Delta University Scientific Journal
Journal home page: https://digitalcommons.aaru.edu.jo/dusj/

Renewable Energy Resources Modeling Survey

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ABSTRACT
Renewable energy resources (RES) have become multiple, which made the world interested in developing them because of their continuity, relieving pressure on fossil fuels, as well as the environmental impact. Using RERs will lessen reliance on conventional fossil fuel-based electrical power generation and is more ecologically friendly and eternally sustainable. In this paper, modelling of several renewable energy resources (RERs) including photovoltaic solar (PV), wind, hydro power, geothermal, biofuel, and battery power storage is presented. Modeling of these sources is very important because of their impact on the smart grid and because of their variable nature and different from the components of the traditional electrical network. For battery, the battery storage is very important because many RERs are not fixed in the amount of power generation or they are not sufficient for the loads. For hydro power, Water flows at different rates, small hydropower generators operate at different speeds. For geothermal, geothermal thermal energy includes drawing steam or warm water from wells buried kilometers under the surface of the Earth which is constantly changing. Burning a variety of biomass fuels, which after combustion are transformed into various kinds of energy, can provide sustainable biomass energy that is also unstable. This paper discusses the modelling of all of these resources as well as their benefits and drawbacks.

Keywords: *Smart Grid, Traditional network, RER, distributed generation.*

1. Introduction

One significant obstacle to the widespread integration of renewable energy resources (RERs) into the electric grid is the fluctuating/intermittent character of these supplies. RER use has grown as a result of their ability to lessen environmental impact and satisfy rising energy demands. Every country in the globe is encouraging the development of renewable energy facilities. By 2050, the European Union (EU) and the United States have established goals for RER power generation of 100% and 80%, respectively. Recently, a number of nations have established goals for increasing the percentage of RERs in order to reduce greenhouse gas emissions. Photovoltaic (PV) power plants powered by wind and sun have dominated new RER installations. However, effective models to define their intermittent and changeable behavior must be developed and implemented in the operation and planning of electrical power networks [1].

The quantity of renewable energy produced by solar photovoltaic (PV) and wind energy systems solely depends on climatic factors like solar irradiation, air temperature, and wind velocity that are related to the site/location. In order to use wind and solar power systems effectively, it is crucial to analyze the solar insolation and wind speed parameters for a certain installation location. Currently, hydropower generation accounts for over 58% of the electricity produced globally from renewable sources. An intelligent and resilient control strategy is required to fulfil the constantly growing load requirements and for efficient electricity with the changing climatic conditions and resultant change in load [2].

The electricity generated from renewable energy sources has recently increased significantly, and it will soon play a big part in power generation. Delivering the liabilities acted on the whole system as a result of the irregular character of these RERs is necessary to improve the installation of RERs in the traditional power network. The main challenges for system managers are changeability and ramp or slope events in the power production because of their impact on system adjustment, scheduling, reserves monitoring, and commitment of producing units [3, 4].

The ambitious decarbonization of the European power grid and the effective connection of RERs to traditional energy systems have been described in reference [5]. An integrated energy system, or an energy hub made up of electrical, heating, and cooling equipment, demand response, and RER optimization, is suggested in reference [6]. The alterations to optimization methods brought about by extensive RER integration are shown in [7]. Reference [8] discusses the significance of using long-term uncertainty modelling techniques to assess different renewable energy and decarbonization assistance strategies. For simulating the complex behavior of the national power market under various scenario analyses, a computer model based on a systems dynamics technique has been proposed in [9]. A method for minimizing changes in RERs anticipated on various time scales by employing multiple types of demand-side reserve offers has been given in [10]. Reference [11] presents an optimum energy management issue for micro - grids with RERs and devices that store energy.

This paper's goal is to show modelling results for several RERs, including wind, solar, battery, hydro, geothermal, and biomass. The remainder of this essay is structured as follows: The modelling of the wind energy system and its method to addressing uncertainty isdescribed in Section II. Section III describes the modelling of solar PV energy system output power and its uncertainty managing strategy. The modelling of a battery energy storage system is shown in Section IV. Section V provides information on modelling small hydro energy systems. Geothermal energy and biomass energy models are discussed in Sections VI and VII, respectively. The significant contributions are outlined in Section VIII along with some closing thoughts.

2. MODELING OF WIND ENERGY SYSTEM

Wind energy is the kinetic energy (KE) of moving air, which is more dependable, affordable, and easy to use in wind turbines (WT). Pressure is applied to the blade surface area as the wind flows through the WT's blades. The rotor is turned by the blade due to aerodynamic forces. Behind the blades, a single unit houses the generator and gearbox. The generator's output is transferred through for AC to DC conversion. The wind's KE is transformed into mechanical energy by the WT. Electricity might then be produced using this energy.

It is one of the renewable energy sources that were found to alter electric power by improving the smart grid's sustainability, performance, and dependability [12]. By employing a wind generator, the mechanical energy obtained from the wind may be utilized to create electricity. Each type of WT is manufactured with a different vertical or horizontal axis and serves a particular function. The largest wind turbines, for instance, are used to generate commercial electric power, whilst the smallest turbines are used to provide extra power for boat propulsion or battery charging Fig. 1 shows the wind turbine connection with electrical grid.

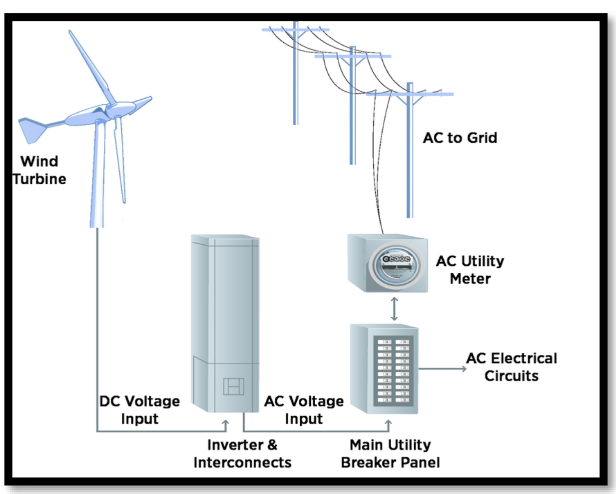

Fig .1 : wind turbine connected to the grid

Since there is no need to consume fuel to produce wind energy, it is both ecologically benign and organically produced. Because wind turbines only occupy a little area of the land—a few square meters—the remainder of the area may be utilized for farming or other agricultural activities. For people who reside 100 meters away from the wind power facility, the wind turbine can generate an annoying noise [13]. Both solo and hybrid power supplies can be provided by wind turbines. Typically, a power regulator is utilized to control the power output between the output of the turbines and the load. Depending on how the voltages are employed, transformers are used to scale the voltages up or down.

With an anticipated lifespan of 20 to 25 years, WT is an excellent alternative power source. It is now understood to be a crucial element of long-term, sustainable economic and environmental well-being, as well as price and supply security for energy. Although wind energy is dependable and affordable, it necessitates the construction of windmills in locations with strong and consistent winds, which might be a disadvantage for some nations. The optimum location for wind power may be offshore because the winds there are often strong and consistent.

The wind turbine's height has a significant impact on how much power it can produce since greater winds are thought to result from taller turbines in the WT, and the surface winds are easily influenced by the texture or imperfections of the earth's surface [14]. Additionally, there are no emissions from wind turbines, and they are quite effective when used to generate green electricity. The turbine's most prevalent problem is that it needs strong winds to produce enough electricity for its intended use, which is peak shaving. When compared to a PV system, the wind turbine is very affordable.

The size, form, and position of the wind turbine, as well as the height of the blades, all affect how well they function. It can be scaled down to small turbines used in businesses to power small institutions, and the offshore advantage allows the mounting of the huge turbine to produce a large amount of energy [15]. The advantages of the wind turbine technology also include: environmental friendliness, low cost in its generation of energy, a big source of energy and large industrial base already exist, and it could be used to power smaller institutions. Nevertheless, there are significant drawbacks, including the intermittent nature of wind power, noise from the revolving motor and blade, and loss of landscape.

In order to model the wind energy system as a whole, we need to model all the components of that system. The wind turbine is the most important component of this system that must be modeled. Also, this turbine is driven by the speed of the wind, so the wind speed must be modeled. After the turbine is powered by the wind, power is output that may be intermittent, unstable, or not in accordance with energy standards, so modeling the energy leaving the system helps to understand this output power.

An inductive/asynchronous device that generates active power (PT) and consumes reactive power (Q) is connected to the WT [16]. The active power is converted to electrical power (Pe). The modelling equation for output electrical power is:

$$P_e=\frac{1}{2}\rho\pi r^2 S^3 T_c \times n_t n_g \qquad (1)$$

Where ρ is air density (kg/m3), r is radius of wind turbine blades, S is the speed of wind (in m/s), Tc is the turbine power coefficient, and nt ng are efficiency of turbine and generator respectively. The speed of wind is modelled in (2):

$$f^t(S) = \left(\frac{k_t}{c_t}\right)\left(\frac{S_t}{c_t}\right)^{(k_t-1)} exp\left[-\left(\frac{S_t}{c_t}\right)^{(k_t-1)}\right] \qquad (2)$$

Where c_t is scale factor at time t, k_t is shape factor at time t, and S_t is the wind speed at time t. the c_t, k_t factors can be evaluated in [17] as shown in (3).

$$c_t = \frac{\mu_s^t}{F(1+\frac{1}{k_t})}, \quad k_t = \left(\frac{\sigma_s^t}{\mu_s^t}\right)^{-1.086} \qquad (3)$$

Where μ_s^t, σ_s^t are the mean and standard deviation of wind speed (St) at a particular time t, and F() is the gamma function.

For the power generated by wind energy generators (WEG), three geographical areas account. The WEG/WT will output zero power when the wind speed (St) is greater than the Scout or lower than the Scin (i.e., $P_w^t = 0$). The continuous range is defined as the region where St lies between Scin and Sr and where the wind power increases linearly as shown in (4). It will produce rated wind power, or P_w^r and it is a discrete when St is between

Sr and Scout. The WT will not produce any meaningful power below the Scin or above the Scout, and it is similarly regarded as a discrete range [18].

$$P_w^t = \begin{cases} 0 & S_t < S_{cin} \text{ and } S_t > S_{cout} \\ \left(\frac{P_w^r}{S_r - S_{cin}}\right) S_t - \left(\frac{S_{cin} P_w^r}{S_r - S_{cin}}\right) & S_{cin} \leq S_t \leq S_r \ldots \\ P_w^r & S_r \leq S_t \leq S_{cout} \end{cases} \quad (4)$$

In [19], the production of wind energy typically depends on wind speed. At a specific time t, the quantity of wind energy produced by a WT may be stated as in (5).

$$P_w^t = \begin{cases} 0 & S_t < S_{cin} \text{ and } S_t > S_{cout} \\ \left(\frac{P_w^r}{S_r^3 - S_{cin}^3}\right) S_t^3 + \left(\frac{S_{cin}^3}{S_r^3 - S_{cin}^3}\right) P_w^r & S_{cin} \leq S_t \leq S_r. \\ P_w^r & S_r \leq S_t \leq S_{cout} \end{cases} \quad .(5)$$

Where S_t is the average wind speed at particular time t. S_r, S_{cout}, and S_{cin} are the rated, cut-out, and cut-in wind speed. P_w^r is rated/ maximum wind power.

3. Modeling of Solar PV

Solar power is an endless source of energy. It is one among the renewable fuels that is changing the way electricity is produced. Scientists have developed techniques for harnessing solar energy by using photovoltaic (PV) cells; the sunlight is converted into electricity during the process. Using the PV effect, PV transforms light into electric current using a photoelectric system which contains multiple components.

The three primary types of solar PV systems are independent/stand-alone, grid-connected, and integrated. While the standalone model has a battery energy storage system and a generator for backup power, the grid-connected solar PV system uses a DC power to a power conversion unit converter that transforms the DC to AC. For instance, the energy generated by panels can be utilized to power a grid, buildings, or other facilities. Since solar PV panels produce DC energy, an inverter is utilized to convert that energy to AC, and a regulator is used to control the power. Depending on the intended purpose for the voltages, transformers are used to scale the voltages up or down. However, with an integrated system, a storage battery or a significant power conducting device are not necessary because the solar PV system is connected directly to the loads [20].

For solar PV systems, insolation/irradiance and emission are the two primary elements taken into account. Insolation is the ability of solar PV energy to be converted into electricity. The temperature at which the solar cells are working, the location of the solar panel, and the amount of light are only a fewvariables that impact solar irradiance. For emission, amorphous silicon and cadmium telluride are two different, ecologically acceptable materials used in solar PV cells which are environmentally friendly.

Solar PV energy systems are used for a variety of purposes, such as solar electricity, solar cars, agriculture, solar lighting, water heating, water cookers, water purification, etc. Solar PV systems provide a number of benefits, including widespread availability, rapid installation, low application and processing costs, little maintenance, and ease of modification [21]. The drawbacks of solar energy, however, include the fact that it is more expensive than fossil fuels, sun-dependent, capital intensive, and difficult to locate solar PV plant development sites. Future solar technology will be more prevalent because of recent advancements that may lead to reduced costs and more efficiency.

In order to properly set up solar PV plants and systems, data collected over the course of a year is often used. This data includes information on temperature, hourly global direct insolation, wind speed, array geometry, and system balance. In order to get the most solar radiation, solar PV panels are often slanted. The amount of energy generated is controlled by the incoming beam and diffuse radiation on solar PV panels' surface [21, 22]. The active power output from solar PV power (P_{Act}^{Pv}) can be represented by the formula (6).

$$P_{Act}^{Pv} = \eta A(BR_b + DR_d + (B+G)R_r) \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where $\boldsymbol{\eta}$ is the photoelectric conversion efficiency, A is the surface area of solar PV systems (in m2), B and D is are the beam part and diffused part of solar irradiations, Rb, Rd and Rr are the tilt factors for beam, diffused, and reflected part of solar radiations. Fig. 2 shows the equivalent circuit for solar PV, The solar PV cell's (IL) load current is provided by (7).

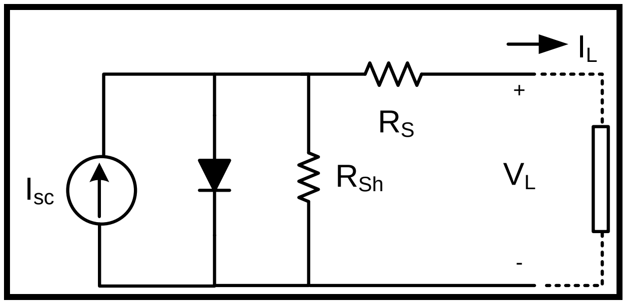

Fig. 2 Equivalent circuit for solar PV

$$I_L = I_{SC} - I_{st}\left[e^{\left(\frac{q(V+I_L R_S)}{nKT}\right)} - 1\right] - \left(\frac{V+I_L R_S}{R_{sh}}\right)\text{……..(7)}$$

Where IL is load current,Isc is the short circuit current, q is electron charge (1.6 * 10 -19 C), V is the voltage across solar cell, RS and Rsh are series and shunt resistance for cell, n is the ideality factor, which is a number between 1 and 2, K is Boltzmann’s constant (1.3807 x 10 -23 joule/kelvin), T is the absolute temperature of the p–n junction, It is the saturation current [22].

For the solar cell array stations shown in Fig. 3, there are N*M cells is connected in series and parallel to reach the demand voltage and current [22].

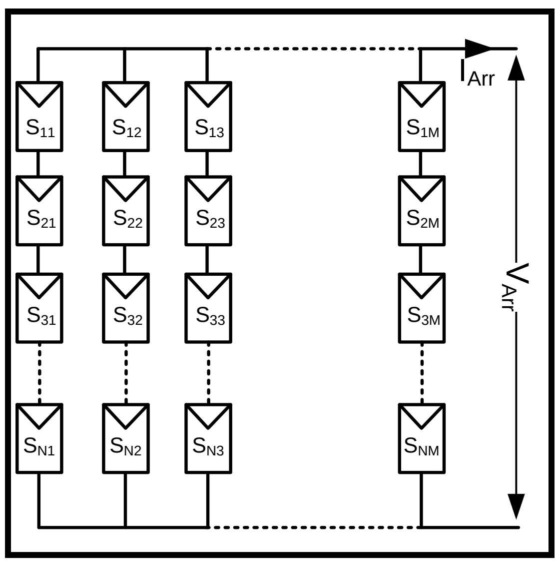

Fig. 3: solar cell array N series cell and M parallel string

The overall current and voltageof the array calculated in (8) and (9).

$$I_{Arr} = M \times I_L\text{………………………………………..…..(8)}$$

$$V_{Arr} = N \times V_L\text{……………………………………….……..(9)}$$

Where IArr and VArr are the current and voltage for array, the IL and VL are the current and voltage for each cell in the array, N and M are thenumber ofseries cells and parallel string.The overall series and shunt resistance is calculated in (10) and (11).

$$R_s^{Arr} = R_s\left(\frac{N}{M}\right)\text{…………………………………......…....(10)}$$

$$R_{sh}^{Arr} = R_{sh}\left(\frac{N}{M}\right)\text{……………………………..……..…..(11)}$$

Where N, M are the number of series and parallel cell junctions of a PV array, R_s^{Arr} is series resistance of the array [22].On the other hand, in [23], the power output of solar PV panel is calculated in (12)

$$P_{pv}(G) = F_{pv}\frac{G_t}{G_{std}}P_{pv}^r + [1+\gamma(T_t + T_{std})] \ldots\ldots\ldots..(12)$$

Where Fpv is the factor reflecting the shading and wiring losses, Gt is irradiation from the sun (W/m2) at time t, Gstd is standard solar irradiance (1000 W/m2), P_{pv}^r is the rated output power, γ is the maximum correction for temperature, Tt is the temperature at time t, and Tstd is standard test conditions temperature (25 °C). these parameters could affect by some factors include type of material, the location's area and sun intensity, the area of the solar PV panel, and the type of connectivity [23].

The quantity of power produced from solar PV cells (Ppv(G)) in (13) is presented in [24], while neglecting the temperature of the solar PV cell.

$$P_{pv}(G) = \begin{cases} P_{pv}^r\left(\frac{G_t}{G_{std}R_c}\right) for\ 0 < G_t < R_c \\ P_{pv}^r\left(\frac{G_t}{G_{std}}\right) for G_t > R_c \end{cases} \ldots\ldots\ldots\ldots(13)$$

Where Rc is a certain solar PV irradiation point (say 150 W/m2).

4. Modeling of battery storage

When the supply from RERs is insufficient to meet the demands of the load, the battery storage system is used as a backup to store the extra energy. When the system's energy needs are more than what the RERs can give, this battery will additionally fill the gap. The additional power generated by the RERs is stored using battery storage devices. Lithium-ion (Li-ion) batteries are typically employed for storage. Compared to other battery types, Li-ion batteries have a lower self-discharge rate, a larger energy capacity, and the capacity to be recharged hundreds of thousands of times [25]. The amount of energy stored in a battery is expressed as in (14).

$$Q_B = Q_B^0 + \int_0^t V_B I_B dt \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(14)$$

The state of charge (SoC) of a battery is expressed as in (15),

$$SoC_B^t = \left(\frac{Q_B}{Q_B^{max}}\right) \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots...(15)$$

Where QB is the total energy of battery at time t, Q_B^0 is initial energy at start the charging, VB and IB are the voltage and current connected to the battery, Q_B^{max} is the maximum energy stored in battery. The SoC of the storage system (in Wh) is presented in [26] and expressed as in (16),

$$SoC_t = SoC_{t-1} + \eta_c^B\left(\frac{P_c^t}{\Delta t}\right) - \left(\frac{P_d^t}{\Delta t}\right) \ldots\ldots\ldots\ldots\ldots\ldots..(16)$$

Where SoC_t the SoC at time interval t is, SoC_{t-1} is the SOC at previous time interval, η_c^B is the charging efficiency of the battery, Δt is the scheduling interval (say 1h), P_c^t and P_d^t are the discharging and charging powers of the battery storage system.

The SoC for the battery could be controlled. In [27], the Soc is controlled and monitored using the variation of battery SoC which expressed in (17).

$$SoC_t = SoC_0 + \frac{1}{Q}\int_0^t i\, dt \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(17)$$

Where Q is the maximum capacity and ∫ i dt is the instantaneous capacity of the battery bank. For the battery to last longer and to avoid overcharging or under discharging, the SoC must be kept within the limitations, and this constraint may be written as [28] in (18),

$$SoC_{min} \le SoC_t \le SoC_{max} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(18)$$

5. Modelling of Hydro Energy Systems

Hydroelectric power is produced by water, another renewable energy source, and is typically found on dams where there is a lot of flowing water. Water is forced through pipes by water energy production industries to drive a turbine that is connected to a generator. Once the turbine has started to rotate, it turns the generator, which generates power. Fig. 4 shows the hydroelectric power station.

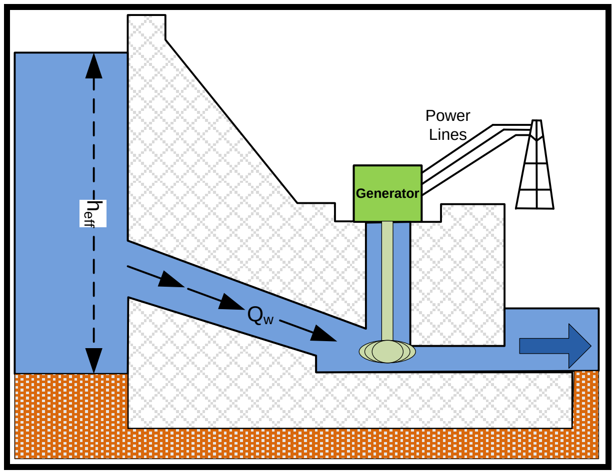

Fig. 4the hydroelectric power station

Kinetic energy is released throughout this procedure, and when it has been converted into mechanical energy, electricity is produced. A pumped-hydro storage facility operates on the same principles as a conventional hydropower facility. Because water flows at different rates, small hydropower generators operate at different speeds.

The fundamental benefit of hydro energy is that it is natural, can be stored in one place, and may be utilized to generate energy in the future. Hydropower is a clean form of energy since it is powered by water rather than fossil fuels, which cause air pollution. Due to the ability to adjust the water flow through the turbines, this power can be easily made available on demand (with extremely high ramp up and ramp down limitations). Hydropower plants provide reservoirs that offer a variety of leisure opportunities [29].

The construction of hydroelectric power dams is quite costly and requires careful planning. Since we will still need water as a resource and these dams are expected to last 100 years, this technology is extremely sustainable. These facilities don't emit any pollutants or generate trash, but the dams damage the neighboring lands, the aquatic ecology, and the beauty.

To create water energy, factories that do so force water through pipelines to drive turbines that are connected to generators that provide power. Depending on how such voltages are employed, transformers are used to scale the voltages up or down. In [30], the quantity of electrical power produced by a tiny hydro generator (PH) is presented and expressed in (19).

$$P_H = \frac{g\eta_h h_{eff}\rho_W Q_W}{1000W/kW} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(19)$$

Where g is acceleration (9.81 m/s2), ηh is the efficiency of hydro generator (%), heff is the effective height (m), ρw is the water density (kg/m3), Qw is the flow rate of water (m3/s).

6. Modeling of Geothermal Energy

Heat from the earth is known as geothermal energy. The word part "geo" (earth) and thermal (heat). Due to the ongoing production of heat deep inside the ground, geothermal energy is a renewable energy source. Geothermal energy is used to produce electricity, heat buildings, and provide hot water to people [31].Using geothermal energy could reduce fossil fuel costs by roughly 80%. It also lessens our reliance on fossil fuels because geothermal energy doesn't require fuel to produce electricity. The fact that geothermal energy does not contaminate the air and that people use it to heat and cool their houses and prepare their meals while also creating jobs for the local population is significant advantage of using this resource. Fig. 5 shows the geothermal planet.

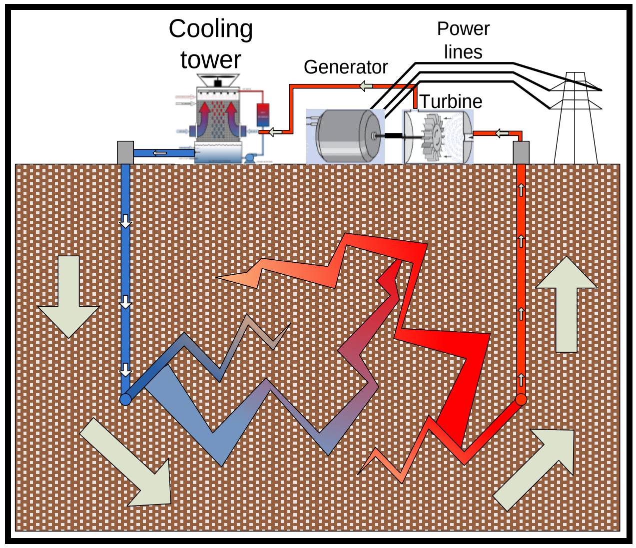

Fig. 5 the geothermal planet

Geothermal energy has some drawbacks. This kind of energy power is not frequently used, the procedure necessitates hiring highly qualified individuals for the job, who are typically moved. High investments are needed to establish a power plant that draws steam from deep under the ground. Another drawback is that the geothermal site may run out of steam after considerable investment, causing businesses to lose a lot of money. Only places with low temperatures may access this energy, which can create steam for a very long time [32]. However, geothermal energy is not eco-friendly and might include toxic chemicals that could leak from the holes that the workers have excavated.

Geothermal facilities could be connected to a grid to give electricity to a city, town, etc. because of the significant electrical energy output. Depending on how such voltages are employed, transformers are used to scale the voltages up or down. The cost of geothermal energy fluctuates depending on a number of factors, including temperature, drilling depth, and other factors. There are primarily three types of geothermal power plants. First, dry-steam power plants which drive the turbines using underground steam. Second, flash power unit which extract water from underground under high pressure and use it to generate electricity. The pressure decreases as the water level increases, and as a result, the water vaporizes into steam that powers the turbine. Finally, a working fluid is heated to a boil in a binary cycle power unit, where it vaporizes in a heat exchanger before turning to the turbine.

In order to reach the hot water and subterranean steam from wells many miles below the surface of the Earth, geothermal energy is used depending on steam turbine. Essentially, the steam that escapes from the earth's crust is utilized to power a turbine, which then turns on a generator to provide the needed electricity. Some power plants utilize hot water to evaporate a liquid, which then drives a turbine, while others use steam that is acquired directly to power a turbine [33]. The heat energy (H) equation is given by (20).

$$H = m \times C_p \times \Delta T \text{...(20)}$$

Where m is mass, CP is specific heat, and ΔT is change in temperature. In [34], the maximum heat power generated from a geothermal source is presented as shown in (21)

$$P_{max} = kv(T - T_g) \text{......................................(21)}$$

Where k is thermal conductivity, v is water outflow capacity, T and Tg are water and border temperatures.

Geothermal technologies are safe, dependable, affordable, and sustainable. It doesn't need fuel and is more environmentally beneficial than fossil fuels since it emits less pollutants. The range and size of power attained here have expanded as a result of technological developments, although this has mostly been restricted to regions near to tectonic plate borders. It is exceedingly expensive to drill wells and explore pipelines for deep subterranean deposits. Greenhouse gases that are underground are released by geothermal wells. But compared to the gases released by fossil fuels, these gases are far less polluting.

7. Modeling Biomass Energy

Biomass produce a fuels called Biofuels, which can come from plants directly or indirectly from waste from businesses, households, industries, and/or agriculture. They resemble fossil fuels but are produced from modern plants, as opposed to those that were cultivated millions of years ago. They may be created quickly and are renewable. The two main biofuels are bioethanol and biodiesel. Plants including corn, sugarcane, and sweet sorghum are fermented to create the alcohol known as bioethanol. It may be added to gasoline or used as a fuel to increase octane and lower carbon emissions. Vegetable fats are used to create biodiesel, an oil-based biofuel, including rapeseed, sunflower, soya, and palm oils. Vegetable fats are used to create biodiesel, an oil-based biofuel, including rapeseed, sunflower, soya, and palm oils. It can be used to directly fuel cars or to reduce diesel-powered vehicles' emissions of carbon monoxide, hydrocarbons, and particulates [35].

Biomass is employed as the feedstock for the manufacture of biogas, which is created from waste products from households, farms, and forests. The potential for biomass feedstock is estimated using a collection efficiency of 75% and an average feedstock yield of 160 kg/ha/yr. It is recommended to employ a gasified biomass-based system to convert 80% of the potential biomass feedstock into energy. Calculations may be made using [36], the biomass generator's hourly power output (PBio in kW) is determined in (22).

$$P_{Bio} = \frac{\eta_{Bio} F_A CV_{Bio} \times 1000}{365 \times 860 \times Oh_{day}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (22)$$

Where ηBio is the efficiency of biomass generator (%), FA is total fuel availability (in tons/year), CVBio is the caloric value of biomass, Ohday represents the number of operating hours per day.

8. Conclusion

When it comes to a specific region, the production of renewable energy from solar PV and wind energy systems is practically complimentary since wind speed is high at night and solar irradiance is high during the day. Consequently, obtaining the perfect mix will provide the system the biggest benefit conceivable. This study has examined the modelling of numerous renewable energy resources (RERs), such as solar, wind, photovoltaic (PV), small hydro, geothermal, and biomass. The battery has been represented as a key storage strategy.

WT is a great alternative power source because of its projected long lifespan. The wind turbine has been modelled since it is the most crucial part of the wind energy system. Additionally, as the wind speed is what propels this turbine, it has been modelled. Wind energy drives the turbine, which produces power that may be intermittent, unstable, or not up to energy standards. To comprehend this output power, output energy has been modelled.

One of the renewable fuels that is transforming how energy is generated is solar power. Irradiance and emission are the two main factors considered in solar photovoltaic systems. Systems using solar photovoltaic have both advantages and disadvantages. However, solar energy does have certain disadvantages, such as being more expensive than fossil fuels, dependent on the sun, capital-intensive, and hard to find development locations for solar PV plants. Modeling has been done for solar PV's power production, total current for cells and arrays, and array voltage.

Another sustainable energy source, hydroelectric power is generated by water and is often found on dams where there is a lot of moving water. A small hydro generator's (PH) capacity to create electrical power has been modelled.Geothermal energy is utilized to create power, heat structures, and give people access to hot water. The cost of fossil fuels might be reduced by around 80% by using geothermal energy. Due to the fact that geothermal energy doesn't require fuel to generate power, it also reduces our dependency on fossil fuels. The utilization of this resource has several benefits, including the fact that geothermal energy does not pollute the air, that people use it to heat and cool their homes, cook their food, and support the local economy. Modeling has been done to determine the heat energy and maximum heat power produced by a geothermal source.

Biofuels are fuels made from biomass. They are made from contemporary plants, yet they mimic fossil fuels. They are renewable and can be produced fast. Bioethanol and biodiesel are the two primary biofuels. In order to raise octane and reduce carbon emissions, it can be added to gasoline or used as a fuel. It may be used to directly fuel automobiles or to lessen the carbon monoxide, hydrocarbons, and particle emissions from diesel-powered vehicles. The main advantage of geothermal energy is that it is less costly than fossil fuels. The power production of the biomass generator has been predicted hourly.

Disclosure
No conflicts of interest in this work.

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