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IMPACT OF COMPACT URBAN MORPHOLOGY ON WIND BEHAVIOR USING CFD FOR SUSTAINABLE DEVELOPMENT

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ABSTRACT

The growing global interest in reducing energy consumption has increased public awareness of raising energy efficiency and using more benign forms of energy. Meanwhile, compact development became a solution for the expected increase in population in cities where 70 percent of the total world population are expected to live by 2050. Despite its great role to enhance sustainability, it can also impact wind behavior and heat removal negatively that will result in increasing energy consumption. This paper studies the relation between urban morphology and wind behavior in compact urban communities to enhance energy efficiency by increasing potentials of generating power from small-scale wind turbines integrated inside cities for more sustainable development. The research is divided into two parts; the first part presents the impact of compact development and wind energy on sustainable urban communities in addition to the role of Computational Fluid Dynamics, CFD in urban microclimate. The second part investigates the impact of wind behavior and speed on both straight and broken streets with different urban blocks heights using ANSYS Fluent software as an application of CFD programs. The paper came out with recommendations related to urban morphology using street form and buildings heights to enhance wind behavior and speed inside compact urban communities.

KEYWORDS: Urban morphology, Wind behavior, Compact development, ANSYS Fluent, Wind energy.

1. INTRODUCTION

The current rate of unprecedented urbanization especially in the developing countries increases the importance of the environmental quality concern especially in urban level. Emissions from residential, industrial, commercial and institutional activities in addition to transport means increases air pollution and create negative

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impact on pedestrian comfort and urban microclimatic conditions [1]. Thus, understanding the relation between wind behavior and urban morphology in cities is important to provide innovative approaches that help in minimizing these negative impacts, besides enhancing the quality of life in the urban environment [2]. In addition, the growing concern among urban planners and architects in designing environmental friendly communities lead to increase the awareness of integrating renewable potentials inside cities [3] especially in compact ones.

This paper aims to conduct a better understanding of the relation between urban morphology and wind speed in compact urban communities, which in turn can help in increasing potentials of generating power from wind resources inside these communities. In order to achieve this, the paper is divided into two parts; the first part introduces compact development as an approach for sustainable urban communities and studies its relation with wind behavior besides the role of Computational Fluid Dynamics, CFD in urban microclimate and principles of generating power from wind energy to raise the energy efficiency of urban communities. The second part investigates impact of two different compact urban morphologies on wind behavior and speed using ANSYS Fluent software as a valid CFD program.

2. COMPACT DEVELOPMENT AS AN APPROACH FOR MORE SUSTAINABLE URBAN COMMUNITIES

According to the UN-Habitat in 2015, the increasing percentage of population living in cities is expected to increase from 54% in 2010 to 70% in 2050 [4] that will affect the expansion of many facilities in the urban communities (such as educational, health and residential facilities). Urban growth, which develops according to demands of dwelling, industry and business sectors, causes occupation of agricultural lands and forests. This uncontrolled and unplanned growth is defined as urban sprawl [5].

Urban sprawl is associate with negative impact on the built-up environment. While urban sprawl increases, awareness of new approaches such as smart growth and new urbanism increases. Smart growth strategies aim to control sprawl using the connection between transportation and land uses [6].

New urbanists advocate compact development as the main approach for smart growth to reduce urban sprawl and promote sustainable development. Hence, cities started to be oriented toward development plans that adapt mixed-use policies, providing public spaces that enhance the quality of life and promote non-motorized and mass transit modes. Therefore, the concept of compact cities was developed to improve efficiency and sustainability in cities [7].

2.1 Principles of Compact Urban development

Compact urban development is characterized by high buildings' density where small block sizes and mixed land use that reduce infrastructure and encourage accessibility of residents to services. Also, an integrated transport system is provided to minimize dependence on private vehicles and enhance walkability that promotes public health by encouraging daily physical activities [8]. It also conserves land as it slows the spread of low-density development, avoids fragmentation of wildlife habitat and losing farmland [9].

Thus, compact development affects urban morphology and meets sustainability requirements as it results in enhancing resource efficiency and minimizing energy activity patterns that reduce carbon emission and global warming in addition to improving biodiversity and human health [10]. Achieving sustainable and livable cities is strongly linked to the future of our planet nowadays [11].

2.2 Compact Healthy City

Despite the importance of compact development, its relationship with sustainability is not that simple [12] as high building density could also increase heat island effect, traffic congestion, local air pollution and reduces thermal comfort in addition to losing green or open spaces [13].

Hence, the expression of "Compact healthy city" appeared that requires development process characterized by higher density with mixed-use activities in the central area [14] besides being sensitive to the social, economic, and ecological considerations [15].

3. WIND ROLE IN COMPACT URBAN COMMUNITIES

The combined effects of global warming and urbanization can increase heat island intensity and decrease the quality of air in cities. Wind behavior has a great impact on urban heat island as decreasing wind speed lead to a significant reduction of natural ventilation and heat removal in urban areas as well as increasing the overall energy demand especially in hot regions. According to a study conducted on Athens in 2013, decreasing wind speed lead to double the cooling loads in urban areas because of the higher ambient temperatures [16].

Moreover, wind behavior is considered as the main factors that affect pollution dispersion in urban areas besides other factors such as the ratio between street width to building height, streets' orientation, the presence of intersections and building forms [17]. Previous numerical simulations of airflow and pollution dispersion in urban intersections concluded that the average pollutant concentration in an infinitely long street is significantly higher than that observed along a finite street [18].

Since high building densities in compact development cause stagnant air that leads to many health-related problems and higher energy demands for cooling, many factors should be considered in compact development especially in hot regions such as heat removal, ventilation and wind flow patterns inside the city.

4. RAISING ENERGY EFFICIENCY IN URBAN COMMUNITIES BY CONSIDERING WIND ENERGY

Energy consumption in buildings accounts for almost half of the total energy use [19]. So, an environmental friendly design becomes essential importance. Raising energy efficiency of cities in addition to relying on renewable energy becomes an important approach to achieve sustainability in cities.

Wind energy is broadly available as a source of renewable energy. It is considered as one of the most competitive renewable energy technologies with fossil-based systems. Generating power from wind resources has increased rapidly worldwide. In Egypt, according to the Egyptian Energy Strategy, the targeted contribution of wind energy is 14% by 2035 from the total energy generated in the country as shown in Fig. 1 [20].

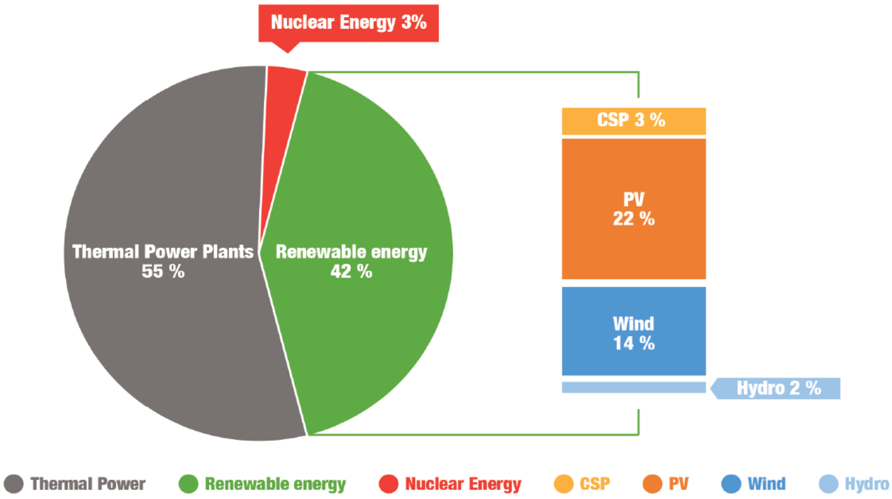

Fig. 1. Egyptian electricity production in 2035, [20].

There are two main points that should be considered regarding generating power from wind turbines [21] as shown in Fig. 2:

- Increasing the rotor diameter of wind turbines will result in a greater than proportional change in the rated power.
- The generated power is directly proportional to the cube of wind speed. This means that doubling the wind speed will result in roughly eight-time increase in the generated power.

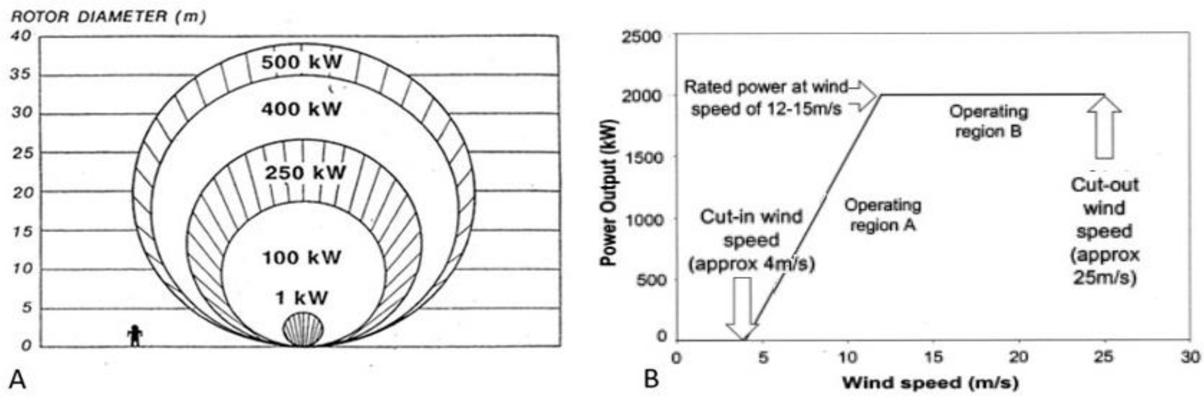

Fig. 2. A) Rotor diameter versus output generated power, B) Wind speed versus generated power output, [21].

Accordingly, wind speed profile analysis in the built-up environment has a major impact on the output power of wind turbines installed inside urban environment.

5. ANSYS FLUENT AS A CFD TOOL FOR STUDYING WIND BEHAVIOR IN URBAN COMMUNITIES

CFD is the field that uses computer resources to simulate airflow related problems. ANSYS Fluent is one of CFD software application tools. It is an American computer-aided engineering software used by engineers for designing and analyzing model flow, turbulence and heat transfer in a virtual environment. CFD can resolve the transfer of heat and wind and their interaction with individual obstacles such as buildings. Also, a significant increase in using CFD analysis of urban microclimate over the years has been documented [22].

Early CFD microclimate studies were conducted for model development. However, later studies were conducted as a predictive methodology. Different aspects (such as economy) and different buildings scales (ranging from the meteorological mesoscale over the microscale, building and indoor scales) can be linked up with results from CFD simulations. Thus, an important role in transferring urban climate knowledge into engineering and design practice can be introduced by computational simulation.

Wind flow patterns, ventilation inside the city and heat removal in human settlements can be strongly impacted by many elements of urban morphology in the built-up environment [23] such as streets forms and orientations, building's heights to street width ratio [24], networks of open spaces and walkways [25], buildings forms, spacing between them and solid to void ration [26]. However, the scope of this paper is limited on studying impact of streets form and buildings heights on wind behavior as a sample of changing urban morphology.

6. IMPLEMENTATION

This section investigates impact of changing both streets form and buildings heights in compact urban morphology on wind behavior using 3D wind analysis performed by ANSYS Fluent software through two different alternatives. Information for each alternative is indicated. Then, analysis and justifications of ANSYS Fluent are introduced. Finally, the results and recommendations are presented.

6.1 Alternatives Information

Two alternatives of compact urban morphologies with almost the same solid to void ratio are introduced for straight and broken streets with different urban blocks heights and relatively small blocks sizes (to enhance connectivity and encourage walkability). Alternative 1 indicated in Fig. 3 shows straight street where height of two buildings is higher than the surrounding. Alternative 2 indicated in Fig. 4 shows a broken street with an inclination angle of 45° with building heights at the inclination angle higher than the surroundings.

Each alternative will be analyzed through the following three wind cases (where inlet wind speeds and directions are variable):

- Case (A), inlet wind speed 7 m/s, wind direction parallel to the main street.
- Case (B), inlet wind speed 7 m/s, wind direction inclined 45° with the main street.
- Case (C), inlet wind speed 9 m/s, wind direction parallel to the main street.

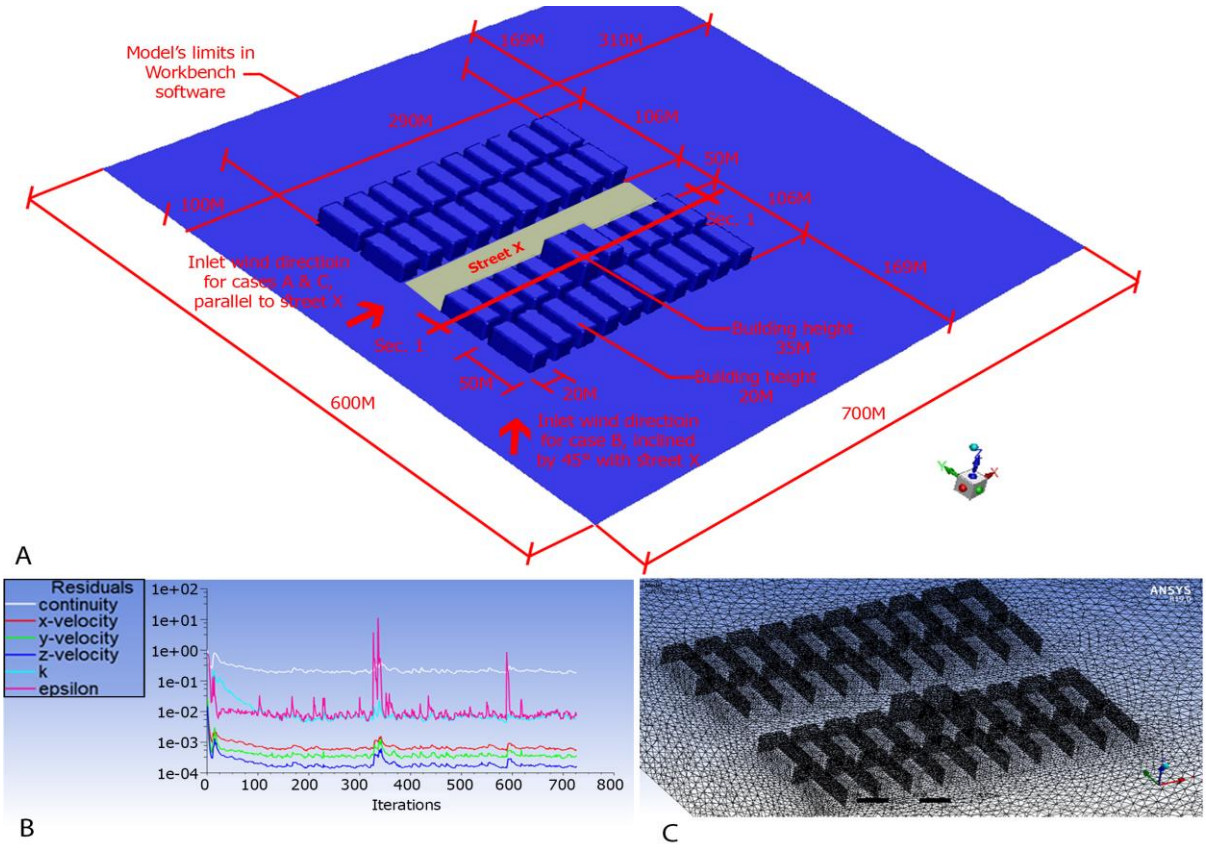

Fig. 3 Alternative 1, A) dimensions and inlet wind directions, B) Residuals by ANSYS Fluent software, C) Mesh by ANSYSWB module software.

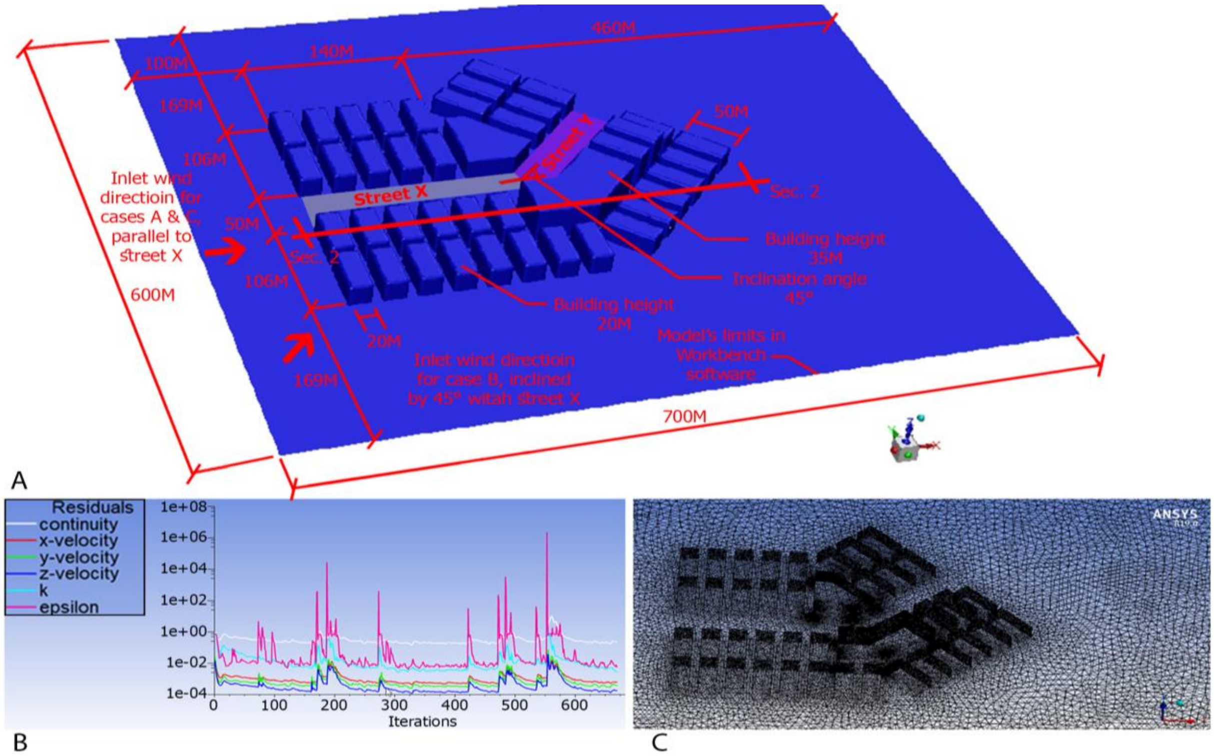

Fig. 4 Alternative 2, A) dimensions and inlet wind directions, B) Residuals by ANSYS Fluent software, C) Mesh by ANSYSWB module software.

Each alternative is identified through one physical property (urban form) and two virtual properties (Residuals and Mesh). Urban form indicates street's orientation and building's heights, while residuals show number of running model's iterations in k-ε model and mesh shows accuracy for ANSYS Fluent model as indicated in Table 1.

Table 1. Proprieties of each alternative.

	Alternative 1	Alternative 2
Urban form	• Straight street • Heights of low-rise buildings= 20M • Heights of high-rise buildings= 35M	• Broken street with inclination angle between street X and Y= 45°. • Heights of low-rise buildings= 20M • Heights of high-rise buildings= 35M
Residuals	• No. of iterations = 730	• No. of iterations= 680
Mesh	• No. of elements = 1,200,000 • No. of nodes = 220,000 • Maximum face size = 10 M • Minimum face size = 0.1 M	• Number of elements = 2,200,000 • Number of nodes = 380,000 • Maximum face size = 10 M • Minimum face size = 0.1 M

6.2 Alternatives Analysis

The below section introduces analysis and justifications of ANSYS Fluent software for the mentioned three wind cases on the two alternatives above both street level and buildings as a sample for the possible locations of installing small scale wind turbines in urban communities.

6.2.1 Studying wind speed magnitude above street level

ANSYS Fluent results performed at height 15 meters above street level for both alternative 1 shown in Fig. 5 and alternative 2 shown in Fig. 6 are indicated in this part.

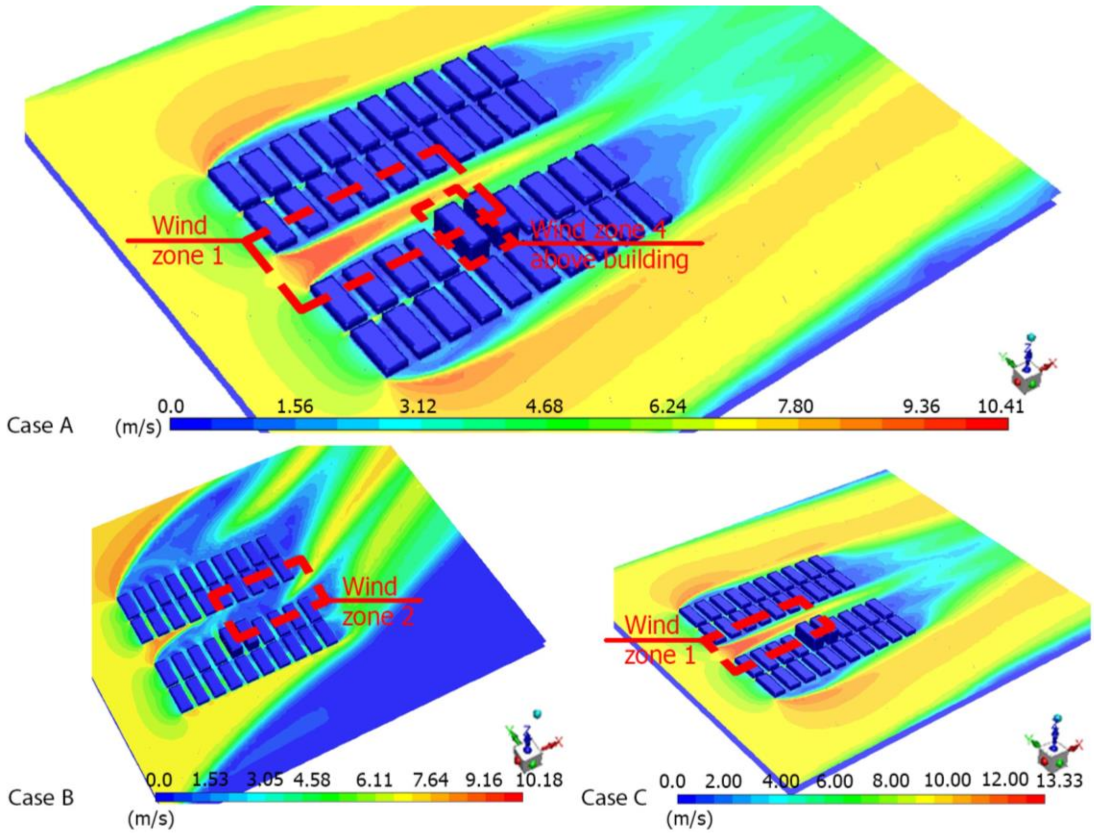

Fig. 5. Alternative 1, wind speed magnitude at height 15 m above street level in ANSYS Fluent software (version19) showing wind zones 1, 2 and 4.

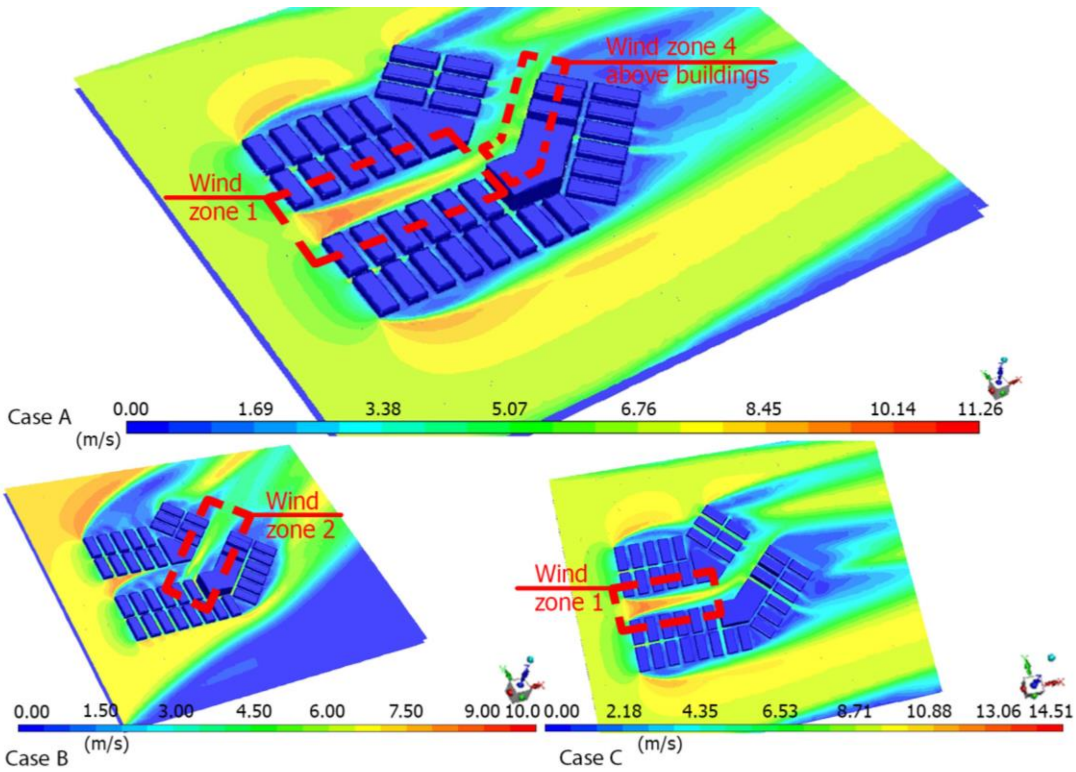

Fig. 6. Alternative 2, wind speed magnitude at height 15 m above street level in ANSYS Fluent software (version19) showing wind zones 1, 2 and 4.

- In cases A and C indicated in alternative 1 (shown in Fig. 5) and alternative 2 (shown in Fig. 6):
  - Although the inlet wind velocity is 7 and 9 m/s respectively, maximum wind speed detected at the beginning of the main street reaches 10 m/s in case A and 13 m/s in case C (as indicated in wind zone 1) due to the solid (buildings) to void (street) ration and the relation between inlet wind direction and direction of the main street that increases the potentials of generating power from wind turbines installed in the median area which will also enhance ventilation above street level and pollution removal results from vehicles.
  - Wind speed has relatively low magnitudes between buildings due to their relatively narrow width (6-10 meters) compared with the block dimensions besides the relation between their orientation and the prevailing wind direction.

  - Wind speed is reduced gradually as street X (in alternative 1) gets longer and in street Y (in alternative 2) based on the surrounding building's heights as wind flow is blocked by buildings in the inlet wind direction.
- In case B indicated in alternative 1 (shown in Fig. 5), and alternative 2 (shown in Fig. 6):
  - In alternative 1 and in street X in alternative 2: changing wind direction with angle 45° with the main street leads to reduce wind speed to below 2 m/s (as wind flow is blocked by buildings in the inlet wind direction) but enhance wind speed in the intermediate streets between buildings compared to cases A and C.
  - In street Y in alternative 2: Wind speed magnitude increases to 7 m/s as indicated in wind zone 2 (as the prevailing wind direction is parallel to street Y) that enhance ventilation above street level and pollution removal results from vehicles.

6.2.2 Studying wind speed magnitude above buildings

ANSYS Fluent results performed at 45 meters below the main street's centerline for both alternative 1 (shown in Fig. 7), and alternative 2 (shown in Fig. 8) are indicated in this part.

- In cases A and C indicated in alternative 1 (shown in Fig. 7), and alternative 2 (shown in Fig. 8):
  - As indicated in wind zone 3: Wind speed reaches its maximum magnitude above buildings (10 m/s in case A and 13 m/s in case C) and reduced gradually as height increased until it reaches origin inlet wind speed. In addition, below 40 m height above street level wind speed has very low magnitude (below 1.5 m/s in case A and 2 m/s in case C) for 120 m behind the wind collision point with buildings due to the existence of wind turbulence, then increases to 6 m/s in case A and 8 m/s in case C after 120 m as wind turbulence effect reduced gradually.
  - As indicated in wind zone 4: Wind speed increases above high-rise buildings (with height 35 M) that reaches 9 m/s in cases A and 11.5 m/s in case C. Increasing buildings height allows installing wind turbine in a better wind zone

above them but low wind speed magnitudes in the leeward wind direction is occurred due to blocking wind flow by these relatively high-rise buildings.

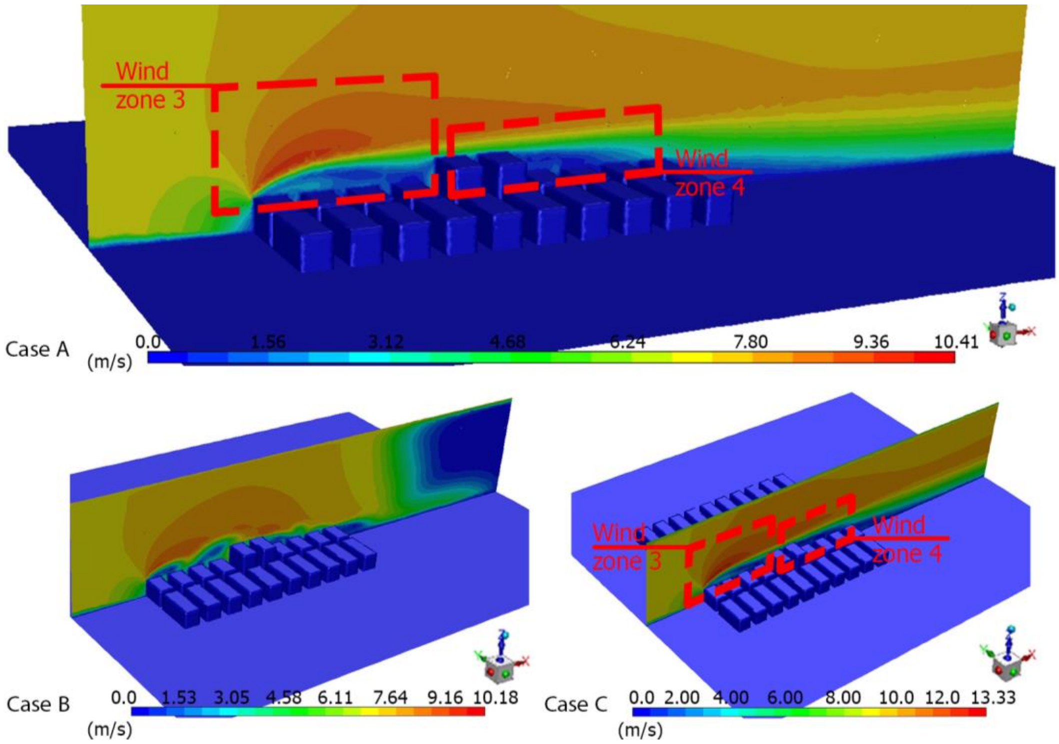

Fig. 7. Alternative 1, wind speed magnitude at section 1 in ANSYS Fluent software (version19) showing wind zones 3 and 4.

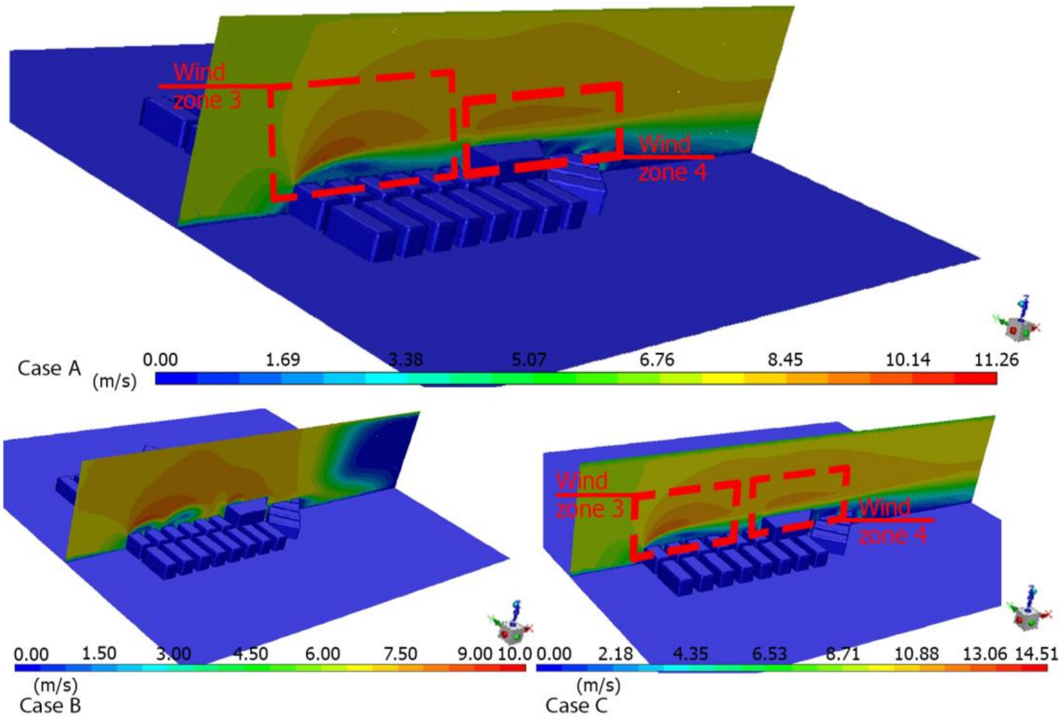

Fig. 8. Alternative 2, wind speed magnitude at section 2 in ANSYS Fluent software (version19) showing wind zones 3 and 4.

- In case B indicated in alternative 1 (shown in Fig. 7) and alternative 2 (shown in Fig. 8):
  - Area below 40 m height above street level in both alternatives 1 and 2: Wind speed is negatively impacted by buildings in the inlet wind direction that reduce wind speed down to 1.5 to 6 m/s, wind turbulence is also detected (negative impact for turbulence could be ignored starting from 35 m height), in addition to the reduced wind velocity this situation complicates generating power from wind resources and will not enhance ventilation in the city nor pollution removal results from vehicles.
  - Area above 40 m height above street level in both alternatives 1 and 2: Wind speed increases especially above high-rise buildings (reaches 9 m/s) as the negative impact of high-rise building is reduced that could be considered in generating power from wind resources, enhance ventilation in the city and pollution removal results from vehicles.

6.3 Results and Recommendations

From the previous analysis conducted by ANSYS Fluent software on the two alternatives with three wind cases for each, the below results and recommendations were concluded related to compact urban morphology to enhance wind behavior and speed that will consequently lead to increase potentials of generating power from small scale wind turbines integrated inside it:

- Adjusting streets orientations to be parallel to the prevailing wind direction and locating open spaces in front of them lead to enhance wind behavior in addition to increase wind speed by 3-4 m/s (40% - 45%) in specific areas above both street level and buildings as indicated in wind zone 1 and 3 shown in Figs. 5 to 8.
- In locations where prevailing wind directions are changing with an average inclination angle of 45°, wind behavior and speed in the broken street (with an inclination angle similar to the average change in wind direction) is better

than that in straight street (oriented toward the prevailing wind direction) above both street level and buildings as stated below:

- Above street level: In both cases A and C, wind speed magnitude in the back area of alternative 1 and in street Y in alternative 2 are almost the same. However, in case B a major difference in wind speed magnitude is detected between these two areas (1.5 m/s in the back area of alternative 1 and 7 m/s in street Y in alternative 2) as indicated in wind zone 2 (shown in Figs. 6 and 7) this difference occur as the inlet wind direction is parallel to street Y.
- Above buildings: Changing the location of the high-rise buildings (with height 35 m) to be as indicated in alternative 2 (instead of alternative 1) lead to increase area of high wind speed magnitude (9 m/s in cases A and B and 11.5 m/s in case C) above these high-rise buildings that face prevailing wind direction. In addition to reduce area of low wind speed magnitude (1 m/s) in the leeward wind direction of these high-rise building as indicated in wind zone 4 shown in Figs. 5 to 8. This will allow more wind turbines to be installed a better wind zone.

- Wind turbines should not be installed in location where wind turbulence occurs in the urban areas as wind speed magnitude becomes very low. Figure 9 below indicates this low wind speed zone in alternatives 1 and 2.

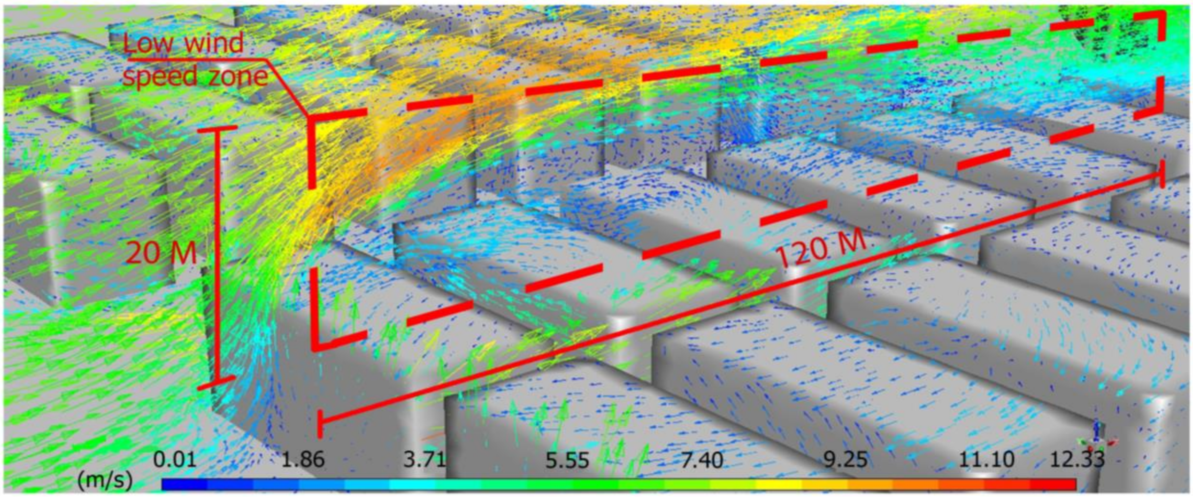

Fig. 9. Low wind speed zone created above buildings in alternatives 1 and 2 by ANSYS Fluent software (version19), inlet wind velocity 7m/s.

7. CONCLUSIONS

This research attempted to study the interactive relation between urban morphology and wind behavior in compact urban communities to enhance energy efficiency by increasing potentials of generating power from small scale wind turbines integrated inside cities for more sustainable development.

By analyzing 3D wind results performed by ANSYS Fluent software on two different alternatives with three wind cases for each, it was verified that changing street form and buildings heights (as a sample of changing urban morphology) has a major impact on wind behavior and speed based on potentials of generating power from wind turbines besides their effect on ventilation, heat removal, reducing heat island effect (especially for those located in hot climate zones) and pollution dispersion inside the city.

Recommendations related to urban morphology to enhance wind behavior and speed in compact urban communities are introduced to increases potentials of generating power from small scale wind turbines integrated inside it.

This paper emphasizes the importance of using CFD applications (such as ANSYS Fluent software) in urban areas as an approach that could assist urban designers and urban planners through the design and planning process to improve wind behavior in compact urban communities. In addition, these applications can also be used to determine the exact locations to install wind turbines in either the already existing urban areas or the newly planned ones. This will result in generating more energy from renewable and clean resources that will reduce carbon emissions, enhance the environmental and air quality inside the city and accordingly human health.

DECLARATION OF CONFLICT OF INTERESTS

The authors have declared no conflict of interests.

REFERENCES

1. Fenger, J., “Urban Air Quality”, Atmospheric Environment, Vol. 33, No. 29, pp. 4877-4900, 1999.

2. Hang, J., Sandberg, M., and Li, Y., "Effect of Urban Morphology on Wind Condition in Idealized City Models", Renewable and Sustainable Energy Reviews, Vol. 43, pp. 869-878, 2009.
3. Abohela, I., Hamza, N., and Dudek, S., "Effect of Roof Shape, Wind Direction, Building Height and Urban Configuration on the Energy Yield and Positioning of Roof Mounted Wind Turbines", Renewable Energy, Vol. 50, pp. 1106-1118, 2013.
4. Buettner, T., "Urban Estimates and Projections at the United Nations: The Strengths, Weaknesses, and Underpinnings of the World Urbanization Prospects", Springer International Publishing, United Nations, Berlin, Germany, 2015.
5. Hanif, I., "Impact of Fossil Fuels Energy Consumption, Energy Policies, and Urban Sprawl on Carbon Emissions in East Asia and the Pacific: A Panel Investigation", Energy Strategy Reviews, Vol. 21, pp. 16-24, 2018.
6. Moonen, P., Defraeye, T. Dorer, V. Blocken, B., and Carmeliet, J., "Urban Physics: Effect of the Micro-Climate on Comfort, Health and Energy Demand", Frontiers of Architectural Research, Vol. 1, No. 3, pp. 197-228, 2012.
7. Susanti, R., Soetomo, S., Buchori, I., and Brotosunaryo, P., "Smart Growth, Smart City and Density: in Search of the Appropriate Indicator for Residential Density in Indonesia", Social and Behavioral Sciences, Vol. 227, pp. 194-201, 2016.
8. Bibri, S. E., Krogstie, J., and Kärrholm, M., "Compact City Planning and Development: Emerging Practices and Strategies for Achieving the Goals of Sustainability", Developments in the Built Environment, Vol. 4, pp. 101-121, 2020.
9. Mouratidis, K., "Compact City, Urban Sprawl, and Subjective Well-Being", Cities, Vol. 92, pp. 261-272, 2019.
10. Roychansyah, M. S., "Paradigma Kota Kompak: Solusi Masa Depan Tata Ruang Kota?", INOVASI, Vol. 7, pp. 19-27, 2006.
11. Elekwa, A. K., "Innovative Urban Interventions as an Approach for Livable and Sustainable Cities", Journal of Engineering and Applied Science, Vol. 66, No.3, pp. 355-378, 2019.
12. Chen, H., Jia, B., and Lau, S., "Sustainable Urban Form for Chinese Compact Cities: Challenges of a Rapid Urbanization Economy", Habitat International, Vol. 32, pp. 28-40, 2008.
13. Tappert, S., Klöti, T., and Drilling, M., "Contested Urban Green Spaces in the Compact City: The (Re-) Negotiation of Urban Gardening in Swiss Cities", Landscape and Urban Planning, Vol. 170, pp. 69-78, 2018.
14. Burton, E., "The Compact City: Just or Just Compact? A Preliminary Analysis", Urban Studies, Vol. 37, pp. 1969-2001, 2001.
15. Saniroychansyah, M., Farmawati, A., Anindyah, D. S., and Atianta, L. "Urban Compactness Effects on the Distributions of Healthy Houses in Yogyakarta City", Social and Behavioral Sciences, Vol. 227, pp. 168-173. 2016.

16. Tong, Z., Chen, Y., and Malkawi, A. “Defining the Influence Region in Neighborhood-Scale CFD Simulations for Natural Ventilation Design”, Applied Energy, Vol. 182, pp. 625-633, 2016.
17. Yang, J., Shi, B., Shi, Y., Marvin, S., Zheng, Y., and Xia, G., “Air Pollution Dispersal in High Density Urban Areas: Research on the Triadic Relation of Wind, Air Pollution, and Urban Form”, Sustainable Cities and Society, Vol. 54, pp. 101941, 2020.
18. Soulhac, L., Garbero, V., Salizzoni, P., Mejean, P., and Perkins, R. J. “Flow and Dispersion in Street Intersections”, Atmospheric Environment, Vol. 43, pp. 2981-2996, 2009.
19. United States Green Building Council, “Leadership in Energy and Environmental Design Reference Guide for Green Building Design and Constriction”, version 4, Washington DC, 2013.
20. NREA, “Annual Report”, El Ahram printers, Egypt, 2018.
21. Smith, P., “Sustainability at the Cutting Edge”, 2nd Edition, Architectural press, Oxford, London, 2007.
22. Toparlar, Y., “A Review on the CFD Analysis of Urban Microclimate”, Renewable and Sustainable Energy Reviews, Vol. 80, pp. 1613-1640, 2017.
23. Allegrini, J., Carmeliet, J., “Coupled CFD and Building Energy Simulations for Studying the Impacts of Building Height Topology and Buoyancy on Local Urban Microclimates”, Urban Climate, Vol. 21, pp. 278-305, 2017.
24. He. Y., Tablada. A, and Wong. N., “Effects of Non-Uniform and Orthogonal Breezeway Networks on Pedestrian Ventilation in Singapore's High-Density Urban Environments”, Urban Climate, Vol. 24, pp. 460-484, 2018.
25. Mrkajića, V., and Anguelovskib, I., “Planning for Sustainable Mobility in Transition Cities: Cycling Losses and Hopes of Revival in Novi Sad”, Serbia, Vol. 52, pp. 66-78, 2016.
26. Azizi, M., and Javanmardi, K., “The Effects of Urban Block Forms on the Patterns of Wind and Natural Ventilation”, International high - performance built environment conference - A sustainable Built Environment Conference 2016 Series (SBE16), iHBE 2016, Energy Procedia Journal, Vol. 180, pp. 541-549, 2017.

تأثير التشكيل العمراني المتضام على سلوك الرياح باستخدام ديناميكا الموائع الحسابية لمدن أكثر استدامة

أدى الاهتمام العالمي المتزايد بخفض استهلاك الطاقة إلى زيادة الوعي العام برفع كفاءتها على مختلف المستويات الحضرية واستخدام أشكال أكثر اعتدالًا منها، وفي الوقت نفسه أصبحت التنمية العمرانية المتضامة حلاً للزيادة المتوقعة في النمو السكاني في المدن والتي تقدر بنسبة ٧٠ في المائة من إجمالي سكان العالم في منتصف هذا القرن. وعلى الرغم من الدور الكبير الذي تلعبه التنمية المتضامة في تعزيز الاستدامة، إلا أنها يمكن أن تؤثر أيضًا بشكل سلبي على سلوك الرياح وإزالة الحرارة في المجتمعات الحضرية مما يؤدي إلى زيادة استهلاك الطاقة. تدرس هذه الورقة العلاقة بين التشكيل العمراني وسلوك الرياح في المجتمعات العمرانية المتضامة من أجل زيادة كفاءة الطاقة عن طريق زيادة إمكانات توليد الطاقة من توربينات الرياح صغيرة الحجم داخل المدن لتحقيق تنمية أكثر استدامة. ينقسم البحث إلى قسمين؛ يتناول القسم الأول تأثير التنمية المتضامة وأسس توليد الطاقة من الرياح على المجتمعات العمرانية المستدامة بالإضافة إلى دور ديناميكا الموائع الحسابية في المناخ العمراني المحلي، ويبحث القسم الثاني في تأثير سلوك الرياح وسرعتها على كل من شارع مستقيم وأخر منكسر بارتفاعات مباني مختلفة باستخدام برنامج ANSYS Fluent كأحد تطبيقات برامج ديناميكا الموائع الحسابية. استنتجت الدراسة بعض التوصيات التي تتعلق بالتشكيل العمراني لشكل الشوارع وارتفاعات المباني لتحسين سلوك الرياح وسرعتها داخل المجتمعات العمرانية المتضامة.