# Bladeless wind turbines

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## Key Messages

- Urban areas have a high potential for wind energy which is a promising renewable energy resource in the power generation sector.
- Bladeless wind turbines are a completely new concept of wind turbine. It reduces investment, maintenance, and operation costs, which has great potential to bring benefits to investors.
- Barriers such as the low retail price of electricity and policy uncertainty should be considered to deploy this new trend in wind energy.
- Scenarios for future application include the deployment of bladeless turbines for energy generation of traffic equipment and hybrid renewable energy systems for improvement of the overall system efficiency.

## Introduction

*The bladeless wind turbine is a flexible cylindrical structure that harnesses wind energy from a resonance frequency between the system and air flow, which generates electricity through an alternator system.*

The impact of the current generation's energy consumption on the next generations poses issues that need to be effectively addressed. In 2018, global energy consumption peaked at 13,864.9 Mtoe. This year's increase in total energy consumption of 2.9%, which is double the average growth of the 10 preceding years, highlights the urgency and importance of these issues.[1] Facing this enormous problem, national governments need to work closely together to develop timely, coherent, and considered policies. Renewable energy plays an important role in mitigating and adapting to climate change in countries around the world.[2,3] Electricity generation from sustainable sources achieved 7% growth in 2020, accounting for a large proportion of the 3% increase in renewable energy use.[4] Renewable electricity generation in 2021 is expected to expand by more than 8% with a major contribution of solar photovoltaics (PV) and wind.[4]

Besides the obvious advantages of renewable energy, such as zero greenhouse gases (GHG) emissions and low operational costs, solar panels and wind turbines also have their own drawbacks. The use of solar panels raises enormous questions about expired solar cells, while wind turbines have been considered unsuitable for urban areas. Harnessing wind power in urban areas requires overcoming the disadvantages of vibration and noise as well as challenges related to the space of installation.[5] Bladeless wind turbines (BWT) are an advanced technology that converts wind energy to electrical energy in cities.

BWT can easily be deployed in urban areas and even integrated into the overall architecture of buildings.[3,4] The advantages of this approach are that it reduces noise, avoids intermittent shade effects, and prevents impacts on migratory birds.[6] Considered a solid-state wind energy transformer, the maintenance costs are generally lower than those of conventional wind turbines.[5] BWT can be combined with solar energy panels to form a hybrid system, which could be considered for increasing electrical power production and improving the system's overall efficiency.[5] Accordingly, BWT could be considered a sustainable solution for wind energy in cities.[7]

Occupying only vertical space, the cylindrical form of BWT was judged by experts to be suitable for implementation in residential areas.[7,8] With the advanced design, BWT would contribute to the modernity in urban architecture.[8]

In this policy brief, we aim to explore the opportunities and challenges, as well as investigate feasible scenarios, of implementing BWT technology. The policy brief is composed using the knowledge from a literature review and multi-stakeholder interviews.

## Current State

The innovative aspects of bladeless wind turbines and their capacity to produce electricity at low wind speeds under turbulent flow conditions in the city surroundings are the key factors that promote the deployment of this technology in built-up areas with significant potential for wind energy. Such areas in cities include rooftops of high-rise buildings, areas around multistory buildings, city roads, railway tracks and subway networks.[7]

*Figure 1. Structure of bladeless wind turbines*

Despite being in the prototype stage, the vortex bladeless has proven its value as a new wind energy technology particularly designed for on-site generation as it can be placed in an open environment or residential areas.[8] In addition, bladeless wind turbines can work on or off grid, along with solar panels or other generators.

Two commercial-scale bladeless turbines have been developed with generation capabilities of 100 W and 4kW. Smaller-scale turbines measure 3 meters in height and weigh only 10 kilograms but supply enough power for lighting and some utilities. Since such small turbines are not yet industrially produced, an investment is estimated to cost about $250.[9] Larger-scale turbines with a height of 13 meters and total weight of about 100 kilograms can generate continuous electricity for a house if installed in a location with enough wind. A tentative price for this model is evaluated to be about $5000.[9]

In addition to the two commercial models, development of a giant vortex turbine model is also underway. Such a bladeless turbine would measure 150 m in height and 100 tons in weight and was calculated to be able to generate 1MW.[21] The estimated costs for this model have not been determined yet but are expected to have a lower price in proportion to its capacity compared to the two smaller models.

The average cost of power generation per Watt for bladeless wind turbines may be higher than that for solar panels.[10] However, bladeless turbines are still economically attractive in windy regions where the system are able to function more effectively than solar panels do.

## Opportunities and Challenges

Urbanization and growth in economic activity are the cause of 75 percent of global primary energy consumed by urban areas, and around 60 percent of the world's total greenhouse gases are produced in cities.[11] Authorities need to address global climate change by 2030, while meeting the goals set for reducing air pollution, energy security, and long-term economic growth. Through improving the share of renewable energy in electricity production, European countries have the opportunity to become nearly carbon neutral by 2050.[12] For example, Finland is aiming to become self-sufficient with regard to electricity production in 2025, which is based on renewable energy.[13] More than 260 GW of renewable energy capacity has been generated in 2020, to which wind energy contributed 111 GW.[14] Unlike solar PVs, wind energy systems are able to operate during the day and nighttime. The adoption of wind energy systems is worth considering as a technological strategy for sustainable development.

The urban wind energy resource has not efficiently been explored yet. Deploying wind turbines in cities encounters some challenges such as availability of sites, impacts of grid power quality, and public acceptability.[15] In addition, due to the presence of obstructions, the turbulent nature of wind is a complication.[16] Thus, small wind turbine technology adapted to the built environment was developed. Small wind turbines are environmentally friendly. The life cycle of a wind turbine model (V90,3MW) was investigated, and the system was estimated to become carbon neutral after 6.6 months of energy production.[17]

Despite advanced design techniques for small wind turbines, technical matters related to safety, vibration, and noise under low urban wind regime and turbulent flow cannot be perfectly controlled due to the rapidly changing wind direction and the presence of obstacles. The prominent concerns of small turbines include fatigue damage, inconsistent power output, and unexpected downtimes due to failure during operation.[18] Turbulent wind interactions with building structures have impeded the safety, durability and performance of small turbines.[19]

These problems can be addressed with the design of BWT, which harvests energy from oscillation. BWT is designed to generate energy from low wind speeds in residential areas. With its cylindrical shape BWT adapts quickly to wind direction and wind turbulent intensity by a self-synchronization system that allows to capture a wider range of wind speeds and stay in resonance without any interference.[9] Experimental and analytical data showed that BWT can generate electricity at wind speeds as low as 3 m/s, where conventional wind turbines may not attain required performance.[20] Without moving gears, BWT overcomes the disadvantages of small turbines such as friction losses, and investment and maintenance costs.[21] Compared to small turbines, the price of BWT and the cost required for installation are of interest to investors.

With wind speeds in the range of 3 to 8 m/s, BWTs perform better than other wind turbines. However, beyond 12 m/s BWTs stop working while regular wind turbines keep generating.[22] Wind speeds are estimated to be ~4 m/s in 27% of the neighborhoods over 20 km from the city center of London, and average wind speeds in European locations are between 4 to 6 m/s.[23] The potential of BWTs is promising, but its implementation requires more studies on wind data. The optimization of bladeless turbine design is also necessary to enhance their efficiency.

## Barriers and Recommendations

To harness the potential of wind energy, it is necessary for BTWs to be adopted and widely used in urban areas. Therefore, the obstacles and barriers to deployment of bladeless wind turbines need to be investigated in order to implement this technology.

### Low Retail Price of Electricity

In developing countries, use of renewable energy is only available to high-income people. Indeed, the demand for green energy is dominated by the practicality of using cheap energy. In some developing countries, using fossil-fuel power is cheaper than investing in solar or wind energy, particularly for industrial and civil sectors.[24] The low retail price of electricity is maintained for the purpose of sustaining economic development. However, it has unintendedly prevented renewable natural resources from being explored and invested in.[2]

### Policy Uncertainty

One of the big challenges for the implementation of bladeless wind turbines is the uncertainty in policies.[6] Different countries have their own policies about how to facilitate renewable energy sources. Particularly, policy uncertainty relating to carbon emissions reduction and fossil fuels significantly affects investments in renewable energy.[25] For instance, Thailand and China have approved policies with the aim of building a future of renewable resources. As a result, investments in green technologies have sharply increased in both countries in recent years. In some developing countries, infrastructure of the power grid is outdated. This is a great concern for investors. Inconsistent policies fail to respond to the output of electricity produced by individual investors, which results in the loss of capital investment over a longer period.

## Recommendations

Low pricing of electricity makes it harder for renewables and innovations to compete with the established and subsidized technologies. Therefore, policies regarding electricity pricing should be changed without imposing a financial burned on low-income populations. Governments should consider regulations and fees for environmental protection that would be applied to factories and industrial buildings. An environmental fund could be used to harness local renewable energy potential, thereby gradually bringing green energy to all populations at an affordable price. Investments in renewable energy infrastructure for industrial manufacturers and production companies could be encouraged with incentives or persuasive measures, such as compensating the costs of transporting materials and equipment for renewable energy systems and extending the duration of land use rights. In addition, loan investment incentives are always expected from pioneers in new renewable technologies.[6]

The acquisition policy of electricity from investors must remain stable to avoid risks that vortex turbines deployers could encounter. In order to promote investments in vortex turbines, governments should approve policies that allow investors to trade electricity produced by wind turbines with their customers directly. Removing the monopoly of state companies helps increase investments in renewable energy systems. Energy policy uncertainty, therefore, limits renewable energy investments in new technologies like vortex wind turbines. NGOs need to help developing countries improve their national electricity grid, assuring that all output of renewable systems will be consumed.

## Future Scenarios

By evaluating expert opinions and analyzing the advantages and disadvantages of bladeless wind turbines through a literature review, different future scenarios for the differently powered turbines were constructed. These scenarios are outlined below:

### Wind-Solar Hybrid Energy Systems

Erratic weather conditions pose a challenge for renewable energy. Wind energy systems can operate during the day and at night, but their energy yield depends on wind speeds while solar panels operate an average of 5 hours per day.[1] Thus, relying on a single renewable energy source is particularly problematic in terms of operational efficiency and cost-effectiveness. However, two or more renewables can be combined to form a hybrid system: a wind-solar hybrid system could be a solution to improving system efficiency. BWTs' cylindrical form particularly would minimize the power losses from temporary shading compared to traditional wind turbines. In order to enhance the performance of a renewable energy system, investments in energy storage are also necessary.[1,2] However, research on storage capacity improvement is costly and requires the contributions of scientists. In addition, research evaluating local renewable energy potential, which could facilitate profitable investments of new technologies like bladeless wind turbines, needs to be done by local authorities as soon as possible.

### Bladeless Turbines on Roads

By taking advantage of natural wind and air flow generated by vehicles on roads, BWT could be placed along roadsides to supply electricity for traffic lights, camera surveillance, or other measuring equipment. Considering the opinions of experts, the installation of BWT along streets requires a clever arrangement of architecture and compliance with regulations in certain areas involving religious, historical, and cultural values.[8] Most importantly, streetside BWTs should never obstruct the view of drivers.

A BWT is designed to work at a maximum oscillation amplitude of 2.7°, which barely obstructs the drivers view.[9] However, a series of BWTs can cause issues of visual disturbance. In order to deploy BWTs on roads, urban planners should consider widening the sidewalk with specific locations for the installation. Moreover, criteria on the appropriate height of BWTs should also be approved by authorities.[7,8]

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# Annex

## ANNEX 1: Consulted experts

| Superscript | Name of Experts | Institution | Position | Interview date | Country |
|---|---|---|---|---|---|
| 1 | Nguyễn Mộc Đức (Mr) | Green power company | Manager | 19/11/2021 | Viet Nam |
| 2 | Huỳnh Tấn Đạt (Mr) | Hoang Lien Son Construction Company Limited | Manager | 22/11/2021 | Viet Nam |
| 3 | Ronald. M. Galindo (Dr) | Cebu Technological University | Dean, College of Engineering | 25/11/2021 | Philippines |
| 4 | Erik Velasco (Dr) | Molina Center for Energy and the Environment | Research scientist | 26/11/2021 | Mexico |
| 5 | Wilen Melsedec Narvios (Dr) | Cebu Technological University | Chair, Electrical Engineering | 29/11/2021 | Philippines |
| 6 | Nguyễn Phương Lâm (Mr) | Long Hau industrial zone<br><br>Long Hau Joint Stock Company | Director, system management – Human Resources Administration | 1/12/2021 | Vietnam |
| 7 | Nguyễn Công Huân (Mr) | Saigon Technology University | Lecturer | 2/12/2021 | Viet Nam |
| 8 | Lý Khánh Tâm Thảo (Mr) | Ho Chi Minh City Department of planning and Architecture | Head, Division of Urban Technical Infrastructure Management | 2/12/2021 | Vietnam |

## ANNEX 2: Methodology

*SWOT Analysis*

Based on a SWOT analysis, opportunities, challenges, and barriers involving bladeless wind turbines were investigated through their advantages and disadvantages. Policies were proposed with the aim of deploying this technology in urban areas.

*Expert Consultation*

The opinions of the eight experts in different fields (architecture, mechanics, engineering, renewable energy investors and civil engineering) were considered in order to build the scenarios associated with the deployment of bladeless wind turbines in the futures. The interviews were conducted online with systematic questions prepared with respect to each of the experts.

## ANNEX 3: Summary of the technology

| Table 1. Summary of the Technology [9] | | |
|---|---|---|
| Scale | Technical specifications | Cost in USD |
| Mini vortex | Height: 3 m<br>Weigh: 10 kilograms<br>Generation capability: 100W | 250 |
| Mid-size vortex | Height: 13 m<br>Weigh: 100 kilograms<br>Generation capability: 4kW | 5000 |
| Giant vortex | Height: 150 m<br>Weigh: 100 tons<br>Generation capability: 1MW | Depends on the installation site |