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Performance Analysis of Hybrid Power System Along With Conventional Energy Sources for Sustainable Development in Rural Areas

Suresh Vendoti , M. Muralidhar, R. Kiranmayi

Abstract*: The energy demand within the world has improved for a few reasons because of technical advancements, increasing enterprises, and increasing commercial energy consumption. Sufficient energy models will support the accurate use of renewable resources like solar, wind, biomass, biogas, and the fuel cell is a portion of the advantages used. Hybrid energy systems of these advantages will contribute viably to sustainable development and electrification in rural areas that do not access power grids. This study reviews the performance analysis of hybrid system along with conventional resources for sustainable development in remote areas. This paper also reviews the recent trends in energy usage from available renewable energy sources in addition to examine an expansive review of the performance analysis of different hybrid energy technologies in rural areas. It is also discussed the relative investigation of hybrid energy systems along with conventional energy sources particularly suited to the small and isolated areas supported by the literature. In continuation of this, the paper also discusses the future energy sources.

Index Terms*: Renewable Energy Systems, Conventional Energy System, Grid Connected Systems, Multi-Objective Optimization, Future Renewable Energy Sources.

I. INTRODUCTION

Sustainable energy sources like solar PV, wind, fuel cells, biogas, and biomass are mainly raising sources towards building a nation with economy. But, renewable resources experience as a few restrictions while used in a stand-alone application. The energy developed from wind turbine and solar PV sources are particularly depending on environmental factors; while fuel cells need hydrogen en-rich fuel. Biomass/biogas energy generating systems are sophisticated technologies that have been developed newly and are extensively uses the off-grid mode for concerning the rural area energy demands. Fuel cells are producing a huge amount of potential in the future green sources as of numerous advantages for example high efficiency, zero emissions, and flexible structure. To conquer these problems, solar PV and wind turbine based energy sources are combined with other sources. A hybrid renewable energy system (HRES) is formed by making more number of renewable resources. Electrification in rural areas is enforced by technical barriers like restricted transmission, hard terrains, and highly dispersed area with low population distinguished by lower the education, load density, and revenues.

Come to power generation from all sustainable energy source assets will incremented by 3.2% every year, and along these lines, the inexhaustible offer of world power generation develop from 19% of from 2007 to 23% of to 2035. The benefit of wind energy, particularly, has full-turned out to be quickly finished the earlier decade, from 18GW of the net power put powering ability at the highest of 2000 to 159GW at the highest of 2009, a trend that returns into all the more long term. In the event that the 4.5 trillion kWh of the most recent reasonable generation side over the making time, 2.4 trillion kWh (52%) be credited on hydal power along with 1.2 trillion kWh (28%) to wind.

The hybrid energy schemes are the only option for solving energy related issues within the rural communities. Hybrid systems are formed by combining more kinds of renewable systems along to provide the output. In any case, the combination of such systems may be an incredibly extraordinary task as a result of the way that the coordination and administration of economical power sources, storage devices, and energy demands are greatly troublesome. Thus optimal designing of HRES is very essential before its building [1].

Electricity is the important part for both financial and economical needs. An all around designed sustainable power system will be effective, to a great degree secure and may enhance the personal satisfaction [2]. Binayak et al. [3] developed a hybrid power system consisting of solar, wind and hydro inside the rural village of Nepal. Lee et al. [4] analyzed the sustainability based high mountain off-grid HRES and their suggestions identifying with the commitment of the system.

Balamurgun P. et al. [5] developed a hybrid energy system for provincial territories of India based on the cost feasibility operation. Rahman M. W. et al. [6] proposed a hybrid power system (PV-biomass-wind) and the system measures the size and its cost acquired by HOMER software.

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* Correspondence Author
Suresh Vendoti, Research Scholar, EEE Department, JNTUA, Ananthapuramu, India.
Dr. M. Muralidhar, Professor, EEE Department, SVCET, Chittoor, India.
Dr. R. Kiranmayi, Professor, EEE Department, JNTUCEA, Ananthapuramu, India.

Distinctive assessment exercises are connected utilizing usual systems like graphical development technique [7], repetitive philosophy [8], trade-off approach [9] and applied mathematics [10].

To conquer these inadequacies different convolution methods are used such as genetic algorithm (GA) [11], particle swarm optimization (PSO) [12], ant-bee and honey-bee colony calculation [13], harmony search (HS) [14], bio-geography based methods [15].

The paper shows the total outline of different combinations HRES along diesel generator (DG) and battery storage. Also, the paper completely surveys distinctive optimal sizing methodologies and improvement criterion of HRES supported by solar, wind, hydro, biomass and battery. For a corrective comprehension; it'll give the different optimizing methods and optimum plans. Finally, the paper also studies the current trend of world energy situations, and advancement of concerned energy demands of potential with significant references.

II. World Energy Scenario's

Right now, every energy needs within the world are depending upon renewable energy sources available in the nature. India's inexhaustible power distribution is among the world's most unique players in reasonable power source use, particularly solar based situated and wind control generation beginning at 31 Aril 2018 showed up in Table-1. India had grid associated introduced ability of around 57.24 GW, non-conventional innovations based power capability, around 16% of its total; exceptional the limit of major hydroelectric power without precedent in history [16]. The signify as far as possible by source wise installed in India as on 30 July 2018 has showed up in Figure 1.

Table-1: Total installed capacity by the renewable power in India

S. No	Type	Capacity (in MW)
On Grid Power		
1.	Wind generation	32,287.27
2.	Solar Systems	12,504.50
3.	Small Hydro power	4,384.85
4.	Biomass/Bagasse process	8,181.70
5.	Excess to Power	114.08
	Total Grid Power	57,472.40
Off-Grid/Hostage Power		
1.	Biomass Process	651.91
2.	Solar Systems (>1 kW)	471.16
3.	Excess to Power	171.22
4.	Biomass Process	161.45
5.	Micro Hydro	18.81
6.	Hybrid Systems	3.15
	Total Off-Grid/Hostage Power	1,477.70

Right now the total power generation developed inside the world for referred case, 19 kWh in 2007, 26 kWh in 2020, and 36 kWh in 2035 (all are in trillion). A sustainable power source is that the quickest developing supply of power generation within the international energy outlook 2010 (IEO2010) referred case. Total power generated by the world through renewable energy sources from 2007– 2035 are given in Table 2 [17].

Renewable energy sources are the future developing energy sources in the world and utilization of these sources are evaluated to 2.6% for each annum. World power generation appeared in source wise in 2015 onwards are shown in figure 2 and it shows 23.70% 1849GW out of total produced energy 6399GW. The energy utilization by various sustainable energy sources is appeared in figure 3 which demonstrates there would be the sharp increment in sustainable power source, coal and fluid substance by 2040 [18].

The world's average PV limit had outperformed 304 GW inside the year of 2016, steady with a report from IEAPVPS. All inclusive, solar-based energy is as of now ready to cover roughly 1.8% of energy request. More than 304 GW of introduced solar power was operational worldwide towards the end of a year ago, as per the report "previews of worldwide photovoltaic markets-2016" distributed by the IEAPVPS. The overall wind limit achieved 4,86,659MW by 2016, from which 54,844MW be further in 2016. This speaks to a rate of development of 11.5%. In worldwide wind turbines are introduced by the tip of 2016 will produce about 15% exploit the worlds energy demand. China and Latin America have upgraded their offer of late establishment to 53 endeavors to 6, 5 the stresses individually [19].

Table-2: World net power generation by sustainable power sources

Sources	2007	2015	2020	2025	2030	2035
Hydro	2999	3689	4166	4591	5034	5418
Wind	165	682	902	1115	1234	1355
Geo-thermal	57	98	108	119	142	160
Solar	6	95	126	140	153	165
Other	235	394	515	653	773	874
Total	3462	4958	5817	6618	7336	7972

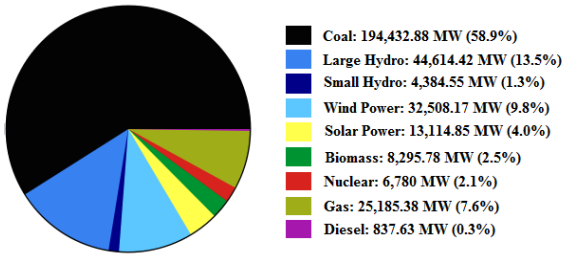

Fig. 1 Total installed capacity in India as on [17]

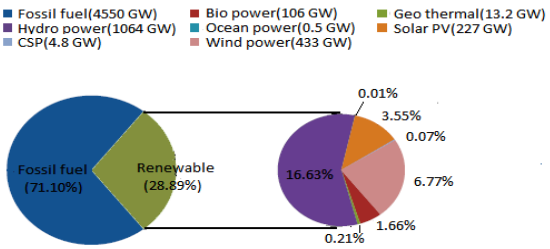

Fig. 2. Electricity produced by renewablet energy sources.

In 2005, world CO_2 emissions from fuel ignition and modern procedures have slowed down, affirming the delay trend found since 2012. It a consequences of auxiliary changes inside the worldwide economy, world energy efficiency improvements and regularly changing energy combining in key nations, finishes up the latest report by the PBL Netherlands Ecological Evaluation Organization.

In 2015, 66% of overall CO_2 emissions from non-renewable energy sources and modern procedures were produced in China (with 29th share of overall world), the US (14%), and the EU (EU-28) (10%), India (7%), the Russian Organization (5%) and Japan (3.5%).

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finishes up the latest report by the PBL Netherlands Ecological Evaluation Organization. In 2015, 66% of overall CO_2 emissions from non-renewable energy sources and modern procedures were produced in China (with 29th share of overall world), the United States (14%), and the European Union (12%), India (9%), the Russian Organization (5%) and Japan (3.5%). Out of these, China adequately limited its outflows, reducing them by 0.7% contrasted with 2014. Likewise emissions inside the Russian alliance, the US and Japan limited by 3.4%, 2.6%, and 2.2% separately. India's emissions development proceeded, with 5.1% expansions in 2015.

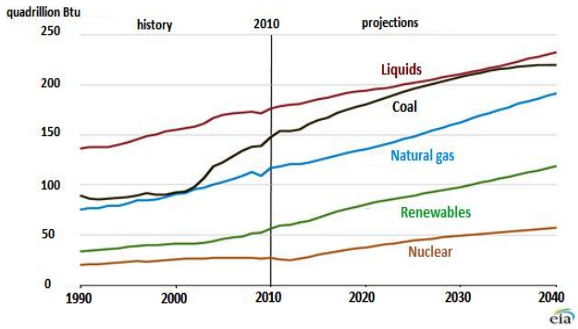

Fig. 3. Patterns of energy uasge from vrious energy sources 1990 to 2040 (quadrillion Btu)

III. DIFFERENT COMBINATIONS OF HYBRID ENERGY SYSTEMS

Hybrid renewable energy systems (HRES) were first developed in Papago village of Arizona in USA which comprising of solar PV and diesel generator on 16th Dec 1978. The total power produced from the hybrid system are used to supply considered energy demand and grid supply is not available the village [20].

Vendoti et al. [21] displayed a strategy to expect the optimal combination of solar PV/wind/diesel based hybrid energy system. Shaahid et al. [22] dissected hybrid energy system comprising of PV-Wind-Biomass with battery reinforcement inside the hybrid energy system.

A. Varieties of HRES

Hybrid energy systems comprising of 100% renewable energy sources which depends on the traditional fossil derivative systems. Compared to the renewable energy sources, conventional based energy sources are less expensive and more reliable. Particularly, diesel generators are more prominent power solutions for remote regions. This section exhibits a relative survey of different hybrid renewable energy systems comprising of sustainable energy sources for the electrification of rural regions.

Number of zones incorporates plenty of renewable energy sources with incredible potential to deal with energy demand. Solar PV, wind, biomass/biogas, hydro energies are an attractive renewable energy sources for inaccessible areas. In perspective of long-term projections, execution of hybrid control systems containing totally of accessible unlimited sources can end up being more achievable than placing resources into conventional energy sources. This section consolidates summaries of different hybrid energy systems.

1) Hybrid Solar - Wind Energy:

Beginning in the earlier period, wind energy was harnessed and production of electrical energy which is transformed into a need just once the oil crisis. The wind is depending upon the wind velocity and is insufficient to some times. In this sense, solar based power is more sufficient. The combination of solar and wind-based energy is most reliable and environmentally friendly energy sources around the world. Therefore, solar or wind energy systems alone can't constantly give satisfactory energy to satisfy the demand.

It's difficult to select a suitable system which gives the trustworthy power system. For obtaining the reliable power system, optimization of HRES components is important. The sizing of the HRES is referred as. The usage of solar and wind hybrid energy systems are more popular since in 1980, researchers are endeavoring to find out most excellent solutions and are introduced a vast kind of options in which to optimize sizing and its overall cost. Diaf et al. [23] designed a combination of different hybrid energy systems with cluster of distinctive climate areas with almost zero LPSP. In which systems are compared with solar only, wind only and combined together to find the least cost of energy. Some near investigations and moreover the results of different HRES are mentioned in table 3.

2) Hybrid Solar – Wind – Hydro Energy:

In the earlier period, hydro-electric energy systems played an important role in the developing world and currently provide the power supply of 19 nations [30]. Hydro-electric power stations having more benefits compared to the conventional sources of atomic or steam based energy sources. The availability of these sources is unlimited and free of cost and is utilized to different purposes like commercial and irrigation.

Hydroelectric energy systems will be characterized into different classifications like large hydroelectric, small hydroelectric, mini hydroelectric, micro hydroelectric and Pico-hydroelectric, however, these terms haven't particular definitions. Numerous nations consider over 25MW as huge hydro power systems, 2.5–25MW as small hydro, under 2MW as scaled down hydroelectric, under 500kW as micro hydroelectric and under 10kW as pico-hydroelectric power systems [31].

Small-scale hydroelectric power is a standout amongst the most encouraging and a beneficial solution for electrification, especially for provincial electrification in creating nations, because of its cost-adequacy and robustness and it's also a naturally kind innovation for electrification. In the worldwide, the power produced from small hydroelectric power is 47,000MW in worldwide at the end of 2010 [31].

Despite the fact that a small scale hydroelectric systems will produce power consistently. It is required to add the additional source to get a dependable power supply consistently. To considering the hybrid energy systems, solar based system is a perfect input on account of its regularity and characteristic accessibility in a kind of areas. Without solar and hydro, there are no other sources is accessible to normally create required energy.

Based on considerations, some investigations near to the study are explained below.

F.M. Hossain et al. [32] presented a review of renewable energy based rural electrification. The increased usage of renewable energy sources which reduces the in-exhaustible energy sources dependence and also brings down the GHG emissions. Comprehensively, power demand could increment by 35% to look over 2010 and 2040, though the measure of power produced in Malaysia is anticipated to increment by just 5.3% to browse 2005 and 2030. The country reduced the CO_2 emission by 7,19,106 tons and trends to create the 10% most of its power through renewable energy by 2020.

3) Hybrid Solar-Wind-Hydro-Biomass/Biogas Energy: Biomass could be a potential hotspot for generous sustainable power creation in India because of its wide accessible. In India, there's a lot of biomass availability; and it has significant economic and ecological impacts, giving organized approaches are being upheld successfully. In the event that biomass generation for energy capacities will be an immediate substitute for fuel, which helps to minimizing CO_2 emissions and thusly decrease heating.

Table -3: Outcomes of applications of Hybrid solar PV/Wind energy systems

Study Location	Load Type	Design Capacity	Outcome	Ref.
Lobon Chora, Bangladesh	A irrigation pump load of 654.73 kWh/d	150 kW solar-PV, 100 kW wind turbine, CELLCUBE FB10-40 battery	1. The hybrid model is compared with and without grid connected systems. 2. The min. cost of energy (COE) of off grid power system for the same load is more expensive ($0.391) than grid connected system ($0.0995).	[24]
Musandam, Oman	30 MW/385 MWh/day	PV- 84,000 kW, Wind Turbine-12000 kW, Batteries-7200 (S4KS25P)	1. In this system three models are compared: First model (Diesel only), second model (Solar PV) and the third model (PV-wind). 2. NPC and COE are compared to others, PV-Wind system is most feasible solution.	[25]
Kuala Terengganu, Malaysia	Resistive load at 10 kW	PV- 4.92 kW, Wind Turbine-8.5 kW, 20 batteries (12V, 46Ah)	1. Simulation is performed for two modes of operations: On-Grid and Off-Grid for a period of one day.	[26]
Rural Village Bhubaneswar, Odisha	The daily energy requirement at the site is 271kWh	50kW PV modules, 16 number of wind turbines (10kW), 20kW diesel generator, 30kW inverter, 96 numbers of batteries (1900Ah and 4V).	1. The COE is 0.266 US$/kWh, where as the initial capital cost, operating cost and NPC are 2, 05,600 US$, 10,274 US$/yr and 3, 36,932US$.	[27]
Yavatmal District, Maharashtra, India	The daily energy consumption is 731 KWh/day and peak load is about 137 KW.	Solar and wind are the input resources	1. This paper shows on the basis of optimization process without and with sensitivity variables. 2. Without considering sensitivity variables, It was found that the system total NPC is 1844577$ and COE is 0.550$/KWh.	[28]
Jamny Ven Barwani, Madhya Pradesh	Daily energy consumption is 111 (kWh/day) and peak load is 4KW	0.280kw PV array, wind 7.5kw DC and battery 12V, 200Ah, 2.4kWh	1. TNPC, COE ($/kWh) and initial capital cost are $263,247, $0.508 and $60,770.	[29]
Baramati is located in the South West of India	Lighting (lamps), TV, Fan and Computer. The load has an average value of 3kWh/day and a peak of 0.255 kW	1kw PV array, one 1kw wind turbine and a 3kw power converter	1. The cost-effective scenario integrating renewable energy suggests that 49% of the yearly house load can be supplied by solar energy and 34% by wind turbine. 2. In this case the electricity contribution by grid is 18% which is minimum as compare to other output results.	[30]
Indian Metropolitan Cities (Chennai, Kolkata, Mumbai and Delhi)	A fluorescent light, fan, television, CD player, computer, water heater and other small loads. The total electrical load is 2kWh / day, 350W peak	PV Panel 1kw Wind Turbine 0.55kw, Electrolyzer 1kw Hydrogen Tank 1Kg, Fuel Cell 2kw, Battery 6V, 225 Ah	1. The cost summary of the overall system and cost analysis of the three different RES options are compared regarding the least-cost scenario. 2. Hybrid system is most suitable for all locations	[31]
Hurghada, Egypt	The motel is populated by 20 inhabitants and a total 8.5KW.	5 kw PV array, 6 kW PV wind turbine, 10 battery each 8.64 kwh and 10 kw inverter	1. The PV-wind- battery system, offers the much lower NPC and LCOE of $69,524 and 0.321$/kWh compared to others.	[32]

A Remote Village in India	Average demand of 623 kWh/d and peak load 65.1kW	150 kW PV, 4 WG system, 100 kW Converter, 50kg Hydrogen Tank and battery 6 hours	1. Several simulations have been made by considering different PV capacities and the number of WG. 2. The cost of generating energy from the above hybrid PV/WG/FC/battery system has been found to be 0.398(US$/kWh).	[33]
Pompuhar, Tamil Nadu	Annual average energy consumption has been found to be approximately 450kWh/day	Capacity of wind machine (kW), solar panels (kW) and Batteries (kW h) are 20, 40 and 200.	1. The optimum combination of the size of wind–PV and battery units of a chosen model that can generate power with a minimum unit cost or minimum UEP.	[34]

Rajanna et al. [33] developed a HRES model comprising of solar, wind, biomass/biogas and hydro for four distinct zones in India. Zone wise advanced optimised cost and COE were resolved through GA based approach. Further, Chauhan et al. [34] developed a feasibility analysis for nine combinations of HRES comprising of solar-wind-biomass-biogas-hydro and they found that LCOE and TNPC.

B. HRES with Conventional Energy Sources

Most of the rural areas, on grid power supply do not exist in which diesel based power generation is prominent and well-demonstrated technology. DG based power supply is most utilized technology in provincial areas, as time goes on the usage of diesel power alone growth toward becoming solar economical due to the variances in diesel costs. Thus, the DG is utilized as a sustainable power resource along with solar and such system generates less emissions compared diesel only systems. This section talks about some energy systems that are actualized throughout the most recent twelve years.

1) Hybrid Solar-Diesel Energy:

In developing countries, renewable sources are played an important role for electrification in rural areas. To empower a continuous supply, the solar-diesel based hybrid system is simple, efficient and environment-friendly solution to these areas, wherever the DG act as a backup while the absence of solar radiation. In view of those issues, a few investigations are led included analysis, reviews, and their discoveries are depicted in Table 4.

2) Hybrid Solar-Wind-Diesel Energy:

For long distance transportation and fuel accessibility, the cost of diesel fuel is more expenses in rural areas. Due to this cost, solar-wind-diesel based hybrid energy systems are more desirable of its economical benefits.

Mohan L. Kolhe et al. [40] developed an off-grid HRES for delivering power to the provincial area in Siyam Balanduwa. Hassan et al. [41] consider a hybrid sustainable power system is centred on optimizing inside the rural remote locale in Diyala State, Iraq.

3) Hybrid Solar-Wind-Diesel-Hydro-Biomass Energy:

In some areas, only few renewable energy sources are possible to the improvement of hybrid systems relies upon those conventional sources and the load demand. These hybrid system are relies upon its number, excellence, and components costs. A few investigations with numerous sections are given here.

Bekele and Tadesse et al. [42] implemented a HRES consisting of solar/wind/hydro/diesel system in Ethiopia and it shows the optimal sizing of the system. In which hydro potential is much more over the other sources

Table- 4: Outcomes of different applications of Hybrid solar-PV/diesel energy systems

Study Location	Load Type	Design Capacity	Outcome	Ref.
SMK Balleh, East Malaysia	Boarding schools with 600 people	35W solar-PV, 150 kW DG	1. The hybrid system is more cost-effective than the DG-only system without battery storage at a PV module price of $2.90/Wp.	[42]
200 km away from Miri, Malaysia	40 houses with a load of 421.94 MWh/yr	60 kW solar-PV, two 50 kW DG, Surrette 6CS25P (6 V, 1156 Ah) battery	1. The hybrid system with battery storage was the cheapest solution when the diesel price was $1.6/l or more 2. The hybrid system reduced the emissions of harmful gases compared to the stand-alone DG system.	[43]
Kolkata, India	Technical college with a load of 338.355 MWh/yr	400 kW solar-PV, 200 kW DG, 120 Surrette 6CS25P (6 V, 1156 Ah) battery	1. The hybrid system reduced the fuel costs by 70%-80% compared to the DG-alone system and reduces the emissions of CO2 and other harmful gases by 90% 2. The hybrid system was also the most cost-effective solution for the location with 95% renewable friction.	[44]
Remote Settlements, Jordan	Houses in off-grid distant areas where the load is 48 kW/day or 17.52 MWh/yr	2 kW solar-PV, 4 kW DG, 2 Surrette 6CS25P (6 V, 1156 Ah) batteries	1. When the fuel price was higher than $0.15/l, the hybrid system became more economical than the DG alone for this site or another site with similar weather.	[45]
Kavala Institute of Technology (EEE Department), Kavala, Greece.	Several types of machines, some regular auxiliary loads such as lights, a refrigerator, air conditioning, PCs	6 kW solar-PV, two 8 kW DG, six Surrette 6CS25P (6 V, 1156 Ah) batteries	1. The solar-diesel hybrid system reduces the diesel consumption by 33.8% compared to the stand-alone DG system and is more cost effective than the PV-hydrogen system	[46]

Dhahran, Saudi Arabia	Dhahran, Saudi Arabia Residential buildings in a remote location with a load of 35.405 MWh/yr load	4 kW solar-PV, 10 kW DG, Surrette 6CS25P battery (6 V, 1156 Ah)	1. The hybrid system yielded a fuel savings of 19% compared with the diesel-only system 2. The hybrid system reduced carbon emissions by 19%, representing 2 tons/year.	[47]
Rawdat Ben Habbas Village near Rafha, Saudi Arabia	Village houses, with a primary load of 17,155 MWh/yr	2000 kW solar-PV, 1250 kW, 750 kW, 2250 kW and 250 kW DG, 300 pieces battery (4 V 19,00 AH)	1. The hybrid system with 21% solar – PV could reduce GHG emissions by 66,422tons throughout the plant's life time 2. The hybrid system would be the most economical solution for the site at a fuel price of $0.60/l or above compared to the diesel generator system.	[48]
Three Sites in Bangladesh	50 rural households with 18.25 MWh/yr primary loads for each site	6 kW solar-PV, 10 kW DG, 10 piece battery (2 V, 800 Ah)	1. The solar-PV diesel hybrid system was more economical and eco-friendly than the commonly used DG system 2. The hybrid system designed here reduces CO2 emissions by 15,421kg or 38% annually.	[49]
Brac Island, South Croatia	Mobile phone base station with a load approximately 3.504 MWh/yr	2.5 kW solar-PV, 0.6 kW DG, 8 piece battery (12 V, 300 Ah)	1. The hybrid solar-PV/diesel system was the economical solution for this location 2. At a diesel price of $1.8/l, the COE of the hybrid solar-PV/diesel system = $0.534/kWh.	[50]

IV. FUTURE RENEWABLE ENERGY SYSTEMS

Over the years one billion people do not utilizes the electricity in rural or remote areas and in such areas renewable energy sources plays an important role. The cost of renewable energy sources are minimum basically a wind and solar keeps on falling, making renewable progressively focused on the other normal energy technologies. For any hybrid power systems, two most crucial worries those are reliability and total cost. Most of the authors endeavoured to optimize either or both of it. The flow chart of possible renewable energy sources in future shown in figure 4 [43].

Biomass gives off an impression of being an attractive feedstock and future supply of biomass energy relies upon energy expenses and specialized advance, each of that is determined by energy needs. Power generation from biomass is observed to be a promising source in the near prospect. The eventual future of biomass control generation lies in biomass incorporated chemical process and gas turbine development that gives high energy conversion efficiencies. The power is made by the direct burning of biomass, progressed coordinate ignition, gasification, and change advancements which are almost prepared for commercial-scale utilize. Creation of biomass and bio-fuels is developing, as interest for economical fuel sources is expanding. Verifiably, biomass has been utilized through direct burning, and this strategy stays wide utilized as a part of a few sections of the world.

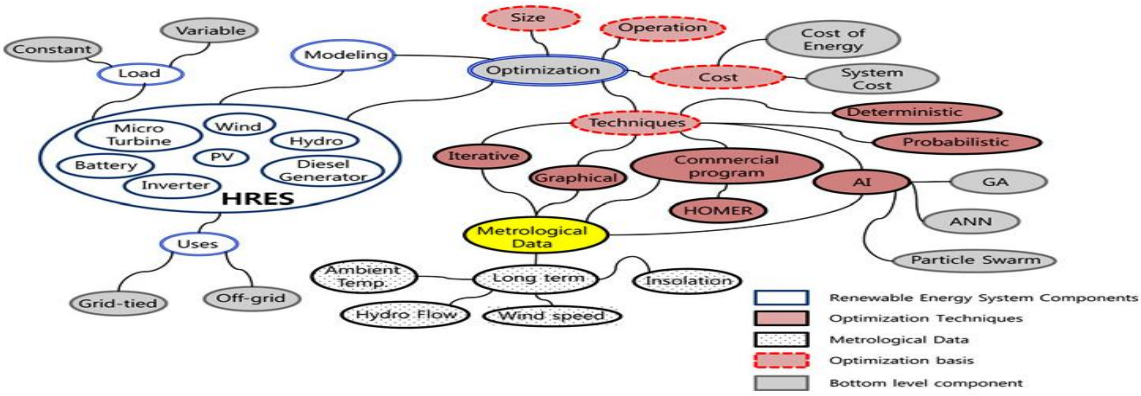

Fig. 4. The flow chart of possible future renewable energy sources

Biogas is a future energy source and is delivered by about an extensive variety of regular constituents. There are not very many biogas procedure volumes at the present wastewater treatment plants, landfill gas foundations, and industry bio-waste process and so on. Biogas from anaerobic absorption is created from a scope of biomass types. The principal source is fertilizer from animal generation, for the most part from cows and pig ranches.

Algae are the speediest growing plants on the planet. Present day industrial reactors for algal civilization are open lakes, photo bioreactors, and shut systems. Algae are imperative as a biomass source. Algae will at some point contend as a source of bio-fuel. Algae are a trade for oil-based fills, one that is more powerful and has no inconveniences. About 500th of the heaviness of algae is oil. This super atom oil is utilized to construct biodiesel for autos, trucks, and planes [44].

These all are the optional energy sources inside the near future and hybridization of these energy sources need to create power for country or remote regions that don't approach power grids.

V. CONCLUSION

The paper presents utility and cost-viability of hybrid renewable energy systems and showing its features for off-grid electrification in rural areas over the couple of decades. A lot of research has been led form this type of energy systems for the feasible source of energy development. This survey shows that the recent twelve years of research, demonstration and its relative analyses found that hybrid renewable energy will be a suitable solution for the supply of power in rural areas.

The most important advancements in renewable power generations are seen in solar PV, wind power, biomass and small hydro-energy production along with conventional power sources. Solar PV, biomass, and wind energy sources will be organized to assume an indispensable part within the energy situations of the feature. In the event that selected power supply is accepted for the years up to 2040, the commitment of sustainable power sources to this field is substantially higher contrasted and total energy supply. The power generations from renewable will be over 80% of the entire world supply in 2040. Plenty of good research work is completed and going on throughout the world during this area. Researchers have tried to resolve the superior energy designing problems by modelling, simulation, and optimization. Finally, this paper will help to research on hybrid renewable energy systems performance and its analysis on rural application. The paper also analyzes the choice of different sources within the distant future.

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