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POTENTIAL SOURCES FOR ENERGY DEVELOPMENT/CONSERVATION & ITS APPLICATIONS: A REVIEW

Dhairya J. Zaveri[1] ,Rishi R Saxena [2], Dr. P.V.Ramana[3]

[1]*Department of Mechanical SVIT, VASAD;*
[2]*Department of Mechanical SVIT VASAD;*
[3]*Department of Mechanical SVIT VASAD;*

Abstract*— *Utilization of wind energy is an ancient technique where wind turbines are used to harvest kinetic energy from the wind & utilize in different forms for hundreds of years. This paper discuss about the utilization of various sources of air to generate the useful power. High rise buildings and moving rail wagon, industries have the great possibility to abstract wind energy & generate power. Energy recovery, as well as extraction, depends on the area of the duct & velocity of the wind. The wind coming out from the duct has great potential to recover energy. Various source for the same is been listed in this paper. Turbine blade material & no. turbine blades are the crucial part of the recovery/abstraction system. Hence, the review is focused on the types of material and its blade along with the effect of nozzle, diffuser, and nozzle-diffuser is been discussed. This work can be utilized by the successive research scholars to have idea in the field of wind energy recovery system.

Keywords— Wind Turbine, High Rise Buildings, Blade Materials, No. of Blades, Energy Sources

I. INTRODUCTION

This Per Capita Energy(PCE) consumption is increasing as the world progress. To meet the energy demand energy production as well as conservation should be increased. Fossil Fuels have been key contributor having share in 86% of total energy production till 1970. Due to development of clean energy sources like Solar as well as wind, world show 5% reduction till 2014 in Fossil Fuel contribution. Solar & Wind Energy's contribution till 2014 was only 4% but it is expected to increase by 16% - 36% till 2060 as per the World Energy Scenario 2016 to accomplish rise in PEC consumption.

Conservation of energy can be achieved by Internal energy management which has numerous techniques after Energy Audit & by waste energy management with waste energy recovery systems. Recovered energy can be obtained in forms of Thermal Energy, Electrical Energy and Chemical Energy. Electric Energy is prime source for modern appliances and machines, recovery of it are important. Wind turbine can be utilized to recovery energy coming out of the bag filters, pumping stations ,cooling towers, etc and utilize in form of electric energy.

Pollution and global warming are major issues, government of various nation have decided guidelines about the emission of air & its qualities. Hence, availability of clean air with high Kinetic Energy is there. Wind turbines can also be implemented on fast moving vehicles and high rise building in smart cities to harness wind energy. Usage of these sources of energies is challenge to engineers. Great efforts by researchers, planners, developers had been made on this concept to evolve. There studies consist of the wind patterns, velocities, materials, no. blades. This review emphasized on some notable work done in production as well as conservation by wind turbines.

II. POTENTIAL ENERGY SOURCES

This section focuses about the various Potential Energy Sources that can be harnessed for conservation and the management purpose.

A. Energy available at urban location with high rise buildings

Z.R. Shu et al [1] describes about the integration of wind turbine in high rise buildings. Four wind tunnels had been installed at different heights at Pearl River Tower. Maximum wind velocity changes with different seasons as well as height. Variation in season varies from 2.75 m/sec to 3.56 m/sec, maximum at winters producing 64.60 W/m^2 to 77.76 W/m^2. These results are obtained without presence of high rise building in neighbourhood. As Guangzhou has low wind conditions significant power isn't generated but high power generation can be expected at cities with huge buildings & windy atmosphere.

Amir Bashirzadeh Tabrizi et al [2] gives the insight of four main hindrances that are wind recirculation, blocking, acceleration & channelling in Urban wind flow pattern for power generation due to close proximity of the buildings present around the area. They gives experience of inflow conditions with the help of CFD,CFX & WAsP at Alcoa RDA Lake meteorological station & Bunning warehouse in Port-Kennedy, Australia.

An-Shik Yang et al [3] studied the behaviour of wind affected by neighbourhood, turbulence intensity due to different topology of buildings & roof structure of buildings, variation with height and CFD implementation to find the perfect location for installation of wind turbine. Study was carried out at National Taipei University of Technology campus. I was concluded from the study is by increasing hub height and installing turbine at windward site of the buildings increases the chance of power production. It is advisable to have round roof compared to rectangular roofs for low turbulence intensity and high power generation.
Lin Lu, Ke Sun et al [4] analysed around the area of Lee Shau Kee building in the university campus at Hong Kong which is densely populated by tall buildings. They researched on wind aerodynamics and flow of wind in the area with CFD Fluent 14.0 software. Tsim Sha Tsui has recorded weather report for Hong Kong Observatory from 1978 till 2007 with & without buildings. It indicated that urban area with buildings has low Wind Speed and Shape Factor. With the data, analysis showed that there are areas where there is high velocity available due to building concentration effect. Hence Velocity can increase by 1.3 to 5.4 with inlet velocity of 5-7 m/sec at inlet. Hence, such spot can be identified and turbine can be installed.

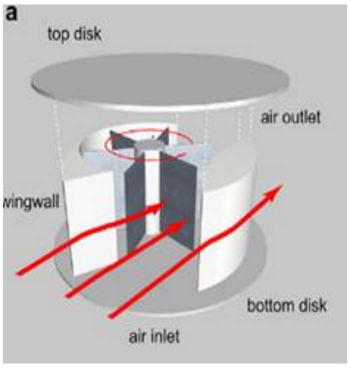

Figure 1 Turbine at High Rise Buildings [29]

B. Energy available at moving Vehicles

Hasan Asif et al [5] gives approach of power generation through railways. They described outline for the energy generation and equipment utilized for the same. By comparing merits and demerits of different types of the turbines, suggested shrouded type of the wind turbine to recover max. energy present in the wind.
G. Prasanth et al [6] describes the hybrid form of the energy harness by the combination of the wind as well as the solar energy. Solar energy can be converted by the us of Photovaltic cell & wind energy by the conversion of kinectic energy. Futher, measured power generated by train with length 656 feet long moving at 125 m/sec i.e. 2.6kW for 8seconds.
Ravi Dwivedi et al [7] the idea of mounting 3 turbines on the roof of each compartment producing power of 483W at 60 km/hr speed of the train. This can be utilized in lighting system of the compartments & for mobile charging. They also gave the concept of the hybrid turbine used alone with diesel systems.
Srinivasan. S1 et al [8] describes that when train is moving, the air is compressed in front of the train which will creating vacuum, more air will be sucked due to negative pressure. Turbine is placed in the converging and diverging nozzle further increasing the velocity of the turbine. Generator used in this research required min. torque of 1.14Nm i.e. 43.2 km/hr is the min. velocity required by the train to generate the electricity. CFX analysis was done for the validation of theoretical outputs. Hence, train running between 43.2 km/hr to 120 km/hr has the potential of generating power for audio facilities, wifi facilities & lighting schemes.

C. Energy available with at buildings at ventilation hub

Jung Ha Park et al [9] used the exhaust air coming out of the building from Living room, Bathroom and Kitchen. This exhaust air gets combined with the outside flowing air the exhaust air duct cap of the system to increase the incoming velocity of the system. Exhaust Air patterns various with different seasons & occupancy. The annual power generation was 23.45-27.36 kWh/ year at 100m height. By increasing the height of the building i.e 200m -300m power generation quantity increased by 9.9% and 6.2%.
S.-W. Hong et al [10] experimented the potential of power recovery by attaching turbine with ventilation fan. The air behind the fan is useless for indoor ventilation but it is dense & having high velocity i.e. upto 10 m/sec compared to natural source varing between 3-4 m/sec. From experiment it was found that 350 W of energy is generated by turbine but due to transmission losses 300 W is obtained which is 30% of energy. Hence, 30% of the energy is recovered yearly 2497 KW/year/system. At 2012 they had 3700 households with 12 or more ventilation fan around the year. So, there is huge amount of energy recovery.

D. Energy recovery from commercial Buildings

Industries like textile, pulverizing units, etc have different systems like exhaust Air Systems, Ventilation Systems, Air filter Systems from where air is constantly flowing into the atmosphere. This air has high kinetic energy and act as steady source to recover the power. So, wind turbines are utilized to harness the power form these systems. Research is going on this topic to minimize the waste energy from the systems and increase the overall efficiencies of the system.

ARCHIT PATNAIK et al [11] studied various output sources from the industries & found that avg. velocity of the air coming out of the Rourkela Steel Plant varies from 15.5 m/sec to 16.4 m/sec which is 1.5-2 times more than atmospheric air . Hence, there is huge opportunity to harvest the energies from such plant. They also conundrums that system may face are

- Turbine blade design should be such that it can withstand high velocities.
- Find the appropriate location for the installation of the turbine as it may get disappears when diffused in the large surrounding.
- Power storage capacity is challenge as huge amount of power will be recovered.

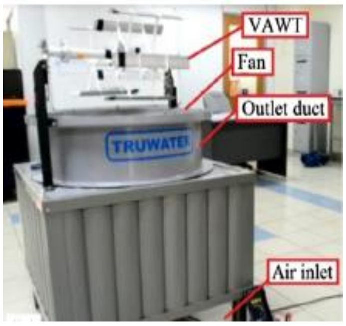

Figure 2 Cooling tower with HAWT [15]

Ratul Paul et al [12] compared the power density available at 30m height at Bangladesh and power density of the exhaust air system with avg. air velocity of 15.4 m/sec & found that power density is four times greater than off shore. They carried out static analysis at kaltimexbangla factory, Bangladesh and found 1.4 MW capacity by ignoring factors like velocity deviation, temperature effect, density of air.

Solomon Tesfamariam Teferi et al [13] used ducted design to harness the exhaust air. Duct length is so maintained that it gives uniform velocity profile as well as provides venturi effect to increase the velocity the from 15.719 m/sec at exhaust fan to 20.7 m/sec. The ideal power was increased from 5.04 to 9.15 KW. The system yearly recovered 47.88 MWh which is 23% of the energy required at the weaving room of the company.

Chong Wen Tong et al [14] installed recovery system at the cooling tower. This cooling towers depends on the draft fans. Maximum velocity recorded at 0.3m away from the exhaust was 18 m/sec. A small scale experimentation was carried out with 0.39A motor of the fan generating avg. velocity of 1.8 m/sec. 115 & 150 RPM was recorded without and with enclosure at the turbine to provide venturi effect and safety concern. Result shows almost 30% increment in RPM with enclosure. Considering this effect it was concluded that 17.1 GWh/year energy can be recovered from such 3000units operating for 16 hours a day having 2 m diameter cooling tower which is almost 13% of the total energy required to operate the cooling towers.

S.Y. Yip et al [15] carried out an experimental studies on the cooling tower. They used 2 5-bladed H-type VAWT as the recovery system at the outlet of the cooling tower. They found system doesn't only recovery the energy but also reduce the power consumption by the exhaust air system

Harjeet Singh Mann et all [16] found chimney exhaust as the has high potential to recover the energy with the flue gases. The avg. velocity of the gases with density 0.816 kg/m^3 is 22m/sec for 600MW plant . 6 bladed HAWT was used in the studies and found by CFD & CFX analysis that 34 KW power can be extracted with the recovery system.

III. TURBINE MATERIALS

Habali et al [17] used Glass Fiber Reinforced Plastic for designing 20KW turbine of FX66-S-196 airfoil profile further FEM analysis was done & stress, strain, deflection were analysed.

Mishnaevsky et al [18] studied performance of Small wind turbine with different timbers i.e. were Lakuri, Pine, Sal, Saur, Sisau, Uttish, Tuni, and Okhar. Of which Pine & Lakuri were vailable.

David Wood et al [20] compared 4 different timbers for Small Wind Turbine . All 4 timbers are promising for low speed operations .

Out of which alder solid blade would be better than the beech, hornbeam and ash.

For the hollow blades, the alder and beech timbers could be used for windy areas and all four timbers are very promising for operation in low wind speed region.

Collier et al [21] at present, most of the blades are made from polymer composite reinforced with mainly glass fibre, some carbon fibre and the hybrid combination of glass fibre and carbon fibre.

Ramachandra M et al [23] Studied various materials and compared them to develop advance material. Carbon Nano Tubes(CNT) composites can further be developed with better properties like hybridization with natural fibers for an eco-friendly material with high strength, low weight characters which makes it a suitable advanced material for wind turbine blade

IV. EFFECT OF NUMBERS OF BLADES

Dr. Subha Kumpaty et al[24] analysed stationary turbine model & found, the power coefficient actually decreases as the number of blades increases.

Torgeir Moan et al[25] carried time domain simulations demonstrated that the aerodynamic loads and structural responses are strongly dependent on the number of blades.

- In particular, by increasing the number of blades from 2 to 3 reduces the variation in the tower base bending moment more significantly than increasing it from 3 to 4 .
- The blade number does not significantly affect the generator power production due to the control strategy employed.

Manouchehrad et al [26] found no. of blades directly affects rotational speed of turbine. By adding each blade 10%-12.5% speed is reduced.

Takao Maeda et al [27] studied VAWT & found Power coefficient decrease with increase in no. of blades.

V. EFFECT ON POWER WITH AND WITHOUT DIFFUSER

Buyung Kosasih et al [28] Experiment was carried out on 3-bladed horizontal wind Turbine of NACA 63-210 airfoil profile.

Experiment was carried at 3 stages

Stage1 :- Bare Turbine

Stage 2:- With Diffuser

Stage 3:- With Nozzle-Diffuser

Coefficient of Performance Cp was measured for all the 3 stages

It was observed that Cp increased by 60% with diffuser & further 63% increment was observed with Nozzle-Diffuser Shrouded arrangment.

As discussed about inlet velocity increasing with diffuser. It was observed that the SWEPT having diffuser of almost same length as the diameter of SWEPT can produce 1.4 to 1.6 times higher electrical power.

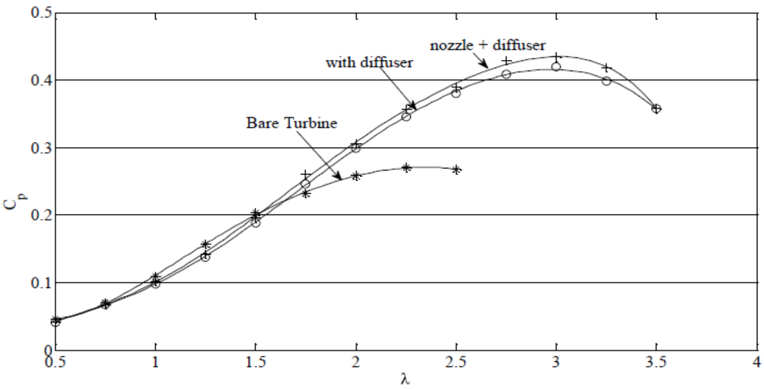

Figure 3 Comparison of bare, diffuser only, and nozzle-diffuser shrouded micro wind-turbine coefficient of performance, Cp [28]

Sr. No.	Source of Energy	Velocity (m/sec)
1	Kombolcha Textile Share Company , Ethopia	15.719
2	Rourkela Steel Plant, India Sinter Plant-1	16.4
3	Rourkela Steel Plant, India Sinter Plant-2	15.5
4	Rourkela Steel Plant, India Sinter Plant-3	16.2
5	Thermal Power Plant @ 660MW	22
6	Cooling Towers, Malaysia & Singapore	18

7	Kaltimexbangla factory, Dhaka	15.38
8	Building @ 100m	3.92-6.10
9	Building @ 200m	4.55-6.85
10	Building @ 300m	4.91-7.25

Table 1 Flow of Exhaust Air/Gases in Industries and Buildings

VI. Conclusions

It can be found that there is great potential to conserve and manage power from above mentioned sources. Kinetic Energy depends on the Area as well as Velocity of the air/gases flowing. At the commercial buildings wind is flowing with low velocity but area is large. So, sufficient power can be developed. On the other hand from industrial exit, velocities are twice or thrice the avg. wind velocity. Hence, by deployment of energy efficient system, waste or free flowing energy can be well managed and conserved.

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