Catalog of AIR STREAMS FORCED BY HUMAN ACTIVITY

Katalog powstał w ramach projektu LIFE–UrbanWind.PL zgodnie z programem priorytetowym LIFE (2014–2020)
(LIFE – Climate Change Mitygation)

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European Commission

CATALOG

OF AIR STREAMS

FORCED BY HUMAN ACTIVITY

While developing the catalog, an attempt was made to systematize air flows forced by human activity in urbanized space in terms of their places of occurrence and in terms of their characteristics.

CATALOG OF AIR STREAMS - PART I

Characteristics according to the places of occurrence of the air stream

- urban, built-up areas
- industrial streams
- man-made green spaces
- viaducts, bridges
- railway, industrial, subway tunnels, expressways
- internal non-production lines

CATALOG OF AIR STREAMS - PART II

Characteristics of air streams according to their features and parameters

The basis and the first measurements taken into account in the catalog were originally planned locations of the Urban Wind Power Station installation in selected locations, namely:

- Warsaw ..... (patrz zał. 1),
- Cracow ..... (patrz zał. 2),

- Czosnów …… (patrz zał. 3),
- Sobienie Królewskie …. (patrz zał. 4).

The research at the places of installation and testing of the prototype was very important due to the possibility of mapping the main characteristics of the selected air streams to the test conditions in the aerodynamic tunnel, in order to create a state similar to real conditions for testing the device.

At the installation sites, data on the properties of air flows were collected, which will allow to specify the current wind conditions in each of the tested locations, as well as confirm the strength of the air flows. In case of a surprising effect, the possibility of changing the location is reserved to ensure the optimization of the economic and ecological effect.

In the first part of the catalog, air streams were cataloged and systematized according to the places of their formation, and in the second part, air streams were cataloged and systematized according to their features and defined parameters.

On the basis of an earlier diagnosis and recognition of the places of occurrence of air streams, the Catalog divides the streams into groups that have been verified, detailed and expanded. As previously mentioned in the second part, air streams have been cataloged and grouped according to the features and defined parameters of the discussed air streams.

The use of air flows forced by human activity in urban areas, especially in large cities, is extremely important from the point of view of climate change. Metropolises are changing into Urban Heat Islands. This phenomenon is complicated, and climatologists and urban planners have been focus on this problem for years, not only to explain it, but also to find solutions.

AIR STREAM CATALOG that occurs in urbanized and built-up areas tested under the LIFE-UrbanWind.PL project may become one of the important and very useful tools in the fight against the problem described above.

On the basis of the previous diagnosis, it should also be noted and emphasized that:

NO USE OF AIR STREAMS FORCED BY HUMAN ACTIVITY FOR THE REPRODUCTION OF CLEAN ENERGY, THIS IS THE CREATION OF ENERGY WASTE DURING THE NECESSITY OF CREATING AND OPTIMIZING ANY POSSIBLE DISSOLVABLE ENERGY RECYCLING SYSTEMS.

Although for years it has been a pro-social and pro-ecological activity to recover secondary raw materials from the waste stream, despite the significant increase in pro-ecological awareness, so far in all kinds of activities, "energy waste" has been omitted and all activities or attempts aimed at energy recovery have been abandoned, in particular everywhere there where possible, economically viable and environmentally and climate positive. It should be emphasized that taking into account the current situation and conditions that occur in the energy systems of the European Union countries as well as geopolitical and economic conditions, ENERGY RECYCLING can be considered as particularly justified - even necessary and profitable for the economy and society of individual European Union countries.

As part of the LIFE-UrbanWind.PL project, we want to draw everyone's attention, and even build awareness and conviction, especially among decision-makers, that the recycling of dispersed energy is possible and by all means justified - even necessary.

THE COSTS OF ABANDONING ACTIVITIES ENABLING THE RECOVERY AND USE OF THE AIR STREAMS DESCRIBED ABOVE IN DIRECT USE OR FOR THE PRODUCTION OF PURE ENERGY, AND THUS ABANDONING THE USE OF A NEW AND AT THE SAME TIME EXISTING SOURCE OF RENEWABLE ENERGY FOR MANY YEARS, THANKS TO WHICH WE CAN ACT TO SLOW DOWN CLIMATE CHANGE CAN BE VERY DANGEROUS AS TO THE CONSEQUENCES OF CLIMATE CHANGE AND THE COST-EFFECTIVE COST OF THESE CHANGES IN THE NEAR FUTURE AND ESPECIALLY FOR THE NEXT GENERATION.

With the current rate of growth in electricity and fuel prices, all renewable energy sources are of particular importance, especially in distributed energy systems.

Among renewable energy sources, an important position is occupied by: low-power wind turbines, up to several hundred watts (up to several kilowatts) due to the fact that currently wind facilities in urbanized areas are practically non-existent, and they could perfectly cooperate in synergistic systems with photovoltaic devices. The

introduction and widespread use of devices using urban air streams can play a special role in the activities aimed at energy conservation and recycling, such as in the Urban Wind Power Station system tested in the LIFE-UrbanWind.PL project under the LIFE priority program (2014-2020), LIFE Climate Change Mitigation sub-program.

CATALOG OF AIR STREAMS is a study on the quantitative and qualitative recognition and flow paths of air streams caused by human activity in urbanized areas and in places built-up with buildings, technical and communication infrastructure.

Below we present explanations of definitions and terminology used in the catalog.

Urbanized areas
a morphological unit with an urban character of buildings and infrastructure, where clear transformations of development and development are related to non-agricultural economic activity or result from adopting an urban lifestyle and work.

Buildings
is a construction object that is neither a building nor a small architecture object. A building can also be a building device that can be used z obiektu budowlanego do jakiego należy zgodnie z jego przeznaczeniem.

Technical infrastructure
devices, transmission networks and related facilities providing necessary services for a given spatial and economic unit (housing estate, district, city, industrial plant) in the field of energy, heat and water supply, sewage and waste disposal, transport, telecommunication technology, etc.

Communication infrastructure
includes road, rail and inland waterway networks, motorways of the sea, maritime and inland waterway ports, airports and other points of interconnection between modal networks.

This CATALOG organizes and systematizes the collection of measurement data from the previously unrecognized and undefined area such as urbanized areas or in locations located in the areas of installation of technical infrastructure or structures.

The condition for the economic operation of a typical wind farm is its location in an area with good wind conditions. In the Urban Wind Power Station device, the above-mentioned condition does not play a very important role due to the fact that the main source driving the wind turbine is the forced stream, which is the result of human activity.

This catalog contains findings and observations made during the measurements of air streams as well as preliminary, approximate conclusions and suggestions as to the direction of further work and preliminary assumptions as to the integrated system

concept of distributed energy recycling and the method of using the energy of forced streams.

As part of the analysis of measurement data collected using stationary and mobile (portable) monitoring stations and based on the map of the distribution of the energy potential in Poland, places were selected where air flow measurements were carried out in urbanized areas, using stationary monitoring stations and a mobile mobile station.

Below, there are Photographs A and B - stationary air stream monitoring stations Foto C - manual, portable air stream monitoring station.

Foto A

Monitoring station

Foto B

Monitoring station

Foto C

Manual station

Each monitoring station operates using a set consisting of the following devices, elements, subassemblies and sensors: digital controller, GSM / GPRS digital data transmission module, pressure gauge, hygrometer, gas flow rate meter, mains and emergency power supply system.

The tests were carried out at an altitude where the stream shows the most stable velocity over the longest period.

The measurements were recorded in a tabular format with the date and place of the test.

PART I

Characteristics of the places where air streams occur

I. URBAN AND BUILT-UP AREAS

The city is an organism that functions as a system of interconnecting vessels, even a slight change in the average temperature can have catastrophic consequences.

The increase in population and the development of cities translates into:

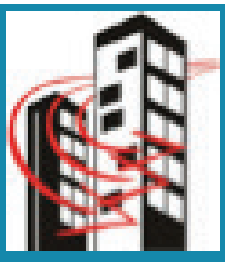
- building density
- creating taller buildings
- expansion of built-up areas,

and this translates into difficulties in heat dissipation outside the urban area, which enhances urban heat islands, because the denser the buildings, the greater the thermal accumulation of buildings.

The use of air flows forced by human activity in urban areas, especially in large cities, is extremely important from the point of view of climate change. Metropolises are changing into Urban Heat Islands. A complex phenomenon that climatologists and urban planners have been focusing on for years, not only to explain it, but also to find solutions to its problems.

THE URBAN HEAT ISLAND is created as a result of the city's functional and spatial structure, i.e. the accumulation of artificial surfaces, a small share of urban green areas and weakened ventilation.

Materials such as concrete, asphalt and brick absorb more sunlight than they reflect, and then release energy, increasing the ambient temperature. Human activity contributes to increasing the air temperature in the city - heating and air conditioning in buildings, car traffic, production of goods.



1.1 High and very high built-up areas residential and office buildings with a height aboveIV floors

AIR STREAM CATALOG in urbanized areas and Urban Wind Power Station device build and tested under the LIFE-UrbanWind.PL project may become a tool in this fight.

Housing estates, especially large clusters of high-rise buildings such as "block housing", cause severe disturbances of the natural air flows, the so-called aeration corridors. Often, an estate of high-rise buildings located on the outskirts of an urban agglomeration may constitute a barrier that disturbs or even prevents the free flow of air in the natural aeration channel, causing its deformation or forcing a change in the natural path of the corridor. Such effects obtained as part of the development of urban agglomerations are inevitable, especially if the aerodynamics of the planned housing estate or city is not taken into account at the design stage. At the stage of creating spatial development plans and in all kinds of economic strategies, such issues should be taken into account in such a way as to minimize such phenomena as part of human activity, and in particular any negative effects related to it.

In urbanized areas, aerodynamic phenomena are very complex. The air hits a highly deformed hardened surface, which heats up more intensively than the surrounding area..

The geometrical characteristics of buildings are the factor that most strongly influences the nature of aerodynamic phenomena in cities, but they can only be predicted partially - their full recognition requires experimental research.

At the same time, in a small area, the movement of air can take place in different directions and at different speeds. The air stagnation zone may be adjacent to the places of its rapid acceleration.

This is shown in the diagram below of the air movement around the building (according to Klaus Daniels).

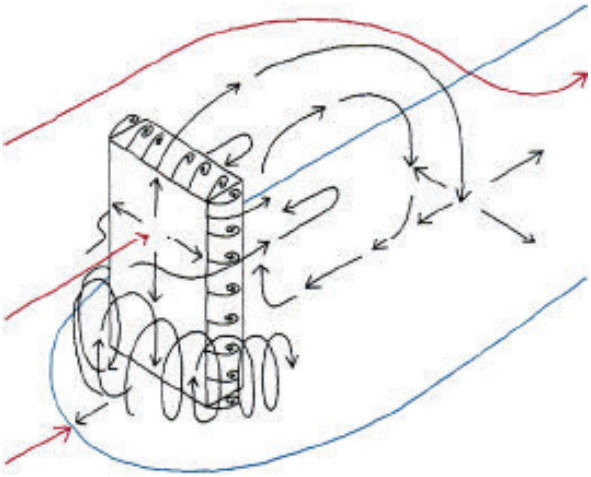


Diagram from the archive Katarzyna Zielonko-Jung from the Faculty of Architecture of the Gdańsk University of Technology

Aerodynamics, initially used by the aviation and automotive industries, has expanded its applications to new fields, especially architecture and urban planning. The urban diversity of urban buildings results in three basic effects related to the flow of air streams:

VACUUM FORMATION when there is an outflow of air from a densely built-up area to an open space.

NOZZLE CREATION, which is created by serial-parallel buildings, especially when the buildings are located in such a way that they gradually move closer to each other or move away from each other.

CHANGES IN THE DIRECTION OF THE STREAM, which most often occurs when the air stream, when it encounters the partition, suddenly slows down, which causes local swirls and a significant increase in the speed of the stream.

This group includes hotels, office buildings, residential buildings, sports facilities, galleries, etc.

The study of streams covered:

- roofs,
- corners,
- exterior walls of buildings,
- routes between buildings,
- external ventilation air streams.

In the complex structure of the ecosystem, there are a number of interrelationships and dependencies, including in the climate sphere related to air flows and local mini and micro climate zones. It has been noticed that "aggressive" and beneficial to a human behavior in one place can cause many negative effects in another, even very remote place, due to the above-mentioned mutual connections and dependencies that occur in the ecosystem.

The issues discussed in this catalog concern the "post factum" stage, ie the period when human interference has already occurred and certain effects (good or bad) have already occurred. The aim of the project is to show the benefits in the field of energy, even if the activity, human intervention disturbed the natural flow of air streams, changed, blocked or impeded the natural aeration corridors.

Considering the fact that almost all human activity usually produces positive and negative effects, it is advisable to try to neutralize and minimize any negative effects or compensate them with other positive effects that will, if not completely, at least partially, compensate for the damage or disturbance caused.

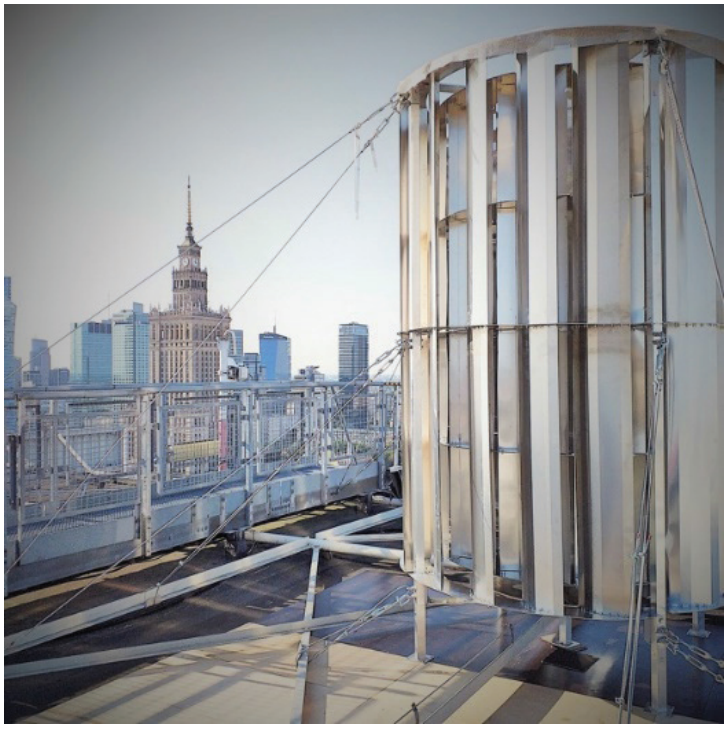
In the case of high-rise buildings, we are dealing with large areas of building facades with different solar exposure, depending on the location, time of the year.

In connection with the above-mentioned differentiated illumination, local differentiated conditions for the degree of heating of the air masses arise. The differences result in a local pressure difference, causing the air mass to move, which can be used to drive wind turbines..

During the measurements, an interesting phenomenon was noticed, the occurrence of particularly favorable conditions for the installation of wind turbines at all kinds of building corners, i.e. wherever we deal with the presence of two planes (facades) with different sunlight exposure next to each other.

During implementation of the LIFE-UrbanWind.PL project, air flows on the roof of the Novotel Warszawa Centrum hotel were measured and examined, where the Urban Wind Power Station device with a power of 5.0 kW is being tested

In this building category, airflows in office buildings in Łódź at ul. Lutomierska No. 111 (see Anex 5) and ul. Odolanowska No. 7 (see Annex 6), as well as in Warsaw at ul. Domaniewska No. 73 (see Annex 7)



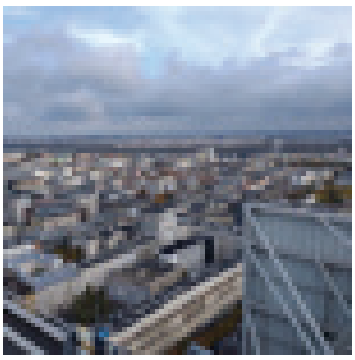
A detailed explanation of the issue of the occurrence of favorable conditions for installing a wind turbine at the corners of buildings requires additional research and measurements in order to determine the repeatability of this type of phenomenon, and above all the causes that caused it and the conditions for the occurrence of this type of phenomenon.

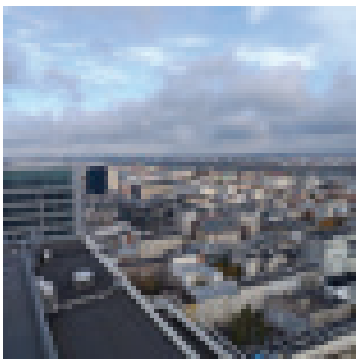
It has been noticed that one of the most favorable conditions for the installation of wind turbines are the corners of buildings in which the building is situated in such a way, where one of the building façades is significantly sunny and the other is shaded. At such corners, the occurrence of the most favorable conditions for the location of wind devices was noticed. In order to determine the repeatability coefficient of this phenomenon and finally determine whether the measurements made were an isolated and a typical case, or whether the observed phenomenon is repeatable and typical for this type of development, the tests should be repeated in similar conditions.

The use of air streams forced by human activity in urbanized areas, especially in large cities, is extremely important from the point of view of a significant impact on climate change. Metropolises are turning into Urban Heat Islands, which are a complex phenomenon that climatologists and urban planners have been looking at for many years, not only to explain them, but above all to find economically and climatically justified, neutral solutions to the problems associated with this phenomenon.

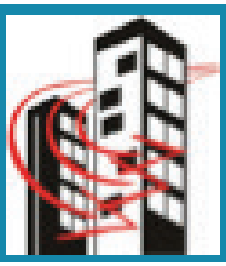
AIR STREAM CATALOG in urbanized areas and built and tested under the LIFE-UrbanWind.PL project may become one of the most important and extremely useful tools for combating and counteracting the formation of Urban Heat Islands.

UWPS device can produce emission-free electricity using urban air streams. If we think whether it is worth introducing new solutions, let's think what the cost of inaction will be, if we do not take decisive action in this area today.





1.2 Medium-high built-up areas; mainly collective housing and administrative and office spaces up to the 4th floors.



This group includes buildings belonging to housing cooperatives, hospitals, schools, lower office buildings, low-rise hotels, military facilities, sports and recreational facilities, etc.

The study of the occurrence of air streams was mainly covered:

- roofs,
- corners.

In this building category, airflows in lower office buildings in Łódź at Sacharowa 45 (see Annex 8), Służbowa 33 (see Annex 9), in Skierniewice, and in Warsaw at Wał Miedzeszyński 438 (see Annes no. 11) were measure

1.3 Low-rise areas; mainly one and two-floors individual residential buildings, but also office pavilions.

The study of streams covered mainly roofs, although the research was also carried out on a storage container.

To set the UWPS generator set, the roofs must be flat, as in photo D. In the case of a sloping roof, we can use a different building element, as in photo E - a storage container, or even a light structure, as in the case of Strzeszkowice Duże - Photo F.

Fot .E

Fot F

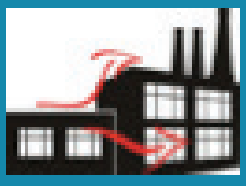
The studies of this type of streams were carried out in Kazimierz Dolny (see Annex 11), Krychów (see Annex 12 and photo D), Kaczki near Pruszcz Gdański (see Annex 13 and Photo E), and large Strzeszkowice near Lublin (see Annex 12 and photo D) . 14 and Photo F)

In urbanized areas, it is impossible to intuitively indicate the optimal place for the installation of a wind turbine due to the complex paths and channels of air flows depending on many factors such as:

- distribution of lumps of individual buildings,
- their height,
- the degree of sunlight during the day,
- landform,
- the presence of green areas in the form of a tree stand
- and many others..

During the measurements carried out in such an area, it was noticed that there was a possibility of significant differences in the velocity of the air stream flow when the measuring point was shifted by a section of 1.5 to 2.0 m. or reduction) of air, often by as much as 50-100%.

Due to formal and legal limitations, and above all due to the content of the construction law regarding the permissible sizes of wind turbines installed without a building permit in low-built areas, the main optimization effort should be focused on wind turbines with a lower unit capacity built in a modular form with standardized power for a single module. This arrangement of many smaller Urban Wind Power Station units will be perfect for a single-family housing estate, where several wind turbines can be connected to one automation and control system..



II. Industry streams

Most often, plots with industrial halls are paved and mostly devoid of green areas and trees. The halls themselves constitute a steel structure enclosed with sandwich panels with an external coating in the form of a thin-walled aluminum sheet with an applied protective coating. In the southern part of Poland, industrial facilities most often blended into urban development. Newly built industrial halls - mainly warehouse halls of logistics centers, wholesalers and network centers of commercial structures in which there is a significant amount of traffic of vehicles and people, therefore activities aimed at recovering energy from air streams are significantly difficult, especially in shopping centers due to the displacement of person.

The analysis of the collected data showed that due to the installed capacity, it is profitable to recover energy from forced air flows related to maintenance installations such as: ventilation systems, cold stores and air-conditioning systems, and due to the high volume of vehicle traffic on access and exit roads, it would be advantageous to install energy recovery systems from air streams (gusts) caused by the movement of passing vehicles. In open areas (areas outside the city limits) where logistic centers are most often located, the conditions of air flow flow are similar to those of golf courses.

The research covered industrial plants, warehouse logistics centers, wholesalers and network centers of commercial structures, and among them:

2.1 Air flows forced by humans inside objects

- internal ventilation drafts
- internal communication routes

2.1 Air flows forced by humans outside the facilities

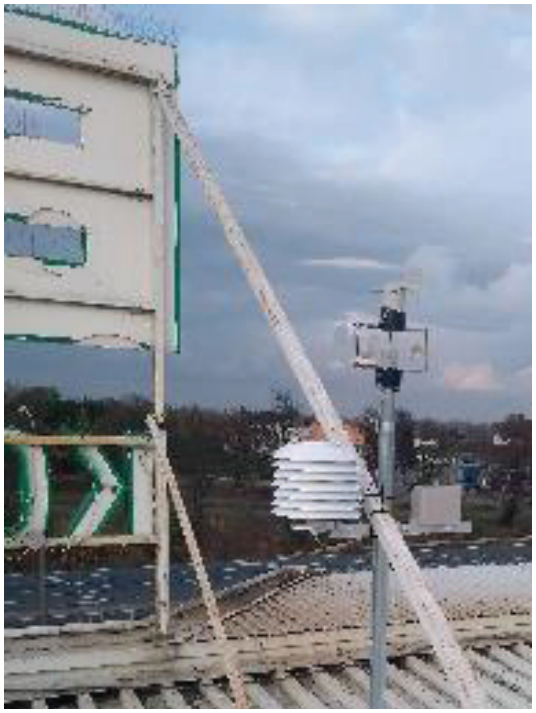
- streams sucked into ventilation systems
- air flows blown to the outside after the work is done

In conditions where we are dealing with air flows caused by human activity, the nominal operation time tends to the limit value of 8760 hours / year due to the fact that many of these flows occur almost continuously and the jet velocity is much higher than the typical limit speed for wind turbines 2.5 m / sec.

It should be emphasized that in most cases of human activity, the phenomenon of air mass flow allows the installation of micro or low power wind farms, i.e. up to a maximum of 5.0 - 20.0 kW. This type of limitation of the maximum power that can be obtained results primarily from the limitation of the maximum sizes of wind turbines and mounting structures that can be used in the case of power plants installed in highly urbanized areas in which we are also dealing with many limitations resulting, among others, from the fact that this environment is a natural space in which people live and work, therefore the issues related to the possibility of providing the most comfortable, achievable conditions are a superior value and requirement,

and a matter such as the possibility of implementing the energy recovery process (recycling) is treated as a secondary matter and a conditional value added.

In industrial streams forced by human activity, we often deal with its individual resources and significant dispersion, which makes it difficult or even completely impossible to build devices with significant power.



Spectacular air streams (such as in fan rooms of large shopping malls, subways or hotels) often have so many technical limitations that even in their case sets of modules with a lower power than a high-power device may be better suited, but due to the weight of the troublesome requirements related to the movement of people.

However, we see a great potential for the issue of energy recycling of industrial air flows caused by human activity to be implemented by means of many smaller devices organized in a network structure with a significant dispersion and low unit power (1.5-2.0 kW) instead of a small number of networks of devices and unit power in the range of 10 to 20.0 kW.

The research was carried out in Warsaw (see Annex 15), Skierniewice (see Annex 16) and in Kutno, see Annex 17)

III Man-shaped green spaces

The research covered golf courses as places using large amounts of electricity locally.

Golf courses, just like housing estates, are the result of human activity. Most often, golf courses are built in suburban areas, "green" areas, partly wooded and bushy wastelands. The roughness class of such terrains prior to conversion to golf courses is usually much higher than when the terrain becomes a golf course. The difference in roughness can be up to several rows. The roughness coefficient of the terrain before it is converted into a golf course may range from 0.1 to 0.5 [terrain with shrubbery and tree belts, agricultural land with slight obstructions], and after conversion to a golf course, the roughness coefficient may be within the following limits: 0.005-0.0002 [water surfaces, open areas]. As can be seen from the above, the transformation of landscape and vegetation varied terrain into a golf course favors the process of the emergence of conditions predisposed for the installation of wind turbines due to the fact that in open areas, without obstacles (with little roughness), the flowing air masses move at a high speed, therefore the potential energy that can be obtained from a wind turbine installed in such an area, theoretically, in the absence of restrictions as to the size of the wind turbine, may range from several to several dozen kW.

These places, due to their enormous potential, have been studied in the context of various air streams, namely:

- Air flows concentrated by maintaining a large empty space (e.g. between trees)
- Air streams created as a result of the intervention of the architect of greenery and the raised elevations in the area.
- Air streams on the banks of large reservoirs created especially for the field
- At the clubhouse and apartment buildings (tests according to points 1.1-1.3.

The streams were investigated in the context of placing the UWPS-05, UWPS-10 and UWPS-20 devices in one line across the air stream and on an almost triangular plan.

The research was conducted on the golf courses of Sobienie Królewskie Golf & Country Club near Warsaw (see Annex 18), Mazury Golf & Country Club (see Annex 19), Postołowo Golf Club near Gdańsk (see Annex 20), Kraków Valley Golf & Country Club (see Annex 21)

IV Viaducts, bridges

Contemporary structures in the form of bridges, viaducts and multi-level communication junctions are complex and extensive structures spread over an area from several to several dozen hectares, of significant heights, often reaching 100 meters or more.

The research covered:

- Air streams concentrated by viaducts or bridges as a result of the collision of natural air drafts with buildings partially destroying free air movement, i.e. streams under bridges and viaducts
- Flows resulting from the forced air movement of vehicles along transit roads with heavy traffic of large wheeled vehicles, captured as streams:
- Flows caused by the movement of vehicles in one direction of travel
- Streams caused by the movement of vehicles in both directions of travel
- Combination of air traffic caused by vehicle traffic with the effect of the concentration of viaducts and bridges, i.e. streams caused by vehicle traffic in both directions and concentrated under the viaducts).

The conducted measurements showed that the installation of wind turbines on viaducts and bridges can bring specific benefits in terms of energy recycling, provided that it is technically possible to collect the energy produced or that there is local demand and the possibility of using the generated energy.

The structures of viaducts and bridges are strong and massive, therefore there are potentially technical conditions for the installation of wind turbines, even of considerable weight and size, but on the other hand, due to the nature and purpose of these facilities, there are strong formal and legal restrictions as to the possibility of attaching wind turbines to construction of this type of building.

The research was carried out in Legionowo (see Annex 22), Stryków (see Annex 23), Warsaw (see Annex 24) and Łódź (see Annex 25)

V. Railway and industrial tunnels, subways, routesfast movement

5.1 RAIL VEHICLES

Although the issue of forced air flows concerns various means of transport: metro trains, railways, i.e. rail vehicles, on the one hand, and vehicles used in road transport, such as heavy goods vehicles (TIR) and passenger vehicles, on the other hand, due to the characteristics and parameters of air flows caused by the above mentioned means of transport, it is reasonable to consider them together, because the streams generated by the above-mentioned means of transport have very similar parameters and features, especially if we consider urban and suburban transport on the part of rail vehicles. Due to this approach, both in the case of rail vehicles and motor vehicles, we deal with the movement of transport units at a similar or similar speed. In the case of metro trains, the speed of movement of the train set ranges from 0 to 80 km / h, and the frequency during the peak period is 1 train / 3-5 minutes.

The research covered:

- The streams caused by the movement of trains in the tunnels generate the movement of air streams with a speed equal to the speed of the train
- A special case is the underground railway with high traffic frequency. In the case of metro trains, the speed of the train set travels within the limits of 80 km / h, and the frequency during the peak period is 1 train / 3-5 minutes.
- Air flows in the zone of urban tram tracks.

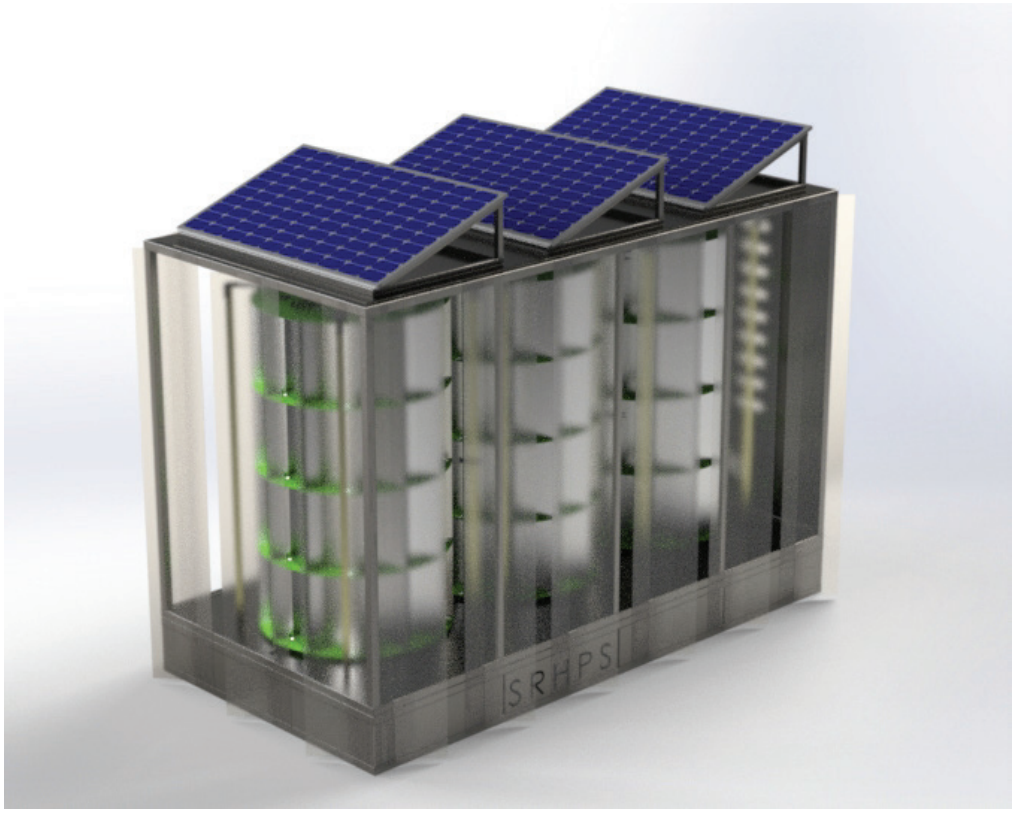
5.2 WHEELED VEHICLES

In the case of heavy goods vehicles on highways and motorways, the speed of a motor vehicle (TIR) is similar, usually 60-90 km / h, and in the case of passenger cars up to 140 km / h. For motor vehicles, we deal with a much higher frequency of vehicle movement, for example, the average traffic intensity of vehicles on the A2 expressway in the area of the Stryków junction is over: 55,000 vehicles a day, in the Konotopa junction about: 75,000 vehicles a day, and on the ring road of the city of Poznań, vehicle traffic is approximately:

82.000 vehicles per day

The zone of the lane separating traffic lanes and the shoulders of road lanes, especially at the end and beginning of noise barriers, should be considered as the most advantageous place for the installation of vertical low-power wind turbines. Due to the specific flow of the air stream, a special shape of the rotor and the diffuser of the power plant will be required, adapted to work on the border of two areas: the area where vehicles move and the area behind the sound-absorbing screen.

On the basis of the measurements taken and the analysis of the collected materials, air streams forced by passing rail vehicles (suburban railways, subway trains) and motor vehicles should be classified as the most attractive in terms of energy and business from the point of view of activities aimed at recovering energy generated by human activity.



As part of the analytical work, it was decided that the issue of hybridization of wind power plants (synergistic operation with photovoltaics) should be developed in order to propose a solution using hybrid electricity generation blocks for the construction of a HYBRID POWER PLATFORM FOR ELECTRIC VEHICLES by powering fast chargers using zero-emission energy from from the production of the Urban Wind Power Station generator set supported in synergy with photovoltaics.

VI. Internal non-production lines At the ventilation and air conditioning outlets.

Each modern hotel and office building, as well as the so-called shopping malls have extensive technical service systems, such as: ventilation and air conditioning systems. Most often, buildings of this type have a large cubature, so ventilation and air-conditioning systems are systems of high or very high power, and therefore tens of millions of cubic meters of air flow through the outlet ducts during the year.

Typical capacities of ventilation systems are in the range from several hundred to several thousand m^3 per hour at the stream flow velocity from 2.5 to 3.5 m / sec. According to the technical parameters of ventilation systems, the annual air flow in such systems may be in the range from several to several dozen million m^3, which means that the issue of installing wind farms that would be driven by the exhaust air stream from the ventilation or air conditioning system should be of interest and further tests and measurements, in particular the issue of determining the coupling level and the use of the air stream to drive a wind turbine without affecting the flow of air streams resulting from the basic functions performed by individual installations.

This category was indicated in point I. However, it requires special attention, because every modern hotel and office building, as well as the so-called shopping malls have extensive technical service systems, such as: ventilation and air conditioning systems.

The solutions, however, differ in:

- hotels
- Office buildings
- subways

After analyzing the places that characterize the occurrence of air streams, it is necessary to systematize them in terms of their features.

PART I I

Characteristics of the places where air streams occur

II.1 TECHNICAL TELEMETRY SYSTEM. THE OUTPUT

In order to develop a catalog of streams, tests were carried out in the places of their occurrence, and in order to define their properties, long-term tests were carried out by measuring parameters such as:

- speed,
- temperature,
- humidity,
- pressure,
- time and periods of occurrence per year.

The research was carried out with the use of a technical telemetry system which included a measurement station and a base station supporting the network structure ensuring the collection and collection of measurement data. The measuring station consisted of the following blocks, modules, subassemblies and elements:blok sterownika cyfrowego:

- transmission module GSM/GPRS,
- pressure gauge,
- hygrometer,
- temperature sensorry,
- air flow speed meter,
- air flow direction indicator.

The tests were carried out at an altitude where the air stream shows the most stable speed over the longest period of time.

The measurements were listed in a tabular format with the date and time of measurement, the values of recorded parameters and the location of the test (measurement):

A/B	C dd-mm-rrrrr	D hh-mm-ss	E m/sek	F hPa	G °C	H %	Remarks

A - place of measurement
B - measurement height [m]
C - date [dd–mm–rrrr]
D – time of measurement [hh-mm-ss]
E - jet speed [m/s]
F - air pressure [hPa]
G - temperature [°C]
H - humidity [%]
I - remarks

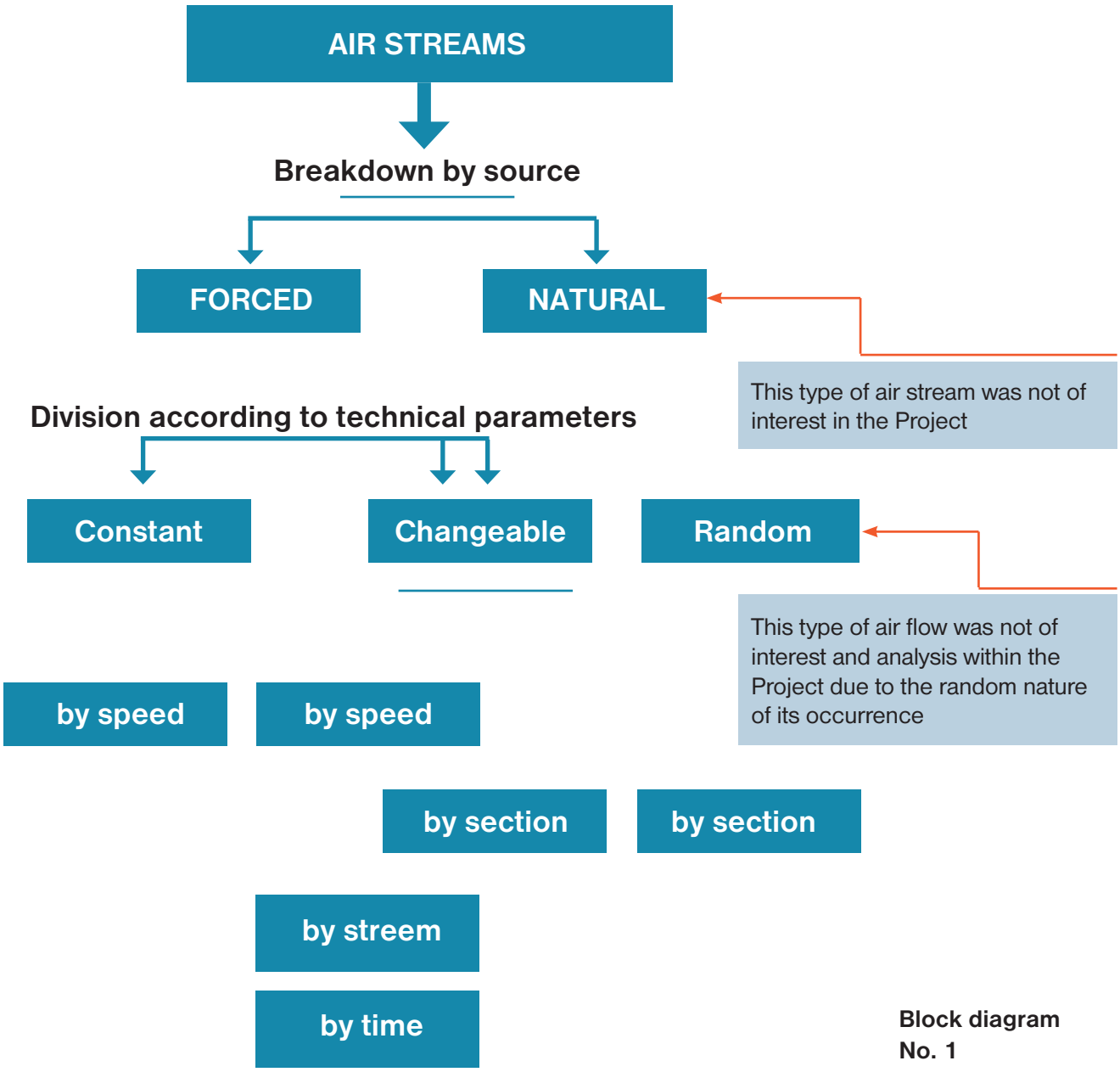
Measurements were made with an accuracy of about 1.0%, and the obtained results were rounded to whole numbers. The selection of sensors, measuring devices and the telemetric data collection system was made by the company that won the competition for offers for the monitoring of stream parameters in the LIFE-UrbanWind.PL project, with the condition that the data collection system meets the requirements and expectations of the Principal contained in the competition inquiry.

On the basis of the collected measurement results and their analysis based on the established methodology and the established criteria for the qualification and division of streams, air streams were cataloged in accordance with the established division and according to the criteria as in the block diagram No. 1, on page 30.

The developed catalog of streams will make it possible to decide on the choice of the installation site for UWPS (Urban Wind Power Station) devices, to optimize their parameters and characteristics, and to prepare the installation for connection to the network and the mounting system.

PART I I

Criteria and methodology of stream division



Block diagram No. 1

Characteristics of cataloged air streams resulting from human interference

III.1 DESCRIPTION. QUANTITATIVE AND QUALITATIVE CHARACTERISTICS OF INDIVIDUAL STREAMS

This catalog of streams includes only forced streams that arise as a result of deliberate activities related to human interference. The second type of air streams resulting from the natural flows of streams was not of interest in the framework of the LIFE-UrbanWind.PL project.

In the LIFE-UrbanWind.PL project, forced air streams are those that are the result of deliberate human activity.

For example, this group of streams includes:

- air stream created behind the fan as a result of the mechanically forced process of air pressing by the fan,
- air stream created as a result of the movement of a rail vehicle in the underground tunnel of the underground,
- air stream resulting from the movement of a motor vehicle on the road,
- air stream that arises as a result of air movement caused by the different degree of heating, absorption coefficient and permeability of building surfaces and other,
- Many others.

Each of the forced air streams created as a result of human interference has individual physicochemical characteristics and parameters that allow for the preparation of its description-characteristics that enable comparison and assessment of the suitability of a given stream for applications in wind energy systems. As mentioned in the introduction, the LIFE-UrbanWind.PL project covers all types of air streams that are generated as a result of human activity. Therefore, this type of group of all types of streams, unlike natural streams, should be treated as a group of forced streams, where the forced effect is a stream, and the forced effect is the activity, interference or presence of a human or an object, object, structure, etc. related to his activity. The air stream is a process of air masses shifting as a function of time. Due to the time of presence (availability) of the air stream, the streams can be constant streams and alternating streams.

According to the block diagram - drawing No. 1, page 32, the following air streams may arise as a result of human activity:

- constant air stream,
- variable air stream,
- random air stream.

As part of this project, as well as due to the randomness and the associated low usefulness in the field of wind energy, random air flows were not taken into account, and therefore they were not tested or monitored during the project duration.

III.2 CONSTANT AIR STREAMS

Constant air streams are those that occur continuously over time. Due to the constant occurrence of these types of air streams, they should be considered the most beneficial and useful in the field of energy, but they are not very frequent and common. Constant streams are present all the time, and the only parameter that can result in further splits in this group is their speed.

III.2a BREAKDOWN OF CONSTANT STREAMS BY SPEED

Therefore, by dividing the streams depending on their speed, we can distinguish:

Rodzaj strumienia wiatru	km/h	m/sek.
Strumień stały **spokojny**	<1	<0,3
Strumień stały **zefirek**	1 – 5	0,3 – 1,5
Strumień stały **lekki**	6 - 11	1,6 – 3,3
Strumień stały **słaby**	12 - 19	3,4 – 5,4
Strumień stały **umiarkowany**	20 - 28	5,5 – 7,9
Strumień stały **świeży**	29 - 38	8,0 – 10,7
Strumień stały **silny**	39 - 49	10,8 – 13,8
Strumień stały **sztywny**	50 - 61	13,9 – 17,1
Strumień stały **burzliwy**	62 - 74	17,2 – 20,7
Opis matematyczny **strumienia**		
$S_{pow.\ (t=const.)} = f(V_{wiatru})$		

III.2.B DIVISION OF CONSTANT STREAMS ACCORDING TO THE CROSS-SECTION

Przekrój
punktowy
liniowy
powierzchniowy
stały
zmienny

III.3 VARIABLE AIR STREAMS

Variable air streams are those whose quantitative and qualitative parameters, and in particular their duration, vary over time. These types of air jets are much more common than solid jets. Due to the variability of quantitative and qualitative parameters, their management is much more difficult than in the case of solid streams.

III.3.a BREAKDOWN OF VARIABLE STREAMS BY SPEED

Rodzaj strumienia wiatru	km/h	m/sek.
Strumień zmienny **spokojny**	<1	<0,3
Strumień zmienny **zefirek**	1 – 5	0,3 – 1,5
Strumień zmienny **lekki**	6 - 11	1,6 – 3,3
Strumień zmienny **słaby**	12 - 19	3,4 – 5,4
Strumień zmienny **umiarkowany**	20 - 28	5,5 – 7,9
Strumień zmienny **świeży**	29 - 38	8,0 – 10,7
Strumień zmienny **silny**	39 - 49	10,8 – 13,8
Strumień zmienny **sztywny**	50 - 61	13,9 – 17,1
Strumień zmienny **burzliwy**	62 - 74	17,2 – 20,7
Opis matematyczny **strumienia**		
$S_{pow.(t)} = f(x)$		

Each of the streams listed in the table can be a constant or variable flow. The variable air stream, which arose due to human interference in a given environment or its presence, may be a variable or impulse flow with predictable and quantifiable quantitative and qualitative characteristics.

III.3.b DIVISION OF VARIABLE STREAMS ACCORDING TO THE CROSS-SECTION

Typ - Przekroju	Podgrupa typu
Punktowy typu dysza	Stały lub zmienny
Wielopunktowy	Stały lub zmienny
Liniowy	Pionowy poziomy
Powierzchniowy	Stały - zmienny
Turbulencyjny	Stały - zmienny

In point or multipoint type variable airflow, the jet cross section may be constant

or time varying. As for the cross-sections of the streams, its spatial orientation is also important due to the fact that it has a significant impact on the method, type, location and mounting of the wind turbine. In general, for the cross-sections of linear-type streams, detail should be used in the form of division into subgroups, which details the characteristics of the stream in terms of linear - vertical or linear - horizontal orientation.

When determining the cross-sections of surface air streams, it was appropriate to define whether a given cross-section is a constant or time-varying surface cross-section, hence the division into subgroups in this group, similarly to the cross-section of a stream with complex (disturbed-variable) characteristics called turbulent because this type, the variability of the cross-section of the transverse streams occurs wherever there are phenomena of turbulence, turbulence. This type of phenomenon was noticed when the study of streams was carried out along road routes, and in particular its occurrence behind moving vehicles such as railways or subways, and in the case of vehicles such as lorries, lorries with a trailer or a passenger car. In the studied speed range, the phenomenon of turbulence and swirls of the air stream increased with the increase in the speed of the moving object. In wind energy systems based on forced streams, this phenomenon should be taken into account when planning the construction of the power plant in the structure of rail or road communication, because the phenomenon described above may have a significant and significant impact on the total energy balance of the system for obtaining and recovering energy from streams forced by human activity.

III.3.c DIVISION OF VARIABLE STREAMS ACCORDING TO THEIR FORM

Postać strumienia
impulsowy
okresowo-impulsowa

For the correct definition and description of variable air streams, it is necessary to determine whether a given stream is a stream of a continuous or impulse nature. In order to determine the usefulness of the air stream, and in particular to calculate the recoverable energy, and also due to the characteristics of the stream, it was necessary to introduce parameters that in the case of natural streams are not defined because there is no such need due to the fact that the vast majority of natural processes (including air streams) is usually continuous. In the natural - natural environment, impulse (violent) processes are most often associated with catastrophic events (e.g. volcanic eruption, avalanche, etc.). Therefore, when dividing the streams in the Catalog in question into constant and variable streams, it was necessary to introduce additional definitions and parameters that would allow to precisely characterize and describe variable streams in the form of pulses. Variable air streams, which are in the form of a pulse, apart from the frequency characteristic, have different time characteristics, such as the duration of the pulse, its amplitude, as well as the speed of the pulse front rise and the slope falling speed, therefore a simplified characteristic related to the frequency characteristic has been defined for

the description in this catalog, describing only its frequency form, and its duration is defined in the time characteristic.

III.3.d BREAKDOWN OF VARIABLE STREAMS BY DURATION

Czas trwania strumienia w postaci impulsu
Bardzo krótki (pik)
Krótki [kilka sekund]
Długi [kilkadziesiąt sekund do kilku minut]

Graphically, the amount of energy of a single pulse illustrates the surface area of the pulse with amplitude A and duration t. the greatest influence on the power of the air stream::

$$P_w = 0{,}5 \bullet ß \bullet A \bullet V^3 \qquad [1.1]$$

smbols:
ß - air density (assumed 1.225 [kg / m^3],
A - the surface through which the stream flows,
V - air flow velocity at the site under consideration (wind speed). If we consider and analyze forced streams, the parameter V is the forced flux velocity.

As it can be seen from the formula [1.1], the component that has the greatest influence on the power contained in the air stream has its velocity, which in the formula [1.1] occurs in the 3rd power.

In the case of small wind power plants (power plants), the most important factor that is taken into account, apart from the ecological factor, is the issue of the economic effect, which, due to the recent increases in energy prices and forecasts for the coming years, becomes more and more expressive and significant. It should be emphasized that in the case of low-power wind turbines, such as turbines that appear in the subject, after cataloging the forced streams, a simplified procedure can be used when formulating the parameters of a given installation and determining the power of the turbine, which will enable optimal use of energy obtained from the forced air stream.

III.4.e FINAL CONCLUSIONS FROM THE ANALYSIS OF DATA OBTAINED FROM MEASUREMENTS AND MONITORING

CONDITIONS FOR URBANIZED (URBAN) AREAS

1 Dynamic development of cities - their expansion with a simultaneous, significant increase in the height of buildings, especially in the so-called the very center (city) results in a strong transformation of the environment, including the flows of air streams and climate. An excellent example of such a transformation is the city of Warsaw and many other cities in Poland.

View of the center of Warsaw

2 The main characteristic features of the climate of modern cities have become the excess heat and weakened air exchange (ventilation).

3 All flows of air streams in urbanized areas have undergone significant transformations in relation to the flows and their parameters that took place in recent years, as well as in relation to air flows that occurred or occur in open areas.

4 High buildings (especially in the strict city centers) and considerable roughness of the city surfaces caused a significant reduction in the velocity of air flows in the urban area. It is estimated that the speed of air flow in the city center decreased by an average of 30%, and in the housing development of the outer zone by 15-20%.

5 Significant changes and modification of the air flow (channels) in urbanized areas caused significant differences in pressure between the urban area and the suburban area, which are most often associated with the excess heat, the sources of which are: solar radiation heat, heat accumulated by the artificial city surface and the emission of waste heat. In such conditions as described above, as well as with poor circulation of the atmosphere, during the period of weak winds and atmospheric silence, the so-called urban heat islands and associated breezes towards the city center.

6 In conditions of commonly weakened air flow in cities, the infiltration of air streams from external (suburban) areas usually takes place through river valleys (if a river flows through the city) and main communication routes.

7 In the city, in narrow passages between buildings, the flows of air flows slow down and often have the nature of turbulent flows, and there are sudden changes in the direction of their flow.

8 The above-mentioned negative effects of the development of urban areas are inevitable, therefore the only rational solution that remains for humanity is to act to transform or use negative effects and phenomena

in such a way that they become beneficial and useful for humans. One of the methods of converting the above-described negative effects of the occurrence of climate change into beneficial and beneficial effects is the action related to the use of air flows occurring in urban areas for the purposes of wind energy due to the fact that::

- air streams forced by human activity carry significant kinetic energy that can be recovered and converted into clean electricity,
- air streams forced by human activity are an excellent source of renewable energy both in terms of technological lines and free streams,
- urbanized space with its infrastructure can be used for the installation of low-power generating devices producing electricity from the energy of air streams, both technological and free, using optimally cylindrical, environmentally safe wind turbines, which can be successfully used in any type of development, including also urban buildings,
- air streams in urbanized space are potentially a favorable source of power for generating devices from which the generated electricity can be locally and advantageously managed,
- surbanized space properly developed with generating devices using air streams may constitute the basis for the structure of clean electricity production in a distributed system,
- sUrban Wind Power Station power generator is a good example of a power generator designed and dedicated to use air streams in urban areas to produce electricity, especially with current and future electricity prices.

9 The expansion of cities and the related construction of new, most often tall buildings, which results in a significant negative impact on the climatic conditions (such as: deterioration of the ventilation process of built-up areas, reduction of aeration, significant increase in dust, increased concentration of exhaust gases, etc.) the local appearance of zones, areas of high velocity of movement of air masses and their swirls, which is a very favorable phenomenon from the point of view of using the flowing air masses for the purposes of the above-mentioned wind energy.

10 The dynamic process of urban development and the construction of, above all, communication infrastructure (expressways and highways, high-speed lines, river water transport, …), which cause or strengthen negative climatic effects and accelerate the process of environmental degradation, are also one of the most important, and at the same time favorable factors favoring the process of development and construction of local wind energy systems, based on climate changes and anomalies caused by the urbanization process, which result, among others, in phenomena such as those mentioned in point 9 and the appearance of forced air streams resulting from deliberate or secondary human activity.

11 The data obtained from the measurements and the achieved ecological and economic effects confirm that:

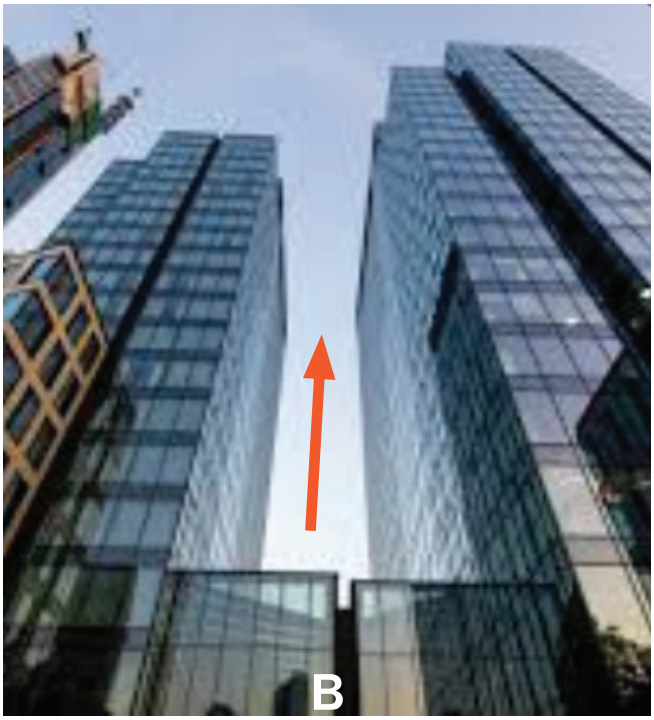
a installation of Urban Wind Power Station generating sets in cities

and at all types of communication infrastructure buildings in order to recover energy from air streams resulting from human activity is fully justified, financially beneficial, as well as organizationally, technically, environmentally and architecturally feasible,

b city development is in many cases shaped in such a way that its shape and characteristics constitute a nozzle, tunnel or corridor structure which unintentionally forces and organizes the flow of air streams, and at the same time is predisposed to install wind turbines in it ,

c the process of expansion of cities and the high height of buildings favor the process of the appearance in the urban space of air flows favorable for use in UWPS, including in particular::

- on corridor-type urban inlets where the maximum acceleration factor can reach a value of up to 1.6
- at the outlets from the corridor-type buildings, the acceleration factor may reach a value of up to 1.2
- on the corners (edges) of windward buildings, where the acceleration factor can reach a value from 1.6 to 2.2.powietrza typu „korytarz”



A - The development of two-story buildings along the street creates a channel for the flow of streams "corridor" air

B - Two buildings situated in parallel form a type air flow channel "corridor"

CONDITIONS FOR INFRASTRUCTURE AND FIELD STRUCTURES

1. Construction of a motorway and reconstruction of expressways, high-speed rail lines, river water transport, results in the appearance of zones where there are flows of air flows caused by human activity.
2. On motorways and roads, forced air flows are created by the movement of vehicles, and on railways by the movement of trains.
3. Streams, although they are the result of the movement of vehicles (trains), can be described as predictable and determinate, because the parameters (mass, area, speed, frequency of travel, etc.) related to the movement of vehicles, generating the said streams, are known.
4. Due to the fact that air streams generated by vehicles and trains (metro) are determined, this type of streams should be considered the most advantageous from the point of view of their use in wind energy systems as in the Urban Wind project.
5. Due to the high intensity of traffic in road transport, wind turbines installed on communication infrastructure buildings (along roads and railways, in subway tunnels, etc.) enable the generation of electricity with the use of wind turbines driven by air blasts generated by moving vehicles or trains almost continuously. Such a state of affairs as described above enables the production of a significant amount of energy, and at the same time, due to its location, it allows for the creation of a system for powering electric vehicles from RES, including heavy goods vehicles, synergistic with electromobility.

IV. QUANTITATIVE AND QUALITATIVE AIR STREAM CATALOG

KARTA KATALOGOWA

Opis	Parametry - typ - dane
Lokalizacja	STRUMIEŃ POWIETRZA W TUNELU METRO
Nazwa strumienia	wymuszony
Parametry strumienia	
Typ	zmienny
Prędkość	strumień zmienny świeży [8,0 - 10,7] m/sek
Czas trwania	długi [kilkadziesiąt sekund]
Charakterystyka	powierzchniowy
Częstotliwość	okresowo-Impulsowa
Charakterystyka impulsu	krótki czas narastania, krótki czas opadania
Dostępność strumienia	20 h/dobę - docelowo 24/24 h
Moc dostępna w 1 imp.	23,0 kW

OPIS STRUMIENIA WYMUSZONEGO ZMIENNEGO

1. Dane do karty katalogowej pozyskano wykonując pomiary na stacji metro.
2. Strumień wymuszony przejazdem składu metra ma postać impulsu o czasie trwania od kilku do kilkudziesięciu sekund.
3. Ekwiwalent przekroju poprzecznego wymuszonego strumienia powietrza można opisać powierzchnią o nieregularnych bokach i powierzchni od 4-12 m^2
4. Częstotliwość impulsów uzależniona jest od częstotliwości przejazdów składów pociągu

KARTA KATALOGOWA

Opis	Parametry - typ - dane
Lokalizacja	STRUMIEŃ POWIETRZA W REJONIE MOSTU NAD RZEKĄ
Nazwa strumienia	wymuszony
Parametry strumienia	
Typ	zmienny
Prędkość	strumień zmienny świeży [8,0 - 10,7] m/sek
Czas trwania	długi [kilkadziesiąt sekund]
Charakterystyka	powierzchniowy
Czestotliwość	okresowo impulsowa
Charakterystyka impulsu	długi czas narastania, długi czas opadania
Dostępność strumienia	24/24 h
Moc dostępna w 1 imp.	3,0 kW

OPIS STRUMIENIA WYMUSZONEGO ZMIENNEGO

1. Dane do karty katalogowej pozyskano wykonując pomiary pod wiaduktem przy autostradzie.
2. Strumień wiatru przemieszczający się pod mostem ma postać impulsu o czasie trwania od kilku do kilkudziesięciu sekund.
3. Ekwiwalent przekroju poprzecznego wymuszonego strumienia powietrza można opisać powierzchnią zajmowaną przez wirnik o nieregularnych bokach i wynoszącą 6,5 m².
4. Częstotliwość impulsów uzależniona jest od częstotliwości podmuchów wiatru.

KARTA KATALOGOWA

Opis	Parametry - typ - dane
Lokalizacja	STRUMIEŃ POWIETRZA NA PERONIE STACJI KOLEJOWEJ
Nazwa strumienia	wymuszony
Parametry strumienia	
Typ	zmienny
Prędkość	strumień zmienny świeży [8,0 - 10,7] m/sek
Czas trwania	długi [kilkadziesiąt sekund]
Charakterystyka	powierzchniowy
Częstotliwość	okresowo-impulsowa [co 3 minuty - szczyt, co 10 min poza]
Charakterystyka impulsu	krótki czas narastania, krótki czas opadania
Dostępność strumienia	24/24 h
Moc dostępna w 1 imp.	14,0 kW

OPIS STRUMIENIA WYMUSZONEGO ZMIENNEGO

1. Dane do karty katalogowej pozyskano wykonując pomiary na stacji kolejowej.
2. Strumień wymuszony przejazdem składu pociągu ma postać impulsu o czasie trwania od kilku do kilkudziesięciu sekund.
3. Ekwiwalent przekroju poprzecznego wymuszonego strumienia powietrza można opisać powierzchnią o nieregularnych bokach i powierzchni od 5-14 m^2
4. Częstotliwość impulsów uzależniona jest od częstotliwości przejazdów składów pociągu

KARTA KATALOGOWA

Opis	Parametry - typ - dane
Lokalizacja	STRUMIEŃ POWIETRZA NA POLU GOLFOWYM W TERENIE GÓRSKIM
Nazwa strumienia	wymuszony
Parametry strumienia	
Typ	zmienny
Prędkość	strumień zmienny świeży [8,0 - 10,7] m/sek
Czas trwania	długi [kilkadziesiąt sekund]
Charakterystyka	powierzchniowy
Czestotliwość	okresowo impulsowa
Charakterystyka impulsu	długi czas narastania, długi czas opadania
Dostępność strumienia	24/24 h
Moc dostępna	uzależniona od parametrów siłowni wiatrowej

OPIS STRUMIENIA WYMUSZONEGO ZMIENNEGO

1. Dane do karty katalogowej pozyskano wykonując pomiary na polu golfowym na zboczu terenu pagórkowatego.
2. Strumień wiatru przemieszczający się ma postać impulsu o czasie trwania od kilku do kilkudziesięciu sekund.
3. Częstotliwość impulsów uzależniona jest od częstotliwości podmuchów wiatru.

KARTA KATALOGOWA

Opis	Parametry - typ - dane
Lokalizacja	STRUMIEŃ POWIETRZA NA POLU GOLFOWYM
Nazwa strumienia	wymuszony
Parametry strumienia	
Typ	zmienny
Prędkość	strumień zmienny umiarkowany [5,5 - 7,9] m/sek
Czas trwania	długi [kilkadziesiąt sekund]
Charakterystyka	powierzchniowy
Czestotliwość	okresowo impulsowa
Charakterystyka impulsu	długi czas narastania, długi czas opadania
Dostępność strumienia	24/24 h
Moc dostępna	uzależniona od parametrów siłowni wiatrowej

OPIS STRUMIENIA WYMUSZONEGO ZMIENNEGO

1. Dane do karty katalogowej pozyskano wykonując pomiary na polu golfowym w pobliżu zbiornika wodnego.
2. Strumień wiatru przemieszczający się ma postać impulsu o czasie trwania od kilku do kilkudziesięciu sekund.
3. Częstotliwość impulsów uzależniona jest od częstotliwości podmuchów wiatru.

KARTA KATALOGOWA

Opis	Parametry - typ - dane
Lokalizacja	STRUMIEŃ POWIETRZA NA BUDYNKACH PRZEMYSŁOWYCH
Nazwa strumienia	wymuszony
Parametry strumienia	
Typ	zmienny
Prędkość	strumień zmienny świeży [8,0 - 10,7] m/sek
Czas trwania	długi [kilkadziesiąt sekund]
Charakterystyka	powierzchniowy
Czestotliwość	okresowo impulsowa
Charakterystyka impulsu	długi czas narastania, długi czas opadania
Dostępność strumienia	24/24 h
Moc dostępna	uzależniona od parametrów siłowni wiatrowej

OPIS STRUMIENIA WYMUSZONEGO ZMIENNEGO

1. Dane do karty katalogowej pozyskano wykonując pomiary na halach przemysłowych.
2. Strumień wiatru przemieszczający się ma postać impulsu o czasie trwania od kilku do kilkudziesięciu sekund.
3. Częstotliwość impulsów uzależniona jest od częstotliwości podmuchów wiatru.

KARTA KATALOGOWA

Opis	Parametry - typ - dane
Lokalizacja	STRUMIEŃ POWIETRZA PRZY AUTOSTRADZIE
Nazwa strumienia	wymuszony
Parametry strumienia	
Typ	zmienny
Prędkość	strumień zmienny umiarkowany [5,5 - 7,9] m/sek
Czas trwania	bardzo krótki [pik] + długi [kilkadziesiąt sekund]
Charakterystyka	powierzchniowy
Częstotliwość	okresowo-Impulsowa
Charakterystyka impulsu	krótki czas narastania, krótki czas opadania
Dostępność strumienia	24/24 h
Moc dostępna w 1 imp.	3,0 kW

OPIS STRUMIENIA WYMUSZONEGO ZMIENNEGO

1. Dane do karty katalogowej pozyskano wykonując pomiary przy drodze szybkiego ruchu.
2. Strumień wymuszony przejazdem składu metra ma postać impulsu o czasie trwania od kilku do kilkudziesięciu sekund.
3. Ekwiwalent przekroju poprzecznego wymuszonego strumienia powietrza można opisać powierzchnią o nieregularnych bokach i powierzchni od 6,5 m²
4. Częstotliwość impulsów uzależniona jest od częstotliwości podmuchów wiatru wytwarzanych przez przejeżdżające pojazdy .

KARTA KATALOGOWA

Opis	Parametry - typ - dane
Lokalizacja	STRUMIEŃ POWIETRZA POD WIADUKTEM PRZY AUTOSTRADZIE
Nazwa strumienia	wymuszony
Parametry strumienia	
Typ	zmienny
Prędkość	strumień zmienny świeży [8,0 - 10,7] m/sek
Czas trwania	bardzo krótki [pik] + długi [kilkadziesiąt sekund]
Charakterystyka	powierzchniowy
Czestotliwość	okresowo impulsowa
Charakterystyka impulsu	długi czas narastania, długi czas opadania
Dostępność strumienia	24/24 h
Moc dostępna w 1 imp.	3,0 kW

OPIS STRUMIENIA WYMUSZONEGO ZMIENNEGO

1. Dane do karty katalogowej pozyskano wykonując pomiary pod wiaduktem przy autostradzie.
2. Strumień wiatru przemieszczający się pod mostem ma postać impulsu o czasie trwania od kilku do kilkudziesięciu sekund.
3. Ekwiwalent przekroju poprzecznego wymuszonego strumienia powietrza można opisać powierzchnią zajmowaną przez wirnik o nieregularnych bokach i wynoszącą 6,5 m².
4. Częstotliwość impulsów uzależniona jest od częstotliwości podmuchów wiatru.

KARTA KATALOGOWA

Opis	Parametry - typ - dane
Lokalizacja	STRUMIEŃ POWIETRZA NA SKRAJU OBSZARÓW ZALEŚONYCH
Nazwa strumienia	wymuszony
Parametry strumienia	
Typ	zmienny
Prędkość	strumień zmienny umiarkowany [5,5 - 7,9] m/sek
Czas trwania	długi [kilkadziesiąt sekund]
Charakterystyka	powierzchniowy
Czestotliwość	okresowo impulsowa
Charakterystyka impulsu	długi czas narastania, długi czas opadania
Dostępność strumienia	24/24 h
Moc dostępna	uzależniona od parametrów siłowni wiatrowej

OPIS STRUMIENIA WYMUSZONEGO ZMIENNEGO

1. Dane do karty katalogowej pozyskano wykonując pomiary w pobliżu terenów zalesionych.
2. Strumień wiatru przemieszczający się ma postać impulsu o czasie trwania od kilku do kilkudziesięciu sekund.
3. Częstotliwość impulsów uzależniona jest od częstotliwości podmuchów wiatru.

KARTA KATALOGOWA

Opis	Parametry - typ - dane
Lokalizacja	STRUMIEŃ POWIETRZA PRZY BUDYNKACH NA ZBOCZACH TERENU WYŻYNNEGO
Nazwa strumienia	wymuszony
Parametry strumienia	
Typ	zmienny
Prędkość	strumień zmienny świeży [5,5 - 7,9] m/sek
Czas trwania	długi [kilkadziesiąt sekund]
Charakterystyka	powierzchniowy
Czestotliwość	okresowo impulsowa
Charakterystyka impulsu	długi czas narastania, długi czas opadania
Dostępność strumienia	24/24 h
Moc dostępna	uzależniona od parametrów siłowni wiatrowej

OPIS STRUMIENIA WYMUSZONEGO ZMIENNEGO

1. Dane do karty katalogowej pozyskano wykonując pomiary na polu golfowym w pobliżu zbiornika wodnego.
2. Strumień wiatru przemieszczający się ma postać impulsu o czasie trwania od kilku do kilkudziesięciu sekund.
3. Częstotliwość impulsów uzależniona jest od częstotliwości podmuchów wiatru.

KARTA KATALOGOWA

Opis	Parametry - typ - dane
Lokalizacja	STRUMIEŃ POWIETRZA BUDYNKI O NISKIEJ ZABUDOWIE NA TERENIE NIZINNYM
Nazwa strumienia	wymuszony
Parametry strumienia	
Typ	zmienny
Prędkość	strumień zmienny świeży [8,0 - 10,7] m/sek
Czas trwania	długi [kilkadziesiąt sekund]
Charakterystyka	powierzchniowy
Częstotliwość	okresowo impulsowa
Charakterystyka impulsu	długi czas narastania, długi czas opadania
Dostępność strumienia	24/24 h
Moc dostępna	uzależniona od parametrów siłowni wiatrowej

OPIS STRUMIENIA WYMUSZONEGO ZMIENNEGO

1. Dane do karty katalogowej pozyskano wykonując pomiary w pobliżu budynku 1 piętrowego. w terenie nizinnym.
2. Strumień wiatru przemieszczający się ma postać impulsu o czasie trwania od kilku do kilkudziesięciu sekund.
3. Częstotliwość impulsów uzależniona jest od częstotliwości podmuchów wiatru.

KARTA KATALOGOWA

Opis	Parametry - typ - dane
Lokalizacja	STRUMIEŃ POWIETRZA DOMY JEDNORODZINNE W DOLINACH GÓRSKICH
Nazwa strumienia	wymuszony
Parametry strumienia	
Typ	zmienny
Prędkość	strumień zmienny świeży [8,0 - 10,7] m/sek
Czas trwania	długi [kilkadziesiąt sekund]
Charakterystyka	powierzchniowy
Częstotliwość	okresowo impulsowa
Charakterystyka impulsu	długi czas narastania, długi czas opadania
Dostępność strumienia	24/24 h
Moc dostępna	uzależniona od parametrów siłowni wiatrowej

OPIS STRUMIENIA WYMUSZONEGO ZMIENNEGO

1. Dane do karty katalogowej pozyskano wykonując pomiary na dachu budynku 2 piętrowego. w terenie wiejskim.
2. Strumień wiatru przemieszczający się ma postać impulsu o czasie trwania od kilku do kilkudziesięciu sekund.
3. Częstotliwość impulsów uzależniona jest od częstotliwości podmuchów wiatru.

KARTA KATALOGOWA

Opis	Parametry - typ - dane
Lokalizacja	STRUMIEŃ POWIETRZA MIĘDZY BLOKAMI MIESZKALNYMI
Nazwa strumienia	wymuszony
Parametry strumienia	
Typ	zmienny
Prędkość	strumień zmienny umiarkowany [5,5 - 7,9] m/sek
Czas trwania	długi [kilkadziesiąt sekund]
Charakterystyka	powierzchniowy
Czestotliwość	okresowo impulsowa
Charakterystyka impulsu	długi czas narastania, długi czas opadania
Dostępność strumienia	24/24 h
Moc dostępna	uzależniona od parametrów siłowni wiatrowej

OPIS STRUMIENIA WYMUSZONEGO ZMIENNEGO

1. Dane do karty katalogowej pozyskano wykonując pomiary pomiędzy czteropiętrowymi budynkami mieszkalnymi.
2. Strumień wiatru przemieszczający się ma postać impulsu o czasie trwania od kilku do kilkudziesięciu sekund.
3. Częstotliwość impulsów uzależniona jest od częstotliwości podmuchów wiatru.

KARTA KATALOGOWA

Opis	Parametry - typ - dane
Lokalizacja	STRUMIEŃ POWIETRZA NA DACHU WYSOŚCIOWCA
Nazwa strumienia	wymuszony
Parametry strumienia	
Typ	zmienny
Prędkość	strumień zmienny umiarkowany [5,5 - 7,9] m/sek
Czas trwania	długi [kilkadziesiąt sekund]
Charakterystyka	powierzchniowy
Częstotliwość	okresowo impulsowa
Charakterystyka impulsu	długi czas narastania, długi czas opadania
Dostępność strumienia	24/24 h
Moc dostępna	uzależniona od parametrów siłowni wiatrowej

OPIS STRUMIENIA WYMUSZONEGO ZMIENNEGO

1. Dane do karty katalogowej pozyskano wykonując pomiary na dachu budynku 30 pięrowego.
w terenie zurbanizowanym.
2. Strumień wiatru przemieszczający się ma postać impulsu o czasie trwania od kilku
do kilkudziesięciu sekund.
4. Częstotliwość impulsów uzależniona jest od częstotliwości podmuchów wiatru.

KARTA KATALOGOWA

Opis	Parametry - typ - dane
Lokalizacja	STRUMIEŃ POWIETRZA MIĘDZY WIEŻOWCAMI (BUDYNKI O WYSOKIEJ ZABUDOWIE)
Nazwa strumienia	wymuszony
Parametry strumienia	
Typ	zmienny
Prędkość	strumień zmienny świeży [8,0 - 10,7] m/sek
Czas trwania	długi [kilkadziesiąt sekund]
Charakterystyka	powierzchniowy
Częstotliwość	okresowo impulsowa
Charakterystyka impulsu	długi czas narastania, długi czas opadania
Dostępność strumienia	24/24 h
Moc dostępna	uzależniona od parametrów siłowni wiatrowej

OPIS STRUMIENIA WYMUSZONEGO ZMIENNEGO

1. Dane do karty katalogowej pozyskano wykonując pomiary pomiędzy budynkami 10 piętrowymi w terenie zurbanizowanym.
2. Strumień wiatru przemieszczający się ma postać impulsu o czasie trwania od kilku do kilkudziesięciu sekund.
3. Częstotliwość impulsów uzależniona jest od częstotliwości podmuchów wiatru.

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