RENEWABLE ENERGY IN URBAN PLANNING ON THE EXAMPLE OF WIND ENERGY

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Introduction

Necessary transformation of energy sector, connected with gradual leaving off nonrenewable energy sources is directly connected with developing and planning of space in which there are located power-generating devices. It should be considered if planning systems and legal regulations concerning spatial development and local planning in Poland are favorable to production of clean and local renewable energy or, what we can observe at the moment and what is hopefully passing, those regulations rather create barriers for this solution.

Energy independence is one of the most important factors leading to transformation of energy sector. It is an important problem for the European Union. Energy security is crucial for this organization and it depends on the energy imported from the third countries. Renewable Energy Sources (hereinafter referred to as „RES") allow adding needed local potential. It was defined by the EU in 2007 in decision on increasing share of final usage if energy coming from RES up to 20% in 2020 (European Commission 2009). In 2010 share of renewable energy from the newly installed power stations in the EU was 62% and RES produced 8,7% of gross energy usage in the EU, so it was 44% of assumed target for year 2020 (Eurostat 2010). To fulfill this obligation, the EU countries must continuously increase the share of RES, because fulfilling this policy, that is obligatory in the EU countries, would lead to increasing share and it would simultaneously ease barriers and improve mechanisms for RES energy production support (Panzer et al. 2012). Fast development of RES was especially visible in the area of wind energy, which global power at the end of 2012 was 77% higher than in year 2009 and amounted to 282 GW.[1] In 2010 wind industry generated 430 TWh, that is around 2,5% of worlds' electricity usage[2], that means an increase from the level of 1,5% in year 2008 and 0,1% in year 1997[3] (il. 1).

At the end of year 2012, the power of wind stations in the EU countries, that amounted to 105,6 GW, contributed to slowing emission of CO_2 (il. 2). Those stations were as much as 26% of all new power stations installed in the EU at that time (EWEA[4] 2013). Unfortunately, this pace of land wind stations development slowed down because of arising barriers.[5] One of those barriers is the issue of social acceptance that leads to delaying or, sometimes, to constant blockade of around 30% of wind projects (DWIA[6] 2010). The basic problem that leads to lack of social acceptance for wind farms is the visual effect of new investments (Thayer and Hansen 1989[7]). It poses a very essential challenge for urban planning which mechanisms can help to solve arose problems.

Wind industry in Poland is in the first place among RES, amounting to 57,6% of all renewable sources powers (co-burn technology not included). The power of wind stations at the end of June 2012 was 2 189 MW, what means increase of 437 MW comparing to year 2011. However it also shows substantial delay comparing to trade expectations connected with regulation and financial risk. Wind stations are mainly situated in north and central part of the country. The most energy from wind sources was produced in zachodniopomorskie province (716,8 MW), pomorskie province (246,9 MW) and wielkopolskie province (245,3 MW). Taking into consideration tendencies mentioned above, development of wind industry in Poland can be expected, however there are needed some necessary changes of regulations supporting this development.

[1] *Global Wind Report Annual market update 2012*, Global Wind Energy Council.
[2] *World Wind Energy Report 2010*, World Wind Energy Association. February 2011.
[3] *Wind Power Increase in 2008 Exceeds 10-year Average Growth Rate*, Worldwatch.org.
[4] European Wind Energy Association
[5] Around 90% of all wind projects in Poland are interrupted or blocked (private conversation, Polish Wind Energy Association, 2013).
[6] Danish Wind Industry Association.

I. Technical parameters of wind stations

Wind power plant is a complex consisting of wind engine, generator and work machine. According to the power of wind turbines (power plant) wind stations are defined as: micro (below 100 W); small (100 W to 50 kW); medium (50 kW to 100 kW); and large (over 100 kW). There are also differentiated wind turbines with horizontal and vertical axle. In turbines with horizontal axle, the rotor is rotating around the axle situated in the horizontal plane [8]and, accordingly in vertical plane.[9] For the reason of prices for electric energy, especially in case of large wind turbines, more profitable are power plants with the horizontal axle[10]. For energy diversification there are important different sizes of wind turbines, for spatial planning the most important are large turbines, up to 7,5 MW of large height[11] (il. 3).

Aiming at larger and larger rotors is connected with their efficiency: because the output power of the wind stations increases in progress together with the increase of the rotor's diameter. To keep an adequate distance of rotor's wings from the terrain's surface, the height of tower also increases. This height in the latest solutions goes already up to 198 m[12], bringing the scale of windmills closer to the scale of high-rise buildings (il. 4).

Wind power plants are not only objects of large height, they are also very complicated devices, which esthetics comes mostly from technical conditions. Comparing to high buildings, powers working on the turbines are much stronger because of placement of rotor's propellers and their rotation, as well as emergency coming to a stop and aerodynamic powers. (il. 5).

Appearing limitations of turbines and wind farms designing are coming not only from complicated nature of technical solutions of those devices. Far more serious problems are connected with their location. For their functioning there are necessary favorable wind conditions, close distance to energy network and access roads and, especially, low population density on the area of wind investments, adequate features of terrain surface or sufficient distance from the birds' habitats.[13]

II. Renewable Energy in Poland – Legal Aspects

First wind station was built in Poland in year 1991 in Żarnowiec, however serious development of this type of investment is observed from year 2005. Although those investments have the highest share in production of renewable energy in Poland (Tab. I) and the highest dynamics of development (il. 6), the number of wind stations is one of the lowest in Europe (PAWE[14] 2011). Accelerating of this type of investments should be expected by foreseen development of marine wind industry.

Today in Poland, development of renewable sources of energy, including development of wind power industry, is essential taking into consideration the necessity of fulfilling ecology obligations of Poland and adjusting Union's directives (Directive 2001/77/EC)[15]. In order to complete it, the authorities of Poland prepared numerous documents. **Assumptions of energy policy for Poland till year 2020**[16] indicate „increase of RES role in the nearest energy balances of the country" up to 6,5% in year 2020. In **strategy of renewable energy development**[17] there has been estimated technical potential of RSE for almost 60% of country demand for primeval energy. Strategic target that was set in the document is increase of RSE energy share from 2,6% up to 14% in year 2020. The strategy assumes that wind power industry will be one of the most essential parts of this target's realization.

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[7] R. Thayer, H. Hansen, *Consumer Attitude and Choice in Local Energy Development.* Department of Environmental Design, University of California – Davis 1989, pp. 17-19.

[8] Or creating with it a slight angle of rotor's lift.

[9] E.g. Darrieus'es rotor, Savonius'es rotor

[10] Wind stations are both single wind turbines as well as farms of windmills.

[11] On the land there currently are turbines of size up to do 7,5 MW (Turbine Enercon E-126), however with development of technology it is possible to foresee further increase of turbines' power as well as their height.

[12] Total height (together with the wing of the rotor) of Enercon 126 turbine (height of tower 135 m).

[13] Rough of terrain – agreed parameter applied in models of horizontal profile of wind speed, expressed in units of length distinguishing different classes of terrains according to the type of their surface.

[14] Polish Association of Wind Energy (hereinafter referred to as "PAWE").

[15] Directive of the EU on promoting usage of RES electric energy on the internal market.

[16] Accepted by the Cabinet on February 2, 2000.

[17] Accepted by the Seym of Poland on August 23, 2001. Estimations according to the European Center of Renewable Energy.

Other document entitled **Energy Industry Law** [18], introduces adequate definitions[19] and orders to take into consideration that assumptions of power industry policy of the country would define development of RES, and building of renewable sources would be taken into consideration in spatial development of communes. Another rising programs are to create economic and legal conditions and preparation of local governments, industry and investors in wind power industry sector to such increase of investment that would enable national increase of production with gaining maximum environment, economic and social benefits.

Great meaning for wind power industry in market economy, as well as necessary financial, legal and formal conditions were also emphasized in other, national documents[20] Undoubtedly however, those prolonging works over the bill on RES as well as incoherence of existing legal system in the area of wind power industry, including planning situation, led to limitation of its development[21]. Essential barrier for wind power industry development is uncertainty of financial return conditions connected with unstable support system. One of the elements of RES support are, so called, green certificates – estate claims coming out of certificates of energy extraction. The height of prices of tradable certificates is slightly predictable because it depends on market demands. In order to fulfill obligations towards the EU as well as achieving expected positive effects of implementation of wind power industry development in form of reduction of greenhouse gases, creation of additional work places and economic development, it is necessary to use the best practices while realization of wind power industry, among others in the area of support system, planning processes as well as social consultancies.

II.1. Current conditions for designing and location of wind turbines

For well-balanced programming of wind power industry development, its designing and location there have to be taken into consideration legal, economic, planning, social and property conditions. Development of RES should be harmoniously included to planned and balanced economy. Essential element of designing should be preservation of landscape and cultural values of country areas, existing planning assumptions, protection of biological diversity, sustaining system of nature's protection and improving areas attractive for tourists. Additionally, complicated nature of wind technologies as well as responsiveness of machines effectiveness for environmental conditions makes this harmonious coordination consisting of such number of elements[22] a real challenge.

In current legal regulations and administrative procedures, designing and building wind turbines is not strictly regulated in terms of their location, building and exploitation.[23]The *Concept of National Spatial Planning* worked out for Poland in January 2013 cedes definition of directions of renewable power industry on regional solutions concerning spatial planning by defining directions of RES development as well as mapping out protection zones.

Study for Conditions and Directions of Spatial Planning

Taking into consideration areas on which there will be placed devices producing energy from RES

[18] legally binding from December 4, 1997; Dziennik Ustaw no 54, pos. 348 with later changes.

[19] E.g.: defining RES as non using burning of organic connate fuels and using cumulated solar energy in different forms.

[20] Among documents indicating essential role of wind power industry are: *Decree of the Minister of Economy from May 30, 2003 on detailed range of obligation of buying electric energy and heat from renewable sources of energy as well as electric energy produced in association with heat production* (Dziennik Ustaw no 104 pos.971); *Climate policy of Poland. Strategies of reduction of heat gases emission in Poland till year 2020*, accepted by the Cabinet on November 4, 2003; *Program for electric power industry*, document accepted by the Cabinet on March 27, 2006; *National Ecological Policy in years 2009 – 2012 with perspective till year 2016*, document accepted by the Seym of Poland on May 22, 2009; *Power Industry Policy for Poland till year 2030*, accepted by the Cabinet on November 10, 2009; *National plan of action in the area of energy from renewable sources*, accepted by the Cabinet on December 7, 2010.

[21] Comparison of percentage increase of wind energy production on the territory of Poland indicates gradual slowing down the increase from year 2009: 2004: 142,3 GWh; 2005: 135,3 GWh (increase 5,2%); 2006: 388,4 GWh (increase 35%); 2007: 494,2 GWh (increase 79%); 2008: 790,2 GWh (increase 63%); 2009: 1029 GWh (increase 77%); 2010: 1485 GWh (increase 69%); 2011: 3126 GWh (increase 48%) (PAWE).

[22] Embraces also military areas, landslides areas, recreation areas, health resort areas and areas near historic objects.

[23] Basic legal acts in which there are regulations in the area of planning terrains surrounding power stations are: *Bill from April 27, 2001 - Law on environment protection* (Dziennik Ustaw 2008 no 25, pos. 150, with later changes) and *Bill from March 27, 2003 on planning and spatial development* (Dziennik Ustaw no 80, pos. 717, with later changes).

of the power over 100 kW, it is necessary to define in the commune Study their placement and to map out protection zones connected with limitations in buildings and usage of terrain.[24] Because the subject of renewable energy in Poland is relatively young, the 2003 legislation does not provide adequate regulations, and a number of Studies of Conditions and Directions of Spatial Planning passed before the amendment of the Renewable Energy Act did not incorporate renewable energy issues. These Studies do not provide information about the location (on the investment) wind farms, causing controversy in the field of their construction. Prospective investors should request the amendment of the Study. A similar situation should oblige local authorities of municipalities and provinces to take the relevant planning initiatives. This is due to the fact that the Studies must take into account the need to adjust the country's energy system to the EU requirements in the field of renewable energy. This can cause complications, because the Study should determine the location of renewable energy sources with an output exceeding 100 kW. RES should not be (although in practice they often are) localized only on the basis of the decision on spatial development.

Local Plan of Spatial Development (hereinafter referred to as LPSD)

Procedure of enacting LPSD is long-lasting and it can even take two years time. Because of its expenses for communes (connected with change of value of the areas), it is procedure difficult to perform for the organs of public administration. However it is not the only reason why so many areas do not have enacted local plans Issuing decision on the conditions of building in situation where there is no plan, gives freedom to executive organ of the commune, practically without any control from the commune council. Because appeal authority that is Local Government Appeal Council usually does not adjudicate on the essence of the issue. It can happen that authority of the first instance numerously refuses to set building conditions even if it is not content wisely justified. Potential investor has to take into account similarly long procedure in case of change of local plan of spatial development. In case of already enacted local plan, there can also rise complications connected with procedures, because it can turn out that, for example it was presented for the public inspection for too short time what causes repealing or annulment of the commune's council act. Acts are also controlled by judicial and administrative authorities.

In case of investment concerning wind power industry it is essential to lead procedures of passing LPSD for the location of each new investment, including:

- Route of noise counter line, especially important in case of neighborhood of residential buildings, where level of noise during day and night is according to legally binding bill defined within limits of 40-50 dB[25]. This level of noise means different distances depending on the type of turbine (different technologies of wind turbines cause different levels of noise), but the average distance is around 500 m. Local regulations can be locally different (e.g. regulations on some areas define more restrictively minimal distance from residential buildings that can be even few kilometers long).

- Location of particular turbines and other elements of infrastructure, such as roads, energy lines as well as location of the main power point. If the power of wind turbine or the group of turbines crosses 100kW it is necessary to define in the commune's planning documents, that is in the Study or LPSD, the borders of the areas of their location.

- Eliminating investment from the areas of high-class evaluation soil (of I – III group), as well as areas that need to be excluded from the agricultural production and the agreement of the Ministry of Agriculture and Food Economy.

Decision of Building Conditions and Spatial Development (hereinafter referred to as BCSD)

In case of LPSD lack, the investor can annex to the motion on defining conditions of wiring installation to energy network also decision on the conditions of building and area development (BCSD). Decision BCSD can also be a basis to locate wind farm in case of lack of LPSD. Such procedure usually causes limitations connected with legal obligation to fulfill the rule of „good neighborhood", what means adjusting character of new building to features of building that already exists. Procedure of issuing

[24] According to t*he Bill from March 27, 2003 on planning and spatial development* (Dziennik Ustaw from year 2003 no 80, pos. 717, with later changes).

[25] For detached houses.

permission for building wind farm on the basis of decision on building conditions is impossible in case of necessity of farmland conversion of the areas of evaluation soil of I-III classes as well as in case of the location areas of the acreage over 0.5 ha.

Investment for the public aim („hereinafter referred as IPA") is determined by the county authorities and applied usually in case of crossing part of the installation of energy network over the area of LPSD, because wind turbines, taking into account current understanding of the Bill, do not exemplify IPA[26], although there have been some exceptions of this rule in the past.

Areas of special status and protected areas. Elements of wind farm infrastructure can go across the areas of special status (egg. roads, railways), what requires obtaining additional administrative decisions ensuring servitude of transit. In case of project of wind farm location in the areas of Nature 2000, areas of protected landscapes, reserves and national parks it is obligatory to lead procedures and prepare report on Evaluation of Affection on the Environment (hereinafter referred to as OOŚ). This report should include three alternative variants of location (optimal, alternative and the most beneficiary for the environment). Procedure above mentioned also includes other elements of spatial planning because it requires evaluation of the investment's affecting on the historical and protected objects. In this evaluation, among others, there is taken into consideration affecting of the investment on the landscape, birds and bats as well as affecting in the area of electromagnetic and acoustic field range.

III. Wind power industry and spatial planning

Wind power industry has a low coefficient of energy density[27] comparing to conventional fuel (e.g. crude oil and its derivatives or coal), what causes increased absorbing of space. Excluding surfaces, connected with foundations, technical sites, access roads as well as periodic surfaces connected with installment is a relatively small space (diameter of footing of the tower with 2MW power can amount to around 4 m), however absorbency of space is bigger because of the distance between turbines connected with shadowing. It is assumed that, depending on local wind characteristics, distance between turbines is from 5 to 8 diameters of the turbine's rotor. Those distances, together with scale of large wind turbines cause that wind farms have potentially large influence on space and landscape.

III.1. Spatial conditions of wind power industry location

Development of wind power industry causes affecting of wind stations on environment, natural resources, public safety, touristic and health resorts values, cultural values as well as landscape. Evaluation of power industry development possibilities, according to the rule of balanced development should take into account conditions resulting from: 1. nature protection; 2. protection of touristic and health resort areas; 3. protection of cultural landscape; 4. public security; 5. landscape protection**.**

1. Nature's protection. To systematize issues of wind power stations there have been worked out location criteria indicating areas that should be ruthlessly excluded from this kind of investment (taking into consideration legal and financial consequences generated by negative influence on protected species), areas possible for limited development of wind power stations as well as areas where this kind of investment can be located without greater obstacles.[28] In national parks and nature reserves investment connected with wind power industry are practically excluded. In landscape parks and in the areas of protected landscape realization of undertakings that can seriously influence environment is forbidden.[29] Bans do not include realization of IPA, but even in case if wind power industry is not embraced with this category it is hard to imagine its coexistence with areas of protected landscapes and landscape parks. Within the confines of these

[26] It is confirmed by interpretation of the Minister of Infrastructure (letter from November 5, 2008 sign BN1j-0701-12(2)/08), justified with National Administrative Court verdict from May 15, 2008 r. signature II OSK 548/07.

[27] Energy density is the amount of energy located in defined volume or mass. The meaning of this term depends on the possibility of this energy extracting – e.g. by burning.

[28] *Bill from April 16, 2004 on nature protection* (Dziennik Ustaw no 92, pos. 880, with later changes).

[29] Defined in *Decree of Minister of Environment from November 9, 2010on undertakings that can significantly influence the environment* (Dziennik Ustaw 2010 no 215, pos. 1397).

areas especially sensitive are points and panorama sights, natural landscape of river's valleys and water reservoirs, landscape of natural ecosystems, tourist trails and recreation areas. Although it is not definitely included in legal regulations there are accepted sight protection zones of the size from 3 to a dozen or so kilometers. Areas of birds and bats special protection should be excluded from the wind power industry development with preservation of minimal buffer from the areas of mainstay (there is used 5 km protection zone with possibility of its reducing to 4km[30]; there is proposed 10 km protection zone from sensitive areas)[31]. Protection of forest resources[32] consists in, among others, limitation assigning forest grounds for non-forest or non-agricultural targets as well as creating protected forests what means planned successive enlarging areas of protected forests on which surface wind farms cannot be located. Additionally it is indicated to exclude forests and shelter wood forests and zone of 200 m from their frontier as well as neighborhood of tree espaliers [33] from wind farms location.

2. Protection of tourist and health resorts areas. Areas of health resorts protection of „A" category (direct curative area), „B" (health resort protection zone designed for objects that are not bothersome during the process of curing) are excluded from location of wind power stations, in zone of „C" category (health resort cover) location of turbines is not advisable because of landscape values.[34] In spatial planning, taking into consideration wind turbines, it is necessary to consider both existing as well as designed areas of health resort protection. In the area of touristic and recreation terrains protection wind turbines are recognized in Poland as worsening touristic values of the region. Protection of natural, landscape and cultural values of the recreation areas is the aim of the most planning strategies in Poland. However there are differentiated areas of very high and high sightseeing and recreation values of national and international meaning, on which terrains legal regulations limit possibility of wind power stations' building. It is also suggested to exclude terrains of existing and being designed climate protection zone, protection areas of recreation zones, areas of fairly high and above average sightseeing and recreation values.

3. Cultural landscape. When choosing location of wind turbines it is necessary to introduce protection requirements[35] included in the bill on protection of historic monuments and taking care of the historic monuments, according to which taken care of and protected are elements of cultural landscape: historical town and rural planning teams, objects of sacral and secular architecture, palaces, gardens and court complexes, historical technological and military monuments, places of remembrance, cemeteries and memorials of extermination, places of religious cult and archeological positions. It is assumed that wind power stations should be built with respect to preserving of sight protection zones on the basis of sight study, taking into consideration landscape protection, sight axles, exposition zones and archeological observation. Investment intentions, concerning objects above mentioned and also in the area of their sight influence, require achieving permission of Province Conservator of Historical Objects. Terrains sensitive to planning wind power industry are also proposed forms of landscape protection and cultural heritage in forms of cultural parks, pointed in provinces' plans. Postulate of keeping regional and historical scale and settler units is also a challenge.

4. Public safety. Under the location of wind power stations are excluded floodplains as well as terrains in distance not closer than 50 m from embankment foot on the side of land. There should also be excluded terrains endangered with soil sliding. In the area of noise and optical disturbance protection it is especially essential to ensure adequate distance of wind power stations from buildings, in order to

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[30] E.g. On the territory of Pomorskie Province. Written in *Decision of Pomorskie Province Governor* from March 21, 2008 sign: ŚR/VII.AM/6671-94/07/08

[31] *Evaluation of environmental risk by realization of investment when realizing investment in wind power industry. Guide for investors. Polish Economy Chamber of Renewable Energy*

[32] *Bill from September 28, 1991 on forests* (Dziennik Ustaw 2005 no 45, pos. 435, with later changes), and *Bill from February 3, 1995 on protection of agricultural and forest grounds* (Dziennik Ustaw 2004 no 121, pos. 1266, with later changes).

[33] *Temporary guidelines concerning evaluation f wind power stations influence on bats (2009)*.

[34] *Bill from July 28, 2005on health resort curing, health resorts and areas of health resorts protection and health resort communes* (Dziennik Ustaw 2005 Nr 167, pos. 1399, with later changes).

[35] *Bill from July 23, 2003 on historical objects protection and taking care of historical objects* (Dziennik Ustaw no 162, pos. 1568, with later changes). Historical objects protection forms are: registration in the register of historical objects, recognition as a historical monument, creation of cultural park, protection regulations in local plan of spatial development.

keep emission standards (among others: noise and vibrations) and adequate distance in order to avoid stroboscope effect (also called the effect of flashing shadow). Building wind turbines in administrative borders of cities and villages is excluded. Minimal distance of wind distance of wind power stations from concentrated buildings, single buildings, hospital areas and places of school children meeting points is not legally defined[36]. Areas on which wind turbines location is limited or excluded are also airports – in their neighborhood built objects have to meet adequate technical demands,[37] depending on purpose and project of landing fields up to 15000 m of total length of the field of rise/landing of demanded height from 80 m and angle slope 1:20. Areas connected with public security are also closed areas connected with national defense. [38] Around those areas there are created protection zones with limited usage and limited building height. Those limitations depend on military infrastructure character and they are pointed by units.

5. Landscape protection. Non-built-up areas and harmoniously built-up part of Polish landscapes are legally protected and important non-renewable resources[39]. To preserve unique esthetic landscape values it is important to preserve its features, virtues and values – both natural as well as cultural. In the Polish law those protected areas are[40] national parks, landscape parks, areas of protected landscape, agricultural-ecological parks and zones of natural and harmonious agricultural landscape of recreation values as well as zones of tourist trail landscapes. Protected are also zones of visual landscape (panoramas and sight point with their foregrounds, zones of landscape exhibition of protected areas, sight axles, areas of high landscape values), in which interference requires preparation of landscape studies which are set of guidelines for spatial planning. Some of planners consider wind turbines as technical elements that are disharmonious towards landscape and aggressive, interfering in the place identity. That is why the landscape is protected from wind turbines' inserting. The scale of large turbines sight influence causes that the choice of their location should be prepared very carefully taking into consideration their influence on the landscape including variant visualizations of proposed investment locations. It is necessary to prepare analysis of interference scale taking into consideration interference zones and the specificity of landscape surface.[41] On the flat ground there can be distinguished four zones of large wind turbines interference (Tab. II).

III.2. Technical Conditions for Wind Power Industry Designing

Economics of wind technology is sensitive on local conditions of infrastructure and geography what narrows area possible for power station's location to: 1. Wind conditions and 2. Infrastructure conditions.

1. Wind conditions. Maps of wind conditions currently used in Poland are very simplified (il. 7). To perform analysis of wind energy resources

[36] There is a lack of such regulations in *Decree of the Minister of Infrastructure from April 12, 2002 on technical conditions of buildings and their location* (Dziennik Ustaw no 75, pos. 690,with later changes). In §13 point. 3 there is mentioned location of shadowing object in distance no closer than 10 m from the window of shadowed room what can be applied in case of wind power stations that are not defined as investment that can seriously influence environment – of Total height up to 30 m. Estimated distance 500 m is a real wind power stations noise range (depending on the producer, size and type of machine) and Polish norms in the area of acceptable levels of noise emissions, that in the most restrictive cases allow the level of noise up to 40 dB. *Decree of the Minister of Environment from June 14, 2007 on acceptable noise levels in the environment* (Dziennik Ustaw no 120, pos. 826).

[37] *Decree of the Minister of Infrastructure from June 25, 2003 on conditions that should be fulfilled by natural and building objects in the airport's surroundings* (Dziennik Ustaw from year 2003 no 130, pos. 1192, with later changes.) and *Decree of the Minister of Infrastructure from July 20, 2004on requirements for landing fields* (Journal of Bills no170, pos. 1791, with later changes).

[38] *Decree of the Minister of National Defense from July 18, 2003in the area of closed terrains indispensable for national defense* (Dziennik Ustaw from 2003 no 141, pos.1368).

[39] Through regulations of Natura 2000, other protected areas and planning forms.

[40] In wind power industry spatial planning it is necessary to take into consideration both existing as well as being designed forms of landscape protection.

[41] Together with increase of distance of wind power station observation, its landscape dissonance is decreasing (horizon in the flat area is in distance of around 5 km. Together with increase of height of observation point horizon is distancing – e.g. With difference of heights of 100 m, horizon is on around 36 km. Essential element of terrain's surface specificity, that affects visibility of dominants, are also natural shadowing elements such as hills, which influence should be included in visibility analysis. In prepared analysis there should be taken into consideration following issues: physiography, ecological and landscape values, communication passages, terrains' functions, etc.

it is required to include classes of terrain's rough because the structure of buildings and terrain surface has influence on turbulences and speed of air stream (Tab. III).

2. Infrastructure conditions Essential influence on location of wind turbines has accessibility to energy network. It is a great blockade for development of wind power industry, because of small reserves of transition power as well as high costs of modernization and network and transformer stations' development. Taking into consideration legally binding regulations[42] it is necessary to attach to proposal concerning wiring wind farm to network, that is to be applied in energy company, among others the extract from LPSD or decision DNCSD for real estate as well as an expertise on influence of attached devices and installations on the energy network. In case of energy network, essential issue is also distance to this network[43] and distance to the nearest wiring point. Another important aspect of wind power stations' location is accessibility of transportation infrastructure. It concerns, first of all, road network that makes transport of large elements of wind turbines possible[44].

IV. Suggestions for wind power industry spatial planning

Numerous aspects of wind power industry spatial planning is caused by its relatively large influence on the environment. It is also connected with complicated technical requirements. In this situation there are no unified regulations and requirements concerning planning process, and those blockades of RES development should be removed. In planning process there should be analyzed numerous planning scenarios together with evaluation of their affection on environment and economy of the analyzed region. In order to execute it, it is possible to use tools facilitating decision making e.g. EnerPol program, created by Laboratory of Energy Conversion ETH Zürich, based on automation of analysis in GIS system in order to design location of wind power industry and optimize development of energy network for purposes of attaching power coming from wind. This program helps in system planning through public accessible analysis,[45] e.g. concerning possibility of modernization and development of regional energy system in order to receive energy from wind power stations. EnerPol, besides 250 already programmed layers of maps and data (Tab. IV), can be adjusted to specificity of spatial planning in Poland. It can also help to evaluate effects of new legal limitations (e.g. in the area of distance of wind turbines from forest borders).

Within the confines of spatial planning, there should be indicated areas excluded from investment (e.g. national parks, concentrated residential buildings) and size of protection areas. It is also necessary to include terrains for development of wind power industry with limitations in the area of investment scale. It is also crucial to indicate the most profitable terrains for wind power industry investment. While planning, terrains of the highest economic potential in terms of wind energy should be taken into consideration. It will allow designing projects for the most effective usage of this resource and simultaneously for limitation of wind turbines into clusters, in order to avoid spatial chaos of singe turbines which landscape effect is far more extensive and efficiency of energy conversion is limited. For spatial design of wind power industry there should be applied multi-level planning analysis including landscape effect analysis. Geological structure of terrain can be automated[46]: terrain model can be digitally transformed in 3d space, what allows approximate visibility defining as well as defining terrains shadowing forms or verifying level of observation panorama opening. However, it will not substitute the necessity of real inspection of the scene in sensitive cases. Apart from spatial coordination, automation with usage of adequate tools allows simulating potential acoustic influence of wind farms on birds and bats passages. Automation of

[42] Amendment of *Bill from April 10, 1997 on Energy Law*, that came into force on March 11, 2010.

[43] It is essential to define not only maximal but also minimal distance of the wind turbine from network. PAWE regulations define, that distance of the most extreme element of the turbine from the NN axle line should be of tripled rotor's diameter size, *Odległość turbin wiatrowych od linii elektroenergetycznych NN. Standardowa specyfikacjatechniczna (Distance of wind turbines from the low voltage power lines),* Standard Technical Specifications, Polish Transmission System Operator SA, Konstancin - Jeziorna, February 2009.

[44] In the area of road way width, including shoulder, limits of heights and adequate roads' geometry.

[45] and not as it was so far – planning for particular locations.

[46] That is an element of EnerPol tool.

complicated planning procedure could help planners in optimal introduction of RES technology on the level of province and commune as well as on the level of central regulations (il. 8).

In order to determine the most optimal parameters it is necessary to consider different scenarios, taking into consideration experiences of countries which deal with this technology for longer time and have knowledge in the area of wind power industry planning. Research results should also be considered.[47] Good practices in planning and realization of wind power industry investment should be systematically analyzed and these results should be spread and applied in „spatial law". Analysis of scenarios will allow optimizing size and range of areas protected, around terrains which are excluded from wind power industry location in case of automation of part of the planning. However introducing development and protection priorities by numbers will be useful. Issues connected with distances that are not determined in Polish law, such as distances from residential buildings, roads and railways, lines of high and medium voltage, forest borders, forests and tree lines or neighboring wind farms, should be put to scenario analysis to estimate effects of given regulations. Large number of scenarios cannot be executed by traditional planning methods because they do not include issues of the undertakings' economy. They also apply to development optimization issues and usage of energy network incompletely. Example of currently used planning tools, comparing to accessible tools, is wind map (Il. VII), which specificity does not allow for the correct evaluation of wind on terrains for the needs of wind investment, what does not allow (on contrary to accessible location programs such as EnerPol) for their optimal locating and choosing types of turbines as well as analyzing their mutual influence for other wind farms what allows choosing distance between farms and turbines in realistic way, dependent on wind characteristics and surface features of given location. Analysis that can be prepared in large-surface spatial planning, do not include also the local level to scale of single buildings or monuments.

Numerous assumptions that are being considered to be introduced in wind power industry planning are disputable. For example, generally accepted in Poland assumption of the negative influence of wind power stations on tourism could be taken into consideration. Initial results of analysis from Scotland, Denmark and Australia[48] indicate rather contrary trend. Debatable are also suggestions on optimal distance from the forest border for the quality of wind. Accidental proposal from 3 to 5 km (Olech 2006) does not find confirmation in the analysis of turbulence and its influence on the economy of the wind industry. Issues concerning distances from forests connected with negative impact for bats are still debatable – in this case, it is possible, for example, to introduce special devices scaring those mammals away. Also the issue concerning avoiding birds passage terrains can be verified once more: in case of w periodical passages, introducing periodical turning off of the turbines situated in this areas can be considered. The postulate of eliminating country areas with high quality soil should also be reconsidered: the size of wind farm areas does not exclude further agricultural production. However, production of bird attracting cultivations (e.g. winter crops) on these areas should be limited. In case of the most favorable areas for wind investment there is also proposed change of IPA definition, so it would include only wind turbines.[49]

Conclusion

Wind farms are considered as relatively new technology and, at the territory of Poland, there are no long-term traditions of wind energy. However, it is technology entering space that is built in a visible

[47] E.g. in Lower Saxony there have been determined distances of 500 m from residential house, 200m from single buildings and housing estates of recreation features, 200 m from forests and 100 m from areas of valuable natural landscape J. Maćkowiak, *Doświadczenia Niemiec w zakresie wpływu elektrowni wiatrowych na środowisko i krajobraz (The German experience of the impact of wind farms on the environment and landscape)*, „Problemy Ocen Środowiskowych", 2002, no 3(18). The European Wind Energy Association (EWEA) gives a number of factors limiting negative influence of wind farms on landscape, among others: visual homogeneousness of wind farm; minimizing amount of fences, facilities and roads; using complete, pipe towers; limiting height depending on the landscape; using underground energy cables. It is also suggested to use power plants of three winged rotor and also choosing less turbines of higher efficiency of a single wind mill (National Wind Coordinating Committee, 2006). Reconsidering ways of signing turbines for the needs of aviation also seems to be essential: differences in regulations in different countries indicate that some changes in this area are possible what could help limiting negative associating caused by sharp colors and luminous signs.

[48] MORI (2002), Brady & Brady (2003).

way, in contrast to electricity produced outside of the community, using natural sources that are very often found outside the horizon of vision. In order to achieve optimal and minimally invasive adaptation, it is necessary to verify priorities that lead to introduction of new legal structures and procedures as well as enabling development of OZE infrastructure on in the country area. Noise and visual impact simulations can be performed on local and regional basis, and integrated within the land-use planning, using the tool such as EnerPol. Future of urban planning should make use of new information technologies, providing process speed-up and up-to-date know-how on such aspects of planning as energy and local economic impact.

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[49] Target of wind Power industry is compatible with target indicated by a bill on planning and spatial development, defining ICP as concerning action of local or over-local meaning, that determine realizations of public goals. Such treatment of wind farms is in accordance with Directive of European Parliament and Council on promoting usage of RSE (no 2009/28/EC).

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