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Electrification in Rural India by Renewable Energy

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Abstract: Faced with growing concerns about global warming and the depletion of fossil fuels, the international community has turned its attention to renewable energy research in the past two decades. In India and many other countries, electricity in rural areas is unreliable, inadequate, or without electricity. Remote area electrification is a major concern for the government of any developing nation. In the new microgrid model, renewable energy could be a profitable various to suburbanized power generation. Unlike households, non-agricultural enterprises that have not received due attention and political support have relatively high acceptance of Microgrid. The government has implemented various plans to realize the electrification of these areas by expanding the network, but so far, many areas have not been included in the proposed plan due to economic, environmental, and geographic reasons. In this article, we analyse the implementation and use of Microgrid in rural communities in villages that are powered by the grid. However, the current low electricity demand of non-agricultural enterprises in rural areas indicates that the increase in electricity demand and the increase in enterprise productivity require additional services and infrastructure
Keywords Electrification, Solar energy, Solar PV, Power grid,

I. INTRODUCTION

Presently, Indian electrical energy demand is growing every year. Till the end of July 2019, electrical energy production in India was 108,370 GWh India has 57% electrical energy production from coal-based power plants. [1] The increasing energy generation with standard coal-based power plants has a serious cause of environmental pollution. As per the mandate of the govt. of India to reduce carbonic acid gas emission and its impact on the environment, renewable-energy-based power generation is the very best answer within the coming back future. India is split into 28 states and 9 union territories, and each state has its energy resources to serve electrical energy demand. The domestically offered resource might be used to supply the electrical energy from technologies such as solar energy, micro grid, hydro power, and wind energy. Micro grids can also provide an independent power supply in remote locations that haven't, however, been electrified which are far from the central installation or in hilly regions. With additional, distributed renewable energy generation, large investments in transmission lines may no longer be required and the Transmission and Distribution (T&D) losses can be greatly reduced [2]. The heavy losses and therefore the poor quality of electrical supply in rural areas haven't been closely evaluated until now and are absent from most of the rural electrification studies. The complex terrain of the region makes the repair and maintenance of transmission systems very tough and time-consuming. several localities, townships during this region, and even massive industries rely on diesel generators throughout these phases of power cuts that are costly operating due to reliance on conventional fuel and also increasing the carbon emissions in the region. Efforts are being completed globally to grip renewable energy sources. India, being on the point of the equator, has tremendous solar energy potential. Contribution from varied renewable sources has been increasing within the country. But the adoption of non-conventional resources has its varied challenges like initial installation cost is more, (e.g., Solar PV) Power generation is not controllable and it also has a high dependency on environmental conditions. Payback of renewable energy produces non-polluting self-generated energy. The solar energy system has been considered for analysis since it is one in all the utmost promising renewable energy because of its clean and free readiness over the years and once the system is installed it can be maintained by the resident people only. Hybrid renewable energy may be a higher reliable solution for a continuous supply of electricity in any area in general, renewable energy resource choice is a difficult issue due to various factors like local availability, the purpose of installation, expected energy demand, and atmospheric conditions. Renewable energy resources being profusely accessible and Eco-friendly have the potential to deliver affordable, sustainable, and clean energy to the whole world community and solve the downside of energy deficiency in developing nations.

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A. *Electrification & type of Electrification*

Electrification refers to the process of replacing technologies that use fossil fuels (coal, oil, and natural gas) with technologies that use electricity as a source of energy. Depending on the resources used to generate electricity, electrification will potentially cut back carbon dioxide (CO_2) emissions from the transportation, building, and industrial sectors. Rural electrification has emphasised the importance of linking its development with productive uses for energy. This has been viewed as necessary to extend the pace of rural electrification and cut back its concentration on a comparatively little cluster of developing countries. Electrification has a positive impact on various of those outcomes: specifically, we tend to show that it will increase social unit expenditures, adult household activity, and therefore the possession and usage of appliances. Besides providing a reputable identification strategy, our analysis makes three key contributions to the literature. First, it has distinct advantages over previous similar designs to detect the impact of electrification using policy-generated geographic discontinuities. [3] Examine the effects of the 2004 Rajiv Gandhi rural electrification scheme (RGGVY) using a population threshold for eligibility. In their case, the electrification scheme specifically targets the smallest and least developed villages, where the preconditions for economic development are weak [4].

B. *Impact Evaluation of Rural Electrification*

The solutions have up to now been limited to either a pure extension of the central power grid or to a stand-alone microgrid. Hybrid solutions with extension of the central grid and extra local generation and storage have additionally been included within the pool of potential solutions to be investigated Fig 1 the optimistic effects of rural electrification better lighting, use of appliances, better time use as well improved health and education results. Investigation states that electrification can improve both monetary and non-monetary indicators of human welfare [5]. Rural electrification South Africa as per investigation shows that electrification has a positive impact on employment. Electrification will increase hours of labour for each man and women, however disproportionately increases male earnings [6] The impact of rural electrification on economic and academic outcomes in Bangladesh. They notice will increase in each annual per capita expenditure and financial gain and, in addition, they report a rise within the range of completed years of schooling and study time. [7]. The improved procedure for village electrification compares grid extension, stand-alone microgrid, and grid extension completed with local renewable energy generation and storage. The planned solutions also take into consideration the final level of reliability of electrical supply for the end-user. Perspective of impact evaluation, it's legal connections that are of primary interest for policy-makers, since the prominence of nonlegal connections jeopardizes the standard and sustainability of electrification programs, probably blunting the impact of electrification policies.

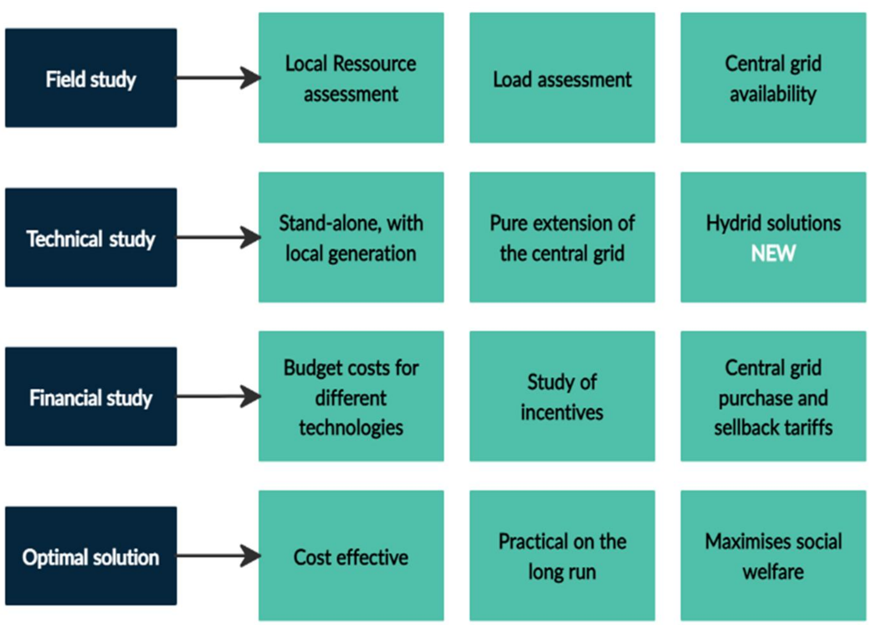

Fig No.1 Rural Electrification Methodology. [8]

The improved methodology for village electrification compares grid extension, complete microgrid, and grid extension completed with native renewable energy generation and storage.

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C. Types of Electrification

Electrification is mainly carried out using two main types of processes.

1) *Direct Current:* Direct current (DC) is the directional flow of electric charge. Hybrid and Electric vehicles are the best examples of DC.
2) *Alternating Current:* Alternating current (AC) is a current that periodically changes direction and continuously changes its amplitude over time, as opposed to a direct current (DC) that only flows in one direction.

The Remote Village Electrification Program (REVP) is one such initiative that financially supports the electrification of non-electrified remote census villages and non-electrified villages that cannot or cannot expand the power grid. Its price is competitive. Electrification can also be done by Turbines. Wind turbines convert the kinetic energy of wind into electrical energy. The energy produced by a wind turbine at a given location is affected by many factors such as air density, altitude, wind direction, ground irregularity coefficient, surrounding terrain, and site temperature.

D. Micro Grid

Selection of renewable energy is very difficult now a days because there is lot of challenging issues to be faced- local availability, purpose of installation, expected energy demand and atmospheric condition. So here micro grid plays an important role. micro grid planning can be developed with various parameters like replacements, goals, constrains and uncertainties. Microgrids is available in both low and medium voltage operating ranges. Microgrids have several possible configurations depending on their size and functionality, which is why they exist in forms both connected to the grid and isolated. While designing microgrid following things are considered- Preliminary Mission Planning, load estimation, Generation assessment, configuration planning, operation planning, cost. Combined cooling, heating and power (CCHP) micro-grid model to improve system efficiency of energy utilization and reduce environmental problems, based on multi-objective optimization of maximizing the energy output from distributed energy resources (DERs) and minimizing the daily system operating cost as proposed [9]. The proposed hybrid microgrid system generates over energy from renewable energy sources and reduces the dependence on the grid by approx. 90%. However, in microgrids stability issues are observed. It works on two modes, in 1st mode it always connected to consumer load and not to isolated mode. And in 2nd mode it is connected to larger grid. Energy transfer between homes, Energy export, Energy import these are some modes of microgrids. The basic data required to design any microgrids are consumer load demand, size of protection devices, insulation capacity. Most of the microgrids designed are hybrid because most of the connections are AC in nature and the customers has an extreme single-phase connection. So, microgrid offers best solutions to meet the energy demand.

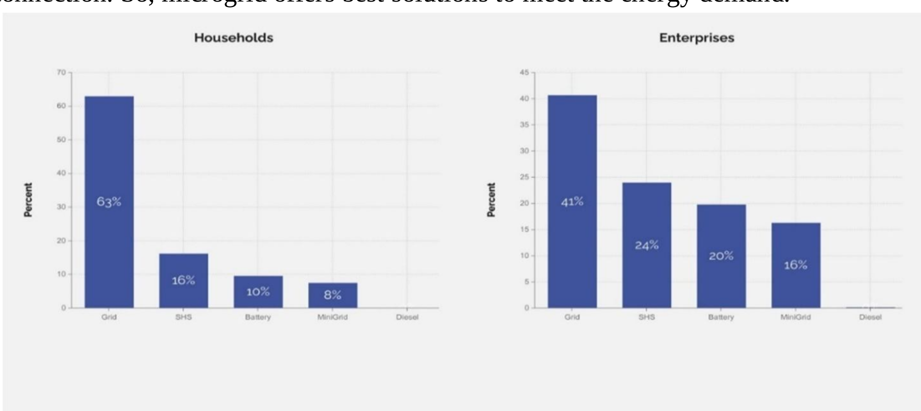

Fig No.2 Enterprises & Household [10]

E. Solar Grid Power

Solar energy converts the energy of sunlight into electrical energy. It can be directly through photovoltaic (PV) energy, indirectly through concentrated solar energy, or a combination of the two. Photovoltaics is rapidly becoming a low-cost, low-carbon technology that utilizes solar renewable energy. Solar energy is commonly used in heat-related applications to heat indoor spaces or liquids. Distributed renewable energy (DRE) solutions, such as solar home systems and mini-grids, have become a popular approach to rural electrification as the cost of solar power has decreased [11]. Although home solar systems that usually provide mobile charging and lighting services make up the majority of today’s remote connections, micro-grids are becoming more and more popular because they can support large commercial and industrial loads.

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Saubhagya, the government of India has given grid-electricity connections to 25 million households, taking the overall electrification rates of willing households to near 100% [12]. In many places, the cost of wind, water, and solar energy has reached grid parity; the reduction in losses has increased the benefits of small renewable energy sources. The reason for considering the analysis of solar power generation systems is that has been one of the most promising renewable energy sources for years because it is clean and free, and once installed, only residents can save it.

The whole world is working hard to develop renewable energy. India, which is close to the equator, has huge solar energy potential. Solar panels absorb solar radiation and convert it into electrical energy. The PV power output is a function of incident global solar radiation, the temperature of the PV panel, and the PV derating factor [13] [14]. Solar energy is abundant all over the world. Photovoltaic is a mature power generation technology, but the disadvantage is that electricity can only be generated during the day, so it is difficult to provide uninterrupted power from an independent photovoltaic system.

F. Pv Solar System

Solar cells convert solar energy in the form of electrical energy. Solar cells are composed of semiconductor materials and have a structure similar to a computer chip. When sunlight is absorbed by these materials, solar energy separates electrons from their atoms, allowing electrons to penetrate the materials to generate electricity. This phenomenon is called PV (photovoltaic effect). In the Narayanpur region of Chhattisgarh, India, there are areas without electricity, and there are various problems such as illiteracy, untreated water supply, and inaccessibility to communication networks[15].To find a feasible way of supplying power to this region, a case study on the feasibility of the floating photovoltaic (PV) system from the grid, the PV system on land, and the expansion of the grid were conducted along with its comparative analysis with certain Parameter i.e. net present value (NPV), energy costs (CoE), cleanliness of the environment and social acceptance. The floating photovoltaic system can be a viable solution and can be installed over existing channels, ponds, and reservoirs. Due to the cooling effect of water, the floating photovoltaic system is more efficient than a photovoltaic system, so it generates more electricity.

The configuration of the On-ground PV system is shown in Fig.2 DC voltage generated from PV modules is fed to the electrical load of households of the village after conversion into AC through inverter [15]. The environmental impact of photovoltaic systems on the land is conditionally positive, because it depends on the trade-off between clean energy production and the degree of deforestation. Deforestation is a major environmental problem in places around the world, and expanding power grids and ground photovoltaic systems in these places may not be a viable option. Therefore, floating PV systems can be a proven way to solve electrification problems in very remote and dense forest areas with water reservoirs.

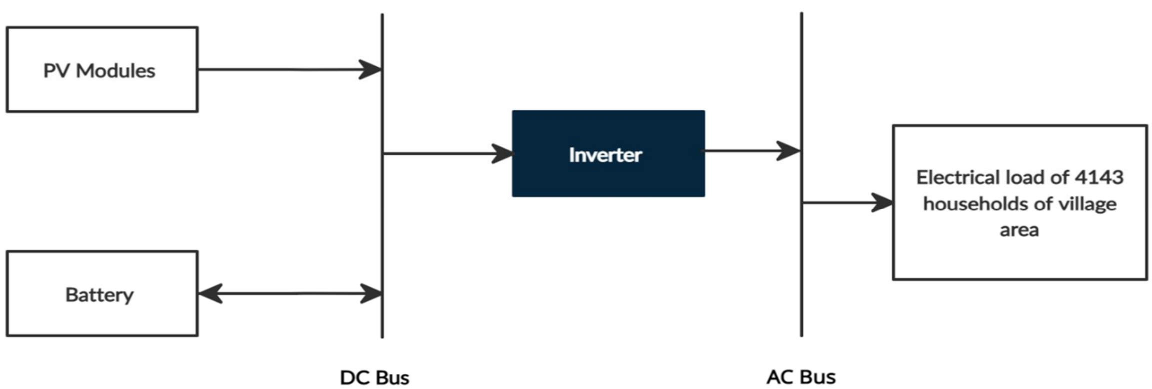

Fig No. 2 PV System Configuration [16]

G. Energy Storage

Renewable energy sources play an important role in resolving population growth and rapid climate change. The over-sized system causes high system costs and generates excess energy, while the undersized system causes the power supply failure to meet the required load demands. Since a large population of India is living in villages, it is not feasible or economical to extend the grid connection to provide electricity for those villages, but an autonomous integrated hybrid renewable energy system can be a good option. This research paper talks about a grid-independent integrated hybrid renewable energy system (IHRES) to provide electricity and freshwater availability. Here twelve different IHRES configurations are modelled using nine metaheuristic algorithms in this environment.

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The sensitivity analysis has been conducted in this paper with the variable input parameters, such as interest rate, biomass collection rate and cost of biomass. It was found that the variation in interest rate affects the system performance significantly and indefinitely. SSA algorithm provides the global best optimal solutions, and levelized cost of energies when compared to other algorithms and is also proven its efficiency in finding the global best optimal solutions through its fast convergence efficiency property. Ni-Fe battery is giving the optimal results. There is some loss of power, the optimal configuration offers better results with respect to the ALC and LCOEs at LPSP* value of 1%. The sensitivity analysis has also been conducted by varying the interest rate, biomass foliage collection rate and cost of biomass. It was found that the influence of the interest rate is affecting more on the system performance when compared with the other parameters. From this research paper we get to know that renewable sources are of great importance (booster) in upcoming future.

II. LITERATURE SURVEY:

A. Abhinandan Baruah et al. [17]

The present work analyses the techno-economic feasibility of an autonomous hybrid renewable energy system for providing electricity for an academic township in the East District of Sikkim, India. With increasing concerns about worldwide warming and fossil fuel depletion, the world community has shifted its attention towards the exploration of renewable energy resources in the past two decades. The advantages of HRES are that they depend on multiple renewable resources for energy supply, which offsets the unreliability of individual renewable energy sources and also reduces greenhouse gas (GHG) emissions.

Large hydropower plants generally have water quality deterioration, soil erosion,

Increased human and animal diseases, ecological deterioration, landslides, flood, etc. in many parts of the world. Therefore, a major investment in large hydropower projects is not recommended for this region, so the idea of implementing as HRES to replace the central grid supply in nearby and existing communities in the region has become a promising prospect. Therefore, renewable energy system must be carefully installed in a given location so that they have a constant positive impact on the socio-economic and ecological environment of that location.

The techno-economic investigation of the hybrid renewable energy system (HRES) has been performed using the HOMER Pro Microgrid Analysis Tool. The selected location is an academic community called the Sikkim Manipal Institute of Technology in Majhitar, Sikkim, India, which is located at latitude 27.10.6′ N, longitude 88 ◦ 31.7 ′ E. The selected location has reasonably good availability of solar irradiation and wind speed. The estimated population of the entire East Sikkim district is about 3,50,000 in 2019. Solar panels absorb solar radiation and convert it into electrical energy. The photovoltaic power output is a function of the incoming global solar radiation, the photovoltaic panel temperature, and the photovoltaic derating factor. A wind turbine converts the kinetic energy of the wind into electricity. The energy generated by the wind turbine at a specific location depends on several factors, such as the density of the air, the altitude of the location, the wind directions, the roughness factor of the ground, the surrounding topography, the temperature. Location etc. The principles of operation and construction of hydrokinetic turbines are the same as those of wind turbines, except that they operate on water, the density of which is much greater than that of air. In an HRES, a battery is provided as a storage device to compensate for the unreliability of other renewable energy sources. The battery capacities can range from a few watts to kilowatts. The main cost output known as Levelized Cost of Energy (LCOE) is the average cost per kWh of useful electricity generated by the system and is calculated. The proposed HRES configurations were simulated in the HOMER Pro Microgrid Tool using the available financial and technical database. The 31 renewable energy combinations were viewed and simulated every hour. Hybrid renewable energy systems (HRES) are feasible for the location of the municipality considered in this study in terms of capacity, land use, and costs, with PV-Wind-Biogas-Syngas-Hydrokinetic-Battery HRES with an electricity generation cost of $ 0.095 / kWh being the best system in this analysis. Hydrokinetic energy has great potential here and further research is needed.

B. Umar Maqbool et al. [18],

In the literature, various mixtures of PV, wind, biomass, diesel generator, and battery bank have been used for an ideal hybrid system. The micro-grid controller was proven and examined on clinical centre micro-grids of 20 MW and 10 MW the usage of an industrial simulation platform. a hybrid renewable energy system (HRES) micro-grid is proposed for rural electrification in Baramulla district, Jammu, and Kashmir, India. It found that power from the Grid is not available most of the time. (HRE) based microgrids have been sized based on Minimizing the cost of energy, Minimizing the probability of power supply loss, Maximizing the renewable fraction, and maximizing the job creation factor. The (HRES) is meant in such a way that the load is glad supported priorities of renewable resources and use minimum burden on the grid. A lower energy cost system will be more beneficial to the user. To calculate Energy cost,

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ECost = ECostPV + ECostBM + ECostGrid – ECostSurplus

In this document, the renewable portion explains the limit of energy supply from renewable sources compared to non-renewable energy sources. Loss of power supply probability (LPSP) is the probability of the unavailability of power to renewable resources. Here the solar PV, Biomass energy is used as renewable energy. Solar radiation is abundant around, with the potential for solar radiation depending on the location. The HRE proposed at the Wanigam Pattan, Baramulla, Jammu, and Kashmir, India. For the biomass, the apple trees are the main source of firewood at recognized locations-Wanigam Pattan, Baramulla, Jammu, and Kashmir, India. The day-to-day load considered for the location through physical assessment is 1187.504 kWh. h. To make the most of the use of renewable energy generation, the load is served on an important basis with the first partiality has given to solar PV, supplying 676.3600 kWh; secondly, biomass generating system, supplying 393.3862 kWh; and least preference is given to grid, supplying only 117.7578 kWh daily. as per the result, corresponding to the finest fitness feature value, the most suitable sizing of the PV plant is the same as 456.3297. But, because the variety of PV panels ought to be an integer value, so the closest better integer value (457) is taken into consideration. It seems that the use of renewable energy also impacts largely on the environment, that the standard coil-fired station encompasses a greenhouse gas emission of 1048 g/kWh and also the wood-pellets biomass plant and solar energy plant manufacture a CO2 emission of 1275 g/kWh and 0 severally.it means it saves around 204.05 tons of Co2 emission per year as compared to the electricity served from a grid or traditional power plant. Savings were also calculated for the hybrid system. The total savings include the energy cost of the asset after the payback period to the full life of the asset and interest on that money.

C. Fabien Chidanand Robert et al. [19]

In this document Globally, 1.2 billion folks have however to be granted access to electricity. Another 2.4 billion receive associate intermittent electrical provide because of undersize and unreliable rural power grids. However, existing rural electrification programs focus totally on extending the central power grid, therefore providing an intermittent supply and increasing the losses on power grid. The reliability of the central power grid, the expected responsibility of electrical supply within the village, thus losses also are introduced as vital design parameters. design parameters, before unnoticed were introduced: reliability of the most grid, Transmission and Distribution (T&D) losses and thus the reliability of provide expected within the village. Additionally, sensitivity analyses were performed with three new parameters such as the reliability of the central power grid, the reliability of electrical supply within the microgrid, the T&D losses improved methodology for village electrification compares grid extension, whole microgrid, and grid extension complemented by innate renewable energy generation and storage.

D. Satya Prakash Makhija et al. [20]

Remote area electrification is a major concern for a government of any developing nation. India is working on it too, but despite ongoing efforts to electrify remote areas, several thousand households in India are not electrified. The Narayanpur district in the Indian state of Chhattisgarh has non-electrified regions and various problems such as a lack of literacy, untreated water supply and lack of access to communication networks Off-grid floating photovoltaic (PV) system, the onshore PV system and the grid expansion as well as their comparative analysis with regard to certain parameters. Many plans in this direction have been announced in India, but many people still live without access to electricity (World Energy Outlook, 2020). This study was conducted to find a solution to the problems of electricity shortage in some areas of Chhattisgarh state in India. Some of these households are covered by the national system of Rajiv Gandhi Gram Vikas Yojna1 (RGGVY), Dean Dayal Upadhyaya Gram Jyoti Yojana2 (DDUGJY) and Decentralized Distributed Power Generation (DDG). Electrification of rural India.

Very few rural households have drinking water facilities and treated tap water, which leads to many health problems. Narayanpur has more than 71% forest cover, resulting in a sparse population of 4,143 households, with an average of only 28 households per village. The expansion of the network requires deforestation, which certainly causes high rights of way (ROW) costs. These facts are the motivation for the present work to find a solution in relation to floating or onshore photovoltaic systems. One of the limitations associated with solar energy is that it suffers from the disadvantage of taking up enormous space, which is a major problem as it requires large-scale deforestation and in the present case it may not be profitable. The state of Andhra Pradesh in India through electrification and has discussed various social factors that are badly affected in the non-electrified villages. Several factors such as poverty, inequality and new technologies were discussed, followed by the government's proposed solutions to establish a clean form of solar energy for the electrification of rural villages, which will mean a significant improvement in the socio-ecological factor.

The site has been assessed for necessary information regarding system requirements and need of electricity. Chhattisgarh State Power Transmission Company (CSPTCL) planned to install a 220/132 kV substation in the Narayan district. The average solar radiation at the project location is 5.34 kWh / m2 / day. Floating photovoltaic systems are installed on water tanks, canals, rivers, etc. The availability of this huge storage area of 18 km2 ensures the potential for the installation of a floating photovoltaic system with a sufficiently large output of 2.5 MW, which will undoubtedly largely cover the electricity needs of the people in this area. The power output of floating PV system is experimentally found to be 11% more than the On-ground system due to lower surrounding temperature above water surface. The three systems considered were on ground PV system, floating PV system and grid extension system. With the SAM software, two photovoltaic systems were designed, simulated and their results compared with the parameters of the grid expansion systems. The present value of all systems was negative in the 25 years of the project, while the floating PV systems achieved a positive present value in the 28th year of their useful life.

III. CONCLUSION

This paper, Discussed the ways which should be used for rural electrification in India. To find the problems and solutions while electrification, many types of research and case studies have been done on the regions-Sikkim, Utter Pradesh, Bihar, Chhattisgarh, North India, and some hilly areas. This study shows the power grid present in the rural areas was unavailable several times because of overload on it, to overcome this the hybrid renewable microgrid system was proposed. Such type of system uses solar potential and ample wood from apple trees and it also reduces the Co2 emission by more than 50%. In this paper, the multi-design power grid system is presented to meet the electricity demand in a hilly region. This system is a very handful because it supplies electricity at less cost, uses minimal space for installation and it can work in limited available renewable resources too. It suggests the further research should be carried out in this region because of the presence of the abundance amount of hydrodynamic energy. A blockchain smart grid is also a noticeable system that can be used in the rural electrification of India. It is capable of a satisfactory supply of electricity at a low cost and it also helps for revenue generation from renewable resources. In the Naxalite or Forrest areas like Chhattisgarh, it proved that floating PV systems are suitable. To analyse this from a technical, economic, and social point of view three systems were considered those are on-ground PV system, floating PV system, and grid extension system. The solar DC system is also playing a vital role in getting electricity to every village in India. Despite it met the needs of electricity of low-income homes still the rural industry is dependent on diesel generators which are quite expensive. Mini-grid primarily based totally can play a function in serving rural corporations in grid-connected areas, in particular, withinside the quick term, even though worries approximately their long-time sustainability remain. however, the mini grind used is very limited and that is for lightning and cooling purpose. The paper suggests controlling the tariff yearly, minimalize the distribution loss and surge the load factor to cut the viability gap. Connecting the main central grid with renewable resources can cut the cost. The effect of rural electrification has a significant impact such as increasing household expenses, adult domestic activity, and appliances tenure and usage. Electrification can touch all sides of life, for example, electrification may increase land or assets values, further increasing the long-term wealth of electrified households. A well-designed, long-term study of a randomly assigned electrification scheme could effectively determine whether this effect exists.

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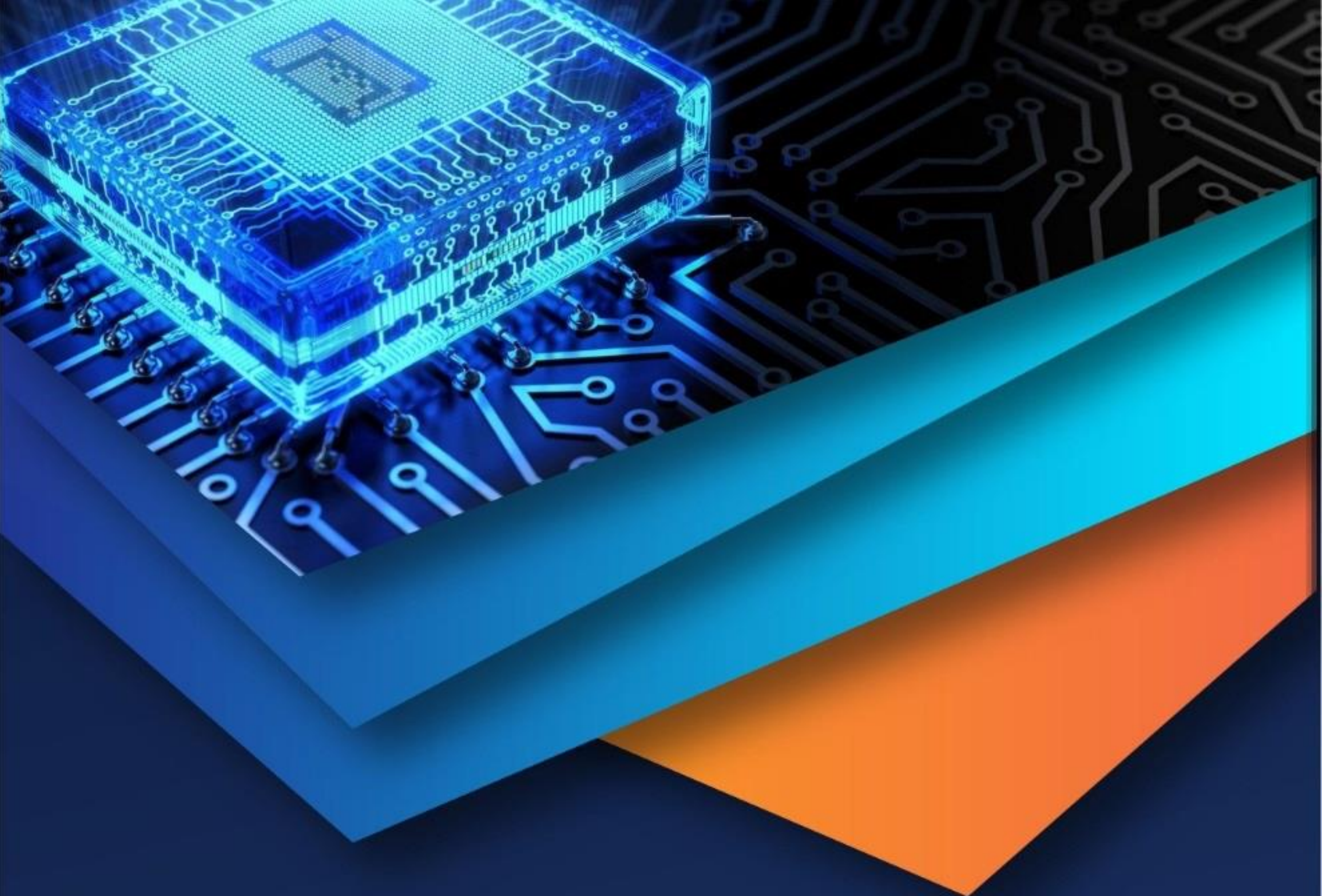

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