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A Comprehensive Review of Vertical Axis Wind Turbines For Urban Usage

Dr. Ahmed Khalid Ibrahim
Mechanical Engineering Department
University of Mosul, College of Engineering
Mosul, Iraq
alnajar.ahmed9@uomosul.edu.iq

Dr. Ramiz Ibraheem Saeed
Mechanical Engineering Department
University of Mosul, College of Engineering
Mosul, Iraq
ramizibraheem76@uomosul.edu.iq

Abstract : The scope of wind innovation was investigated in this review article. Wind energy is among the major sources of renewable energy for producing power, and its use has skyrocketed since 2000. The two most prevalent classifications for the wind turbines are the both horizontal (HAWT) and vertical (VAWT) axis wind turbine. Many countries use HAWTs for different scales scope initiatives involving energy, and they are utilized in most commercial installations around the world. HAWTs, on the other hand, is not considered a feasible solution for harnessing wind energy in metropolitan locations, where The wind isn't as fierce, un-predictable, or tumultuous as it once was. The turbine with vertical axis is indicated as a superior option for different places and manipulates semi-urban areas. Several characteristics are proposed for a non small-scale deployment of VAWTs, incorporating strong, unsteady, no noise, safety problems, and acceptable pleasing for integration in civilian settings. Several studies are published on wind turbine technology and resource evaluation methods. The presented review deals with modest attempt to highlight some of the significant breakthroughs in VAWTs, emphasizing their integration through urban infrastructure. There has been a lot of study in the field of wind power. This study has significant achievements of VAWTs in terms of methodology and resource evaluation, with a focusing on their integration with urban infrastructure. Based on the most data that are related to this subject, some ideas for future research and the use of wind turbines in urban areas have already been developed. More study is needed, according to the researchers, to make VAWTs affects, reliable, and cost-effective energy for a wide range of power applications.

***IndexTerms* - Energy from the wind, Wind farms, Wind turbines with a vertical axis.**

I. Introduction

In recent decades, the energy that obtained form wind has become more efficient in most electrical power systems around the world. So, the presence can be retrieved vital around the world while energy consumption levels are grow up due to climate change [1, 2]. This appears to be a widespread unanimity among scientists that the emission of most greenhouse gases are to blame for the current situation, reinforcing the belief that humanity should devote all available resources to the excerption of energy from relative sources other than fossil sources [3, 4]. Rising cost of fuel are resulted in an excess of renewable power source applications, so the sustainable energy which are extracted from wind is normally considered to be more attractive, high efficiency and low pollution. However, the prolific generated by wind rich transformation frameworks varies depending on the weather and wind speed [5, 6, 7]. The emergence of renewable, particularly wind energy, is warranted, according to the concept presented in the preceding paragraph. As a result, since the turn of the century, the developing types of wind energy converter and related technologies has wide spreads. This leads to the fact that the use of wind energy is the goal by all research areas, such the resource, i.e., the characterisation of wind energy to the devices that directly consume this energy [8, 9]. As a result of all, several works are incorporated that analysed the participations of all of this research, as a state of art review works. A few approaches have recently been used for wind vitality forecasting, which several works are analysed and then dedicated to improve vitality due to extensive experience in preliminary fields. Then, and specifically on wind farms, the strategies for estimation energy from wind resources shows some lack in development and tested [10, 11, 12].

One of the key study topics in renewable energy has been distributed energy production. Figure 1 shows the annual increase in the world. The transference of producing electricity from wind resources promotes the matter of minimizing the dimensionality of power supplies from the large to small scale of wind farm turbines and possibly applying to cities through the complexity and turbulence of wind flow due to the existence of constructions and buildings.

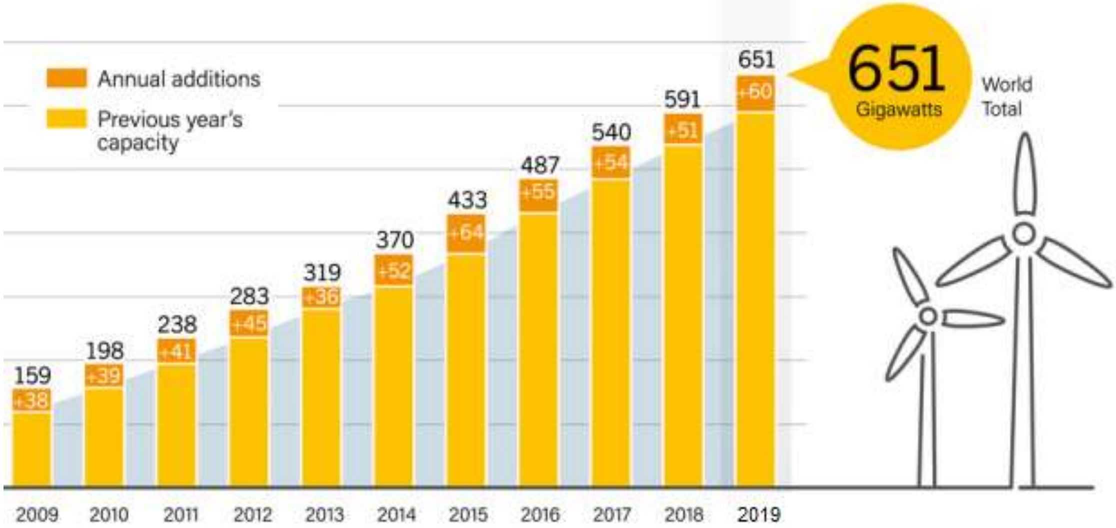

Fig. 1 The annual increase to the world's offshore wind and the past year's capacity chart.

According to this background, a small scale vertical axis of small wind turbines for on-site generating (OSG) is a viable option, provid low sensitivity to turbulent flow and the fact that they do not require alignment with direction of wind, compared to the horizontal axis of small wind turbines. Furthermore, when compared to HASWTs, VASWTs have a modest auditory influence [13, 14]. The necessity of placing the turbines in a proper environment that is astonishingly sophisticate compare to the optimal conditions of open field, where huge wind farms are normally sited, is one of the most difficult associated with dispersed power production. Small wind turbines are placed close to end customers, usually in metropolitan areas or in off-grid configurations [15]. Figure 2 illustrates many types of vertical axis wind turbines (VAWT). Setting up the position of turbine along the alignment of the wind direction at the whole time is not required; the turbine behaves better in turbulent or disturbed flows, and there are fewer noise emissions.

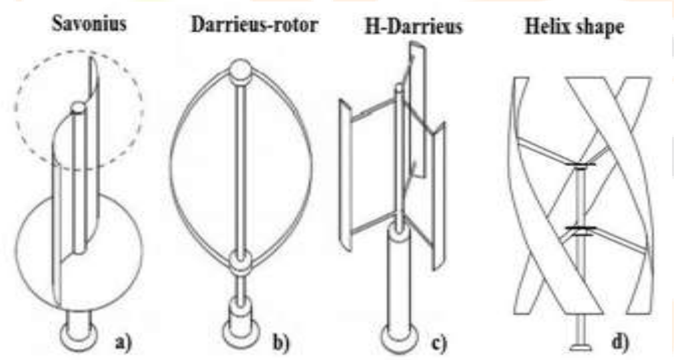

Fig. 2 Variety of shapes of vertical axis wind turbines.

The following assumptions are some of the primary reasons to obtain better condition of vertical axis small wind turbines over horizontal axis small wind turbines [16,17]:

1- The rotor does not have to be oriented with the wind direction all of the time;
2- There are fewer noise emissions;
3- The turbine performs better in turbulent or disturbed flows.

II. LITERATURE REVIEW

The airfoil geometry has a considerable impact on the vertical axis wind turbine's aerodynamic efficiency. Zhu et al. [18,24] have demonstrated that adding a Gurney flap to the end of the straight-bladed can reasonably improve the aerodynamic performance up to 21.32%. They reported that by using a lower TSR, they were able to acquire a higher power coefficient than when using a clean blade and a reduction in torque fluctuation when using TSRs ranging from 2.75 to 3.25. However, the Gurney flap's aerodynamic load is unaffected by its width.

The ability to use flexible blades in VAWTs also can contribute to significant improvements. The changing blade shape during turbine rotation, and hence the flow structure interaction, can result in considerable gains. The blade adjustment can change the blade angle of attacks and this can enhance the lifting force due to alter leading edge, which can increase the power capture. In some cases, with using flexible blades, the power coefficient increases up to 20 % compared to the static blades of VAWT [17].

Improvement the performance of turbine's aerodynamics for the type of rotor vertical axis (VAWT) revealed by Yan et al. [19], used a small cam attached to leading-edge, a passive flow control approach. They explored five kinds of sinusoidal cam having leading-edge with different amplitudes and wavelengths as part of their research. The leading edge cams technique was revealed to be able to avoid a dynamic stall, especially when the tip speed ratio is low, which is essential to VAWT. Figure 3 shows plans for vertical axis wind turbines.

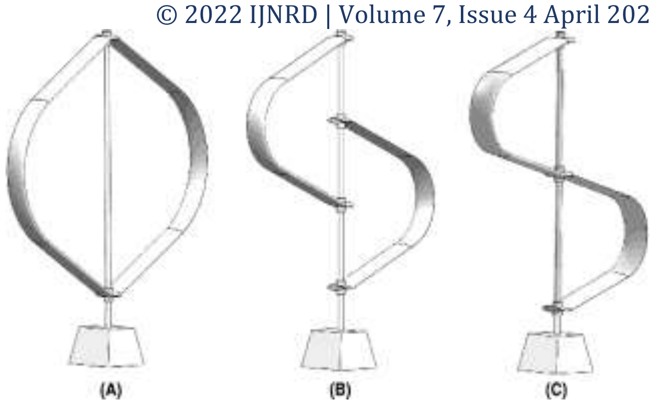

Fig. 3 Vertical axis wind turbine layouts: (A) traditional VAWT, (B) STS modification 50% VAWT, and (C) ST's modification 100% VAWT.

In terms of improving aerodynamic performance, the amplitude of the cam was shown to be more critical than the wavelength. The "bi-periodic" phenomena were seen across the suction side at various angles of attack and it was linked to a variation in static stall behaviour. However, the highest performance protuberance layout provided less turbulent kinetic energy, which results in enhanced aerodynamic post-stall behaviour [20]. Figure 4 shows concept of crosswind turbine.

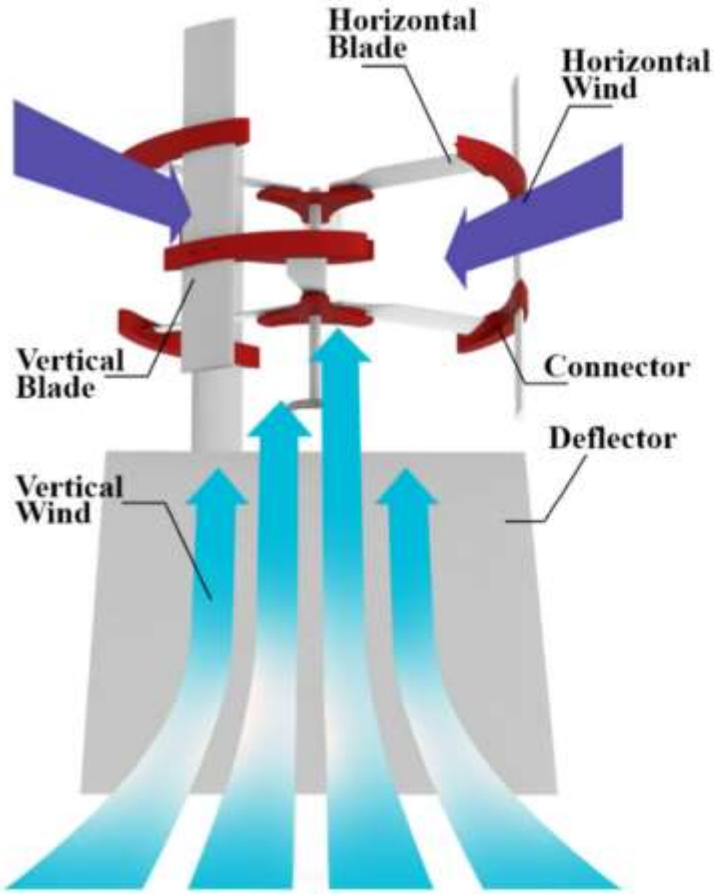

Fig. 4 Concept crosswind turbine.

The platform pitch motion also affects aerodynamic behavior. This effect has been examined by using Improved Delayed Detached Eddy Simulation. Under pitch motion, the VAWT's averaged power production is more than the power outcome from a fixed wind turbine, with a coefficient of net power enhancement of approximately 1.5 to 15% [21]. Other research on offshore wind farms has reached similar outcomes [22,23]. Figure 5 shows the variety of main parameters. This indicates that without considering structural dynamic characteristics, the offshore support wind turbine might capture and convert more wind energy into electricity.

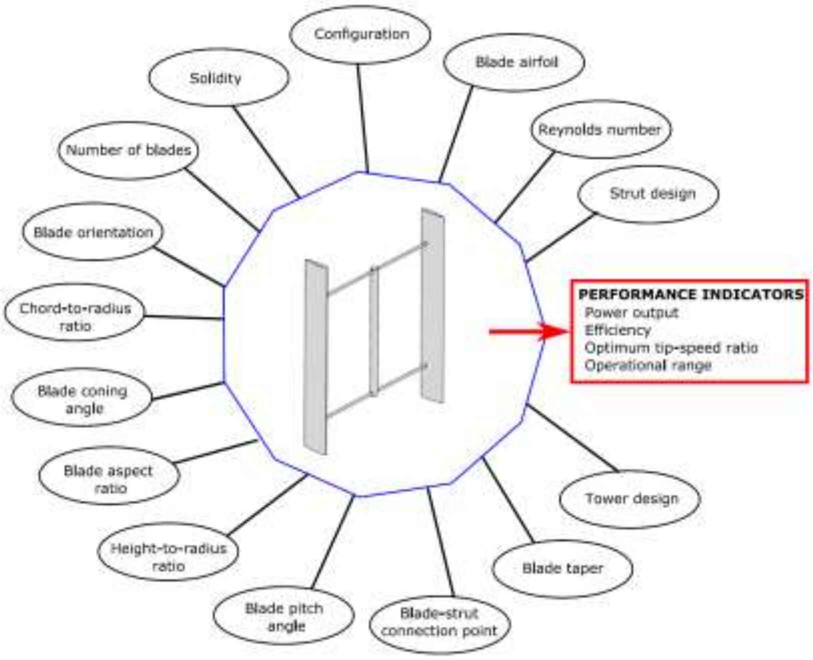

Fig. 5 Variety of main parameters impacts on lift type performance for VAWT.

In VAWT's, many parameters have significantly effect on design of this type of wind turbine such as: configuration variants, solidity, the number of blades, chord/radius ratio, height/radius ratio, blade aspect ratio in addition to the fixed pitch versus variable pitch systems, connection point of blade-strut, angle of pitch, profile of blade taper, angle of coning, the design and orientation of blade air foil, Reynolds number of blade, effect and orientation of strut, blade-strut connection fairing and further flow augmentation devices and control system [25]. Table 1 shows the recommended design parameters according to the literature [25].

Table 1 Recommended design parameters of VAWT according to the literature.

Parameter	Recommended value (s)
Configuration	Straight-bladed (i.e. $\Phi = 90°$)
Solidity (Nc/R)	0.2-0.3
λ	3-4
Number of blades	2-3
H/R	2.6-3.0
Blade pitch system	Fixed-pitch
BSC	0.25c
β	-2° (toe-0ut)
ξ	0°
Blade airfoil profile	DU 06-W-200
Cross-section	Streamlined airfoil
Strut per blade	2
Strut arrangement type	Overhang supported
ζ	0°
Strut positions	0.207H (from each blade tip)
Blade strut connection design	Faired joint
Fairing fillet speed	Variable
Drive train/ generator	Direct drive with auxiliary winding
Control system	Tip-speed ratio control
Aerodynamic regulation	Passive stall

Another factor that can play an important role in the efficiency improvement of a VAWT is using deflectors positioned at the windward area concerning the centerline of the wind turbine. Chen et al. [15] used two deflectors to examine the aerodynamic performance of a three-bladed VAWT using the Taguchi method. The results show that it can achieve from 17 to 20% improvements in the average power coefficients of the VAWT depending on deflector position compared with VAWT without deflectors. According to the authors, a properly installed deflector can considerably enhance the VAWT's efficiency [26,27]. Figure 6 shows savonius VAWT with three blade.

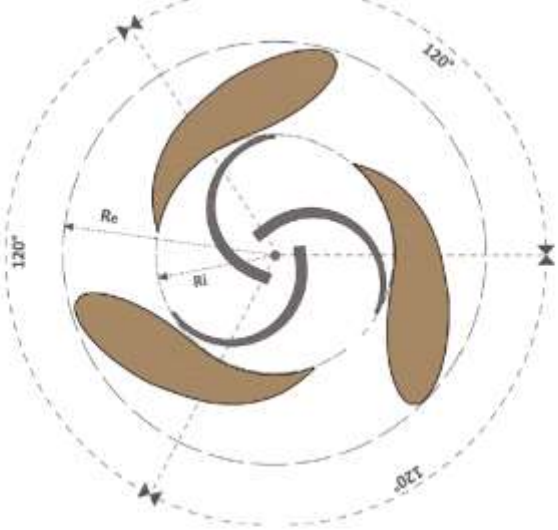

Fig. 6 Savonius VAWT with three blade.

The icing conditions impact the effectiveness of the VAWT [25]. Guo et al. examined the influence of using bladed vertical axis wind turbine set up directly inside the wind tunnel with straight bladed form. The icing conditions have been provided and the icing experiments were performed under different conditions ratios of tip speed. The experiments demonstrate that the blade's rotating speed has a substantial impact on icing conditions. Which the latter increases layer by layer and have a significant forms on the blade's whole surface, when the tip speed ration has lower value than one. But when the speed ratio at the tip increases greater than one, the ice coating accumulates around the leading edge. The experimental study has reported that some of the parameters like angle of attack, rotating position of blade and centrifugal force can be considered as important parameters effect on performance of vertical wind turbine (SB-VAWT). Figure 7 shows efficiency of solidity on VAWT.

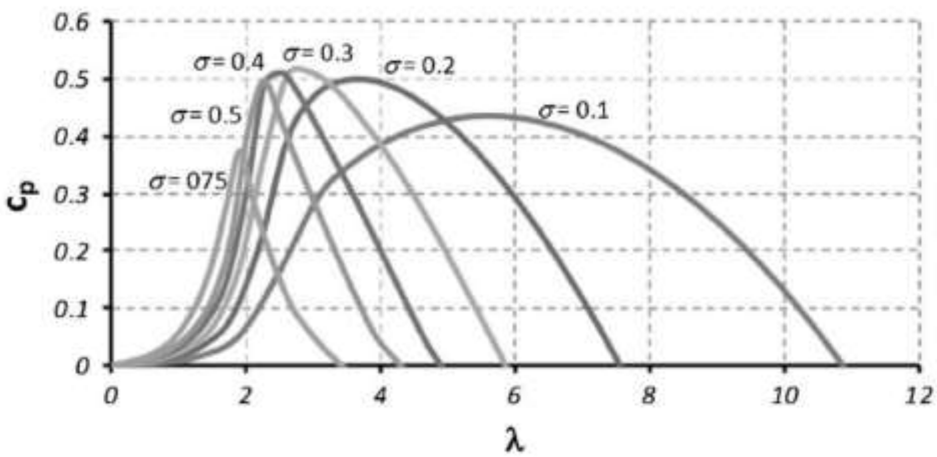

Fig. 7 Efficiency of solidity on VAWT.

III. CONCLUSIONS

This article has a significant because it fills a knowledge vacuum about the barrier things wind energy has to deal with it, also indicates that there is a plethora of information for the sector that might grows into a key force in international society. The reality that present resources are insufficient to fulfill future demand is the driving force behind the search for sustainable energy resources. We are getting closer to identifying more sustainable options thanks to research and technology. Wind farms off the coast, which are the focus of study, have proven to be effective in a variety of areas, including power, economics, socioeconomics, and the environment. Offshore wind farms are an excellent answer to several issues.

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