not permit for optimization of energy sources. There are two versions released in years 2010 and 2012 as TRNSYS 17.0 and TRNSYS 17.1 respectively.

iHOGA: This tool is based on C++. It is used for solar PV, wind turbine, micro-hydro pumped, etc., designing hybrid system with single- or multi-objective function. It uses two versions such as PRO+ and EDU in which EDU is free.

INSEL: INSEL tool was designed by the University of Oldenburg, Germany. INSEL tool has more features for conventional simulation programs. It is utilized for the interpretation of operation and maintenance costs. It performs under the environment of MATLAB and simulink. This is not a free software tool.

SOMES: Simulation and Optimization model for Renewable Energy Systems tool has been developed at Utrecht University, Netherlands, 1987. This consists of a solar PV array, wind turbine, converters, and battery storage. This tool is used to evaluate performance on an hourly basis. It is coded in Turbo Pascal and runs on the windows platform.

SOLSTOR: It was developed by Sandia National Laboratory, 1970. This is used for simulation and optimization of integrated alternate energy systems including the peripherals such as solar photovoltaic, wind energy turbine, batteries, and converters. This minimizes total life cost by selecting the best size of equipments. Currently, this software tool is not under working.

2.5 Planning Methodologies of Hybrid Energy System

Traditionally remote areas are supplied energy by using diesel generators. Research has been carried out and shows the effects of diesel generators with negative results. Then, mostly used solution such as to deliver electricity by using renewable energy sources has been accepted. By keeping all environmental conditions such as solar irradiance and wind speed, there may be problems in the production of electricity continuously. Then, hybrid energy system has been preferred for continuity and reliable power supply. It is common to use, to implement conventional energy sources with alternate energy sources in addition with energy storage to design as microgrid (Emad et al. 2019).

There are different methodologies for the designing of hybrid energy systems with their parameters, power resources, and limitations. There are such as graphic construction method, analytical method, probabilistic method, and artificial intelligence method (Upadhyay and Sharma 2014) (Fig. 2.2).

2.5.1 Graphic Construction Method

This method is designed by Markvart (1996) for designing standalone solar photovoltaic and wind turbine configurations. This method is occupied on a condition in which the mean value of demand must be contented by taking the mean value of solar irradiance and speed of wind for fix capacity of solar photovoltaic generator

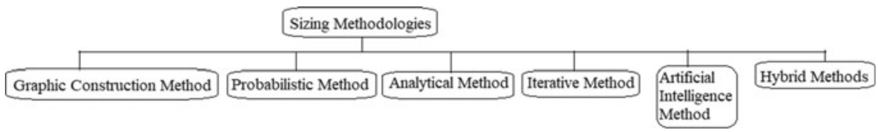

Fig. 2.2 Sizing methodologies of hybrid energy system

and wind energy turbine. On the basis of interpretation data, the trajectory is drawn between solar photovoltaic generator and wind energy turbine. The number of curves depends upon the number of times of data collected.

2.5.2 Analytical Method

In this method, hybrid energy models are shown by computational methods which outline the size of hybrid systems with its feasibility. The time taken in this method is less as compared with the Monte Carlo simulation method.

2.5.3 Probabilistic Method

It is one of the simplest methods for planning and sizing of hybrid energy system. The results obtained by this method may not be the best solution. In this method, few parameters are to be considered for optimization of hybrid energy system.

2.5.4 Artificial Intelligence Method

Many researchers have done work on artificial intelligence methods for finding out the best optimal solution for sizing of hybrid energy system. They have utilized genetic algorithm, particle swarm optimization on different platforms such as HOMER, ARENA 12.0 software, etc. These methods take less time as compared to conventional methods and provide the best solution.

2.5.5 Hybrid Method

These methods combine two or higher number of distinct methods which use positive consequences in order to obtain an optimal solution for the desired problem. The problems may be single objective or multi-objective depending upon the understanding of the importance of using different techniques. Sometimes, these methods may be complex but provide better results.

Table 2.1 represents different methods with their specifications for planning or sizing of hybrid energy systems (Bhandari et al. 2015):

Table 2.1 Sizing methods of hybrid energy systems

S. no	Methods	Parameters	Resources	Drawback
1	Graphic construction technique	Average solar radiation and wind speed data of each hour and month	PV/wind, PV/battery	Not comprising of slope PV module and height of wind tower
2	Logical technique	Average sun radiation and wind velocity data of each hour and month	Solar PV, wind, battery	Low flexibility
3	Probabilistic technique	Probabilistic access of calibrating of solar PV array and wind energy s	Solar PV, wind energy, battery	Not represent dynamic functioning of hybrid energy system
4	Frequent technique	Average sun radiation and wind velocity data of each hour and month	Solar PV, wind, battery	Not comprising of slope PV module and height of wind tower
5	Artificial intelligence technique	Average sun radiation & wind velocity data of each hour and month	Solar PV, wind, battery	Designing is very complex

2.6 Optimization Techniques

In this chapter section, optimization techniques have been discussed considering single objective and multi-objective functions. Many methods have been introduced for finding the best optimal solution of hybrid power system. For determining the reliability of hybrid power system, optimization is performed along with size and location of a component with achieving energy demand. For remote areas, artificial intelligence methods do not demand any requirement of environmental data for designing a unified energy system. There are many methods as described:

2.6.1 Particle Swarm Optimization

PSO method has several advantages over other methods as to reduce levelized cost of energy considering losses between demand and production sides. This method is very fast and reliable to obtain the optimal position. It is developed by Eberhart and Kennedy, 1995. It is based on the exchange of information between particles in the population preferred as a swarm. Each particle behaves as a point in hyperspace with essential properties as a memory of its own position and neighborhood's position. The performance of each particle is evaluated by the fitness function.

2.6.2 Ant Colony Optimization

ACO method is first published in the year 1996 which is influenced by the social act of insects in searching the precise direction for feed. Through this process, each information is shared by other ants by using the substance. This technique has been proposed for encountering the best optimal region and capacity of the system using renewable energy sources. Then it provides a better solution from genetic algorithm in less computational times (Abdmouleh et al. 2017).

2.6.3 Artificial Bee Colony Optimization

This method is inspired from a social act of honey bee swarm. Basically, there are three types of bees such as scout, worker, and onlooker. Worker bees are associated with food searchers and get back to their hive and dance. Onlooker bees watch worker bees' performance and select food sources from where worker bees carry food. At last, scout bees are independent on their own sources to search their food.

2.6.4 Tabu Search Optimization

It is meta-heuristic method discovered in 1996 to evaluate optimization problems. It is most identified for finding location and sizing of hybrid energy performance. It is having explicit memory and can be an application for continuous and discrete variables. The advantages of using this method are having many iterations and depending upon settings of parameters to obtain optimal location.

2.6.5 Genetic Algorithm

This method is inspired from natural selection and it is having different components such as chromosome encoding, selection, recombination, fitness function, and evolution. There are many choices for designing genetic algorithms for different applications. In the selection process, chromosomes are selected from the population and further used for reproduction. Members are selected based on performance and selected members to introduce in the next phase. In the crossover process, two chromosomes mix their genetic material and produce a new chromosome and the last step is mutation in which mutation of parents occur and develop a new chromosome.

Development of Hybrid Energy System Using New Techniques

For obtaining the performance of a hybrid energy system with its precise efficiency, few different combinations have been introduced. Padmanaban et al. (2019) have designed a photovoltaic–fuel cell hybrid grid with the integration of an ultracapacitor power system. To achieve the maximum power of this entire hybrid system, another maximum power tracking technique has been used such as Jaya Based MPPT (Padmanaban et al. 2019). This method is fast and effective with nil deviation near maximum power point. Hybrid optimization techniques such as combination of PSO and ABC for optimal location of energy system. Chakir et al. (2019) have proposed a hybrid PV battery energy system under TRNSYS environment (Chakir et al. 2019). For improvement of power quality of any hybrid power system, some AFACTS devices have been employed for reliable operation. Mostly used FACTS device such as DSTATCOM has been preferred for solar wind hybrid power system (Parija et al. 2019). The other concept has been taken of microgrid in order to decrease energy cost under different constraints. It can be configured under different converters between power sources and load. Hence, a methodology can be used for the purpose of energy-storing systems for charging and discharging (Kafazi et al. 2019). A hybrid system can be configured by using conventional and nonconventional energy sources such as solar and thermal hybrid system with PI controller and considering breaking point factors (Verma and Kori 2020). Similarly, for standalone systems, it is required to optimize the performance of energy system. Solar PV systems with different MPPT techniques can perform under sudden changes in weather conditions for the purpose of overcoming harmonic problems (Pradhan et al. 2020). There are different implementations of MPPT techniques for the operation of solar PV system such as Perturb and Observe and Incremental Conductance methods which perform by considering a few challenges such as steady-state oscillations, drift problem, designing problem, and lack of tracking steps. These all problems may be overcome by using such as drift-free method, variable step method, and prediction of parameters, etc. (Li et al. 2019).

For the optimization of hybrid energy system various techniques have been introduced in addition with multiple maximum power point techniques such as hill-climbing, fractional open-circuit voltage, fractional short-circuit current, etc. (Motahhir et al. 2019). Some of the heuristic techniques are preferred for optimization of hybrid renewable energy systems, for example, solar PV system in which partial shading is another issue which impacts the performance of energy system (Eltamaly and Farh 2019). There are more advantages of DC system over AC systems like DC is most compatible with renewable energy system hence, direct current microgrid has been introduced but having power management issue hence various control strategies have used such as centralized and decentralized. So, sizing of hybrid renewable energy system is an important factor from point of designing (Kumar et al. 2019). For the enhancement of power generation by using renewable energy system such as solar system requires the best MPPT technique, it can use hybridization of ANFIS and PSO methods (Priyadarshi et al. 2019).

There is a requirement for an improved power management control of a hybrid DCMG system which may be the combination of solar cell, fuel cell, and battery energy storage system. Based on the performance of BES, a better power management can be implemented by regulating modulation index and improving voltage stability (Senapati et al. 2019). Among renewable energy sources, wind is widely used energy source which may have integration with supercapacitor and lithium batteries for the establishment of hybrid energy storage wind power system (Yang et al. 2020). For maintaining the reliability of electricity under newly charging method combination with lithium-ion battery energy storage system has been introduced in which meta-heuristic algorithm has been used for the optimization of hybrid energy system (Trpovski et al. 2020). Energy storage system is used for maintaining continuous electricity which also faces the challenges such as best location and its capacity hence a lot of review work has been done by researchers (Ling Ai et al. 2019). There is a process such as distribution system asset which includes installation and optimal size of energy storage system containing other equipments such as transformer and feeders which operate on 33 bus systems (Masteri et al. 2018). For the next generation, flexible AC/DC hybrid energy system has been introduced because sometimes it is difficult for the certainty of generation and load hence this problem can be removed (Liu et al. 2019). Targeting as improving the efficiency of hybrid energy system, a new configuration has been introduced with wind and tidal energy sources. In this configuration, tidal power performs with the fluctuation of wind power under control strategy (Hu et al. 2017). Due to the special load such as EV charges point and new power generation system (solar and wind power generation system) can be taken for improvement of power quality of hybrid system (Luo and Huo 2020). Sometimes due to fluctuations in weather conditions, wind speed may be low or sunlight intensity may be low hence smoothening of such a hybrid system has been carried out with an energy storage system. But this may increase the maintenance cost of an entire hybrid system (Lamsal and Sreemal 2019).

From the point of stability, there are many issues which have to be resolved by configuring a hybrid system with advanced technologies in order to active power control, frequency control, and voltage control (Schinke and Elich 2018). Due to the use of power converters, few harmonics can be introduced specially in solar PV systems hence through the use of impedance transformation harmonics problem can be analyzed (Jingkai and Cao 2019). For hybridization system of HVAC and HVDC, probabilistic power flow can be used line current converter and voltage source converter (Shu et al. 2019). Hybrid energy system is an important element for finding the best optimal location with hybrid energy system planning moth-flame optimization method has been used (Ardabilli et al. 2020). For the minimization of operation cost of microgrid consisting of distributed energy resources combined heat and power generation unit can be installed to keep the balance between energy supply and load demand (Semero et al. 2020). To overcome the problem of switching state optimization hybrid method can be applied which uses DC programming and is compared with other heuristic methods (Schafer et al. 2020). The conventional designing of hybrid system takes a lot of time for simulation hence average models have been employed which may consist of bidirectional half-bridge converter and boost converter in addition to new power filter method for a smooth operation of hybrid energy system (Tang et al. 2020). Under islanding operations, some of the parameters of hybrid system may be in an unbalanced condition which causes instability of power system hence a time delay can be introduced in addition with some batteries (Hashimoto et al. 2019). Hybrid renewable energy source can be preferred as integrated renewable energy system so planning of these systems have been formulated by optimization, formulation, and configuration (Babatunde et al. 2020). Some of the hybrid energy system models have been configured by fuzzy logic method for proper selection of renewable energy sources and focuses on dynamic issues (Aikhuele et al. 2019). Due to intermittent changes in weather conditions, renewable energy sources may have a problem of instability such as small-signal stability hence proper location and sizing of hybrid energy system may overcome these instability problems (Ajeigbe et al. 2020). For the smooth operation of hybrid energy consisting of wind power may be configured with a pumped hydrosystem to improve the power quality of hybrid system by using a single value decomposition matrix (Hassan et al. 2019).

2.7 Conclusion

This chapter deals with a review of planning and sizing methodologies of hybrid system for the achievement of better operation. There are different hybrid energy systems that have been described with their parameters with their working. There are different optimization techniques that have been reviewed with their description and new techniques for the development of hybrid energy system. Hence, we can optimize and obtain the best optimal location and size of hybrid energy system using renewable energy sources.

2.8 Future Work

By hybridization, various energy sources can be integrated with electric vehicles. In this current era, electric vehicle is playing a major role as they are achieving momentum. There is advancement of battery system from lead acid to lithium ion. These batteries are having large potentials as compared with other batteries. Various types of electric vehicles are present which can be incorporated with hybrid energy system to keep a balance between energy supply and load demand.

2.9 Summary

In this manuscript, introduction of renewable energy system has been described with the description of hybrid energy system. As there is requirement of energy supply to fulfill energy demand. Hence through only one source, it is quiet difficult hence hybrid system has been introduced. There is complexity in hybrid system as it requires the best location and sizing for providing reliable energy. Hence different optimization techniques with operation tools for hybrid energy systems have been described. Further, hybrid energy systems can be utilized with electric vehicle technology interconnected with lithium-ion batteries and can be analyzed for their operation.

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