International Journal of Innovation

e-ISSN: 2318-9975
Received: 17 Jan. 2022 - **Approved:** 21 Jun. 2022
Evaluation Process: Double Blind Review
https://doi.org/10.5585/iji.10i3.21474

Special Issue: Technology transfer in innovation and entrepreneurship ecosystems in emerging economies

PATENT PROSPECTION IN WIND POWER GENERATION TECHNOLOGIES FOR USE IN URBAN AREAS

PROSPECÇÃO PATENTÁRIA EM TECNOLOGIAS DE GERAÇÃO DE ENERGIA ELÉTRICA POR MATRIZ EÓLICA PARA USO EM ÁREAS URBANAS

INVESTIGACIÓN DE PATENTES SOBRE TECNOLOGÍAS DE GENERACIÓN DE ELECTRICIDAD A PARTIR DEL VIENTO PARA SU USO EN ZONAS URBANAS

Sandro Bouth Guedes[1]
Rogério Atem de Carvalho[2]
Henrique Rego Monteiro da Hora[3]

Cite as – American Psychological Association (APA)

Guedes, S. B., Carvalho, R. A., & Hora, H. R. M. (2022, July). Patent prospection in wind power generation technologies for use in urban areas. *International Journal of Innovation - IJI*, São Paulo, *10*(Special issue), 555-573. https://doi.org/10.5585/iji.v10i3.21474.

Abstract

Objective of the study: To investigate through technological prospecting patents in the generation of wind energy within urban environments, aiming to generate new options for the transition of electrical energy through a clean and sustainable matrix, meeting concepts of smart cities.

Methodology: The study was carried out in a relevant patent base, such as in journals, observing the volume of patents in the technological area of interest in an exploratory nature, with a prospective objective, for an evaluation in technological intelligence.

Main results: In the volume of technologies for wind power generation, which are possible within urban areas, there is a quantitative yet reduced amount of possible generators for use in urban areas, contrasted to traditional technologies already explored, able to meet the objective of the study, which is to identify opportunities for the transition of electric power through a clean and sustainable matrix, meeting concepts of smart cities, generating new business models and therefore in unfolding new developments.

Theoretical/methodological contributions: It contributes with studies based on technological intelligence that generate opportunities for a deeper analysis of available technologies for this replacement in our energy matrix since Brazil is a protagonist in Latin America in wind power generation.

Contributions of the association/management: This research contributes to the study and use of new opportunities for wind power generation within urban areas with lower socio-environmental impact and business generation in a domestic environment.

Keywords: Renewable energy. Wind energy. Urban areas.

[1]Mestrando em Propriedade Intelectual e Transferência de Tecnologia para a Inovação, PROFNIT, Instituto Federal de Educação, Ciência e Tecnologia Fluminense. Campos dos Goytacazes, RJ – Brasil. bouth.guedes@gsuite.iff.edu.br
[2]Doutor em Engenharia de Produção, Instituto Federal de Educação, Ciência e Tecnologia Fluminense. Campos dos Goytacazes, RJ – Brasil. r.atem@gsuite.iff.edu.br
[3]Doutor em Engenharia de Produção, Instituto Federal de Educação, Ciência e Tecnologia Fluminense. Campos dos Goytacazes, RJ – Brasil. henrique.hora@gsuite.iff.edu.br

Resumo

Objetivo do estudo: Averiguar através da prospecção tecnológica patentes na geração de energia eólica dentro de ambientes urbanos, com o objetivo gerar novas opções para a transição de energia elétrica através de uma matriz limpa e sustentável, atendendo conceitos de cidades inteligentes.

Metodologia: O estudo foi realizado em uma base de patentes relevantes, como em revistas, observando o volume de patentes na área tecnológica de interesse de natureza exploratória, com um objetivo prospectivo, para uma avaliação em inteligência tecnológica.

Principais resultados: No volume de tecnologias para geração de energia eólica, que são possíveis dentro das áreas urbanas, há uma quantidade quantitativa mas reduzida de possíveis geradores para uso em áreas urbanas, em contraste com as tecnologias tradicionais já exploradas, capazes de atender ao objetivo do estudo, que é identificar oportunidades para a transição de energia elétrica através de uma matriz limpa e sustentável, atendendo aos conceitos de cidades inteligentes, gerando novos modelos de negócios e, portanto, no desdobramento de novos desenvolvimentos.

Contribuições teóricas/metodológicas: Contribui com estudos baseados em inteligência tecnológica que geram oportunidades para uma análise mais profunda das tecnologias disponíveis para esta substituição em nossa matriz energética, já que o Brasil é um protagonista na América Latina na geração de energia eólica.

Contribuições da associação/gestão: Esta pesquisa contribui para o estudo e uso de novas oportunidades de geração de energia eólica em áreas urbanas com menor impacto socioambiental e geração de negócios em um ambiente doméstico.

Palavras-chave: Energia renovável. Energia eólica. Áreas urbanas.

Resumen

Objetivo del estudio: Investigar a través de patentes de prospección tecnológica en la generación de energía eólica dentro de entornos urbanos, con el objetivo de generar nuevas opciones para la transición de la energía eléctrica a través de una matriz limpia y sostenible, atendiendo a conceptos de ciudades inteligentes.

Metodología: El estudio se realizó en una base de patentes relevante, como en revistas, observando el volumen de patentes en el área tecnológica de interés con carácter exploratorio, con un objetivo prospectivo, para una evaluación en inteligencia tecnológica.

Principales resultados: En el volumen de tecnologías para la generación de energía eólica, que son posibles dentro de las zonas urbanas, existe una cantidad cuantitativa pero reducida de posibles generadores para su uso en zonas urbanas, en contraste con las tecnologías tradicionales ya exploradas, capaces de cumplir con el objetivo del estudio, que es identificar las oportunidades para la transición de la energía eléctrica a través de una matriz limpia y sostenible, cumpliendo con conceptos de ciudades inteligentes, generando nuevos modelos de negocio y por lo tanto en el despliegue de nuevos desarrollos.

Aportes teóricos/metodológicos: Contribuye con estudios basados en la inteligencia tecnológica que generan oportunidades para un análisis más profundo de las tecnologías disponibles para este reemplazo en nuestra matriz energética ya que Brasil es protagonista en América Latina en la generación de energía eólica.

Contribuciones de la asociación/gerencia: Esta investigación contribuye al estudio y aprovechamiento de las nuevas oportunidades de generación de energía eólica dentro de las zonas urbanas con menor impacto socio-ambiental y de generación de negocio en un entorno doméstico.

Palabras clave: Energías renovables. Energía eólica. Zonas urbanas.

1 Introduction

It is safe to say that we have left behind the dilemma of "either development or environment" (Milaré, 2009). Currently, the development/environment binomial breaks any chance of antagonism, given that the path crosses the study of development alternatives, whether in urban or rural areas, through possible models of *smart cities*, as well as the transformation of this reality requires understanding the model of intelligent energy for a smart city, so it is mandatory to consider renewable energy and its possibilities (Hoang et al., 2021). However, it is a challenge to combine the elements aforementioned without separating one or the other, just as it is a challenge to have the technology, development, and the environment walking hand in hand.

Brazil is the largest electricity market in Latin America. Moreover, factors such as the country's size, abundant resources, and favourable policies have ranked us as the leading renewable energy market in the region and one of the ten most prominent in the world (*Climatescope* 2020, [s.d.]).

Although the Brazilian energy matrix today is still based on hydroelectric power with 58.3%, equivalent to 103.0 GW, in the year 2021, the wind matrix, which is in second place, beat its record with 10.8%, making 19.1 GW (*Associação Brasileira de Energia Eólica*, [n.d.]). However, the advance may seem minor, but it is an opportunity based on current data to perceive the country in complete evolution within this energy matrix, stimulated by governments, to generate jobs, being the option to diversify energy supply sources and promote the reduction of greenhouse gas emissions (GHG) (Neri et al., 2019).

Such a scenario collaborates increasingly for lower carbon emissions in our atmosphere, less water consumption, and lower social impact than the other sources in our electricity matrix. (Reddy, 2020)

In Brazil, the first quarter of 2021 witnessed the expansion of the electric energy matrix. Wind energy production represented 87% of this increased energy (593.61 MW), according to data, five times the same period (117.18 MW) in 2020 (*Press Room* - ANEEL, [s.d.]).

Although there are many positive points, we cannot assess them in an inert and satisfying way because the compatibility of the environment with development follows the need for analysis of environmental problems in a continuous planning process, considering both plus their particularities with the socio-cultural, political, economic, and ecological contexts, within a time-space dimension (Milaré, 2009). Therefore, it is from the present and measured impacts that the technology for the generation of wind energy figures, thus providing the opportunity to study new technologies for this purpose and what can they contribute to the proposal of continuous improvement.

Wind energy is renewable energy. However, claiming that it is harmless or that its installation process is simple is a misconception. In this regard, it is sufficient to consider the structures of a wind farm, towers of up to 150 meters high and rotor blades the size of an aeroplane wing (*Empresa de Pesquisa Energética*, [s. d.]-b), in addition to considering other socio-environmental problems, for

instance, changes in hydrological bodies, alteration of the life routine of communities, damage to the local ecosystem such as deforestation and risk to animals (Dantas et al., 2019).

Thus, it becomes feasible for the business interest to identify what we currently know about the technologies for the production of wind energy, especially the improvements of these existing technologies, on a patent basis, at whatever stage of maturity. These provide a better use of our national wind map (*Empresa de Pesquisa Energética*, [s.d.]-b), with equipment suitable for urban areas, with less impact on communities, animals and plants life, and water resources.

2 Method

The present scientific and technological prospection presents a quantitative and exploratory approach. The research uses bibliographical periodicals and patent databases. We surveyed the technologies between June and July 2021, and the prospective objective is to evaluate technological intelligence.

The objective of the research is not to revisit traditional wind energy generation technologies but rather to prospect new existing options in this energy matrix that contribute to making energy and technology the main engines of a smart city (Hoang et al., 2021) and compatible for installation and use in urban areas.

We ran literature searches following the Boolean system with the keywords "*wind turbine*", "*wind power*", "*wind-powered*", "*generator*", "*turbine*", "*electrical*", "*magnetic*", "*vortex*", "*bladeless*", "*no use propellers*", "*smart cities*", and "*urban areas*", all in advanced searches, in English language only. After preliminary research, as a consequence of the specificity mentioned above, we adopted only one patent bank and three international journals, in addition to internet content on institutional websites.

The patent search considered the classifications present in the *International Patent Classification* (IPC), hence consulting and searching in the IPCCAT platform (*IPC Publication*, [s.d.]) for sentences to be as specific as possible in the following compositions: "*electrical power generator*" OR "*wind power generation technologies for use in urban areas*".

Next, we searched the patent database Orbit Intelligence, which is justified because it is an exhaustive and complete database, being unnecessary to search other smaller databases. Finally, concerning the search for journals, we used the electronic databases *Scopus*, *Science Direct*, and *Web of Science*.

For the results treatment, we identified the most appropriate classification for the study. There was no in-depth analysis of the *Technology Readiness Level* (TRL) of the patents surveyed because it was irrelevant to the objective herein. We analyzed thus the information extracted in terms of the number of documents related to the patent bank, investment trends, chronological evolution, scope of patent protection, technological domain, and patent profile. In a new filter, the attempt is to extract only the patents that meet the indicated purpose.

Table 1

Research protocol

Database	Bibliographic	Patents	Period analyzed	Search terms
Scopus	X		Months 06 and 07 2021	Boolean/ keywords
Science Direct	X		Months 06 and 07 2021	Boolean/ keywords
Web of Science	X		Months 06 and 07 2021	Boolean/ keywords
Orbit Intelligence		X	Months 06 and 07 2021	*International Patent Classification (IPC)* IPCCAT

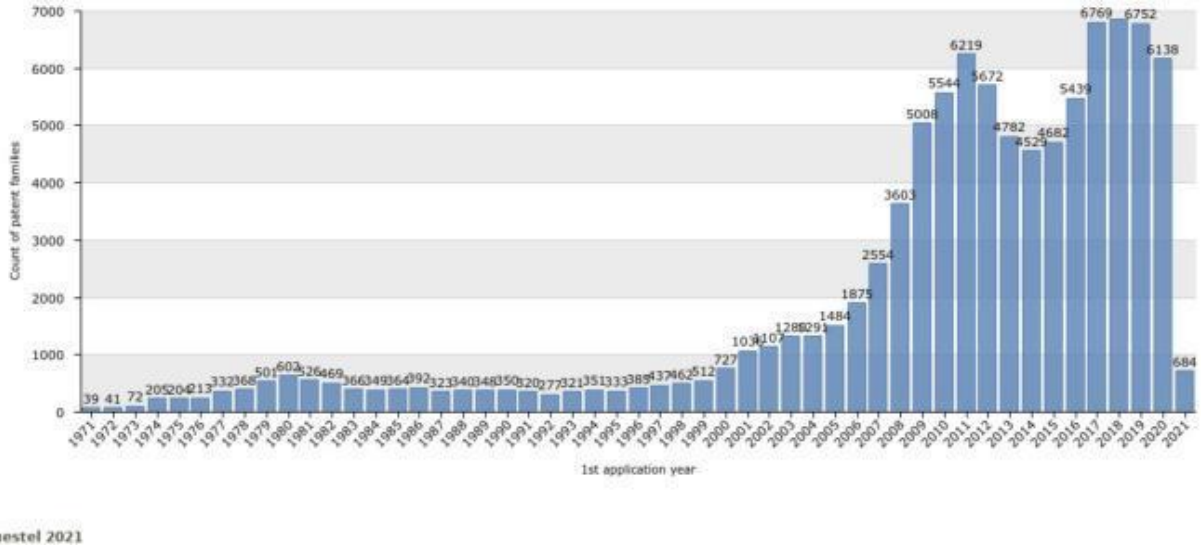
Source: Elaborated by the author (2022).

3 Results and discussion

The initial mapping premise is the overview of the trend of this technology in the last fifty years. The consultation in the patent bank for demonstrating these data are under the *International Patent Classification* (IPC), following the classification F03D (*wind motors*), shown in graphic 1.

Graph 1

Investment trends in the technology classified F03D (wind motors) in the last 50 years



Source: Elaborated from (*Orbit Intelligence*, [s.d.]) (2021).

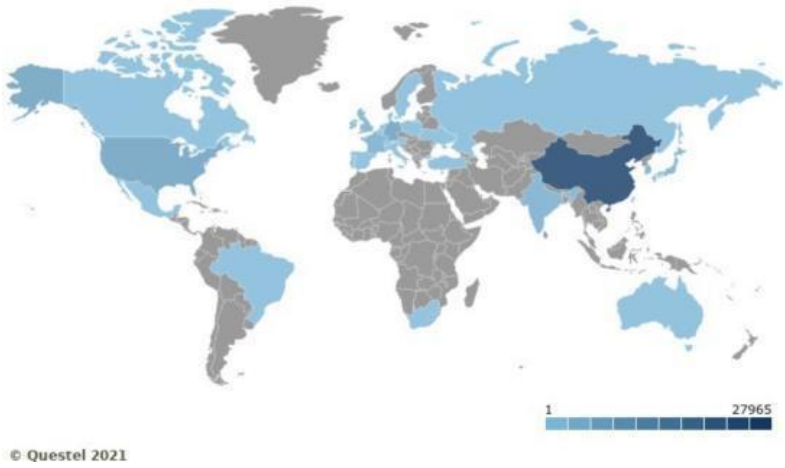
The graph above shows the investment trend in the mentioned period, totalling 96,890 patents on the date of this consultation (June/21). This flow gradually increased from 2001, when we reached the one thousand patents milestone for the first time. Between 2000 and 2010, we witness a demonstration of a prominent investment volume in new patent applications. The flow increased

considerably by 2009, with a peak in 2018. From then on, annual investment rates decreased until the date of this research (June/21), registering average investments in this technological trend similar to that in the 80s. By observing the period from 1971 to 2021 (June), we started with 39 applications in the first year and 684 in the latter. Along this research period, we can also see the patents protected by country, as shown in graphs 2 and 3.]

For the sake of clarity, it is worth mentioning that the topic investment is the expression used to measure the volume of patents and patent families within this technological trend, in research, per year. Given that it would be impossible to enlist the investment made by each player in the current technological set, we comprehend that all intellectual property protected by strategy is an investment.

Graph 2

Patent families by country of protection

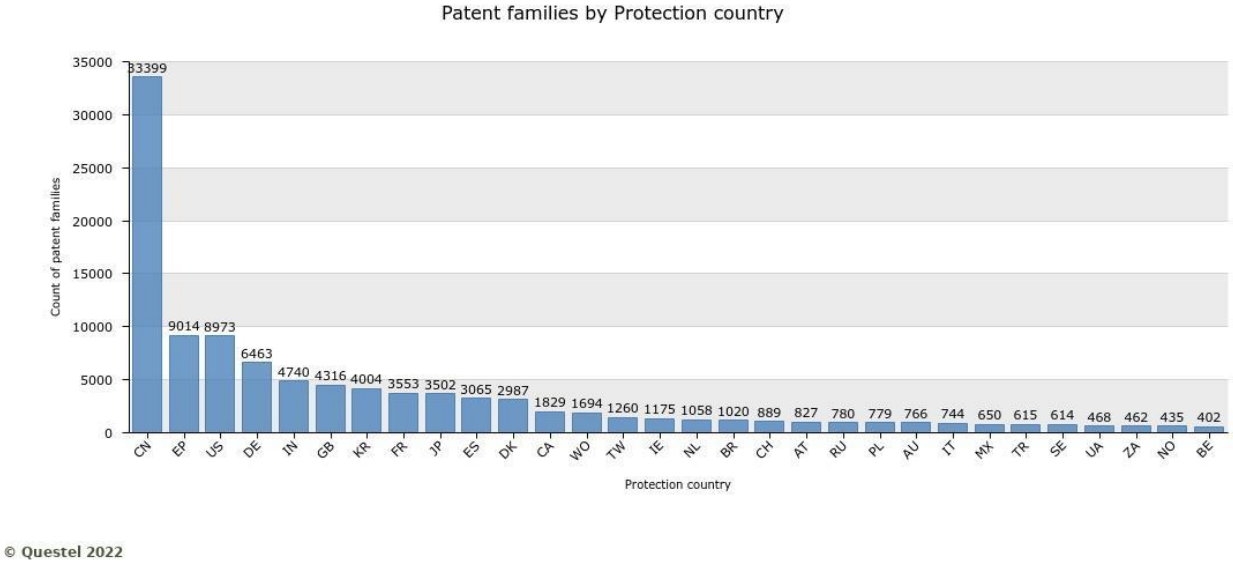


Source: Elaborated from (*Orbit Intelligence*, [s.d.]) (2021).

The investment trend for wind energy patents in this format is coherent to our national scenario, which has undergone considerable transformations concomitantly. Let us observe the relevance of this energy matrix for the national energy supply and demand. In the year 2000, wind energy had the record of contributing 0.1% of the installed electricity capacity in our country. However, by 2018, we reached 9% (Soares et al., 2021). Such analysis becomes more straightforward given the graph above and by indicating that Brazil appears as the South American protagonist in this type of technology because it is the only country in this scenario to have patent families protected by the National Institute of Industrial Property - INPI.

Graph 3

Patent families by country of protection



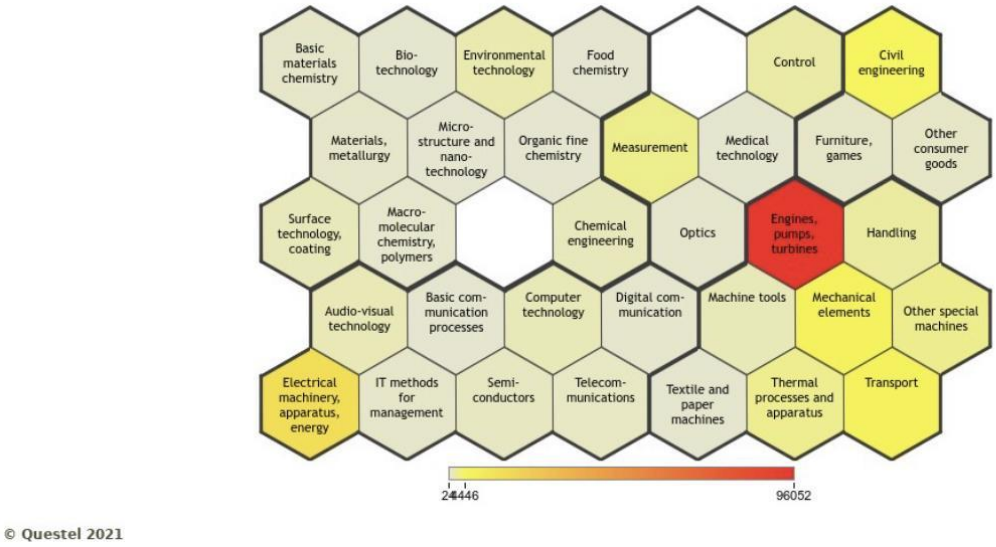
Source: Elaborated from (*Orbit Intelligence*, [s.d.]) (2021).

Charts 2 and 3 highlight two critical points concerning patents for this technology of energy generation/IPC F03D (wind motors): 1) it figures the set comprising the North American continent, especially the United States and the presence of China with the most significant volume of global patents; 2) and the distinctiveness of Brazil given its market position in Latin America (Climatescope 2020, [n.d.]). Brazil is in the top 30 rankings and with some relevance ahead of countries like Mexico, Australia, Russia, and Portugal, for example, having registered 1020 (one thousand and twenty) patent families until now.

It is essential to note the absolute predominance of the patent families with technological domains in engines, pumps, and turbines, with a total of 96,052 patents measured in this regard, as depicted in Chart 4.

Graph 4

Technological field



Source: Elaborated from (*Orbit Intelligence*, [s.d.]) (2021).

The current model for energy generation by wind power is complex and not free of socio-environmental impacts. It takes planning and understanding of how this activity would affect the environment after installation. The concern with flora and fauna, considering birds and bats as well as its acoustic effects (Rediske et al., 2021), makes it necessary to have a thorough study on site selection for the installation of a wind power plant, considering wind farms and giant turbines.

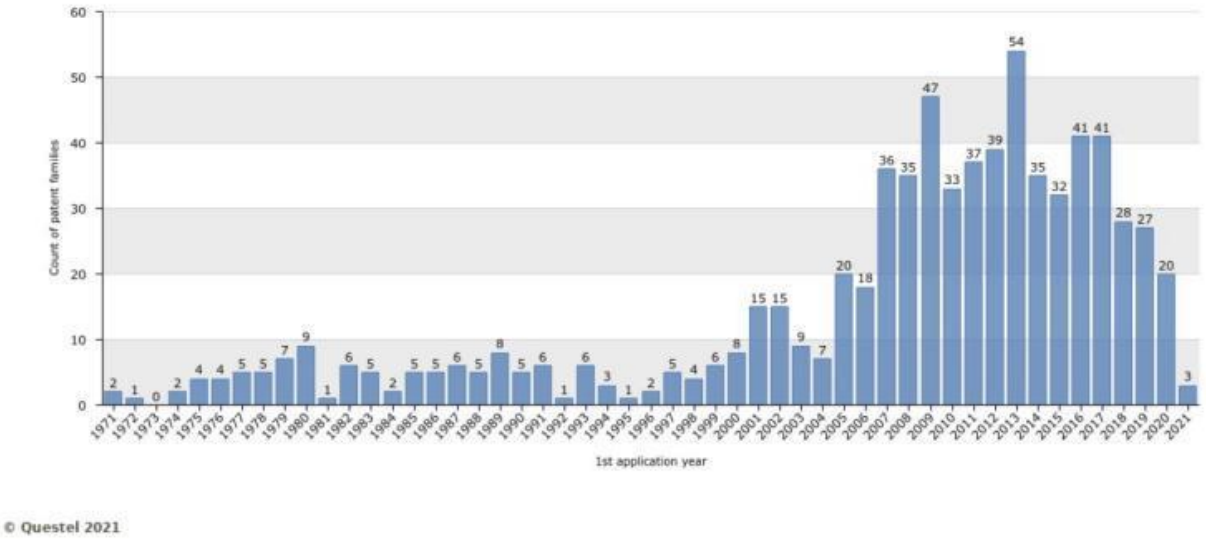
It would be a considerable gain to have the energy generation process by wind matrix simplified, starting from evaluating the use of available technologies. Furthermore, it would help mitigate these socio-environmental effects, reducing the complexity of installing a wind power plant or simply tying significant improvement by the action of some incremental innovation (Carvalho et al., 2011), including the possibility of urban wind farms, private wind power systems in large condominiums, or even individual wind power systems for any house.

Therefore, turbine wind farms currently work with equipment ranging from 95 m hub height and 112 m rotor diameter to 128 m hub height (Empresa de Pesquisa Energética, [s.d.]-a). Thus it is plausible to propose technological solutions, new options, and opportunities, following the *International Patent Classification* (IPC), through the *Orbit Intelligence* platform, now with classification F03D 5/06 (*wind-engaging parts swinging to-and-fro and not rotating*).

Furthermore, based on the classification above, having the same time evaluation used for the F03D classification, for the trend of investments in patents, we found 740 patents, depicted in graph 5.

Graph 5

Trends of investments in technology in the last 50 years

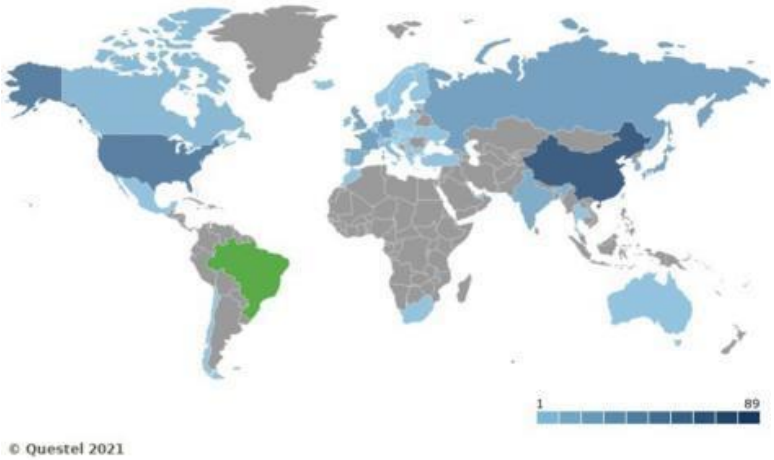


Source: Prepared based on (*Orbit Intelligence*, [s.d.]) (2021).

The classification's technical orientation includes the "wind engines" in a broad sense, with a subgroup called "other wind engines", and specified in the classification of interest to this work as "parts that move from side to side and do not rotate"(*IPC Publication*, [n.d.]). The research starts from the premise of evaluating technologies that initially do not make use of hubs with external blades that essentially rotate; then, we highlight graph 6.

Chart 6

Patent families by country of protection.

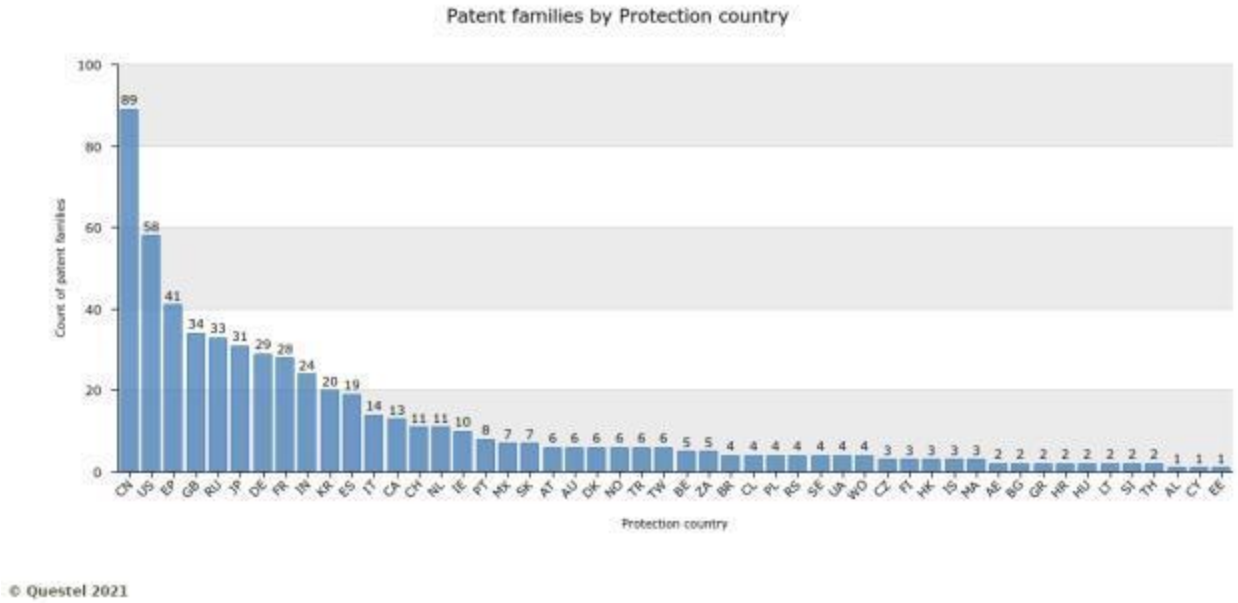


Source: Elaborated from (*Orbit Intelligence*, [s.d.]) (2021).

One can note that there are no significant changes in the map layout comparing the two classifications by IPC concerning patent families, given the scope of protection, up to the date of the survey (Jun/21). As opposed to the former, we call attention to the presence of countries such as Chile, Iceland, United Arab Emirates, Thailand, Vietnam, and Indonesia, for instance, as seen in graph 7. Brazil continues to be the continental protagonist. Hence we have highlighted Graph 6, given the emphasis of the technological search herein.

Graph 7

Patent families by country of protection



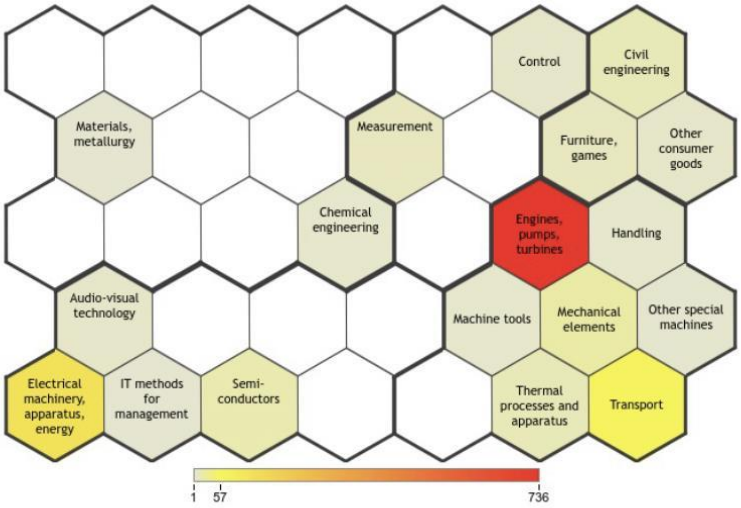
Source: Elaborated from (*Orbit Intelligence*, [s.d.]) (2021).

Although Brazil is the Latin American protagonist regarding the availability and installation of wind energy, it holds four protected patents belonging to patent families. On the other hand, countries like China and the United States lead the field regarding the number of patents.

In summary, to ensure more consistent data, we equalled this classification's technological domain to the search for the broad classification, i.e., *engines, pumps, and turbines*, according to chart 8.

Graph 8

Technological domain



Source: Elaborated from (*Orbit Intelligence*, [s.d.]) (2021).

Among the 740 patents, in their various technical possibilities, it is a fact that not all the patents available in this classification meet the purpose determined in this work. Therefore, from a conservative perspective, let us look briefly at some data on the four patents protected in Brazilian territory.

The first patent is assigned PCT WO2015/103013 A, and its publication date is July 9, 2015. Although it is BR112016015006 A1 for Brazil, published on July 2, 2017, the process status is still pending. The patent refers to methods and systems for the transition of an air vehicle between crosswind and tailwind or headwind.

The invention object notes: In another aspect, a system may include an air vehicle connected to the first end of a cable; a ground station connected to a second end of the cable, and a control system configured to operate the air vehicle to travel a first closed path while oriented in crosswind flight: while the air vehicle is in cross-flight orientation, operate the air vehicle to travel a second closed path so that the air vehicle's speed decreases, and after or while the air vehicle's speed reduces, transition the air vehicle from travelling the second closed path while in cross-flight orientation to hover flight orientation. (*Orbit Intelligence*, [n.d.]). Based on this reading, the exemplified patent is not the subject of the search.

The second patent of the four protected in Brazil holds deposit PCT WO2015/032491 A1, published on March 12, 2015. Although nationally, it holds the procedural number BR112016004456 A1, this deposit had its cover sheet changed, thus resulting in the modification in its kind code from A1 to A8, referenced as BR112016004456 A8. The title of this deposit is 'Device, a method for controlling the load torque of a device, a method for controlling the load rotation speed of a device, use of a device, and flying wind converter'.

The subject invention states: The invention relates to a device for achieving a high range of rotational speed with high efficiency, it is therefore in a drive train of a driven machine or system, comprising (i) two that operate by means of a motor or motor generator (A1, A2), which indirectly through suitable coupling elements, and/or translation devices transfer members (7, 8) or directly with the carrier shaft (S) and the slower of two transmission shafts (2) of an epicyclic gear mechanism (3) are connected to each other fixedly in rotation to the previous one, as well as (ii) a working machine (L), which indirectly through suitable coupling elements, and/or translation devices transfer members or directly to the faster of two stationary gear shafts (1) of the epicycloidal (3) gearbox are connected to each other in a fixed manner in rotation, wherein the internal movements of the epicycloidal gearbox (3) by one or more suitable coupling devices / - s (6) in one direction of rotation and in the other direction of rotation may be permitted. (*Orbit Intelligence*, [n.d.]) It is clear that this does not meet the desired goal of this research.

The third patent application, also by PCT, is a patent granted in our national territory, under registration number BRPI0914879 B1, published on January 12, 2021. Considering its object, we can see: The present invention refers to an optimized structure for the conduct and assisted takeoff of airfoils for the tropospheric airfoil generator. (*Orbit Intelligence*, [s.d.]), so it seems to us that such a patent likewise does not correspond with the object of this research.

Finally, the fourth patent process, also by PCT, is a patent granted in our national territory under the registration number BRPI0821330 B1 and published on May 12, 2020.

Similarly, observe what its object presents: The invention relates to a method and system for converting the natural kinetic energy in horizontal flows accumulated above the ground into usable mechanical energy (*Orbit Intelligence*, [s.d.]). This fourth patent also does not fit the goal of this research for finding solutions to the intended cause.

Proceeding further, delving into the other patents within the classification F03D 5/06, we sought the number of four patents that met this article's purpose and considered that these were not protected in our territory.

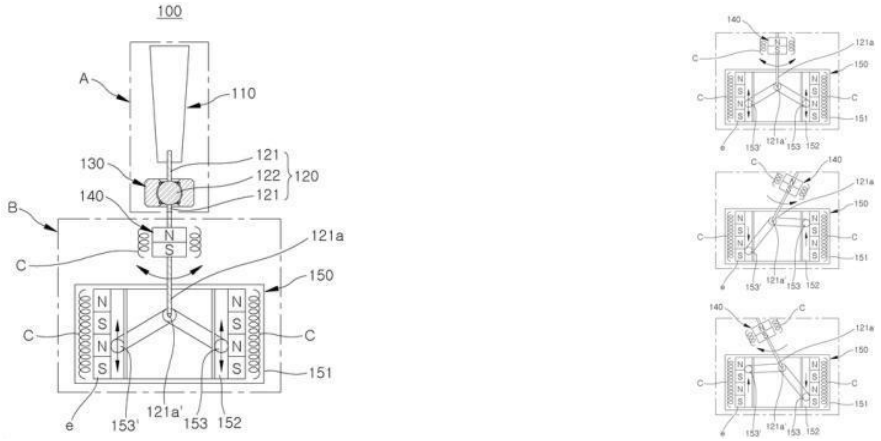
Hence, we can combine smart energy with technology for sustainable development (Visvizi & Lytras, 2019). This article points below the patents raised that fit the research's aim.

1) *Wind Power Generator*, process number KR10-1931268 B1, a patent published on December 21, 2018, protected in South Korea, having as the applicant/holder - KOREA INSTITUTE OF ENERGY RESEARCH, its technological domain concentrated in motors, pumps, and turbines, and bearing the IPC F03D 5/06. *(Orbit Intelligence*, [s.d.])

The description of the technical field notes the following: The present invention relates to a wind power generator, and more particularly to the use of the vortex release effect for generating wind electricity. The wind power generation apparatus of the present invention (Orbit Intelligence, [s.d.]) is in Figure 1.

Figure 1

Wind Power Generator - process number KR10-1931268 B1



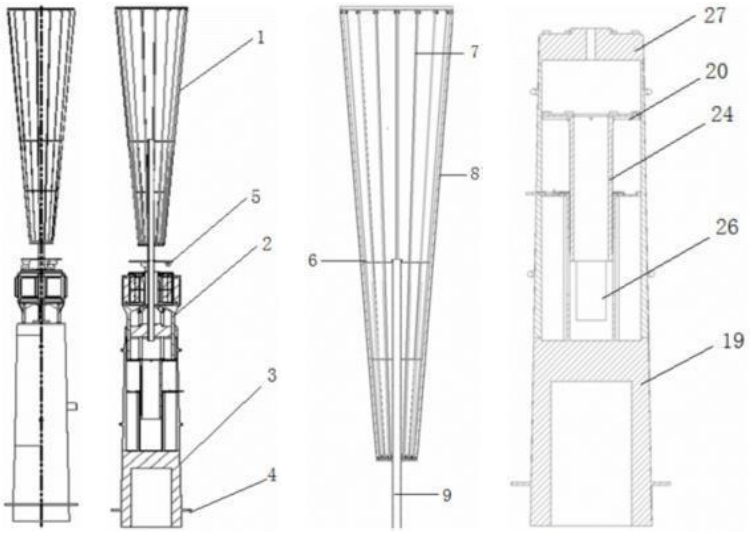
Source: Elaborated from (*Orbit Intelligence*, [s.d.]) (2021).

2) *Bladeless power generation system device*, process number CN108775272 B, a patent published on 06/09/2019, protected in China, having as applicant/holder - NORTHEASTERN UNIVERSITY OF CHINA, technological domain concentrated in motors, pumps, and turbines, bearing the IPC F03D 5/06 (*Orbit Intelligence*, [s.d.]).

The description of the technical field states: The invention relates to the technical field of wind-powered generators, in particular to a bladeless power generation system device (*Orbit Intelligence*, [n.d.]), shown in Figure 2.

Figure 2

Bladeless power generation system device - process no. CN108775272 B



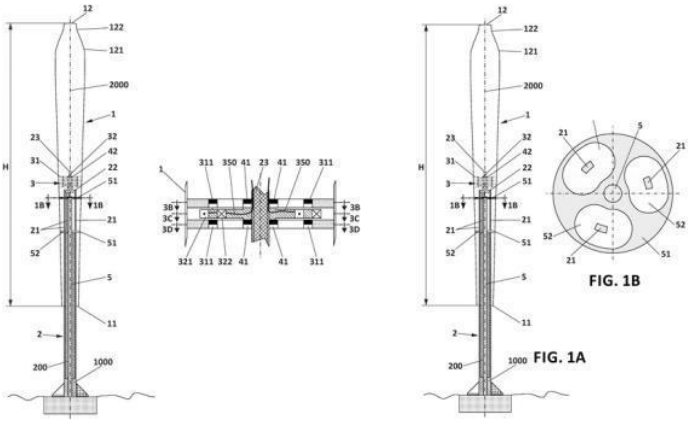
Source: Elaborated from (*Orbit Intelligence*, [s.d.]) (2021).

3) *Electrical power generator*, PCT process number WO2017/174685 A1, published on October 12, 2017, process number US11053914 B2, a patent published on July 6, 2021, process number JP2019510920 A, published on April 18, 2019, process number EP3440344 A1, published on February 13, 2019, process number CN109312713 A, published on February 05, 2019, protected in the European Union, United States, Japan, China, having as applicant/holder - *VORTEX BLADELESS S L*, technological domain concentrated in motors, pumps, and turbines, bearing the IPC F03D 5/06 (*Orbit Intelligence*, [s. d.])

The description of the technical field states: The release refers to the field of renewable energy and, more specifically, to the field of von Karman vortex-based electrical power generation (*Orbit Intelligence*, [n.d.]), found in Figure 3.

Figure 3

Electrical power generator - Process PCT WO2017/174685 A1



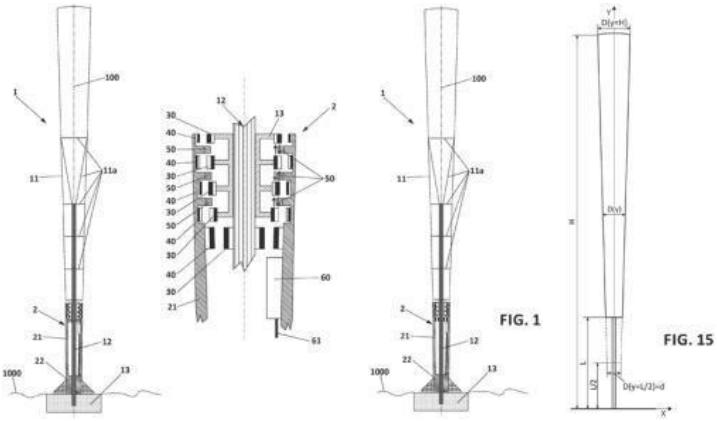
Source: Elaborated from (*Orbit Intelligence*, [s.d.]) (2021).

4) *An electrical power generator and an electrical power generation method*, processed by PCT WO2016/055370 A3, process ES2796283 T3, a patent published on November 26, 2020, process EP3204635 B1, published on May 6, 2020, process JP6762292 B2, a patent published on September 30, 2020, a process CN107078621 B, granted on May 15, 2020, process US10641243 B2, granted on May 5, 2020. Protected in the European Union, United States, Japan, and China, having as applicant/holder - *VORTEX BLADELESS S L*, technological field concentrated in motors, pumps, and turbines, bearing the IPC F03D 5/06 and other classifications (*Orbit Intelligence*, [s.d.])

The description of the technical field states that "the invention relates to the field of renewable energy and more specifically, to the field of electrical power generation based on the motion of a fluid, from vortices generated in the fluid" (*Orbit Intelligence*, [n.d.]), as highlighted in Figure 4.

Figure 4

An electrical power generator and an electrical power generation method - process PCT WO2016/055370 A3.

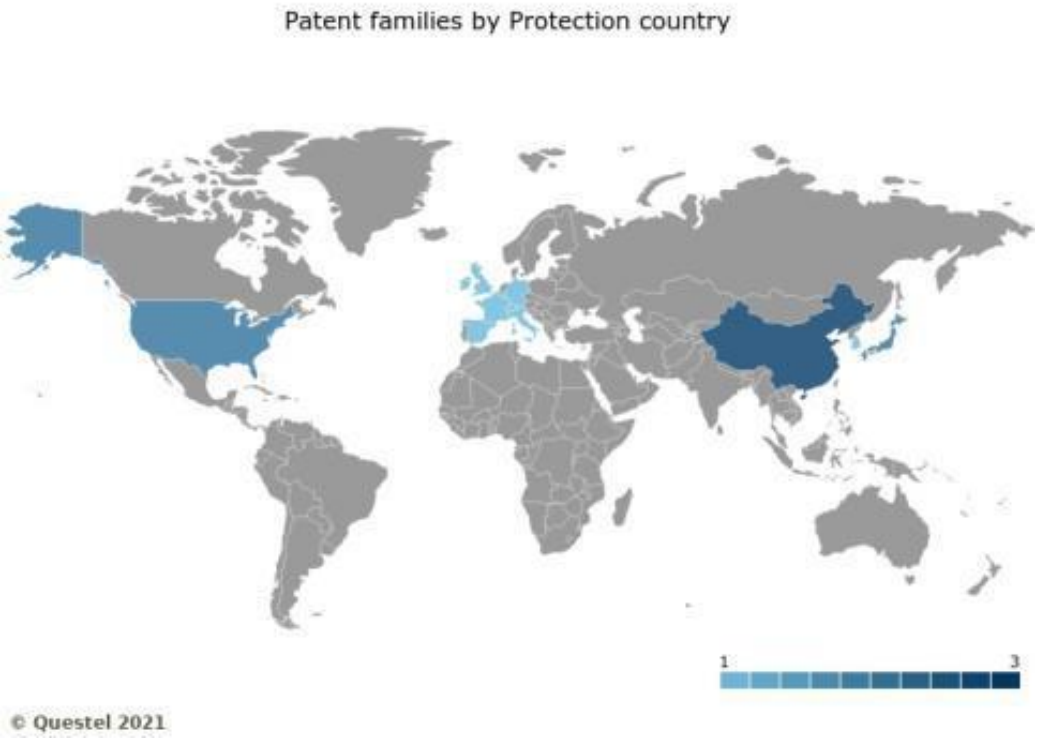


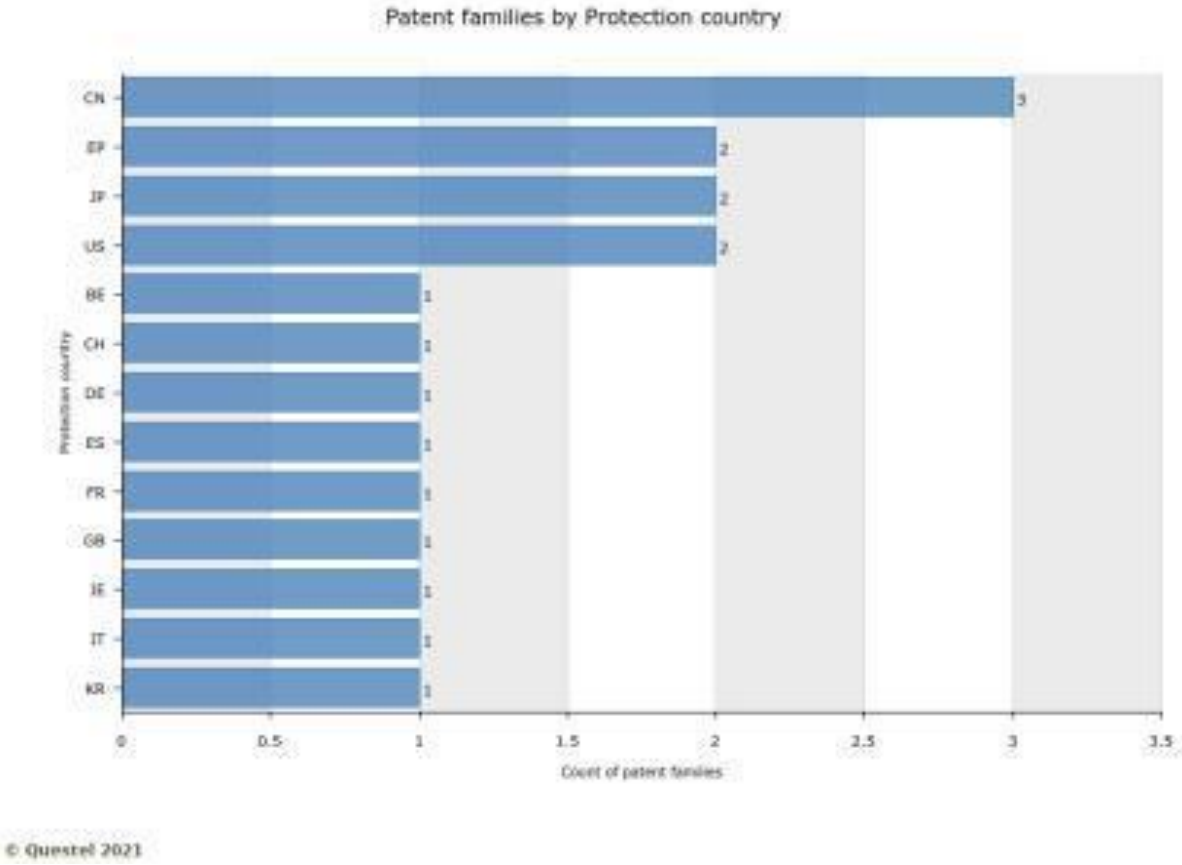
Source: Elaborated from (*Orbit Intelligence*, [s.d.]) (2021).

We should note that of these four holders, two are educational institutions, while the other two are *startups* in the private sector. In addition, the technologies mentioned and described above are protected in the following countries, as shown in Chart 9:

Graph 9

Patent families by country of protection





Source: Elaborated from (*Orbit Intelligence*, [s.d.]) (2021).

The points in common between the four technologies mentioned are the absence of blades/propellers and the principle of oscillation, through vortex and fluid generation, which produces power and, therefore, electricity, unlike the technology that comes from the rotational movement of turbines, these use the pendulum movement caused by vortices thus generating electricity. (Ostia et al., 2019)

To achieve smart cities, we need to look at possibilities that counter conventional wind turbines, which are extremely large and costly to install and maintain, without the need for mechanical gears and teeth, thus eliminating possible failures and repairs. (Hemalatha, 2019)

High requirements on wind speed and specific environments for installation arise within the traditional system, namely with blade wind turbines, used mainly for wind power generation using electromagnetic induction. In contrast, the technology premises on the vibrations originating from the wind energy flow, whose cycle goes from wind energy to vibration energy, to convert this vibration energy into electrical energy using the piezoelectric effect or electromagnetic induction (Wang et al., 2020).

The search for solutions that increasingly mitigate environmental impact, logistical hindrances, and high-cost maintenance installations may arise from these new processes—the Vortex Bladeless (Wang et al., 2020) figures in figure 4.

Figure 4

Vortex Bladeless Turbine

Source: Elaborated from (*Vortex Bladeless Turbine - Reinventing Wind Energy!*, [s.d.]) (2021).

4 Final considerations

Conclusively, after analyzing the patent documents, the search for a specific classification offered better opportunities for technology collection. The prospection revolved around new formats for generating electric energy by the current wind matrix, starting from strategies and incremental innovations and observing the pillars of lower socio-environmental impact and greater adherence to the concepts of smart cities.

When comparing data, we can perceive a window of opportunity for our domestic market once the patents that theoretically fit the objective of this work do not have patent protection in our national territory. Especially being Brazil a significant country, appearing in a relevant way for the generation of energy by wind power matrix, as the most extensive commercial reference in Latin America. Nevertheless, despite these issues, the technologies proved to be compatible with the proposal of this study for further analysis.

As mentioned before, we highlight that there has been no commitment to evaluate the Technology Readiness Level (TRL) of the patents surveyed. However, given the bibliographical, patent, and commercial assessment, the Vortex Bladeless Turbine technology is already available in a business environment for acquisition, in a market and commercial development scenario, in the European Union region, and due to the protections established for the vortex energy generation model, as other countries have also protected, such as China and the United States.

We suggest further research about the practical technical part of wind power generation technology as suggested by the Vortex Bladeless Turbine, for in-depth analysis and combined with a model and business plan, in order to verify the comparisons between the existing technological scenarios as well as a feasibility study for actual deployment in urban environments.

Authors' contributions

Contribution	Guedes, S. B.	Carvalho, R. A.	Hora, H.
Contextualization	X	---	---
Methodology	X	---	X
Software	---	---	---
Validation	X	X	---
Formal analysis	X	X	X
Investigation	X	---	---
Resources	X	---	---
Data curation	X	---	---
Original	X	---	---
Revision and editing	X	X	X
Viewing	X	---	---
Supervision	X	X	X
Project management	X	X	X
Obtaining funding	X	---	X

References

Associação Brasileira de Energia Eólica. ([s.d.]). Recuperado 27 de junho de 2021, de http://abeeolica.org.br/wp-content/uploads/2021/06/2021_06_InfoVento21.pdf

Carvalho, H. G. de, Reis, D. R. dos, & Cavalcante, M. B. (2011). *Gestão da inovação*. Aymará Educação. http://repositorio.utfpr.edu.br:8080/jspui/handle/1/2057

Climatescope 2020. ([s.d.]). Climatescope 2020. Recuperado 24 de junho de 2021, de https://global-climatescope.org

Dantas, E. J. de A., Rosa, L. P., Silva, N. F. da, & Pereira, M. G. (2019). Wind Power on the Brazilian Northeast Coast, from the Whiff of Hope to Turbulent Convergence: The Case of the Galinhos Wind Farms. *Sustainability*, *11*(14), 3802. https://doi.org/10.3390/su11143802

Empresa de Pesquisa Energética. ([s.d.]-a). *Empreendimentos eólicos ao fim da vida útil: Situação Atual e Alternativas Futuras*. 57.

Empresa de Pesquisa Energética. ([s.d.]-b). Recuperado 27 de junho de 2021, de https://www.epe.gov.br/pt/abcdenergia/fontes-de-energia#FONTES-RENOVAVEIS

Hemalatha, B. (2019). Generation Of Electricity Using Bladeless Wind Turbine. *JOURNAL OF MECHANICS OF CONTINUA AND MATHEMATICAL SCIENCES*, *1*(2). https://doi.org/10.26782/jmcms.spl.2019.08.00052

Hoang, A. T., Pham, V. V., & Nguyen, X. P. (2021). Integrating renewable sources into energy system for smart city as a sagacious strategy towards clean and sustainable process. *Journal of Cleaner Production*, *305*, 127161. https://doi.org/10.1016/j.jclepro.2021.127161

IPC Publication. ([s.d.]). Recuperado 9 de julho de 2021, de https://www.wipo.int/classifications/ipc/ipcpub/?notion=scheme&version=20210101&symbol

=F03D0005060000&menulang=en&lang=en&viewmode=f&fipcpc=no&showdeleted=yes&indexes=no&headings=yes&notes=yes&direction=o2n&initial=A&cwid=none&tree=no&searchmode=ipccat

Milaré, E. (2009). *Direito do ambiente: A gestão ambiental em foco: doutrina, jurisprudência, glossário* (6a. ed. rev., atualizada e ampliada). Editora Revista dos Tribunais.

Neri, M., Jameli, D., Bernard, E., & Melo, F. P. L. (2019). Green versus green? Adverting potential conflicts between wind power generation and biodiversity conservation in Brazil. *Perspectives in Ecology and Conservation*, *17*(3), 131–135. https://doi.org/10.1016/j.pecon.2019.08.004

Orbit Intelligence. ([s.d.]). Recuperado 11 de julho de 2021, de https://www.orbit.com/?locale=en&ticket=278967de-08eb-4b39-8e88-ae6e6da1d047&embedded=false#PatentDocumentPage

Ostia, C., Martinez, J., Aglipay, E. E., Morata, M., Solidum, C. M., & John Tamano, A. (2019). Design of an Ornamental Bladeless Vortex Generator. *2019 IEEE 11th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management (HNICEM)*, 1–5. https://doi.org/10.1109/HNICEM48295.2019.9072884

Reddy, S. R. (2020). Wind Farm Layout Optimization (WindFLO): An advanced framework for fast wind farm analysis and optimization. *Applied Energy*, *269*, 115090. https://doi.org/10.1016/j.apenergy.2020.115090

Rediske, G., Burin, H. P., Rigo, P. D., Rosa, C. B., Michels, L., & Siluk, J. C. M. (2021). Wind power plant site selection: A systematic review. *Renewable and Sustainable Energy Reviews*, *148*, 111293. https://doi.org/10.1016/j.rser.2021.111293

Sala de Imprensa—ANEEL. ([s.d.]). Recuperado 24 de junho de 2021, de https://www.aneel.gov.br/sala-de-imprensa-exibicao-2/-/asset_publisher/zXQREz8EVlZ6/content/id/21866628

Soares, Í. N., Gava, R., & Puppim de Oliveira, J. A. (2021). Political strategies in energy transitions: Exploring power dynamics, repertories of interest groups and wind energy pathways in Brazil. *Energy Research & Social Science*, *76*, 102076. https://doi.org/10.1016/j.erss.2021.102076

Visvizi, A., & Lytras, M. (2019). *Smart Cities: Issues and Challenges: Mapping Political, Social and Economic Risks and Threats*. Elsevier.

Vortex Bladeless Turbine—Reinventing wind energy! ([s.d.]). Vortex Bladeless Wind Power. Recuperado 11 de julho de 2021, de https://vortexbladeless.com/

Wang, J., Geng, L., Ding, L., Zhu, H., & Yurchenko, D. (2020). The state-of-the-art review on energy harvesting from flow-induced vibrations. *Applied Energy*, *267*, 114902. https://doi.org/10.1016/j.apenergy.2020.114902