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Wind-energy Conversion for Low Wind–speed Areas of India

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Abstract: *This is the methodology to conversion of electricity through wind energy using convergent nozzle in low wind speed area. By the help of this process of conversion we convert low wind speed in sufficient power conversion with the use of nozzle. Then this maximizes the wind speed, that maximum wind speed rotate fan blade at useful speed level, and then sufficient amount of energy is produced.*

Key words: *Wind Energy, Renewable Energy, Nozzle, Energy, Power.*

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Introduction:

In its origins, the Indian renewable-energy program was a response to the rural energy crisis prevalent in the 1970s (Bhattacharya and Chinmoy, 2009). In this sense, the renewable energy program has resulted in unrealistic targets and allocation of budgets, which have led to failure (Pillai and Banerjee, 2009). Implementation of energy-conservation initiatives in India has suffered from loopholes, such as numerous independent ministries, namely, the Ministry of Power, Ministry of Petroleum and Gas, Ministry of Coal, Ministry of Nonconventional Energy Sources (MNES), and Department of Atomic Energy, which deal with energy resources in India; this multiple control has, consequently, resulted in weak coordination links (Nandi and Basu, 2008). Currently, fossil fuels account for about 64% of the total primary energy supply in India, whereas traditional biomass accounts for about 33% of the total. As expected, the energy consumption of India will continue to grow at a significant rate in the future and hence highlights the need to reduce India's dependence on both coal and oil. To achieve this objective, India has independent ministries for new and renewable energy and for renewable energy technologies, which are now well established in India and handle energy aspects that include solar photovoltaic, solar thermal, wind, biogas, and bio-mass for both power and heat generation, in addition to cogeneration and small hydro projects (Hiremath et. al., 2002). India is one of the very few countries in the world to have such portfolios. Promoting renewable energy in India has assumed great importance in recent years, and the technology that has achieved the most dramatic growth rate and success is wind energy (Pillai and Banerjee, 2009). For example, in 2002, India had a wind-power capacity of 1267 MW, generating about 6.5 billion units of electricity; it currently occupies the fifth position in wind-power installation in the world, placed after Germany, United States, Denmark, and Spain. Although large turbines are also manufactured in India, relatively small turbines have a significant share in the total installed capacity. Furthermore, in spite of the relatively low wind regimes at 50-m hub height, comparing by international standards, India has made significant progress in wind-based power generation, and the installed capacity of wind increased from 41 MW in 1992 to 6053 MW in September 2006. Finally, although the emphasis on renewable energy in India has been growing, aggressive policies, targets, and work programs for promoting RETs are still lacking (Hiremath et. al., 2002). The rural areas provide a significant opportunity to apply photovoltaic, microhydro, and biopower technologies in future years (Urban et. al., 2009). Furthermore, there is a need for targeted technology development and research and development for cost reduction–low wind–speed machines, inverters, and controllers of a few kW—for reduction of the manufacturing cost of photovoltaic modules. In the present article, the actual conversion of wind energy in India will be reviewed, and future corrections are proposed, with special emphasis on rural areas and low wind–speed energy converters (Urban et. al., 2009).

Methodology:

In this article, a detailed review on the wind energy and its future in rural areas of India, has been presented. We have discussed about the facts related to wind energy and problems of conversion of wind energy.

Results and Discussion:

1. Decentralized Energy Technologies in Rural Areas: In recent research works, it was shown that decentralized energy technologies based on the availability of local resources can be a viable alternative to rural electrification in India through the extension of the main grid (Urban et. al., 2009). Most of the decentralized plants are based on wind power, hydroelectricity, and biomass gasification. At the village level, the decentralized planning approach has been attempted on a small scale for isolated projects that meet limited energy needs. Another recent research investigated how rural electrification could be achieved in India using different sources of energy and the effects that it would have on the steps toward climate change mitigation (Ghosh et. al., 2002). With this aim, the electrification options for rural nonelectrified households in India were modelled, and the impacts of the four different types of electrification were assessed: central grid–based, using electric appliances; decentralized diesel-based, using electric appliances; decentralized renewable energy–based, using electric appliances; and decentralized renewable energy–based, using mainly renewable energy–based appliances. The results of the above study showed that rural electrification with renewable energy could reduce up to 90% of the total CO_2 emissions originating from the residential sector, compared to electrification with grid and diesel systems, and therefore have very high climate change–mitigation potentials (Ghosh et. al., 2002). It is also expected that renewable energy–based electrification could also reduce use of primary energy, compared to electrification with grid and diesel systems, and thereby save energy resources. Similarly, research on adaptation of wind turbines for remote and stand-alone applications is receiving increasingly greater attention. For example, hybrid power systems using 1–50 kW wind turbines are being developed for generating electricity in the grid and, in many parts of India, for grid connections. In the latter case, distributed energy resources, such as small wind systems ranging from 50 to 300 kW, provide energy for village electrification, water pumping, battery charging, use by small industries, and so on. In India, however, the use of wind as an energy source for decentralized energy generation is at a preliminary stage. One of the principal decentralized applications is the pumping of water from groundwater for irrigation (Purohit, 2007). There were reportedly more than 15 million electricity-driven pumps and 6 million diesel pumps in operation in the agriculture sector in the year 2003. Under this situation, diesel is expected to become increasingly expensive and scarce and, in consequence, a substantial potential for using renewable sources of energy for pumping of irrigation water is expected (Purohit, 2007). In India, the options of renewable energy for water pumping include solar photovoltaic pumps, windmill pumps, and dual partial substitute for diesel. When the photovoltaic pump system was analysed, it was concluded that the power obtained from this system in the field is generally less than the rated power. It is due to reasons such as decreases in the efficiency of a solar cell when temperature increases, solar irradiance lower than 1 kW/m^2, and the high downtime required for repair and maintenance. However, when the use of the windmill pump was analysed, it was noted that the total number of windmill pumps installed was far below their estimated potential of 0.4 million. One of the main barriers against the large-scale adoption of windmills is the financial viability, because the annual useful energy delivered by a water-pumping windmill depends on the wind-power availability feasibility in a region and the corresponding problems related to wind-energy conversion, which are discussed below.

2. Facts related to Wind Power in India: Wind-power technology is experiencing a major growth, especially in the United States and Europe, and a significant growth has been observed in developing countries such as China and India. As a result of scientific assessments of wind resources throughout India, wind power has emerged as a viable and cost-effective option for power generation. Thus, the wind-power potential in India has been assessed at 45,000 MW, with 1% land required for wind-power generation in potential areas. Assuming a capacity utilization factor of 25%, the identified potential can generate electricity equivalent to approximately 100 TWH per annum. On the basis of the growth trends, the predictions about the future of wind energy in India showed that 99% of India's technical wind-energy potential may be achieved by the year 2030. Furthermore, it has been assumed that with better resource assessment and further increase in conversion efficiencies, the identified potential can generate approximately 117 TWH by 2051–2052. To accomplish these improvements, the MNES, Indian renewable energy development agency, and the wind industry are working together through various

R & D programs (Bhattacharya and Chinmoy, 2009). For example, Herbert *et al.* reviewed the models used for wind-resource assessment, site selection, and aerodynamics, including an analysis of the wake effect. They concluded that with reference to the site selection, the coastal and dry arid zones have good wind potential, and the winds blowing during the period from November to March are relatively weak in India. Of the five potential Indian states, Maharashtra and Karnataka show a relatively steep increase compared with other states. When the aerodynamic models were analysed, it was observed that both the horizontal-axis wind turbine (HAWT) and vertical-axis wind turbine (VAWT) design are very efficient; however, both are being rigorously tested and improved until date. In spite of these developments, wind speeds less than 5 m/s are not of much relevance to wind-energy applications. Chikkodi, Horti, Kahanderayanahalli, Kamkarhatti, Raichur, and Bidar have wind velocities greater than 5 m/s for most of the months of the year; the wind-energy potential is high in these locations and, therefore, construction of wind farms is recommended at these locations.

3. Problems of Wind-energy conversion: As shown before, the electricity generated by wind is still more expensive than power obtained from conventional power plants, unless the environmental benefits of wind power are taken into account. If the cost of wind energy could be reduced by an additional 30–50%, then it would be globally competitive. The goal of achieving this reduction has inspired designers to seek cost reduction by increasing the size, tailoring of turbines for specific sites, exploring new structural dynamic concepts, developing custom generators, and power electronics, in addition to implementing modern control-system strategies. It was concluded that to improve wind energy conversion, the principal design factors that must be analysed are the power in the wind, the load factor, wind turbine–axis orientation, the area required, and the grid connection. The power in the wind depends on the wind statistics, the seasonal and diurnal variations of wind power, and variation with time. In particular, when the wind blows strongly (speeds more than 12 m/s, there is no shortage of power, and often, the generated power has to be dumped. Difficulties appear if there are extended periods of low- or zero-speed winds. The load factor is not a major concern when the wind electric generator acts as a fuel-saver on the electric network; nevertheless, if the generator is pumping irrigation water, for example, in an asynchronous mode, the load is very important (Purohit, 2007). To select between different orientations of the axis, according to the orientation of turbines, HAWTs and VAWTs can be considered. The principal advantages of VAWTs over conventional HAWTs are that VAWTs are omnidirectional and, in consequence, they accept the wind from any direction. This simplifies their design and eliminates the problem imposed by gyroscopic forces on the rotor of conventional machines as the turbines yaw into the wind. The vertical axis of rotation also permits mounting the generator and gear at the ground level. On the negative side, VAWT requires guy wires attached to the top for support, which may limit its applications, particularly for offshore sites.

The area of land required depends on the size of the wind farm, and the optimum spacing in a row is 8–12 times the rotor diameter in the wind direction and 1.5–3 times the rotor diameter in crosswind directions. The last parameter is related to the grid connections. For the economic exploitation of wind energy, a reliable grid is as important as the availability of strong winds. The loss of generation for want of a stable grid can be 10–20%, and this deficiency may perhaps be the main reason for the low actual energy output of wind mills compared to the predicted value. Consequently, this is one of the most important factors that must be corrected in future wind energy–converter designs.

4. Future Proposals for Wind-energy Conversion in India: The principal parameters analysed above are related to the cost of wind energy and, hence, with the financial viability; these factors are now considered for a proposal for the future. As shown before, India portrays the need for a renewable energy conversion in decentralized areas, where the principal problem Is the instability in wind velocity, which in turn increases the cost of wind energy. In previous research works, Shikha (Shikha et. al., 2003) proposed a wind concentrator for this same problematic situation. This same concept was further analysed and its energy conversion was improved based on the phase change of moist air. This recent implementation is based on the Foehn effect and consists of a nozzle, a rotor, and a diffuser designed to get the maximum mechanical energy from the free stream of Airflow. Finally, a savonius rotor was proposed for low wind–speed areas, as shown in Figure 1.

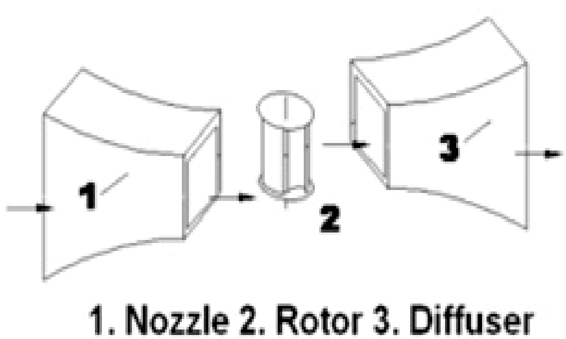

Fig.1. Wind concentrator proposal

Experimental results showed that VAWTs offer a great number of advantages, such as accepting wind from all directions, being easier to build, being able to respond more quickly to changes in the wind direction or velocity, and presenting a higher net efficiency of converting winds to electricity. Furthermore, results have shown a clear increment of three-fold energy conversion. Finally, in recent research works, the combined effect of two wind farms was simulated; one with and another without wind concentrators. Results showed major energy-conversion stability under different ranges of wind speed. Furthermore, other applications of this system, such as controlling the velocity of wind turbines with the relative humidity of moist air, are suggested.

1. Population distribution in India 2011: The population of India as per 2011 census was 1,210,854,977. India added 181.5 million to its population since 2001, slightly lower than the population of Brazil. India, with 2.4% of the world's surface area, accounts for 17.5% of its population. Uttar Pradesh is the most populous state with roughly 200 million people. Over half the population resided in the six most populous states of Uttar Pradesh, Maharashtra, Bihar, West Bengal, Andhra Pradesh and Madhya Pradesh of the 1.21 billion Indians, 833 million (68.84%) live in rural areas while 377 million stay in urban areas. 453.6 million people in India are migrants, which is 37.8% of total population.

India is home to many religions such as Hinduism, Islam, Buddhism, Sikhism and Jainism, while also being home to several indigenous faiths and tribal religions which have been practiced alongside major religions for centuries. According to the 2011 census, the total number of households in India is 248.8 million. Of which 202.4 million are Hindu, 31.2 million are Muslim, 6.3 million are Christian, 4.1 million are Sikh, and 1.9 million are

Jain. According to 2011 census, there are around 3.01 million places of worship in India.

Ever since its inception, the census of India has been collecting and publishing information about the religious affiliations as expressed by the people of India. In fact, population census has the rare distinction of being the only instrument that collects this diverse and important characteristic of the Indian population.

2. Major wind farm considered:

Profiling the top five wind power farms operating in India: Wind power is one of the key renewable energy sources for electricity generation in India. With 37.5GW of capacity installed, the country currently ranks fourth in the world in wind power generation after China, the US and Germany.

Currently accounts for about 10% of India's total installed electricity generation capacity.

The Government of India is offering various fiscal and financial incentives to promote wind power projects across the country via private sector investment. Through the National Institute of Wind Energy (NIWE), the government has installed more than 800 wind monitoring stations. The assessment undertaken by the country's National Institute of Wind Energy suggests a gross wind power potential of 302GW in India at 100m above ground level.

Top five wind farms in India:

1. Muppandal Wind Farm: 1,500MW : Situated in Kanyakumari district of the Indian state of Tamil Nadu, the 1,500 megawatts (MW) Muppandal wind farm is the country's largest onshore wind farm. The project features a large number of wind turbines of varying sizes from 200 kilowatts (KW) to 1650KW. Developed by the state-owned Tamil Nadu energy development agency, the facility uses wind from the Arabian sea to generate renewable energy for nearby residents and contributes to India's overall energy mix. The wind farm features turbines from several manufacturers including Suzlon, NEG Micon, Vestas, and Enercon.

2. Jaisalmer Wind Park: 1,064MW

Developed by Suzlon energy, the Jaisalmer wind park is the country's second-largest onshore wind project. The 1,064 MW project, which is located in Jaisalmer district, Rajasthan, features a cluster of wind farm sites within the Jaisalmer district including Amarsagar, Badabaug, Baramsar, Tejuva and Soda Mada among others.The wind park development started in 2001 and its current capacity was achieved in April 2012. Suzlon's entire wind portfolio, ranging from the earliest 350 KW model to the latest S9X – 2.1MW series, has been used in the project. Renewable energy solutions provider Suzlon built the wind farms for a range of customers, including private and public sector firms, independent power producers and power utility providers.

3. Brahmanvel Wind Farm: 528MW

The 528 MW Brahmanvel wind farm, located in Dhule district of Maharashtra, has been developed by Parakh agro industries. Apart from Dhule, the other places in Maharashtra which have a large number of power generating facilities include Satara, Sangli and Panchgani. Maharashtra has the largest wind energy installed capacity in India after Tamil Nadu with 4098 MW.

4. Dhalgaon Wind Farm: 278MW

Gadre Marine Exports developed the 278 MW Dhalgaon wind farm in Sangli, Maharashtra. The wind farm, commissioned in 2005, features turbines from Suzlon and Enercon. The investor-friendly policies make Maharashtra one of the best states to invest in wind energy. About 2309 MW of private windpower projects have been installed in the state up to March 2011. According to Maharashtra energy development agency, commercial viability of wind power projects is gradually increasing because of technological advancement.

5. Vankusawade Wind Park: 259MW

Maharashtra is also home to the 259 MW Vankusawade wind park, which is one of India's largest wind power production facilities. The Vankusawade wind farm, which features Suzlon S33/350 turbines of 350 KW each, is situated on a mountain plateau 1,150 m above the Koyana reservoir, around 40 km from the town of Satara, Satara district. The windy and cold Vankusawade site has various old, weather-worn turbines with lattice towers and decaying blades.

3. Grouping of Indian population according to major rural area in 2011:

Nearly 70% of the country's population lives in rural areas where, for the first time since independence, the overall growth rate of population has sharply declined, according to the latest census. Of the 121 crore Indians, 83.3 crore live in rural areas while 37.7 crore stay in urban areas, said the Census of India's 2011 provisional population totals of rural-urban distribution in the country, released by union home secretary R.K. Singh."For the first time since independence, the absolute increase in population is more in urban areas than in rural areas. The rural–urban distribution is 68.84% and 31.16% respectively," registrar general of India and census commissioner C. Chandramouli said. The level of urbanisation increased from 27.81% in the 2001 census to 31.16% in the 2011 census, while the proportion of rural population declined from 72.19% to 68.84%. "The slowing down of the overall growth rate of population is due to the sharp decline in the growth rate in rural areas, while the growth rate in urban areas remains almost the same," Chandramouli said. However, according to the report, the number of births in rural areas have increased by 9 crores in the last decade. The statistics reveal that while the maximum number of people living in rural areas in a particular state is 15.5 crore in Uttar Pradesh, Mumbai tops the list having the maximum number of people in urban areas at five crores. The data also reflects that 18.62% of the country's rural population lives in Uttar Pradesh and 13.48% urban population lives in Maharashtra.

Conclusion:

Currently, in India, extensive powers have been handed to the bureau of energy efficiency (BEE) under the energy conservation act, 2001 (Nandi and Basu, 2008). However, for more efficient administration of the act, it is felt that there could be an independent body, called the Association of Indian energy managers, to which some of the tasks and activities of BEE could be delegated. The currently used centralized energy planning model ignores the energy needs of rural and poor areas and has also led to environmental degradation, whereas the decentralized energy planning model is in the interest of efficient utilization of resources. It is found that small-scale power-generation systems based on renewable energy sources are more efficient and cost effective. Thus, the focus should be on small-scale RETs that can be implemented locally by communities and small-scale producers, but which can make a significant overall contribution toward the national energy supply. Although India has made considerable progress in implementing technologies based on renewable sources of energy. The decentralized energy–technology applications are still few. It was found that rural electrification with renewable energy could reduce up to 90% of total CO_2 emissions; therefore, these options have very high climate changes mitigation potentials and could also reduce primary energy use, compared to electrification with grid and diesel systems, and thereby save energy resources. Once a possible solution for this problematic situation was obtained, the reason why it has not yet been corrected has been reviewed. It is concluded that, at present, many renewable sources are in the classic chicken-and-egg situation: the financiers and manufacturers are reluctant to invest the capital needed to reduce cost when the demand is low and uncertain, whereas the demand remains low because the potential economies of scale cannot be released at low levels of production. Renewable energy needs to gain the confidence of developers, customers, planners, and financiers. This can be established by renewable energy establishing a strong track record, performing to expectations, and improving its competitive position relative to conventional fuels. In this sense, the barrier in renewable energy development and penetration is, with reference to wind power, the tapping of wind potential, which is difficult due to the wide dispersal of wind resources. Finally, although the emphasis on renewable energy in India has been growing, aggressive policies, targets, and work programs are still lacking. There is a need for targeted technology development and R&D for cost reduction. For example, for implementation of actual wind-energy conversion, a wind concentrator based on the phase change of moist air and a savonius rotor are proposed, from which obvious increments of three-fold fold energy conversion are expected to be obtained.

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