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SCOPE FOR THE IMPLEMENTATION OF INTEGRATED ROOF WIND ENERGY SYSTEM IN INDIA: AN OVERVIEW

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ABSTRACT

Wind is a non-polluting and renewable source of energy. Wind energy is the fastest growing source of renewable energy in the world. It has an average growth rate of 30%. In terms of wind wind energy production, after USA, Germany, Spain, and China, India occupies the fifth place in the world. There are many issues concerned in the distribution of energy to the definite location where larger scale productions are concerned therefore cost effective solutions have been found at smaller scale . The Integrated Roof Wind Energy System is considered to overcome the existing issues of urban and larger scale renewable energy system. The system is built by using skewed shaped funnels set in an axial array and its function involves acceleration of the wind flow by making use of the Venturi Effect. This leads to a converging air capturing inlet which is carefully designed with innovative shape and geometry to create high wind mass flow and velocity toward a vertical-axis wind turbine on roof top for comparatively high amount energy generation. This review presents an overview of the challenges to large scale wind power development in India and the scope for introducing Intergrated Roof Wind Energy System (IRWES).

KEYWORDS: Integrated Roof Wind Energy System ,venturi-effect, louvers, Vertical Axis Wind Turbine

INTRODUCTION

A promising renewable energy policy development has become a mission among the world wide researchers and governors due to rise in prices for fossil fuels, an increase in energy consumption, and electricity, global climate change,environmental disasters, etc.[9].Wind energy generation is an inexhaustible resource availability and is considered as the most attractive technology, while considering the ecological value and economical prospects. It has the potential to moderate the cost of electricity, to scale down the emissions of CO_2 from power industries and decrease the reliance on costly fossil fuels. Twenty two countries have more than 1,000 MW installed capacity. This development was led by the China, US, Germany, Spain and India, and it brought global cumulative installed capacity to 2,82,482 MW (as of 30 June 2012). The top five countries in terms of cumulative installed capacity are China (75,564 MW), the US (60,007 MW), Germany (31,332 MW), Spain (22,796 MW) and India (18,421 MW) [3]. BP Global has estimated that World proven oil reserves in 2010 are sufficient to meet 46.2 years of the global production [23].

MATERIALS AND METHODS

Wind energy in India

About 53% of electric power in India is generated from coal and lignite based steam thermal plants, which contribute a lot to air pollution. The need of the hour is a cleaner and renewable source of energy, in which off shore wind power can play a major role. India is one of the five largest wind energy markets in the world today. Renewable energy sources (excluding large hydro) represent 12.2% of India's installed capacity, with 70% of this contribution coming from wind energy [13]. India is blessed with a coastline of about 7,600 km. Under a national wind monitoring programme, winds have been measured at 54 locations on the coastline In Wind Chronicle, 2008/09. The onshore wind power potential for India has been estimated as 15000 MW (<60 m depth). There are many potential sites in Indian waters and still this huge potential remains untapped (Awesome Inc.,2011).The western coastline has modest potential at sea level. The southern tip of India starting from Kanyakumari up to Rameshwaram has shown some promising values. Rameshwaram indicates windpower density of 603 Wm-2 at 50 m agl and Kanyakumari has shown wind power density in the range of 370 Wm-2 at 30 m agl [8]. Studies on wind energy development shows that more than 95 percent of the nation's wind energy development today is concentrated in just five states in western and southern India – Tamil Nadu, Andhra Pradesh, Karnataka, Maharashtra, and Gujarat (LBNL, 2012). These five states accounted for over 85% of the total installed capacity at the end of the last plan period [14]. Srinivasa Rao Kasisomayajula [6] listed the State-wise Wind Power Generation and installed capacity in India up to 31st March 2010 (Tamil Nadu-4132.72 MW, Maharashtra-2077.70 MW, Gujarat-1863.64 MW, Karnataka-1472.75 MW, Rajasthan-1088.37 MW, Madhya Pradesh-229.39MW, Kerala-27.75 MW and West Bengal-1.10MW).

Issues related to large scale wind energy production

From the analysis performed by IRENA [20], it was observed that the health of India's wind energy sector gives importance to the issues of grid integration, forecasting and scheduling. There are many problems within the power sector in India and the main problem include the reliability and structural inefficiencies which causes sustained wind power growth poses a challenging environment for the wind power. India being a country largely dependent on tax incentives invites only a mere range of private investors for wind power policy in India.If a reliable energy source has to be ensured in India then there is a need for India to move to a higher trajectory growth as energy is vital for wind sector growth. The power supply position prevailing in India has high prices for industrial consumers and is characterized by unreliability and persistent shortages hence energy scenario in India is not satisfactory [15]. The wind turbine installation and manufacturing requires heavy upfront investments. Wind turbines can be a threat to wildlife in the case of birds and bats having been killed as they tend to fall into the rotors. Noise is regularly reported as a problem by neighboring homes. Even if private lands are available but the supply and transport issues poses problems and the conversion of land use status from agricultural to nonagricultural is a time consuming process. Further if the land is close to a protected area or forestlandsthen obtaining clearance from forest authorities for using the forestland for wind power generation is time consuming [14]. The constraints to large scae wind energy production involves the location of turbines in the remote areas of the country thus the distribution and transmission to the other parts of India lacks intergrity.Another draw back persisting is the variability of wind power which can create problems for the traditional grids in maintaining a supply and demand balance.Indian developers are building fewer wind farms in comparison to 2011 and a transition-phase was seen after government incentives saw significant reductions post March 2012 [22].Due to the various issues that need concern at large scale level the need for the hour is the wind energy at the residential level.

Description of Intergrated Wind Energy System

The concept of the Integrated Roof Wind Energy System (IRWES) was initially designed by Suma in 2009[2]; to harvest winds from any direction. According to Suma et al. [2] the IRWES introduces a novel implementation of the Venturi principle [1] into a residential roof structure or as top-up high-rise roof unit.[Fig.1].The studies made by Ferraro et al [11], showed the lower partof the roof has dual-purpose openings which serveas the inlets to capture incoming air flow andoutlets for the outgoing air flow when the wind comes from opposite direction.

Figure 1:

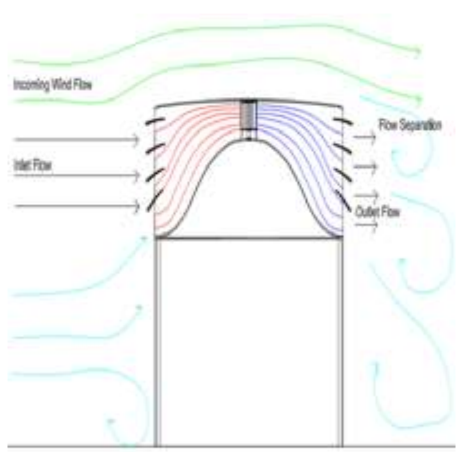

Fig.1 Cross-section of flat-shaped roof with idealized incoming flow

The incoming windflow passes through a number of radiallydistributed inlet guide ducts, and is accelerated by their skewed shape to strike the VAWT located atthe top of the roof. The shape, dimension, and position of thelouvers create higher wind capturing. In addition, louvers at the funnel entrances direct the façade interacting wind flow into the funnel system: increasing the capturing area, total mass flow rate, and prevent vertical outflow along the line of the roof. The louvers also take care of adjusting the incoming wind speed or completely seal the entrance during events of extreme weather conditions.On the leeward side, a low pressure vertical base flow is formed behind the wall and beneath the roof shape. The leeward region has relative lower pressure and creates a suction effect which facilitates the exit of flow through outlets[11].

Figure 2:

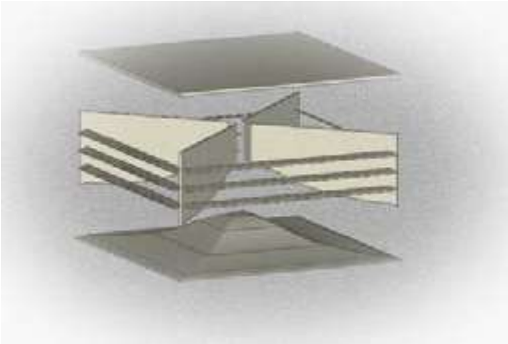

Fig.2 Exploded view of IRWES

From the Investigations of Suma et al. [12],it was observed that IRWES introduced more advantages over conventional VAWT systems and has the potential to meet or exceed the efficiency level of a HAWT:

- Wind capture area for the turbine is formed by the facade of the building from roof top to front facade stagnation point and is substantially larger than a conventionally isolated VAWT
- Converging inlet guide ducts (funnels) accelerate the flow so that the flow speed striking the turbine is substantially greater than the ambient wind speed, generating a larger blade rotating speed
- Passages formed by the blades create favourable pressure gradients and hence, significantly larger work output
- End plates at the turbine entrance will suppress blade tip vortices, and so, generate higher efficiency than conventional VAWT's
- Noise radiation generated by the wind turbine will be significantly lower since the turbine is contained within the roof which will shield the acoustic propagation generated by the blade tip vortices and wakes
- Dynamic loading generated by the VAWT start-ups will be more efficiently absorbed by the axial arched funnel structure than using a HAWT, introducing a more efficient fatigue design and
- Vibrations and dynamic loading is isolated from the building's structure by means of rubber blocks.

Case Study

Dekker et al. [11], describes a case study that comprises of the integration of IRWES on top of the Vertigo building, located in Eindhoven, at the Eindhoven University of Technology (TU/e) campus, see Fig. 2. This high-risestructure is selected based on its urban location with parkland surroundings, rectangular floor plan tominimise an obstructive flow influence by the building itself, orientation, structural capacity and thebenefits associated with the relationship between the research team and University.

Vertigo consists of a low-rise and high-rise part, structurally dilated from each other. Applicationof IRWES on the elevator shaft will only affect the high-rise section (Fig. 2 and 3). The buildingsstructure comprises 14 concrete portal frames placed symmetrically on the west and east wing, twoconcrete cores, located at the south and north ends of the high-rise part, and two concrete elevatorshaft walls situated at the outer south end. The concrete material is of minimum quality C20/25.

Figure 3:

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Fig.3 IRWES on elevator shaft, Vertigo, TU/e

The local prevailing average annual wind direction is South-West with a mean velocity of 3.8 m/s at a height of 10 m. Integration of a wind energy system is preferred at the highest point of the building with an optimal configuration harvesting energy from the governing wind direction. With the north south orientation of Vertigo and the increased height of the elevator shaft at the south end, application of the wind energy system on top of the elevator shaft is preferred (Fig. 2 and 3). The application of IRWES introduces additional loads to the existing bearing structure of thebuilding. The static load increases because of its dead loads (DL). Likewise, the horizontal windforces will increase by the enlargement of the facade area, whereby the wind flowing through thesystem complicates the prediction of the magnitude of these forces. The wind pressure exerts lift toIRWES' rooftop.

Figure 4:

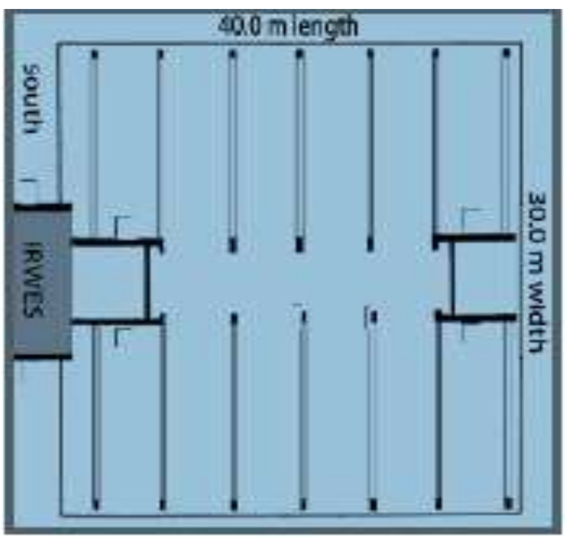

Fig.4 Concrete structure of high-rise part Vertigo

The channel walls are laterally loaded by pressure and suction from two sides, bothaffecting the structural design of the system. Dynamic loads are expected, resulting from wind flowpressure, centrifugal forces associated with the VAWT, and impact forces accompanied by everyturbine start-up launch. Previously described forces are carried by the existing structure, potentiallywith additional measures like reinforcement at the supports, enlargement of supporting walls,columns or additional columns to increase the bearing capacity.The effect caused by addition of this system to the structural stability is of even larger importancecompared to the structural strength. The module needs to provide its own stability resulting in aframework underneath the channels composition. Including stability measures within the modulesimplifies the application of IRWES to existing buildings. However, damping measures remainrequisite to prevent vibrations entering the supporting structure. Thereby the connections need to bedesigned adequate to transfer the lateral loading towards the existing bearing structure.

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CONCLUSION

The existing theories of fluid mechanics, wind power generation, computational fluid dynamics, wind tunnel testing, structural design and material engineering is bridged by the multidisciplinary study of intergrated roof wind energy system. This study involves a spectrum of topics including turbulence compression, geometry, curvatures, skewed flow, dimension scales and, directionality, effect of capturing louvers, fatigue loading, and novel material use with respect to sustainability, architectural aesthetics, functionality and constructability. Inside the roof unit there is about 500 % increment of the wind speeds with straight correlation to the amount of energy that can be reaped.The integration of the wind energy system into the roof structures can be used to generate energy at the location where it is needed and provide an increase in the power production of micro-turbines employed in the built environment. Its application on high-rise buildings allows using the natural higher wind speed of the higher altitudes and facilitates the user's prospective [19].The attractive characteristics of the IRWES includes ,low maintenance cost, short down time for maintenance, aesthetic point of view, noise proof,safety and reliability and customization possibilities.The most important requirement for India is to develop an integrated energy policy framework, which has avision, a plan and an implementing mandate to accelerate deployment of all renewable energy technologies.There is high potential to harvest wind energy based on the average wind velocities in India and this productin would be multiple times the single-family households consumption. When analyzing the wind energy potential in India, it can be seen that Renewable energy shortage can be removed permanently by implementing wind energy harvesting systems.This will also prove to promote a long-term and a sustainable future for the wind sector in India.

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