RESEARCH PAPER

An Investigation of Non-Conventional Resources for Off-Grid Non-Urban Communities in India

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ABSTRACT

The last decade has been a watershed moment for renewable energy. When combined with energy efficiency, they undeniably stand at the front of a monumental worldwide energy revolution. Recent years have seen enormous scientific advancements and price reductions in alternative energy technologies as a result of innovation, heightened competition, and government assistance in more nations. Solar, wind, biomass, and hydropower are abundant in this region. The expected energy and asset expenditures in rural regions are also reduced through the adoption of subsidy-based support schemes. There are environmental and economic stages that are associated with the electrification of urban areas.

Keywords: Integrated, Sustainable, Power, Isolated, Countryside

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INTRODUCTION

DESIGNING AN INTEGRATED CLEAN ENERGY SOLUTION FOR ISOLATED VILLAGES IN INDIA

A nation's socioeconomic progress is heavily dependent on its resources. Important objectives like higher quality of life, economic stability, and environmental preservation may be more easily attained with its help. The generation of electrical energy, which may be derived from both renewable and non-renewable sources, is crucial to the advancement, success, and well-being of nations and societies.

The transmission and distribution of energy encounters substantial obstacles in order to meet demand that undergoes unforeseen regular and seasonal fluctuations. A number of non-renewable energy sources, such as fossil fuels and unconventional resources, are projected to deplete in the future as a result of their heavy consumption. Recently, renewable energy has played a pivotal role in resolving the widening gap between the rising demand for power and the quantity available.[1]

Reduced use of fossil fuels is one goal of implementing sustainable energy systems, which should help bring the world's average temperature down. "Greenhouse gas emissions are leading to environmental deterioration and climate change, which is having an ever-increasing impact on the world's population. Thanks to its accessibility, minimal pollutant emissions, eco-friendliness, and environmental advantages, photovoltaic (PV) technology is seen as a very promising renewable resource. However, solar irradiance's intermittent nature is still a big obstacle.[2] in

Using renewable energy sources to generate power is a hot topic right now in research circles all around the globe. Efforts are underway in many parts of the world to increase the use of sustainable and renewable energy. India has done an excellent job over the last decade of laying the groundwork for further investment in renewable energy sources, both in terms of demand and supply. To satisfy their energy demands for lighting, cooking, and other productive activities, rural regions might reap economic benefits from distributed, decentralised power generation that makes use of renewable energy sources.

The best course of action here would be to generate electricity from the selected remote area's existing clean energy sources. Although India has a lot of wind and solar power, it is not distributed evenly across the nation. The reliability, consistency, and longevity of renewable energy sources are likewise uncertain. Therefore, it is possible that they will not have enough power to meet demand on their own. In order to offer affordable, continuous power, it is crucial to combine these resources. Diesel generators are used to make the system more stable because renewable energy sources are not always constant.7]

COST AND SENSITIVITY ANALYSIS OF AN INTEGRATED CLEAN ENERGY SYSTEM

In accordance with the International Renewable Energy Agency (IRENA), green energy will provide 25% of India's energy needs. Around one-third of the world's power might come from renewable sources by 2030. The target for renewable energy generation in India is 180 GW by 2022. Of this, 110 GW will come from solar power, 15 GW from biomass, 65 GW from wind, and 10 GW from small hydropower. Backers have guaranteed a profit of more than 280 GW, which is far more than the agreed-upon goal. Upcoming forecasts predict that wind power will surpass 421 GW and solar energy will surpass 759 GW by 2047.

RENEWABLE POWER GENERATION TYPICALLY OCCUPIES MORE LAND THAN CONVENTIONAL FOSSIL FUEL SYSTEMS.

Energy capacity and power output per unit are key concepts for understanding the land-use implications of different energy sources. The energy density of a fuel is defined as the quantity of energy stored per unit of volume or mass. Because of their high energy density, fossil fuels like coal and oil can store a lot of energy in a little amount of space. The gravimetric energy density of natural gas is quite high, despite its lower volumetric energy density. Fuels with a high energy density are more convenient to carry and store because of this. Renewable energy systems often make use of power density, which is the rate of energy produced per unit land area. Installations like solar arrays and wind turbines have their spatial needs indicated. Resources, such as the amount of sunshine and the speed of the wind, and the efficiency of the corresponding technologies' conversion all have a role in determining the total power density.10]

OBJECTIVES OF THE STUDY

1. To explore the implementation of a Hybrid green energy system for remote rural communities in India
2. To explore the structure and maintenance demands of standalone solar power systems

TECHNICAL AND ECONOMIC FEASIBILITY OF AN OFF-GRID HYBRID CLEAN ENERGY SYSTEM

Electrical grid expansion to all rural regions is sometimes not cost-effective and technically impracticable due to uneven landforms, distant locations, and high expenses. Diesel generators are not a great option for remote areas looking for renewable power because of the high costs of transportation, pollution, and the depletion of fossil fuels.[6]

According to many studies, about 92% of rural towns do not have access to electricity, and around 87% of the province's population lives in rural areas that are not easily accessible. These little towns and villages dot vast swaths of countryside. It would be inefficient and expensive to connect these areas to the national electricity system. Households in rural areas have a low electrical demand.

Therefore, in order to produce electricity in a more efficient, sustainable, and economical manner, the energy sector is progressively moving toward renewable energy sources. In remote locations with sufficient resources, renewable energy sources such as hydro, wind, and solar power, among others, provide viable possibilities for electrical generation. In recent years, hybrid renewable energy systems (HRES) have emerged as a promising alternative for these regions' electricity needs.

Clean energy sources are readily available, safe for the environment, and easy to tap into. Combining conventional and non-conventional energy sources offers a cost-effective and dependable way to power rural areas through hybrid renewable energy systems, thanks to their complementing properties and little impact on the environment.

CLEAN ENERGY PRODUCTION TECHNOLOGIES

Renewable energy sources are becoming more accessible. The cost of renewable energy generation has decreased for nations in recent years due to substantial expenditures and technical improvements. There was anticipation that a significant increase in the number of nations generating clean energy over 100 MW would occur by 2017. Because conventional energy production is linked to many harmful and permanent external repercussions, it is critical to promote and develop renewable energy solutions. Considering the environmental and societal costs, renewable energy sources can actually end up being more cost-effective than traditional fuels, even if they may not be as cost-effective at first. The cost of producing one unit of energy may be drastically reduced by economies of scale. Costs associated with transmission, distribution, and technology are quite similar for renewable and traditional energy sources. Major renewable energy technology advancements are detailed in the section that follows.

Hydro power

In terms of renewable energy sources used to generate power, hydropower is by far the most prevalent worldwide. The production of hydroelectric electricity has increased dramatically throughout the last half-century. It was almost a third of the world's total electrical consumption in 1950, at 340 TWh. It peaked at 1,500 TWh in 1975 and climbed to 2,994 TWh in 2005. There was a disparity between the two in 2005, with worldwide output reaching 18,306 TWh and consumption reaching 15,000 TWh. Environmental concerns and high initial investment costs are presently limiting hydropower development.

Many local residents have had to be relocated due to the difficulties caused by hydropower development. Dam building results in non-recoverable sunk costs due to its permanent nature. The vast engineering activities involved in the construction of hydropower plants also have an influence on the environment. Nevertheless, hydropower has several advantages, such as a sustainable environment, the ability to retain water and energy, and a consistent water supply for homes, farms, and businesses. In addition to meeting peak power demand, the stored energy may also be used for continuous electrical delivery. [2]

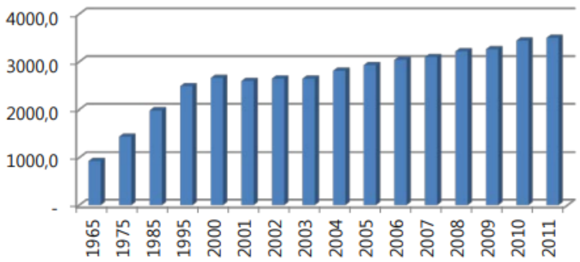

Figure 1: Global Hydroelectric Power Generation, 1965–2011 (in TWh)

The International Energy Agency (IEA) predicted in 2012 that the world's hydropower capacity will increase from 1,607 GW in 2011 to 1,680 GW in 2035. It is estimated that China's capacity will quadruple to 420 GW by 2035, which is comparable to the combined hydropower capacity of all OECD nations in 2011, according to the 2012 World Economic Outlook (WEO) study.

OPERATIONAL MODELS AND CASE ANALYSES OF STANDALONE PHOTOVOLTAIC INSTALLATIONS

Photovoltaic cells, electric appliances, inverters, charge management devices, lead-acid batteries, and independent PV systems are the usual components. The efficient and long-term functioning of off-grid PV systems depends on the correct maintenance and quality control of these parts. Training local operators and cooperating with service providers helps enable dependable operation over the long term. There are specific maintenance needs for each part of the system.[8]

Costs for standalone PV systems can range from quite low to quite high, depending on factors like system size and complexity. Modern technical developments and increased manufacturing volume have caused a precipitous decline in the pricing of small standard systems. Outright purchases of many small PV systems (PPS) and a few small home systems (SHS) are within the financial reach of middle- and low-income families in emerging nations. Without financial aid or suitable banking options, larger SHS and, in particular, solar rural systems (SRS) are often unattainable. Given the rarity of SRS installations and the standard practice of providing PPS only upon full payment, the focus here is on SHS finance and business strategies. The stakeholders' position is that free distribution should never be considered, regardless of the technology used. To appreciate the system's worth, customer participation is crucial from the beginning. The initial outlay for SHS is usually somewhat high, particularly when considering the inclusion of post-sale support.[10]

KEY CHALLENGES IN PROVIDING ELECTRICITY TO RURAL AREAS WITHOUT A GRID CONNECTION

Maintaining the three primary stakeholders—the government, local people, and investors—happy is a common concern, even though we will get into the details in the sections that follow. Everyone in the community wants a cheap tariff and a steady power supply, even while investors only care about the profits made by well-managed systems. Setting sensible price laws that may rely on subsidies is one way the government, as an impartial third party, strives to establish a fair environment for city and rural people.

CHALLENGES WITH POLICIES

Effective enabling policies are necessary for off-grid electrification to be effective. An extensive, long-term electrification strategy is the first step. This plan must have an energy access framework that sorts areas according to the cost and practicality of connecting to the grid. Away from the grid methods are necessary in inaccessible or distant places. Stakeholders rely on this data heavily when deciding on off-grid developments. A major obstacle for companies and investors in emerging nations is the lack of complete and reliable information. Given that mini-grid payback times can easily exceed in the final few years, the government should develop a framework for governance that offers financing assistance or agreements spanning at least ten years to mitigate investment risk. In addition to the overall off-grid plan, monitoring technologies that measure success should be utilised. Duplicated or overlapping activities may occur if an international task force was not set up to manage and supervise monitoring initiatives. Government agencies, non-governmental organisations, microfinance groups, and other important players need to work together more closely on a number of concerns. Investments in off-grid electrification are limited due to a lack of a plan for ultimate grid connection, as well as inadequate government planning for off-grid regions. Once towns are linked to the national grid, mini-grids are frequently abandoned, according to a World Bank analysis. In order to persuade investors that mini-grids would continue to be maintained and utilised following grid expansion, a transparent legislative framework is necessary. Assuming sufficient financial and technical preparations are made, there should be no legal impediments to linking mini-grids to the national grid. But governments are wary of losing flexibility when it comes to expansion plans, which might make mini-grids obsolete due to changes in home demand or technical advancements. This being said, a number of nations have passed laws that address the matter. As an example, when the grid comes to Nigeria, the government gives mini-grid operators a lot of options regarding compensation, continuing operation, and income generation from the mini-grid. Another option is to work with the main grid and get paid to run the distribution system.[5]

Furthermore, private sector involvement in off-grid energy is being constrained due to the absence of sufficient legal guidelines about licensing, technical architectural design, finance, and pricing setting. This research covers the majority of these subjects. Any citizen or prospective investor should be able to easily obtain information on relevant processes and procedures. This degree of openness is provided, for instance, by India's mini-grid portal (minigrids.go.tz).

LICENSING OBSTACLES AND CONCERNS

Businesses and investors may be hesitant to start mini-grid projects due to the lengthy, complicated, and costly licensing processes for retail or power generating. Countries that do not distinguish between small- and large-scale installations have a disproportionate impact on smaller projects. This is a major concern because many developing nations will require hundreds of small-scale power grids in the near future.

One way to lessen the impact of regulations is to streamline government processes and cut out unnecessary red tape by creating a unified system that approves projects on time". The licensing procedure in India is quite efficient; for example, developers may get a single licence that covers numerous sites, and mini-grids with capacities under one megawatt do not need a generating licence because of a capacity carve-out. Similarly, in Sierra Leone, developers just need one licence to produce, distribute, and sell power.

OBSTACLES IN TARIFF REGULATION

In order to recoup their investment and operational expenses, developers of off-grid systems need to charge far higher rates than grid-based power. This makes tariff setting an often controversial topic. Having people in low-income regions who can not pay electricity may be a real problem. It can lead to unauthorised consumption and operators losing money because of the higher load. Incorrect invoicing, unauthorised connections, meter manipulation, and nonpayment are common problems. Because of high tariffs, operators are vulnerable to changes in demand, which reduces the economic attractiveness of rural areas compared to metropolitan ones. On the other hand, pay-as-you-go (PAYG) systems are helping with demand forecasting and operational planning while lowering the amount of illicit consumption.

CONCLUSION

Economic and environmental considerations are interdependent on one another in the context of urban power development. In addition to the current efforts to extend the grid, this study lends credence to the idea of using Hybrid Energy Systems (HES) to increase the amount of power available in cities. An important benefit of the HES's adaptable design is that it can adapt to changing patterns of energy use among various user types, which is becoming more important as urban areas in India expand. One of the biggest obstacles is getting people to pitch in when designing mini-grids, which includes tasks like estimating future energy demands and deciding on a system size. The secure and fair deployment of off-grid technologies is put at risk by the absence of rules and regulations set by the government. In order for off-grid systems to be successful—and to contribute to the social and economic development of rural regions and the country as a whole—it is necessary to address the problems described in this study.

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