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Study on Hybrid Renewable Energy System for A Remote Rural Area in India

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Abstract: *Over the last ten years, renewable energy has seen a spectacular transformation. They undeniably now constitute the front edge of a far-reaching global energy shift, when combined with energy efficiency. Renewable energy technologies have seen huge scientific advancements and dramatic cost reductions in recent years, fueled by innovation, greater competition, and regulatory backing in an increasing number of nations. This location has an abundance of solar, wind, biomass, and hydro resources. Furthermore, the provision of different assistance programmes via government subsidies minimises the assets and energy costs planned for the villages. The progress of urban electrification is linked to economic and environmental stages.*

Keywords*:* Hybrid, Renewable, Energy, Remote, Rural.

I. INTRODUCTION

Hybrid Renewable Energy System for a Remote Rural Area in India

Energy is one of the most important components required for a country's socioeconomic growth. It is the primary means of achieving objectives such as the health of people with a good level of life, a stable economic situation, and a sanitary environment. Electrical energy, which is created from both renewable and non-renewable energy resources, is one of the most important and backbone energies for a country's development and wealth, as well as human well-being.

To meet demand with unanticipated regular and seasonal fluctuations, the electricity infrastructure confronts substantial transmission and distribution issues. Because of their infinite use, different fossil fuels, non-renewable energy, and resources such as petroleum products, coal, natural gas, and nuclear energy are likely to be depleted at some point. Renewable energy has recently played an important role in bridging the gap between rising electricity demand and available power.

The use of renewable energy sources attempts to reduce the usage of fossil fuels and, as a result, global warming. The worldwide community is grappling with environmental degradation and climate change as a result of greenhouse gas emissions. Photovoltaic (PV) technology is the most promising of all renewable energy because of its availability, greenness, low pollution, and environmental friendliness. The fundamental constraints of these renewable energy sources, however, are changes in solar insolation levels.

The use of renewable energy resources to generate electricity is currently a prominent study area across the globe. Efforts are being undertaken all around the globe to enhance the use of renewable and sustainable energy. Over the course of a decade, India has effectively generated a bright outlook for increasing investment in renewable energy demand and supply. Rural regions may benefit economically from decentralised distributed electrification utilising renewable energy technology to satisfy their lighting, cooking, and productive energy demands.

In this scenario, in the planned isolated location, power production from accessible renewable energy resources is the best option. India has a lot of solar and wind power, but it's not distributed evenly throughout the nation. Renewable energy sources are also variable, fluctuating, and irregular. As a result, they may not be able to provide the appropriate quantity of electricity on their own. As a result, it is critical to combine these resources in order to deliver uninterrupted electricity at the lowest feasible cost. Due to the unpredictability and unreliability of renewable energy sources, diesel generators are used to boost system dependability..

Economic and Sensitivity Assessment of Hybrid Renewable Energy System

Non-conventional energy will supply one-fourth of India's energy needs, according to the International Renewable Energy Agency (IRENA). Renewable energy production might account for one-third of global electricity generation by 2030. By 2022, India plans to create 180 GW of non-conventional energy, including 110 GW of solar energy, 12 GW of biomass energy, 62 GW of wind energy, and 7 GW of micro-hydro energy. Financers have guaranteed a profit of more over 280 GW, much beyond the agreed-upon target. According to latest forecasts, by 2047, PV energy will be larger than 759 GW and wind energy will be 419 GW..

Renewable Electricity Uses More Land than the Fossil Fuel System

A few words can help you grasp the land implications of various types of energy. The quantity of energy contained in a fuel by volume or weight is referred to as its energy density. Coal and oil have a high energy density, which means they pack a lot of energy into a little amount of space. Natural gas may not have a high energy density in terms of volume, but it does have a high energy density in terms of weight. Fuels with high energy density may be readily transferred from one location to another, which is advantageous in today's energy system. The amount of land surface area required to create a given quantity of energy is referred to as power density. The term "power density" is often used to characterise renewable energy sources, and it refers to the amount of land area that must be covered by solar panels or wind turbines in order to generate electricity. The average intensity and length of sunlight or wind throughout time, as well as the conversion efficiency of the solar panel or wind turbine, all have a role in the total power density..

OBJECTIVES OF THE STUDY

- To study on Hybrid Renewable Energy System for a Remote Rural Area in India
- To study on System components and maintenance of standalone PV systems

Techno-economic Feasibility of an Off-grid Hybrid Renewable Energy System

Due to variable terrain, geographical inaccessibility, and massive expenses, extending the grid to every rural settlement is frequently uneconomical and physically impossible. Due to the increasing depletion of fossil fuels, high transportation costs, and environmental pollution, using diesel generators as an alternate source for powering rural places is not appealing.

According to many surveys, around 85 percent of the province's population lives in distant locations, and approximately 90% of rural settlements are not electrified. These rural settlements are separated over vast swaths of land. Connecting such places to the national grid is both expensive and inefficient. Household demand for power in remote communities is quite low.

As a result, the energy industry is increasingly transitioning toward renewable energy sources for power production that is more efficient, environmentally friendly, and cost-effective. Such renewable energy sources provide viable electrification choices for rural regions with sufficient renewable energy sources such as hydro, wind, and solar, among others. Hybrid renewable energy sources (HRES) have emerged as a promising solution for powering such regions in recent years. Renewable energy sources are the most plentiful, ecologically benign, and readily accessible in nature.

Due to their balancing nature and low carbon emissions, the combination of solar and wind energy provides dependable and cost-effective choices for forming a hybrid renewable energy system for rural electrification.

Renewable Energy Supply Technologies

The supply of renewable energy is steadily expanding. In recent years, a significant amount of investment has been undertaken, and technological advancements have allowed nations to create renewable energy at a lower cost. By 2017,

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the number of nations generating more than 100 megawatts (MW) of renewable energy is expected to rise dramatically. It is vital to encourage and develop renewable energy supply technologies due to various unfavourable and irreversible externalities associated with conventional energy production. These technologies may not be cost competitive with traditional fuels in terms of production, but they may be when externalities such as environmental and social impacts are taken into account. It should also be emphasised that economies of scale may play a significant impact in lowering unit manufacturing costs. The costs of transmission and distribution, as well as the technology used, do not vary much between conventional and renewable energy sources. The facts concerning the evolution of the major renewable energy source technologies are shown here..

Hydro power

Hydropower is the world's most widely used renewable energy source for power generating. Over the last 50 years, hydroelectric power output has increased dramatically. In 1950, it was 340 terawatt-hour (TWh), covering over one-third of world power consumption. In 1975, it reached 1,500 TWh, and in 2005, it reached 2,994 TWh. In 2005, the worldwide consumption of 15,000 TWh of electricity was compared to the global output of 18,306 TWh. Hydropower production is now challenging owing to high initial fixed investment costs and environmental issues.

Furthermore, hydro power has created issues for local communities due to the necessity to evacuate huge populations, as well as the fact that dam construction is permanent, resulting in a sunk cost of services that cannot be withdrawn. Hydropower construction has an impact on the environment due to massive engineering projects. Hydro power, on the other hand, is appealing owing to a ready supply of water for agricultural, domestic, and industrial use, as well as the fact that it is clean and allows for the storage of both water and energy. Additionally, the stored energy may be utilised for both base-load and peak-load power production.

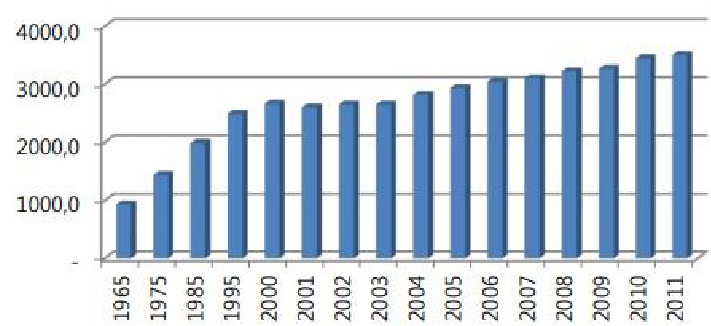

Figure 1: Worldwide hydro electricity consumption, 1965-2011 (in TWh)

Total hydropower capacity is expected to rise from 1,607 GW in 2011 to 1,680 GW in 2035, according to projections (IEA, 2012e). China is anticipated to treble its capacity to 420 GW by 2035, according to the World Economic Outlook (WEO) 2012 study. To put this in context, 420 GW is about equivalent to the whole capacity of OECD nations in 2011..

System components and maintenance of standalone PV systems

Solar modules, charge controllers, lead-acid batteries, inverters, and loads are all standard components of a freestanding PV system (appliances). Maintenance and quality control of these components are critical for PV off-grid systems to operate successfully and sustainably. Long-term professional O&M may be ensured by local operator training and collaboration with service suppliers. Every system component has its own set of maintenance requirements..

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Business models and case study for standalone PV systems

Prices for freestanding PV systems vary greatly depending on the size and complexity of the installation. Prices for small standard systems have decreased in recent years as a result of technological advancements and mass manufacturing. For moderate and low-income groups in developing nations, most PPS and some SHS are even affordable as a complete cash payment. Larger SHS and, of course, SRS, on the other hand, are seldom affordable without some type of assistance or, at the very least, an altered banking paradigm. Because SRS are an uncommon occurrence and PPS are generally offered on a full payment basis, this section concentrates mostly on SHS financing and business strategy. Regardless of the technology used, all development stakeholders agree that free distribution of systems should be avoided at all costs. Customers must participate from the outset in order for the system's worth to be recognised. SHS have a significant initial investment cost, especially if they include an after-sales service..

Key challenges for off-grid electrification in rural areas

While the problems are detailed in the following sections, preserving balance between the triangle of government, community, and investors is a common concern. Despite the fact that investors are focused on the investment returns that follow from a successful system management, the community demands a cheap or rather inexpensive tariff as well as a consistent supply of power. As the third stakeholder, the government seeks to provide a fair environment for urban and rural inhabitants, which includes a fair tariff regulation that may rely on subsidies..

Challenges in regard to policies

Policy support is critical for off-grid electrification to become widely used. This begins with a comprehensive, long-term electrification strategy that includes an energy access plan that classifies various sections of a nation based on their ability to be connected to the grid at acceptable pricing. Off-grid solutions are required in areas that are not accessible. This data is critical for stakeholders to make decisions about off-grid initiatives. In reality, in rising nations, a major stumbling block is a lack of comprehensive and reliable information aimed at companies and investors. Because mini-grid payback times may easily exceed several years, the government must build a regulatory framework that includes agreements or subsidies that are valid for at least 10 years to limit risks for investors. Monitoring tools that measure progress should be used in conjunction with the overall off-grid plan. If the monitoring activities are not coordinated and supervised by a cross-government task force, there is a danger of overlap and duplication of work. Various challenges even demand that the public sector, civil society groups, microfinance firms, and other stakeholders be more integrated.

Apart from a lack of government planning for off-grid locations, investments in off-grid electrification are hampered by a lack of a grid arrival strategy. According to a World Bank report, after a community was linked to the national grid, mini-grids were often abandoned. As a result, a legislative framework must be established to assure investors that mini-grids would be kept and utilised once the grid is expanded. In reality, as long as suitable remuneration and technical arrangements have been agreed, there are no legitimate hurdles to linking the mini-grid to the national grid. Governments, on the other hand, often express concern about losing flexibility. Changing home demands or breakthroughs may have an impact on expansion plans, rendering mini-grids obsolete. Regardless, several nations have already enacted legislation in this area. When the grid comes in Nigeria, for example, the government gives a variety of options for operators, including compensation, continued operation, and income generation from the mini-grid, as well as compensation for simply operating the distribution system or functioning alongside the main grid.

In addition, the lack of precise information in the legal environment regarding licencing, technical system design, funding, and tariff setting is impeding private sector participation in the off-grid sector. The majority of these concerns are addressed in this work. Information on processes and procedures should, in general, be publicly available to the public and prospective investors. India's internet information site dedicated just to mini-grids (minigrids.go.tz) is an example of this.).

Challenges in regard to licensing

Retail or generation licencing processes that are complex, expensive, and time-consuming deter investors and companies from starting mini-grid initiatives. Smaller projects are less likely to be built in countries that do not differentiate between small-scale and utility-scale facilities. This is significant, considering that most rising nations will need hundreds of minigrids in the coming years.

Furthermore, regulatory barriers to obtaining a suitable licence may be minimised by creating a "one-stop shop" that grants all necessary permissions along a project's timetable. This strategy relieves government burdens while also preventing duplication of effort. India is an excellent example of a seamless licencing procedure. Because mini-grids with a capacity of less than one megawatt do not need a generating licence, a capacity carve-out is used. Additionally, India permits developers to secure a single licence for many locations. Sierra Leone is another example of a country where developers may create, distribute, and sell power under a single licence.

Challenges in regard to tariff setting

Tariff design is a frequent subject of disagreement. This is owing to the fact that, in contrast to cheaper grid-based power, off-grid system developers must charge much higher prices to cover investment and operations expenses. The problem becomes obvious when off-grid power is required, particularly in areas where people are poor. The inability to buy power leads to unauthorised consumption by community members in certain situations, resulting in financial losses for the operator, not least owing to the resulting overload. Installing illegal connections, tampering with metres, billing discrepancies, and simple non-payment of bills are all common techniques. Furthermore, high tariffs expose the operator to a demand risk. As a result, from an economic standpoint, rural places are less appealing than metropolitan ones. However, the introduction of pay-as-you-go (PAYG) systems is progressively preventing illicit activities while also improving the operation's demand planning..

II. CONCLUSION

The progress of urban electrification is linked to economic and environmental stages. This study supports the HES for urban electrification, in addition to the present power network expansion plans. As India's urban areas develop, the design and amount of energy consumption for various types of customers changes. Throughout the project, this pattern demonstrates an important aspect of HES's excellent architecture. The inclusion of communities in the design phase of a mini-grid, which involves the size and appraisal of future demand, was found to be a major difficulty. The lack of government-issued standards and regulations jeopardises the safe and equitable adoption of off-grid installations. Improving the flaws identified in this study, and thus establishing an environment in which off-grid systems may flourish, would have a favourable influence on not just social and socioeconomic advancement in rural regions, but also on the overall economic development of respective nations..

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