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Sustainable Development and Wind Farms

Zrównoważony rozwój a farmy wiatrowe

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Abstract

According to assumptions adopted by the European Union, energy production from renewable energy sources (RES) on a community-wide scale will reach 20% by 2020.
One way to achieve this ambitious target is to develop wind energy. However, its evaluation is inconclusive. Among the benefits, its positive impact on the environment is constantly emphasised, in particular the lack of polluting emissions during electricity production. At the same time, wind turbines, a new, unfamiliar element appearing on the landscape could constitute an additional source of human stress.
In this article the authors attempt to assess the investments in wind power in Poland. The discussion takes into account environmental, social and economic aspects in accordance with the concept of sustainable development.

Key words: sustainable development, wind farms, renewable energy sources, health

Streszczenie

Według przyjętych w Unii Europejskiej założeń, produkcja energii z odnawialnych źródeł energii (OZE) w skali całej Wspólnoty ma w 2020 r. osiągnąć poziom 20%.
Jedną z dróg prowadzących do osiągnięcia tego ambitnego celu jest rozwój energetyki wiatrowej. Jej ocena nie jest jednak jednoznaczna. Wśród korzyści podkreśla się pozytywny wpływ na środowisko, w szczególności fakt braku emisji zanieczyszczeń podczas produkcji energii elektrycznej. Zarazem turbiny wiatrowe stanowią nowy, obcy element pojawiający się w krajobrazie, mogąc stanowić dla człowieka źródło dodatkowego stresu.
W niniejszym artykule podjęto próbę oceny ocena inwestycji związanych z energetyką wiatrową na przykładzie Polski. Zgodnie z koncepcją rozwoju zrównoważonego dyskusja została przeprowadzona z uwzględnieniem aspektów: ekologicznych, społecznych i ekonomicznych.

Słowa kluczowe: zrównoważony rozwój, farmy wiatrowe, odnawialne źródła energii, zdrowie

Introduction

Sustainable development is *development that meets the needs of the present generations without compromising the ability of future generations to meet their own needs* (WCED, 1987). It means socio-economic development, in which political, economic and social processes are integrated whilst maintaining environmental balance and sustainability of a community's basic needs, of both today's and future generations (Bernat, 2010). It clearly points to the three pillars of sustainable development which are society, economy and the environment (Figure 1).
According to Tyburski (2007), the realisation of sustainable development is related to the reconcilia-

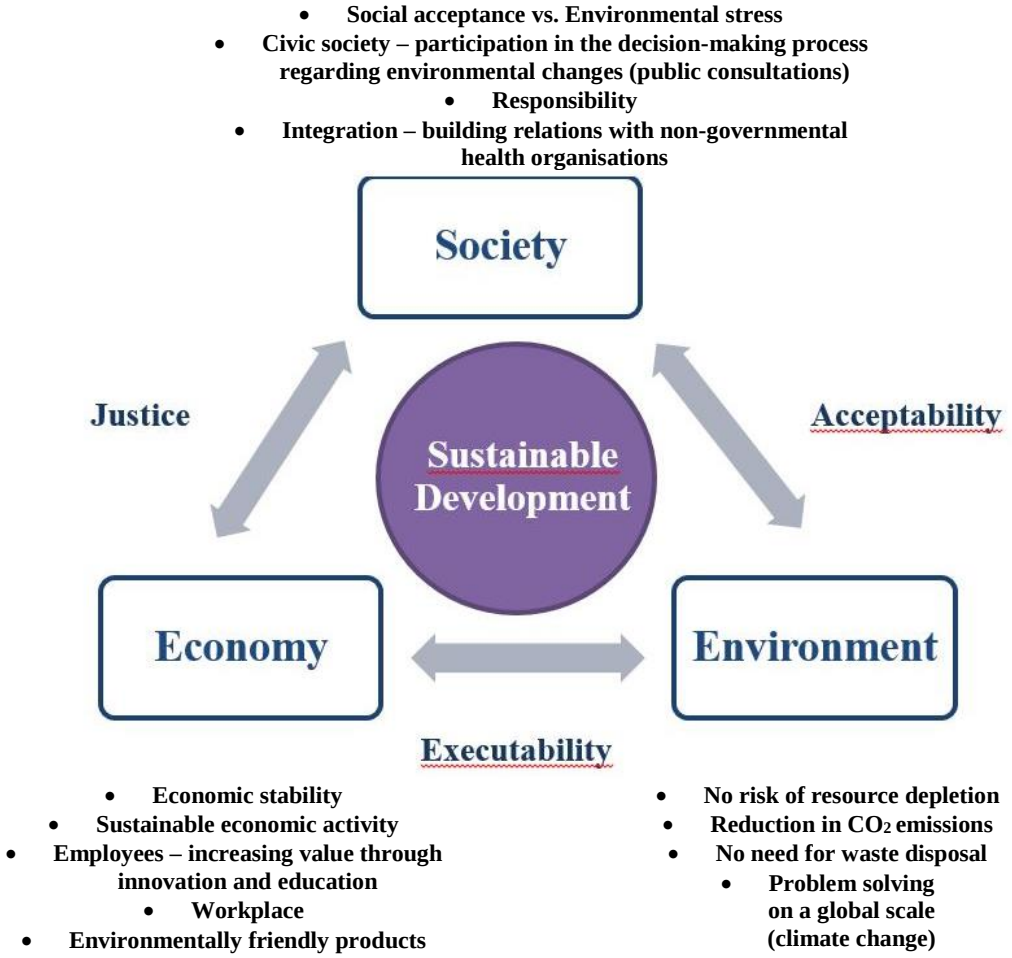

Figure 1. Sustainable development in the context of wind energy. Source: Authors' own work.

tion and harmonisation of governance into the human consciousness in its world of values, as well as political, social, economic and ecological governance. Thus, sustainable development concepts are based on social values such as prosperity, the environment, justice, human rights, political rights, democracy, the rule of law, the choice between *be* and *possess*, that is on the pursuit of not only the material but also non-material well-being in a manner that is friendly both to the natural and social environments. The main challenge posed for societies in realisation of sustainable development is its social legitimacy, acceptance of policies, regulations, initiatives and decisions, and also treating them as legitimate in terms of the currently prevailing social values (Angelstam, Elbakidze, 2010). According to Ingarden (1973), man is capable of co-participating in the world and making successive changes in it, he takes responsibility for himself, for other people and for the environment in which he lives. He is also able to undertake responsible actions with respect to himself, nature, natural and social environments.

However, educated action requires cognitive effort, an established hierarchy of values, feeling of the need for action. This action is realised through well-informed participation in public consultations, seeking reliable information about the forthcoming environmental changes, the impact of these changes on human health and the environment. Taking responsibility and targeting action also relates to human impact on climate change (Ingarden, 1973). Human capability, as indicated by Ingarden, seems to be the basis for the implementation of sustainable development in accordance with the *Decade of Education for Sustainable Development* (Borys, 2010). A contemporary man should have environmental and social awareness, as well as the knowledge to evaluate the consequences of today's actions and understand the need to protect the Earth's natural resources for future generations (Bernat, 2010; Kuzior, 2010, WCED, 1987).

The demand for electricity and wind power

Amongst our civilization's most important challenges, it is necessary to point out the need to ensure a steady supply of electricity, which in the context of civilization can be included in the fundamental rights of modern man (Stappen, 2006).

Areas prevented from using electricity freely are treated as civilization deserts. It is estimated that there are still more than 2 billion people without access to electricity. Differences in access to energy resources and the issue of their exhaustion (Pieńkowski, 2012) multiply the growth in regional differences, reinforcing the economic and settlement slowdown and the sense of social injustice (Berdo, 2006, Figaszewska, 2009).

The moral aspect of the modern use of fossil energy is not only a negative connotation in the context of environmental and health interactions, but also calls into question the legitimate right of contemporary people who have at their disposal non-renewable assets, such as minerals, to which future generations also have the right (Kudełko, 2012). This is also reflected in the concept of environmental restrictions (Steppen, 2006). Despite the widespread introduction of energy-efficient appliances, it is predicted that electricity consumption in the coming decades will continue to grow. It forces decision-makers to explore new ways of ensuring energy security for individual countries (EWEA, 2010; Wiśniewski, Michałowska-Knapp, 2010).

According to the concept of sustainable development, renewable energy sources (RES) seem to be the rational and economically justified response to the need for universal access to energy (Wiśniewski et al., 2008; Kudełko, 2012; Pawłowski, 2009). It is an environmentally friendly alternative to fossil fuels, allowing a country to increase its energy independence reducing, in such a way, its fossil fuel imports (Raport, 2004).

In the European Union the requirement for the development of renewable energy sources (RES) is included in the *Europe 2020* strategy (Hoedl, 2011; Ciżmowska, 2012) associated with the 2009/28/EC Directive.

Among the RES, wind energy plays an important role. Its development is an excellent example of the advantages and difficulties which are inherent in the development of this technology in the context of sustainable development.

In the group of benefits it should be stated that, according to the *2004 World Health Organisation* Report, wind power is the *gentlest* way of generating electricity in the context of impact on human health (McCaffery, 2004). Such a positive evaluation is related to the fact that RES is responsible for the emission of less than two percent of the greenhouse gases that are emitted by the combustion of coal (per MWh upon conversion), even when turbine production is included in the analysis (Global Wind, 2009). Furthermore, it is estimated that in 2007, in the USA wind energy reduced carbon dioxide emissions by nearly 28 million tonnes. Even more has been achieved in Europe, where wind farms reduced annual CO_2 emissions by 106 million tonnes in 2009, which is equivalent to taking off the road 25 % of all cars in the European Union. Wind energy allows Europe to save 6 billion euros annually in fuel costs (Global Wind, 2010). These are important achievements against plans to reduce greenhouse gas emissions by 80 % by 2050, relative to 2005 (Udo, Pawłowski, 2010).

Wind energy development and sustainable development assumptions

In an attempt to assess wind power, let us look at the social, environmental and economic issues in the context of the sustainable development concept.

It should be noted that the construction of wind farms creates concern, doubt, and even resentment among local communities. Consequently this creates a sense of uncertainty which creates tension resulting from the inability to use tested best practices, which is a challenge in the social aspect of sustainable development.

Wind turbines are a new, unfamiliar element appearing on the landscape, and for man they can be another source of stress (Evans, Cohen, 1987). Civilisation achievements within the meaning of the local community can lead towards a *risk society* (Beck, 2002), causing side effects (e.g. industrial disasters, devastation of the natural environment, climate change, diseases) and threaten the sense of security (Sztompka, 2007). Lazarus defines the state of human uncertainty as a stress induced by external stimuli, not in terms of the state of the subject but in the context of a particular type of relation, which occurs at a given time between the individual and the environment. The described state of tension can be evaluated as straining or exceeding the compensation capabilities of the individual and threatening its well-being (Lazarus, 2002; Lazarus, 1991; Łosiak, 2008). Man assesses the cognitive investment because of its importance to his welfare (Łosiak, 2008). This subjective concept, referring to happiness, satisfaction, and satisfaction is derived from optimal functioning in everyday life, in physical, mental, emotional, social, as well as spiritual terms. Such an understanding of welfare as presented by McDowell (2009) corresponds to the World Health Organisation's (WHO) definition of health from 1948, and is still prevalent today, where health is defined as fully physical, mental, social welfare, and not just the absence of infirmity. Announcing changes to the environment in which man lives can lead to changes and dysfunction in each of the previously mentioned health areas. On the other hand, it can also lead to mobilising the body's forces and taking action to adapt to the new situation. This mobilization results from physical health during proper functioning of the various organs and systems, as well as mental health which translates into effective action, satisfactory interpersonal relationships, and the ability to adapt to changes and cope with adversity (Hales, Shahrokh, 2009; Melosik, 1999). Other spheres of health con-

ditioning educated and responsible human activity are the social and spiritual spheres. The state of public health is the ability to establish correct relationships with others and to fulfil social roles, whilst health in the spiritual realm assumes known values. In the socio-environmental paradigm of health, it is pointed out that not only do aspects of biomedical research determine them, but also the whole psychological, social and cultural context in which man operates. He is part of the ecosystem, his health is therefore the result of a dynamic equilibrium of the somatic potential of an organism and the environment in which he lives (Stęplewski, 2012). As a participant in ecological processes, a person is subjected to variable ecosystem interactions, and he transforms it by his own actions.

The physical environments in which a person spends most of his time, is the home, the workplace and their immediate surroundings. Therefore, plans and projects for new investments must take health into account. Particular attention should be paid to the fact that in particular the home is the main space enabling families to implement their health policies, dependent on creating a safe, pollution-free environment. The development of renewable energy plays an essential role in meeting the demands of social, environmental protection and human health from air pollution, and a country's energy security. Investments arising within its framework are included in the construction to help meet the basic needs of society and are one of the essential elements of sustainable development.

In order to create a safe environment and to gain social acceptance for the aims of this development, it is necessary to guarantee residents easy access to reliable scientific information, and also to social support which will contribute towards minimising the consequences of environmental stress (Bołtromiuk, 2012; Damurski, 2012; The Aarhus Convention Journal of Laws 03.78.706, 1998; Balaban, Thayer, 2001; 2003/35/EC Directive; Evans, Cohen, 1987).

Within the context of the problems discussed in this article the main potential source of environmental stress is the construction of wind farms. With this type of investment, as with any other, community law requires the recognition of the needs of all parties concerned in the investment and the preservation of the undisturbed environment. Three parties are usually involved in infrastructure development but guided by different goals, needs and values. These are the investors seeking to rapidly realise the investment, the environmental organisations in defence of the natural environment, and the residents for whom the proposed investment often means a lower quality of life, by needing to adapt to the changes, but is also associated with measurable benefits. The constitutionally accepted concept of sustainable development requires that the investment processes should be planned with regard to the interests of the investor and the social and natural environments. Investors and decision-makers are required to reliably inform all interested parties and prevent any conflict related to the investment. This places an obligation on those parties to conduct public consultations with local communities and non-government organisations, based on scientific knowledge and social skills (Derwich, Iwińska, 2010; Kurpas, 2011; Frączek, 2011). Public consultations should be carried out at the earliest possible stage of the planning process for the development. This way, people are allowed to co-decide on changes that will occur in their environment (Mroczek, 2011; Kurpas, 2011).

The implemented or planned investment relating to the construction of wind turbines, their distance from the homestead, as well as the circulating myths on the adverse effects of wind turbines on human health and the natural environment are environmental stressors whose actions are further compounded by the media (Evans, Cohen, 1987; Bell, 2004; Mroczek, 2011). Concerns about the harmful effects of wind turbines and associated anxiety levels are the beginning of physiological reactions which occur in the body, and consequently affect the health and the quality of life of the residents who live in the vicinity of the wind farms.

Currently, wind farm investors are required to carry out an environmental impact assessment to evaluate any potential impacts before the start of construction (Cianciara, Wysocki, 2008; HIA, 1999; Breeze, Lock, 2001). One of the most important and most frequently conducted national practices, which take into account public opinions, is the progress on the evaluation of the impact of proposed activities on the environment. However, consultation still does not meet many of the requirements of national law and international agreements (PTS, 2011; Długosz & Wygnański 2005; Wiśniewska 2007). Investments in wind energy have a high risk of failure because of local community protests, failure to obtain permits at a given stage or a refusal. Such a situation results from the investment specifics which, being part of a strategic economic sector which energy is, do not remain indifferent to both the natural environment and for the residents nor the location itself. Therefore, this type of investment is associated with a long-term and relatively complicated process (Ernst & Young, 2012; Długosz & Wygnański, 2005; Wiśniewska, 2007). It is essential that a relationship exists between the landlords and investors or developers. Signing civil-legal agreements is not subject to the requirement to inform the local authorities of this fact but it is required in the next stage envisaged by law. Thus, conflicts arise due to the lack of knowledge and a perception of local authorities concealing information about the investment project. This is a common complaint by local communities regarding local authorities. At this stage, wind energy can

become part of a kind of a game between the leaders of local communities, often with the participation of politicians as opinion leaders. Professionally executed promotional consultation programs must therefore be signed up to the communication strategy of the entity implementing the project (Kurpas, 2011). Then they give the chance, not only to meet the requirements of law and the realisation of the investment within the stipulated schedule, but also the opportunity to take into account the demands raised at the planning stage. Moreover, among the public consultation benefits, the following should be emphasized: enabling local communities to influence decision-making on the final shape of the investment, weakening social protests against the planned changes, closer relationship between authorities and citizens, encouraging people to participate in public life, and a sense of influencing the environment which makes the citizens co-responsible for the environment. What is more, involvement in public consultations promotes social cohesion and thus leads to the formation of a civil society (Frączek, 2011; Kurpas, 2011; PTS, 2011; Iwińska, 2010).

According to the concept of sustainable development it is also recommended to evaluate the impact of the construction of wind turbines on health (Health Impact Assessment – HIA). It is a combination of procedures, methods and tools by which the policy, program or project may be evaluated in terms of potential effects on the residents' health and the distribution of these effects within the population. The HIA consists of several elements. The first is to consider the evidence to predict the relationship between policy, program or project and the health of the population. The second element concerns the consideration of opinions, experiences and expectations of the residents, who could be affected by the change. Another is to provide additional information allowing the decision-makers and the local community to familiarise themselves with the potential health effects. The HIA anticipates the presentation of the proposed amendments i.e. options for maximising the positive and minimizing the negative impacts on health (Cianciara, Wysocki, 2008; HIA, 1999; Breeze, Lock, 2001).

Opponents of wind farms often put forward the noise aspect as a fundamental factor which disturbs the functioning of the local community. It is worth noting that the noise emitted by the wind turbines is measured in accordance with the following standard: *IEC 61400-11 Wind turbine generator systems - Part 11: Acoustic noise measurement techniques*. For example, Polish building regulations do not explicitly state the distance that must be maintained between the wind turbine and the homestead. It treats the wind turbine as a building, equal to tunnels, viaducts, and sports buildings (Building Regulations, 2011). In contrast, it is very different in the case of Canadian law. It is very restrictive, it explicitly states the distance from the sound receptor to the wind turbine and the upper threshold of audible sound which should not be exceeded. For a single wind turbine the minimum distance is 550 metres, but when there are for example 5 turbines (wind farm) this distance increases to 950 metres (CMOH, 2010).

Many studies have been conducted on the impact of noise and infrasound generated by wind turbines on the daily lives of people living in the vicinity of wind farms, which showed that the noise is low, provided the wind farm is located properly (Noise, 2000; Ganesh, 2009; den Berg, 2004, 2008; Hanning, 2009; Global Wind, 2009; Pedersen, van den Berg, Bakker, Bouma, 2009; Pedersen, Larsman, 2008; van den Berg, 2004; Noise, 2000).

Researchers from the University of Salford determined that out of the 133 wind installations operating in England, complaints regarding noise at different times of the day were reported in 27 cases. Of the 239 formal complaints received from 1991, up to 152 related to one location (Moorhouse et al., 2007). For comparison, the number of complaints relating to industrial noise exceeds those concerning noise from wind farms by a factor of one thousand. This shows that the noise from the wind farm is a small scale problem compared to other types, but important for the inhabitants of these villages.

Current knowledge allows for the conclusion that the operating noise of wind turbines poses no threat of hearing loss or other adverse health effects, since to date there is no evidence that the audible sounds emitted by wind turbines have any direct physiological effect in humans (Colby et al., 2009; van den Berg, 2004).

In Poland, research was carried out using the SF-36 v.2 questionnaire on the quality of life for a group of 82 residents in the municipality of Wolin located close to wind farms (Tarasiuk, Mroczek, 2011), and for a group of 336 residents in total, living in the north-west part of the country (Mroczek, 2011a). No empirical confirmation as to the quality of life was obtained regarding the effect of distance between the place of residence and the wind farm for up to 2 km. Similar studies were conducted in New Zealand, in which however, it was shown that the noise generated by the wind turbines lowers the subjective quality of life related to social functioning of residents living within 2 km of a wind farm (Shepherd et al., 2011).

Most of the complaints raised by the people living close to wind turbines concerned the discomfort caused by their operation which produces a distinctive hum by the turbine blades, but does not exceed the ambient noise level surrounding people in an average environment. A small proportion of the reported complaints is the resulting agitation and stress from listening to these sounds by people who experience similar effects caused by noise from cars, trains, farm machinery or household applianc-

es (Colby et al., 2009). Agitation is not however a disease but results more from the subjective perception rather than the intensity of the sound (Pedersen, Waye, 2008; Pedersen, Larsman, 2008; Pedersen, Waye, 2007; Pedersen et al., 2009; Pedersen, Hallberg, Waye, 2007). As stated in the *The Potential Health Impact of Wind Turbines* (2010) report, some people living near to wind turbines report such symptoms as dizziness, headaches and sleep disturbances but research shows no direct causal link between the noise generated by wind turbines and negative health effects. However, some people may experience irritation. It has been suggested that it may be a reaction to the characteristic *hum* or the variation in the sound generated by the wind turbines rather than the intensity of the sound. Low frequency sound and infrasound from wind turbines currently in use are well below the acoustic pressure level above which known health effects occur (Gulden, 2008). This is also confirmed by other authors (Jakobsen, 2005; Leventhall et al, 2003; Leventhall, 2006; Rogers, 2009; Pedersen, Hallberg, Waye, 2007; Pedersen, Larsman, 2008). Another conclusion from the report emphasizes the importance of public participation in the planning of wind farms as a factor that could alleviate concerns about the impact of investments on health. In addition, the survey showed that the noise measurements in populated areas near wind farms in comparison with the noise level in other rural and urban areas, when assessing the actual noise level, is the key missing data category which should be supplemented. Assessment of the noise level in the vicinity of wind farms and other residential areas, including monitoring compliance within the permissible noise levels, is a very important condition when making a well-informed decision about the usefulness of epidemiological studies on the effects on health (Gulden, 2008). This research will be conducted in Canada from 2013 (Research Project, 2013).

The decision to build a wind farm must also take into account economic aspects. Here, all the features of local democracy are visible. A unique example are the RES investments implemented in the form of public-private partnership (PPP), in which the local community becomes a real co-owner of the installation and draws real benefits from it (Report, 2012), which is important from the sustainable development perspective. Also, investments in wind power, realised using the investor's capital, fulfils the criteria of sustainability, guaranteeing respect for both the resources and the environment as well as local economic growth, and leads to increased social cohesion. The local community draws various benefits from the realisation of the investment in its locality. The most important is the extra income for the residents from the lease of land, significant budget revenues for the municipality from property tax and income for the whole region from Corporate Income Tax. An increasingly common practice is to involve the investor in the community's current issues. In particular, this relates to the maintenance of the transport infrastructure, thus indirectly contributing to the improvement of the power grid. Realisation of such investments allows municipalities to self-finance projects and initiatives which increase social and economic cohesion, contributing to the growth opportunities and thus reducing energy poverty.

It is estimated that investing in wind farms, due to EU requirements on the percentage of energy derived from renewable sources can bring tangible economic and social benefits for the country as well as for the local community (Soliński, Soliński, Solińska, 2008; EWEA, 2010).

In the group of economic benefits the following should be noted: a reduction in penalties associated with air pollution emissions, including CO_2. Wind power, as an ecological alternative to fossil fuels, can also increase energy security, and thus a country's energy independence, restricting imports of fossil fuels (Polish Energy Policy, 2010; EWEA 2010).

The wind farm generates two types of revenue: sale of electricity and the sale of *green certificates*. Wind energy, available locally, serves to develop local energy markets, develops the energy infrastructure, improves the competitiveness of the energy sector, and contributes by increasing tax revenues for the local municipality. Global turnover in the wind energy sector in 2010 amounted to 40 billion euros, whilst employment in this sector amounted to 670,000 people (International Wind Energy Development, 2006; PSEW, 2011). Current estimates indicate that the wind energy sector directly creates 4.3 jobs per 1 MW of installed capacity. It is expected that over the next decade the wind energy sector with the development of *offshore* farms will create about 250,000 new jobs in Europe. The European Commission estimates that in achieving the Community objective of a 20% share of renewable energy will create 2.8 million new jobs and increase GDP by 1.1% (EWEA, 2010). The development of the labour market is highly significant since demand for wind turbines continuously grows with demand outstripping supply (PSEW, 2011; EWEA, 2007; Kassenberg, 2012). It will include employees with various specialisations in the fields of IT, electronics, construction, telecommunications, energy, manufacturing and consulting. Constructors, designers, wind turbine installers, electrical engineers and control engineers are especially valuable. In addition, the sellers of wind turbines, wind turbine operators, maintenance technicians, managers responsible for environmental protection, financial experts, investment advisers, and others (EWEA, 2012, PSEW, 2011, Wiśniewski, Michałowska-Knapp, 2010). Most companies are trying to take advantage of the

available local human capital when realising projects which result in increased local employment.
The development of the energy sector also involves integrating the scientific communities from disciplines such as sociology, psychology, public health, environmental health, law, and finance.

Conclusions

In conclusion, it should be said that development of wind power is maintained in accordance with the concept of sustainable development.
Taking into account the environmental aspects, the desire to maintain the ecological equilibrium, the lack of pollution emitted into the environment and a reduction in the demand for traditional energy sources should be pointed out. An additional environmental *protection* is an obligation imposed on the wind farm investors to perform a full environmental impact assessment, whose aim is to assess any potential impacts (including effects on human health) even before the start of construction.
In the economic context, taking into account the need to increase the use of renewable energy sources in all EU countries, a sharp rise in investment and new wind farm capacity is anticipated, which with the right organisation should also bring tangible economic benefits to the local community fostering their safety, development and independence (Angelstam, Elbakidze, 2010). Attention should also be drawn to the bilateral relationship between health and economic growth, on the assumption that economic growth is endogenous and depends on two factors, innovation and human capital (Czapiński, 2011; Peter, 2011).
From the social perspective, interactions and integration between the public, private and civil sectors at the local, regional, national, state and international level should be emphasised. It is also important to expand the scope of knowledge by involving representatives from the fields of humanities and social sciences, as well as engineering and technology. However, the local community's perception of wind energy cannot be underestimated which may, but not necessarily, be positive. Widespread free access to information is as equally important as the environmental educational programs.
Currently there are about 100,000 wind turbines (including 10,000 in North America) functioning around the world. According to the World Health Organisation (WHO), wind energy is associated with fewer adverse health effects than other forms of traditional power generation and will have positive effects on health by reducing pollutant emissions. This is confirmed by scientists involved in environmental health and acoustics (Gillis et al, 2009; Leventhall et al, 2003; Leventhal, 2006; Ramakrishnan, 2007; WHO, 2009). Furthermore, noise related nuisance is minimised by introducing new technology and using natural environmental barriers (Rogers 2006, 2006a; Global Wind, 2009). Based on published scientific reports it can be said that no danger from the presence of wind farms on human health has been demonstrated, but research is still being carried out (CMOH, 2010; Global Wind, 2010). It is also an important point in the context of sustainable development (Udo, Pawłowski, 2010), as the increased use of wind energy, both worldwide and in the EU, seems to be at the moment not only beneficial, but simply inevitable (Soliński, Soliński, Solińska, 2008; Pawłowski, 2010).

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