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Exploring the feasibility and outlook of integrating hybrid energy solutions in Karwar, situated within the Uttara Kannada District of Karnataka

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Abstract-The economic development of a nation is intricately linked with its energy consumption patterns. The synergistic interplay between solar and wind energy resources defines the viability and promise of Hybrid Power Generation, rendering it increasingly appealing. This study provides an overview of both grid-connected and off-grid hybrid energy conversion systems. Particularly in remote areas and coastal regions, the Hybrid Energy Conversion System holds significant importance due to its myriad benefits. Through the analysis of solar radiation and wind velocity data in the Uttar Kannada District, this paper proposes a model for both grid-connected and off-grid Hybrid Energy Systems.

Indexed Terms- Hybrid Energy, renewable energy, Solar Energy, Wind Energy.

I. INTRODUCTION

In the contemporary global energy landscape, there is a conspicuous surge in power consumption, indicative of a nation's developmental trajectory. Heightened concerns surrounding environmental degradation stemming from fossil fuel utilization, coupled with the imperative to diversify energy sources, have spurred exploration into alternative energy avenues.

In India, the distribution of electrical energy consumption across sectors delineates a nuanced pattern: approximately 22% in the domestic sector, 17% in agriculture, 45% in industry, 9% in commercial enterprises, 2% in traction and railways, and 5% in other sectors.

Presently, various grid-connected renewable energy generation methods are being embraced, with Solar and Wind Energy Systems emerging as preeminent choices. Solar radiation incident on the Earth's surface accounts for a formidable 90 PW, suggesting that judicious utilization of even a fraction of available land surface could amply meet energy demands. Simultaneously, wind energy boasts substantial power generation capabilities. The symbiotic relationship between solar and wind energy renders the adoption of Hybrid Photovoltaic and Wind Energy Systems increasingly compelling, as they offer enhanced reliability and consistent power output compared to standalone installations.

Hybrid solar and wind power generation systems can be delineated into two principal categories: Grid-Connected Systems and Off-Grid Systems. In Grid-Connected setups, wherein the generation capacity may fall short of or exceed the load demand, integration with a larger grid facilitates seamless energy exchange. Conversely, Off-Grid Systems encompass PV and WT installations, battery units, ancillary electric components, and associated loads. Recent strides in energy storage technologies, encompassing supercapacitors, flywheel energy storage, and compressed air energy storage, have bolstered the efficacy of Off-Grid Hybrid Generation setups, particularly in remote locales and coastal defence applications. Notably, the inherent reliability of hybrid systems translates to reduced battery storage requirements compared to standalone configurations, thereby amplifying their appeal in regions where conventional grid connectivity is challenging.

II. LITERATURE SURVEY

In the paper by Subhadarshi Sarkar[1], a stochastic methodology is employed to formulate the MW Resource Assessment Model (RAM) for Wind Solar Hybrid Energy Conversion Systems (WSHECS) at user-selected locations. The wind segment comprises interconnected wind turbine arrays, while the solar component incorporates a parabolic through solar thermal electric generating system.

Chen Jian[2] extensively examines Grid-connected and off-grid configurations of wind-solar hybrid power generation systems, elucidating their respective advantages and disadvantages. Furthermore, the study delves into diverse operational modes and associated control strategies for optimized system performance.

Ajala Merzic[4], introduces a novel model characterized by calculations grounded in empirical wind and solar energy potential data. Two distinct Hybrid System configurations are proposed, differing in the installed capacities of wind and solar energy conversion systems.

T.V. Ramachandra[6], undertakes an assessment of solar and wind power potentials within the Uttar Kannada District. Notably, findings suggest that solar energy harnessed from the coastal belt alone could cater to approximately 32.5% of Uttara Kannada's existing electricity demand. The study underscores the significant promise of solar conversion technologies, contingent upon effective solutions for storage and addressing seasonal fluctuations such as those observed during the monsoon period.

III. RESOURCE EVALUATION

Our aim is to conduct a comprehensive evaluation of solar energy potential in Uttara Kannada, covering a geographical area extending from 74°9' to 75°10' east longitude and 13°55' to 15°31' north latitude, encompassing approximately 142 km of Coastal Belt. Due to the absence of a dedicated radiation station in Uttara Kannada, we relied on solar climatological data collected from radiation stations established by the India Meteorological Department, primarily located near the district, notably in Goa. This research is part of an ongoing initiative within the Uttara Kannada District, Karnataka State, India, with a principal objective of assessing exploitable wind energy potential.

Radiation and climatological data from the radiation stations at Goa and Mangalore, along with climatological data from meteorological observatories at Karwar, Honnavar, and Shirali, were acquired from the Indian Meteorological Department. Our investigations focused on evaluating the feasibility of Hybrid Power Generation, leveraging both solar and wind energy potential.

The Hybrid generation system comprises multiple wind turbines and photovoltaic arrays. The presented work seeks to quantitatively analyse the resource potential of specific sites for setting up hybrid energy generation systems, facilitating effective planning.

Wind resource assessment forms a critical aspect in projecting turbine performance at a given location. The energy harnessed from wind is directly proportional to the cube of its velocity, while wind resource availability varies with factors such as time of day, season, elevation, and terrain.

Solar energy holds the potential to fulfil various decentralized energy needs within a region. The design and performance of solar devices rely on global and diffuse solar radiation data. While solar power is accessible throughout the day, solar irradiance levels fluctuate due to variations in the sun's intensity and obstructions caused by natural and man-made elements

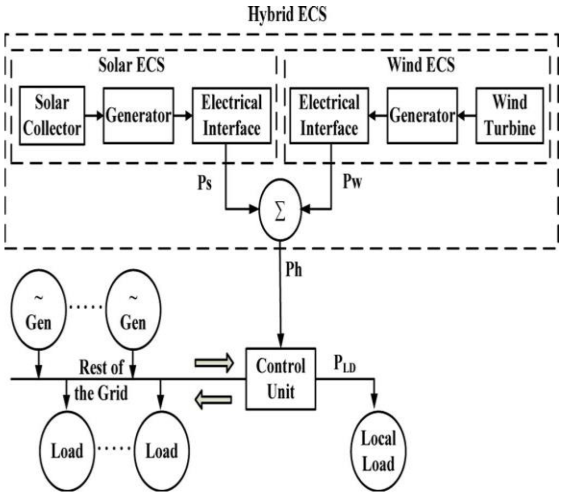

Fig. 1- General layout of Hybrid Energy Conversion System

This paper introduces a model designed to assess the potential power derived from both wind and solar resources at a designated location. The model integrates a wind energy conversion system and a solar energy conversion system, which are interconnected in parallel via a meticulously engineered electrical control unit. This integrated system is tailored to fulfil local energy demands. Figure 1 depicts a generalized schematic layout of the Hybrid energy conversion system. The control unit facilitates seamless operation for grid connection or standalone system functionality. Notably, the interaction with the grid is bidirectional, allowing for the conditional transfer of excess energy generated by the hybrid system to the grid, or the procurement of energy from the grid during periods of low generation to meet local load requirements. Coordinated control by a centralized control centre enables operators to efficiently harness both energy resources, ensuring energy balance and optimal allocation of energy reserves.

IV. DATA ACQUISITION

Wind speed and solar radiation data were collected on a monthly basis for a duration of one year. Radiation and climatological data from the radiation stations located in Goa and Mangalore, as well as meteorological observatories in Karwar, Honnavar and Shirali, were obtained from the Indian Meteorological Department. Graphical representations illustrating the monthly variations of solar radiation and wind velocity are presented for analysis.

A. Solar Radiation:
i. Annual Average: 5.42 (kWh/m2/day)
ii. Monthly Average Solar radiation data:

Months	Radiation in kwh/m2/day
Jan	3.40
Feb	3.68
Mar	4.00
Apr	4.12
May	4.64
Jun	6.14
Jul	6.27
Aug	5.84
Sep	4.26
Oct	3.48
Nov	3.52
Dec	3.94

Table1: Monthly average solar radiation data

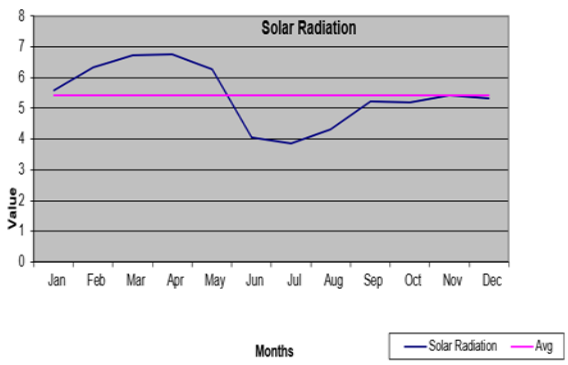

Fig.2 Monthly Solar Radiation graph

B. Wind Speed:
i. Annual Average wind speed: 4.44 km/h
ii. Monthly Average wind speed data:

Months	Wind speed in km/h
Jan	5.58
Feb	6.35
Mar	6.72
Apr	6.75
May	6.27
Jun	4.07
Jul	3.85
Aug	4.31
Sep	5.23
Oct	5.19
Nov	5.41
Dec	5.32

Table 2: Monthly average wind speed data

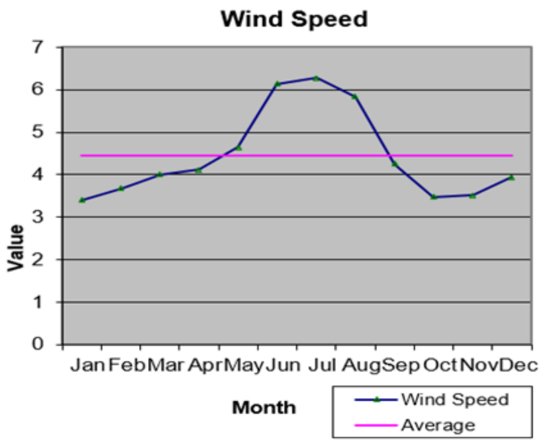

Fig.3 Monthly Wind Speed graph

iii. Monthly mean wind speed data:

MONTH	Avg	Sd	Max	Min
Jan	5.96	1.43	8.3	3.1
Feb	6.55	2.03	10.2	3.4
Mar	8.15	1.99	11.5	4.8
Apr	9.65	2.17	12.4	5.2
May	11.82	2.73	17.8	6.5
June	12.01	3.09	19.4	6.4
July	15.27	4.03	24.4	9.4
Aug	11.98	3.95	20	6
Sept	7.44	2.53	11.8	3.3
Oct	5.41	1.62	9.3	3.5
Nov	4.75	1.56	7.3	1.4
Dec	5.04	1.63	7.8	1.3

Table 3: Monthly mean wind speed data

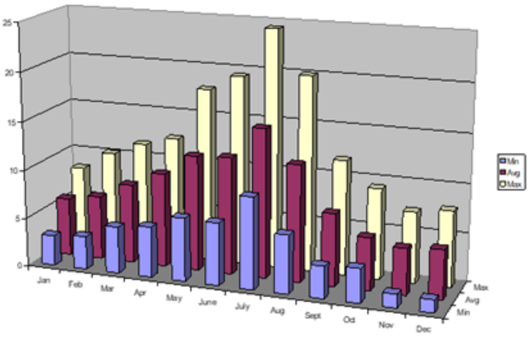

Fig. 4 Monthly mean wind speed graph

Through an examination of solar radiation information and wind speed data in Devabag Village, Karwar, it is determined that implementing a Hybrid Energy Conversion System can effectively meet the local demand for an average of 10 KW to support impoverished economically backword families. The estimated cost for installing a 10 KW system is 18 Lakhs. Considering current electricity tariffs, this capital investment can be recuperated within a span of 10 years. The provision of uninterrupted power supply will significantly benefit underprivileged households, thereby augmenting their means of livelihood.

CONCLUSION

Roughly one-fifth of the global population currently lacks access to electricity, and in India, about one-third of the population, particularly in remote regions, remains deprived of this essential resource. Hybrid Energy Conversion Systems harness the inherent natural resources available locally to generate pollution-free, environmentally friendly energy, thereby addressing local energy needs. While the initial installation costs of renewable energy sources may appear high, they are recoverable over time. Further research is imperative to minimize initial costs and enhance the popularity of Hybrid Energy Conversion Systems.

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