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Generating Electrical Power using Movement of Various Vehicles in New Lighting Base

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ABSTRACT

This work represent a proposed design to supply street lighting power using moving vehicles with an automatic system to guide the fluid flow. In the present design, wind turbines are integrated on the body of the lighting base, which can reduce the construction cost compared to previous designs and use the fluid flow of all vehicles movement with different dimensions to increase system efficiency. Also, present investigation, has been used an automatic system to direct the fluid flow to the wind turbines to increase the efficiency in supplying electricity, which was not installed in the previous designs. Other features of this system include the production of electricity in inappropriate weather and storm conditions, unlike previous designs that had to stop the wind turbine in these conditions to decrease damage. Finally, illuminating the streets and alleys, the stored energy can be used for other purposes, such as charging car batteries and lighting resort stations. Then, comparison between the best design of the third model based on lighting and second model with four vertical wind turbines (VWT) and solar panel (SP), the power generation has increased by 35.55 %. Finally, using an automatic guidance systems (AGS) of fluid flow in the third model based on lighting, the power generation was enhamced by 64.86 %.

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1. INTRODUCTION

The lighting base in the present design is independent of AC electricity and by using the automatic guidance system of air flow due to the movement of various vehicles, it can produce more electricity for the consumption of street lighting. One of the basic methods of lighting in the current plan in the streets and highways to supply and store electricity is completely independent of municipal electricity. In addition to illuminate the streets and alleys, the stored energy can be used for other purposes, such as charging car batteries and lighting resorts and recreation area. So, recently works in this area represented as follow:

Chinforoush and Latif-Shabgahi [1] investigated a new method for detecting heterogeneities in wind data set to predict wind speed based on the well-known Hidden Markov Model. Kashyzadeh et al. [2] presented the line of action of wind or aero-dynamical force applied to the vehicle model to pass through the vehicle mass center. The vibrations of the half-vehicle model have been found via the Runge-Kutta method. Peiravi et al [3, 4], Peiravi and Alinejad [5] numerically investigated arrangement fins in the systems with stable conditions of fluid flow velocity. Also, Marchione [6] numerically investigated the stress distribution in the adhesive layer under buckling condition. The study presented develops with the analysis of a single-lap joint with a combination of steel adherents and three different structural adhesives with different thickness and Young's modulus. Martynyuk et al. [7] surveyed the photovoltaic system that operated in different conditions such as changing solar irradiance and environmental temperature. In addition, Ganji et al. [8], Alinejad and Peiravi [9] numerically surveyed fluid flow phenomena in different condition of systems. Asadollahzadeh et al. [10] studied

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the ionic liquid application development to extract europium ions in single and binary systems. A green procedure for europium extraction from aqueous chloride solution was investigated using phosphonium ionic liquid Cyphos. An extensive work conducted by Peiravi and Alinejad [11], Pasha et al. [12] on numerically simulated fluid flow in a channel and between two equal plates. Jond et al. [13] solved the control problem of a vehicle convoy modeled with linear dynamics. They considered the control problem of a vehicle convoy modeled with linear dynamics. The convoy formation requirement is presented in terms of a quadratic performance index. Zhang et al. [14] proposed a novel method for system failure reasoning based on Bayesian networks to solve emergency airflow control system reliability problems. A system fault tree model was established to identify the logical relationship between the units, which was then transformed into a Bayesian network fault analysis model to determine network node states and the conditional probability table, as well as to carry out diagnostic reasoning on the system node branches. Umana et al. [15] focused on biomass production from palm oil. This work stated on the utilization of biomass products derived from oil palm and oleochemical derivatives extracted. Kerich [16] surveyed on safe drinking water source for the residents and defined a suitable system for potable water treatment from pesticides polluted surface water source. Ha [17] proposed a simple but effective trailing edge flap system. This preliminary concept used a more practical and stable actuation system which consists of a motor-driven worm gear drive and flexible torsion bar. Sawant et al. [18] represented a review of state-of-the-art review works on wind-energy-related issues that classification into several main topics in the field of energy research.

The present work illustrated the lighting base, which is independent of electricity of city power source and includes wind turbines that are installed at regular intervals on the lighting base. Fluid flow is independent of the movement of all types of vehicles in different directions using an automatic flow guidance system for turbines. As a result, with the energy supply unit, the electricity stored for lighting of streets and other uses. This device consists of 6 main parts: wind turbine unit, control unit, energy supply unit, solar panel unit, lighting unit and body.

2. GEOMETRY OF THE INVENTION

This work represented three models of new lighting base that work with the movement of various vehicles for AC electricity power equipped with an automatic guidance system of fluid flow. According to Figure 1, this paper described all models with details that third model is our new patent.

Helical savonius wind turbine used in all models to lighting base has maximum performance for producing AC electricity power. Figures 2 and 3, illustrated schematics of helical savonius wind turbine with presentation view.

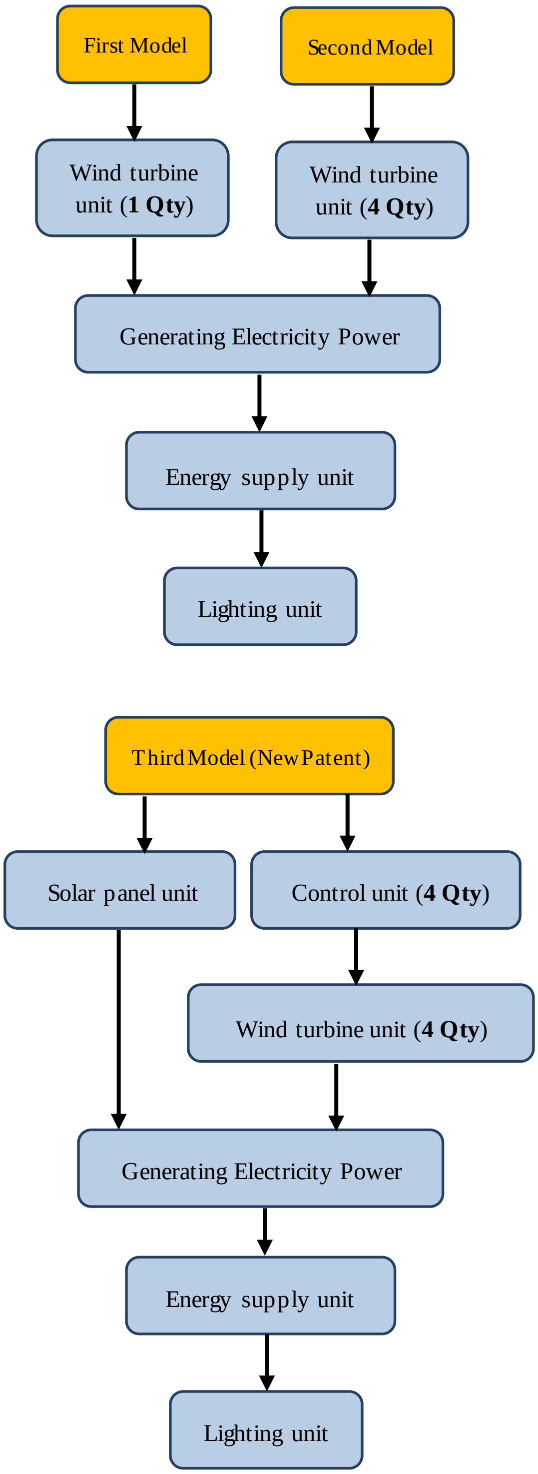


Figure 1. Flowchart of research methodology

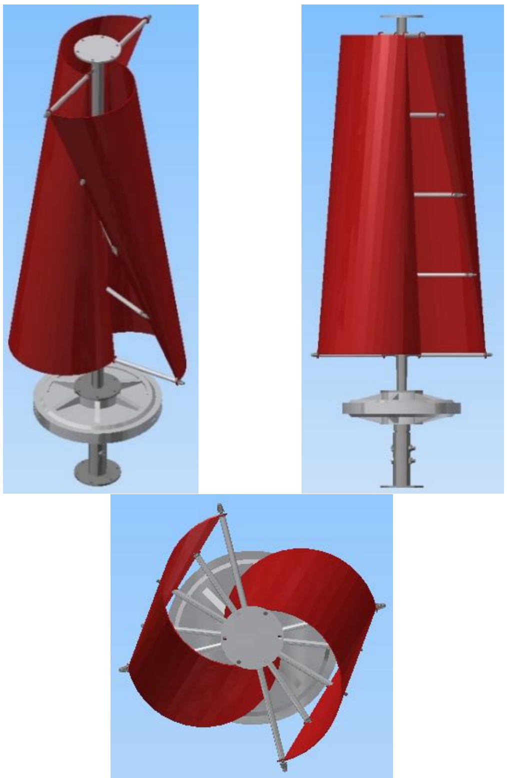


Figure 2. 3D Schematics of helical savonius wind turbine

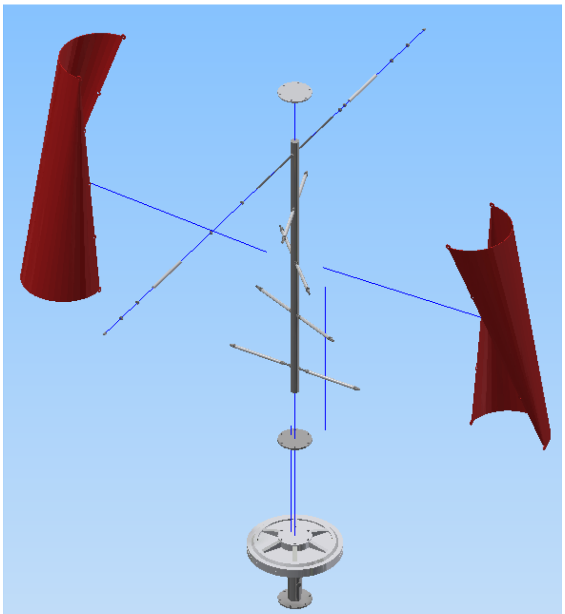


Figure 3. Presentation view of helical savonius wind turbine

The physical characteristics of the savonius blades wind turbine are summarized in Table 1.

2. 1. First Model Lighting base for producing electricity power required to power supply unit. This unit depends on wind turbine unit. So, according to Figure 4, power supply unit and wind turbine unit designed at the top and down of the box in first model, respectively. Figure 5 illustrated installation of these units with details. Also, first model has a fixed guidance systemof air flow as shown in Figure 4.

First model has three units that power supply unit and wind turbine unit represented in Figures 4 and 5. Lighting unit is the third unit with two LED lamps that is illustrated with details in Figure 6.

Table 2 and Figiure 7, represents power generation in the first model based on lighting with changing in use of solar panel (SP), and fixed guidance systems (FGS) of fluid flow as shown below

TABLE 1. Physical properties of savonius wind turbine

Material	Aluminum 6061
Density (g/cm^3)	2.7
Mass (kg)	2.25562
Area (mm^2)	841671
Volume (mm^3)	835416
Yield Strength (MPa)	275
Ultimate Tensile Strength (MPa)	310
Young's Modulus (GPa)	68.9
Poisson's Ratio (ul)	0.33
Shear Modulus (GPa)	25.9023
Power Generation (W)	500

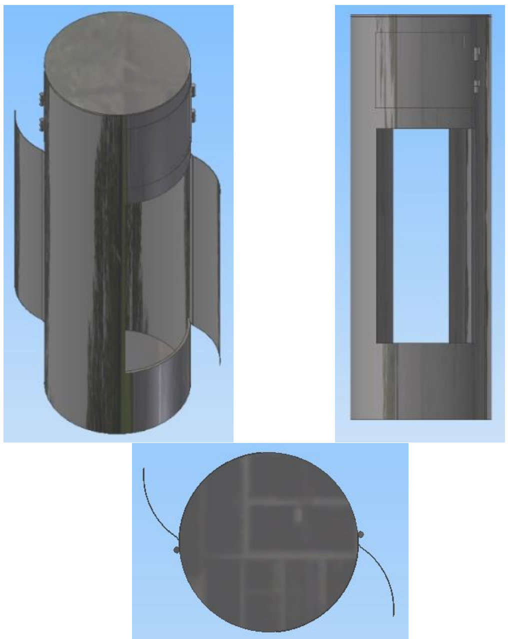


Figure 4. Power supply unit and wind turbine units in first model

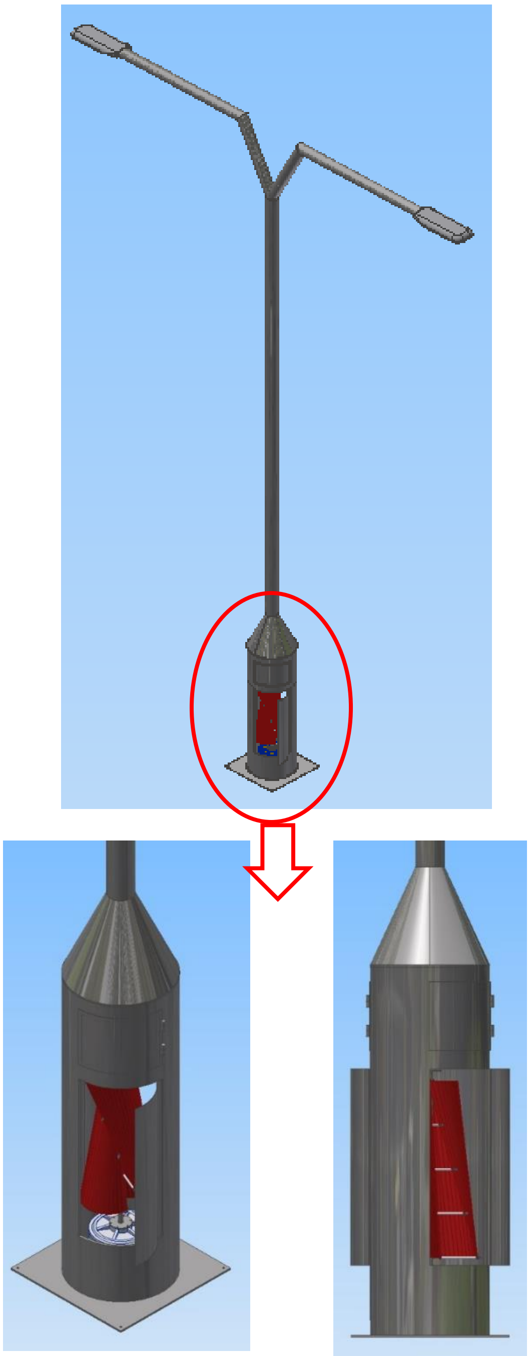


Figure 5. First model of lighting base

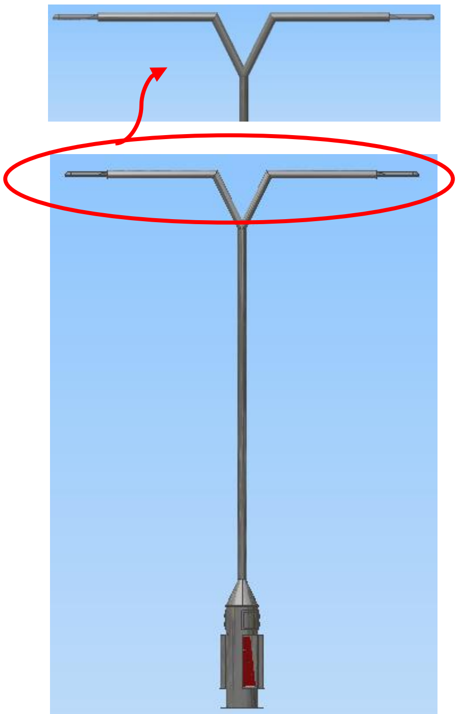


Figure 6. Lighting unit in first model

TABLE 2. Analysis of power generation in the first model base on lighting

Models	Power generation, W
First Model without FGS and SP (A)	400
First Model with FGS and without SP (B)	600
First Model without FGS and with SP (C)	650
First Model with FGS and SP (D)	850

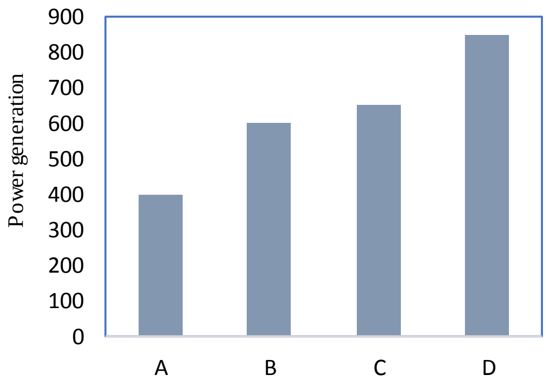


Figure 7. Comparison of power generation in the first model based on lighting

2. 2. Second Model The novelty in the second model was based on using four wind turbine units without guidance system of air flow according to Figure 9. So, air flow of the movement of different vehicles and free air flow applied on wind turbines. Three dimensional of second model illustrated in Figure 10. Power supply unit and lighting unit designed in down and top of lighting base that represented in Figures 8 and 11.

According to Table 3 and Figure 10, power generation in second model based on lighting with modification on quantity of vertical wind turbines

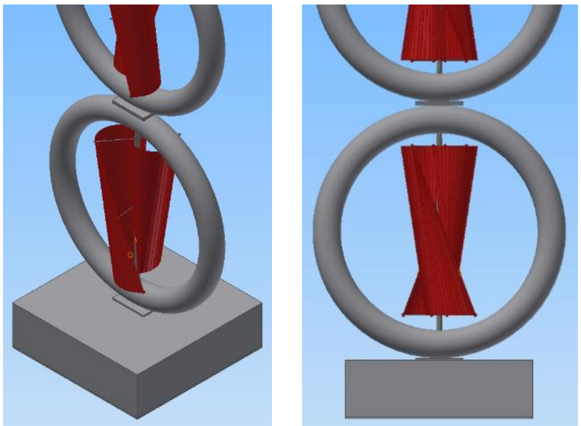


Figure 8. Power supply unit in second model

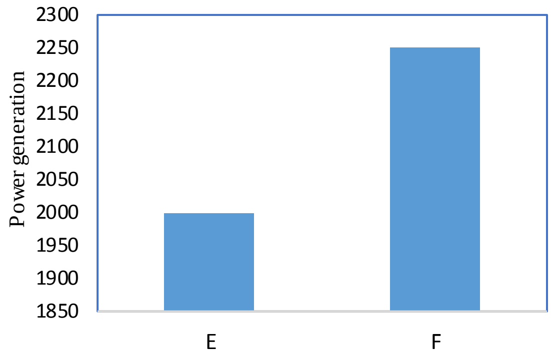


Figure 10. Comparison of power generation in second model based on lighting

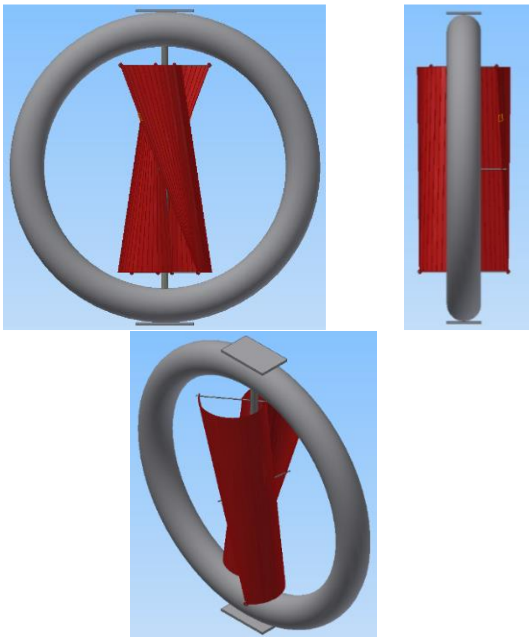


Figure 9. Wind turbine unit in second model

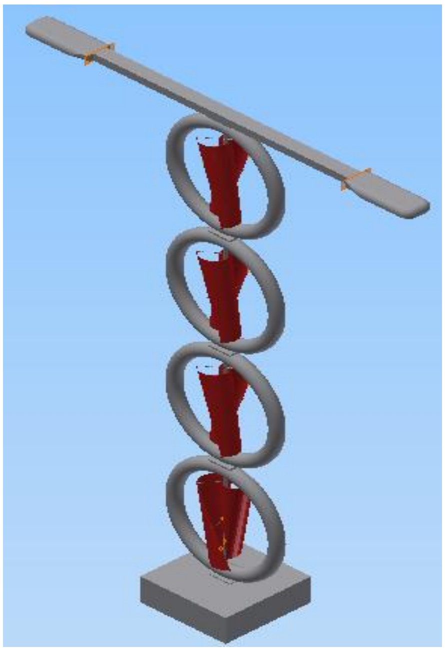


Figure 11. Second model of lighting base

(VWT) and presented with solar panel (SP). This model does not have the fixed guidance systems (FGS) and automatic guidance systems (AGS) of fluid flow.

2. 3. Third Model In this design, wind turbines are used at regular and independent intervals using an automatic system for directing the fluid flow due to the movement of various vehicles in different dimensions to provide street lighting. According to Figure 13, the height of the lighting base is about 7 *m* and its diameter is about 80 *cm*. The present lighting base, is completely independent of the city electricity and consists of 4 basic parts that is described as follows:

TABLE 3. Analysis of power generation in second model based on lighting

Models	Power generation
Second Model with four VWT and without SP (E)	2000 w
Second Model with four VWT and with SP (F)	2250 w

2. 3. 1. Wind Turbine Unit The lighting base in the present design uses four wind turbines to take advantage of the fluid flow of the movement of various vehicles as shown in Figure 14. According to Figure 15, the wind turbines embedded in the lighting base are completely independent of each other for more performance. So each turbine is installed at different heights to take advantage of the fluid flow using the movement of various vehicles.

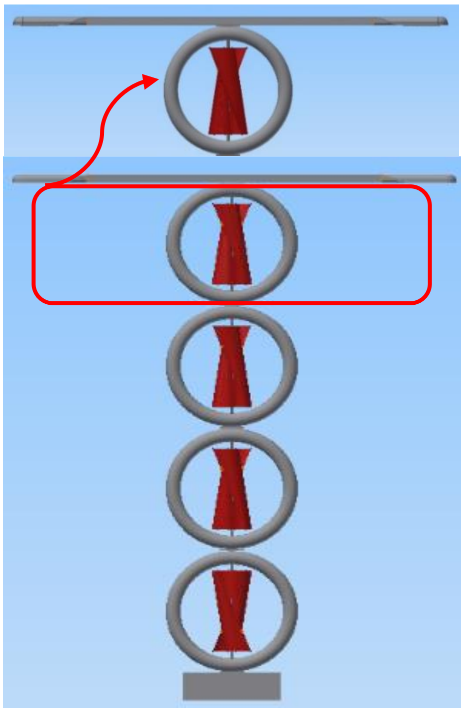


Figure 12. Lighting unit in second model

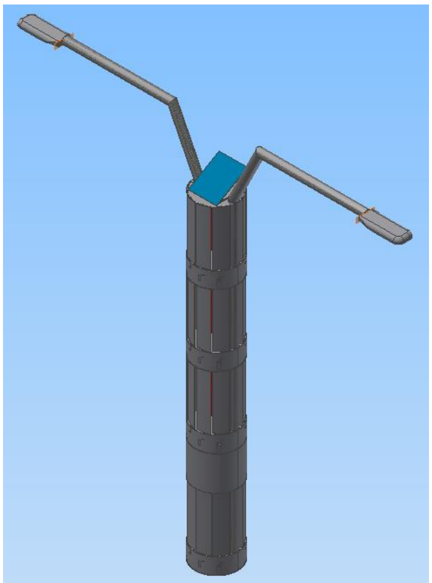


Figure 13. Third model of lighting base

In this section, according to Figure 16, semilunar plates have been used to direct the fluid flow with larger volume to the wind turbine. In each of these turbines, eight semilunar plates have been used, and the rotational motion of each of these plates will be performed in the control unit. Also, in each unit of wind turbine, four rectangular plates are installed next to the body of the lighting base in pairs and with a specific angle, so, its application will be explained in control unit.

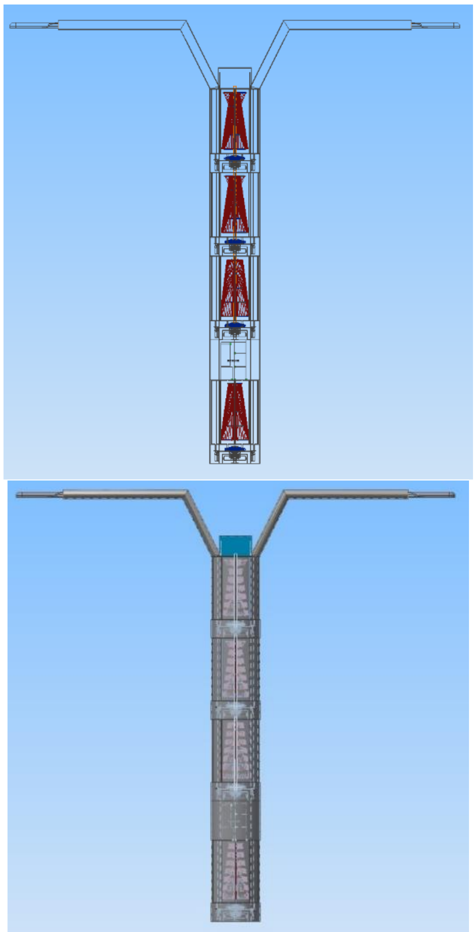


Figure 14. Inside view of third model

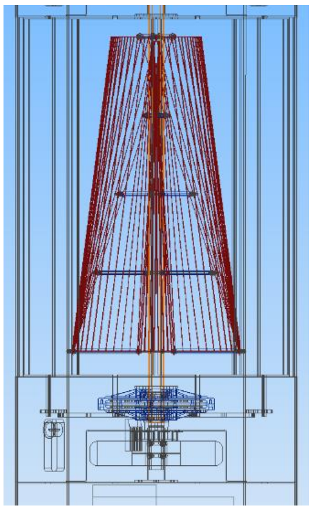


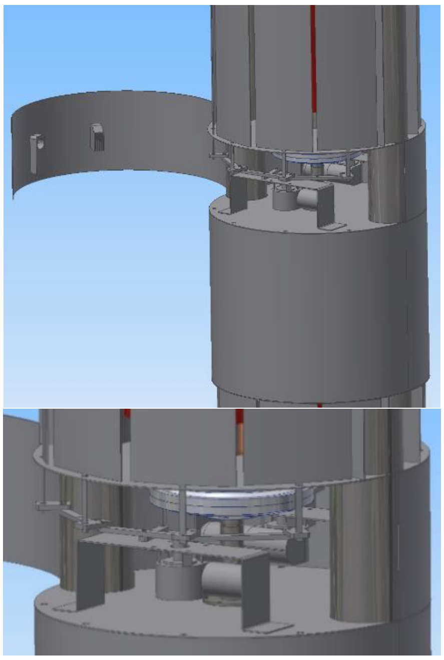
Figure 15. Wind turbine unit in third model

2. 3. 2. Control Unit Due to the fact that in urban areas the velocity of air flow due to the movement of cars is slow, so the use of wind turbines will be challenged in practice. On the other hand, in some areas, due to stormy

Figure 16. Automatic guidance system of fluid flow in third model

weather, the intensity of the air flow may be so more that it causes the blades to rotate too much and the wind turbine to fail. To solve these problems, the current lighting base uses an automatic guidance system for airflow, according to Figure 17. The operation of this system, which some parts is in the control unit and another parts in the wind turbine unit, is described as follows.

First, according to Figure 18, using the anemometers that are installed on the door, the direction and velocity of air flow that is caused by the movement of various vehicles and natural wind is measured. The stored information from the anemometer is transferred to the analog input of the PLC device. The PLC device is installed on the door. According to the program code



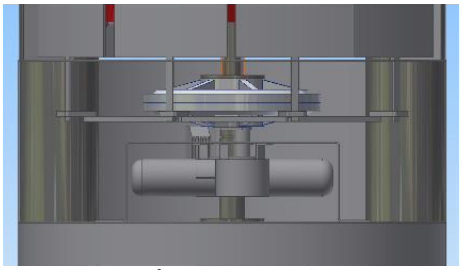


Figure 17. Details of automatic guidance system of fluid flow

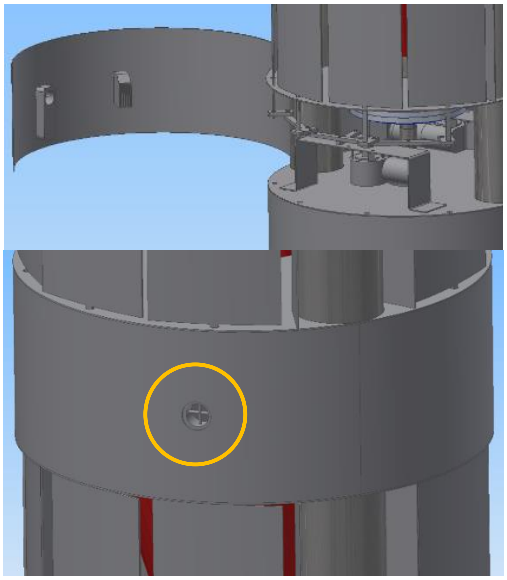


Figure 18. Anemometer and plc on the door

written in this device, in accordance with the speed and direction of the air fluid caused by the movement of the vehicle and the natural air flow, the desired commands and instructions are transmitted to the engine installed in the control unit. Each of semilunar plates, according to the velocity and direction of the air flow, is located in a direction that transmits the maximum air flow rate to the wind turbine so that the wind turbine has the maximum efficiency in order to supply electricity. Also, in cases where the intensity of the air flow is so more (such as storm air), according to the program code that defined in the PLC device, order to the semilunar plates to close in a circular direction and be closed. So, prevent the air flow from entering the wind turbine completely. These components help to completely close the semilunar plates in unfavorable weather conditions and the air flow is sufficient to rotate the turbine blades. Moreover, in this unsuitable condition, the turbine can provide the desired fluid flow and efficiency without decreasing. As a result, in unfavorable weather conditions, not only the additional costs decreased, also, electricity can be generated for the intended use.

2. 3. 3. Power Supply Unit In this unit, an inverter is used to convert the DC current of the photovoltaic cell to the AC current. Also, 4 batteries are used to store energy and one charge controller is used to control the charge of the batteries. according to Figure 19, for controlling, maintenance and repair of electrical equipment, this compartment includes two separate doors. One door has direct access to the inverter and the second door access to other electrical equipment in the enclosure. The number of batteries used varies according to the amount of electricity stored in them for use in the lighting base and other uses. The position of the electrical equipment housing will change according to the installation position of the lighting base and can be moved to the ground with the nearest wind turbine.

2. 3. 4. Solar Panel and Lighting Unit This part of the lighting base is intended to complete the design and achieve maximum energy from renewable sources. According to Figure 20, the desired solar panel with dimensions of 530 × 670 mm^2 is installed on top of the last wind turbine. The location and direction of the solar panel is considered appropriate to the position of the sun's radiations at the desired angle and direction.

In the present design, two sets of LED lighting with low energy consumption and high exposure have been used. The choice of power consumption for each of these lamps is determined by the height of the lighting base and its position.

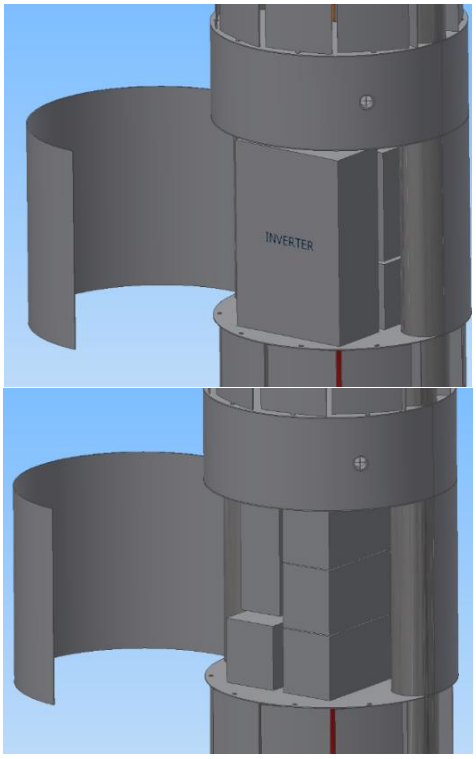


Figure 19. Power supply unit in the third model

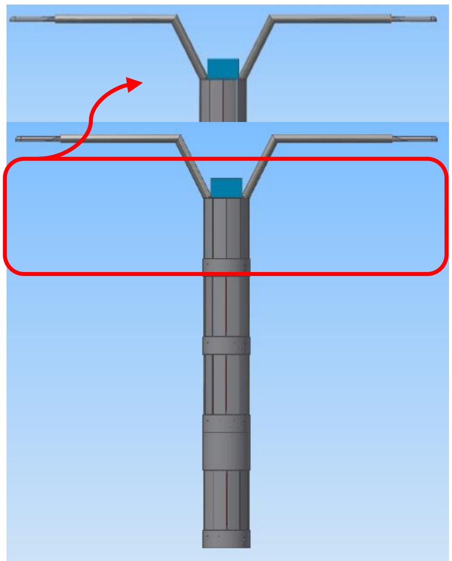


Figure 20. Lighting unit in the first model

Table 4 and Figure 21, represent power generation of the third model based on lighting base with modification on quantity of vertical wind turbines (VWT), solar panel (SP) and automatic guidance systems (AGS) of fluid flow as illustrated below:

Figure 22, illustrates power generation for ten cases of the third model based on lighting. According to this

TABLE 4. Analysis of power generation in all models of lighting base

Models	Power generation
Third Model without AGS and SP (G)	1600 W
Third Model without AGS and with SP (H)	1850 W
Third Model with AGS and without SP (I)	2800 W
Third Model with AGS and SP (K)	3050 W

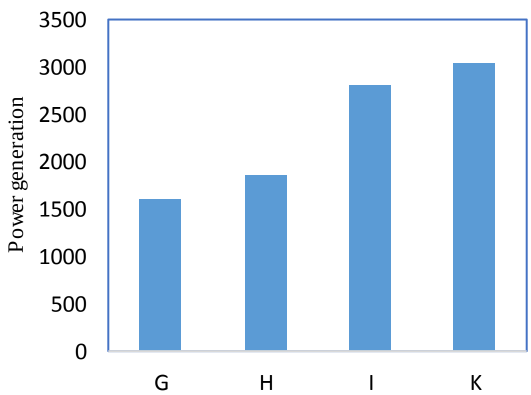


Figure 21. Comparison of power generation in the third model based on lighting

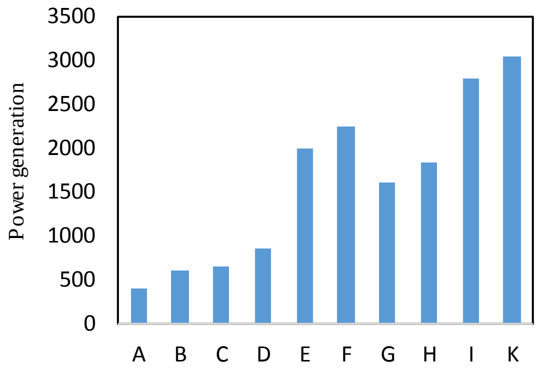


Figure 22. Comparison of power generation between all models based on lighting

figure, the third model based on lighting with automatic guidance systems (AGS) of fluid flow and solar panel (SP) has maximum power generation of 3050 W. Also, comparison between the third and second models with four vertical wind turbines (VWT) and solar panel (SP), power generation has increased by 35.55%.

3. CONCLUSION

study represented the basic methods of lighting in the streets and highways to supply and store electricity completely independent of municipal electricity. The stored energy used for charging the batteries of electric cars and lighting the resort stations. The heights of lighting base and wind turbine unit are 7m and 1 m, respectively. Also, the height of control unit and energy supply unit is 0.3 and 0.65 m, respectively. So, critical results summarized as follows:

- Unlike previous lighting base, in the current design, the wind turbine is integrated on the body of the lighting base. This integration of the design reduces the cost of body construction and power supply, as well as increases the beauty of the lighting base.
- In the present design, several independent wind turbines are installed on the body, which can be used to the fluid flow of all vehicles movement with different dimensions to increase the efficiency of the power generation system.
- In the present design, an automatic system for directing the fluid flow to the wind turbines has been used to increase the efficiency in supplying electricity, which was not installed in the previous designs of this system.
- In the previous designs, in unfavorable weather and storm conditions due to high rotation of the blades, the wind turbine had to be controlled to cause less damage to it, but in the present system, in addition to not damaging the wind turbine, also the turbine can continue to operate and generate electricity.
- Comparison between the third model based on lighting with automatic guidance systems (AGS) of fluid flow and solar panel (SP) and the second model with four vertical wind turbines (VWT) and solar panel (SP), power generation has increased by 35.55 %.
- Using of the automatic guidance systems (AGS) of fluid flow in the third model based on lighting, the power generation has increased by 64.86 %.

4. REFERENCES

1. Chinforoush, N., and Latif Shabgahi, Gh., "A Novel Method for Forecasting Surface Wind Speed using Wind-direction based on Hierarchical Markov Model." ***International Journal of Engineering, Transactions B: Applications,*** Vol. 34, No. 2, 414-426, (2021). DOI: 10.5829/IJE.2021.34.02B.13
2. Reza Kashyzadeh, K., Mousavi Bafrouyi, S. M., and Khorsandijou, S. M., "Effects of Road Roughness, Aerodynamics, and Weather Conditions on Automotive Wheel Force." ***International Journal of Engineering, Transactions B: Applications***, Vol. 34, No. 2, 536-546, (2021). DOI: 10.5829/IJE.2021.34.02B.27
3. Peiravi, M. M., Alinejad, J., Ganji, D. D., and Maddah, S., "3D optimization of baffle arrangement in a multi-phase nanofluid natural convection based on numerical simulation." ***International Journal of Numerical Methods for Heat & Fluid Flow,*** Vol. 30, No. 5, 2583-2605, (2020). DOI: 10.1108/HFF-01-2019-0012
4. Peiravi, M. M., Alinejad, J., Ganji, D. D., and Maddah, S., "Numerical study of fins arrangement and nanofluids effects on three-dimensional natural convection in the cubical enclosure." ***Challenges in Nano and Micro Scale Science and Technology,*** Vol. 7, No. 2, 97-112, (2019). DOI: 10.22111/TPNMS.2019.4845
5. Peiravi, M. M., and Alinejad, J., "Nano particles distribution characteristics in multi-phase heat transfer between 3D cubical enclosures mounted obstacles." ***Alexandria Engineering Journal,*** Vol. 60, No. 6, 5025-5038, (2021). DOI: 10.1016/j.aej.2021.04.013
6. Marchione, F., "Analytical Stress Analysis in Single-lap Adhesive Joints under Buckling." ***International Journal of Engineering, Transactions B: Applications,*** Vol. 34, No. 2, (2021), 313-318. DOI: 10.5829/IJE.2021.34.02B.02.
7. Martynyuk, V. V., Voynarenko, M. P., Boiko, J. M., and Svistunov, O., "Simulation of Photovoltaic System as a Tool of a State's Energy Security." ***International Journal of Engineering, Transactions B: Applications,*** Vol. 34, No. 2, 487-492, (2021). DOI: 10.5829/IJE.2021.34.02B.21
8. Ganji, D. D., Peiravi, M. M., and Abbasi, M., " Evaluation of the heat transfer rate increases in retention pools nuclear waste." ***International Journal of Nano Dimension,*** Vol. 6, No. 4, 385-398, (2015). DOI: 10.7508IJND.2015.04.007
9. Alinejad, J., and Peiravi, M. M., " Numerical analysis of secondary droplets characteristics due to drop impacting on 3D cylinders considering dynamic contact angle." ***Meccanica,*** Vol. 55, 1975–2002, (2020). DOI: 10.1007/s11012-020-01240-z
10. Asadollahzadeh, M., Torkaman, R., and Torab-Mostaedi, M., "Optimization of Green Technique Develop for Europium (III) Extraction by using Phosphonium Ionic Liquid and Central Composite Design Approach." ***International Journal of***

Engineering, Transactions B: Applications, Vol. 34, No. 2, 508-516, (2021). DOI: 10.5829/IJE.2021.34.02B.24

11. Peiravi, M. M., and Alinejad, J., " Hybrid conduction, convection and radiation heat transfer simulation in a channel with rectangular cylinder." ***Journal of Thermal Analysis and Calorimetry,*** Vol. 140, 2733–2747, (2020). DOI: 10.1007/s10973-019-09010-0
12. Pasha, P., Nabi, H., Peiravi, M. M., Pourfallah, M., and Ganji, D. D., "The application of analytical methods in the investigation effects of Magnetic parameter and Brownian motion on the fluid flow between two equal plates." ***International Journal of Engineering, Transactions A: Basics,*** Vol. 34, No. 10, 2341-2350, (2021). DOI: 10.5829/IJE.2021.34.10A.15
13. Jond., H. B., Platoša, J., and Sadreddini, Z., "Autonomous Vehicle Convoy Formation Control with Size/Shape Switching for Automated Highways." ***International Journal of Engineering, Transactions B: Applications,*** Vol. 33, No. 11, 2174-2180, (2021). DOI: 10.5829/IJE.2020.33.11B.07
14. Zhang., J., Ai, Z., Guo, L., and Cui, X., "Reliability Evaluation of a Disaster Airflow Emergency Control System Based on Bayesian Networks." ***International Journal of Engineering, Transactions B: Applications,*** Vol. 33, No. 11, 2416-2424, (2019). DOI: 10.5829/IJE.2020.33.11B.32
15. Umana, U. S., Ebong, M. S., and Godwin, E. O., "Biomass Production from Oil Palm and Its Value Chain." ***Journal of Human, Earth, and Future,*** Vol. 1, No. 1, (2020). DOI: 10.28991/HEF-2020-01-01-04
16. Kerich, E. C., " Households Drinking Water Sources and Treatment Methods Options in a Regional Irrigation Scheme." ***Journal of Human, Earth, and Future,*** Vol. 1, No. 1, (2020). DOI: 10.28991/HEF-2020-01-01-02
17. Ha, K., " Innovative Blade Trailing Edge Flap Design Concept using Flexible Torsion Bar and Worm Drive." ***HighTech and Innovation Journal,*** Vol. 1, No. 3, (2020). DOI: 10.28991/HIJ-2020-01-03-01
18. Sawant, M., Thakare, S., Prabhakara Rao, A., Feijóo-Lorenzo, A. E., and Bokde, N. D., " A Review on State-of-the-Art Reviews in Wind-Turbine- and Wind-Farm-Related Topics." ***Energies,*** Vol. 14, No. 8, (2021). DOI: 10.3390/en14082041

Persian Abstract

چکیده

در این اختراع، طرح پیشنهادی جهت تامین نیروی برق روشنایی خیابان ها با کمک حرکت انواع وسایل نقلیه به همراه سیستم خودکار جهت هدایت جریان سیال هوا ارایه گردیده است. در طرح حاضر برخلاف طرح های پیشین، توربین های بادی بر روی بدنه پایه روشنایی به طور یکپارچه نصب شده اند که می توان هزینه ساخت را نسبت به طرح های پیشین کاهش داد و از حرکت جریان سیال هوای تمام خوردوها با ابعاد مختلف جهت بالابردن بازدهی سیستم استفاده کرد. همچنین در طرح حاضر از سیستم خودکار جهت هدایت جریان سیال هوا به توربین های بادی برای افزایش بهره وری در تامین انرژی الکتریسیته استفاده شده است که در طرح های قبلی این سیستم تعبیه نشده بود. از قابلیت های دیگر این سیستم می توان به تولید انرژی الکتریسیته در شرایط نامناسب جوی و طوفانی اشاره کرد برخلاف طرح های پیشین که می بایست توربین بادی را در این شرایط نامناسب متوقف می کردند تا آسیب کمتری به آن وارد شود.