Assessment of wind energy development opportunities and potential in Poland until 2020

1. Introduction

During the March summit of the European Union in Brussels leaders of member states committed to generate 20% of the UE energy from renewable sources by 2020. It was decided that the target for particular countries will be differentiated depending upon the starting point and renewables potential as well as its current use and fuel structure in the energy sector. Poland, similarly to other Community states, faces an important task of establishing the national target for year 2020.

Identification of renewable energy sources in Poland generating electricity is fully possible due to the certificates of origin system. Therefore determination of the so – called "starting point" is relatively simple.

Table 1. Installations generating electricity from RES – licenses valid on 31st of December 2006 (Source: URE)

RES type	Installed capacity [MW]	Number of installations [pcs.]
Biomass power plants	238,79	6
Biogas power plants	36,76	74
Wind turbines	152,56	104
Hydro power plants	1 081,43	684
Total	1 307,54	868

Apart from development of the technologies mentioned above additional reserves of „green energy" production from conventional sources were used /co – firing technology/. Owing to that initial, quite common skepticism concerning the viability of the obligation in 2005 and 2006 led to optimism insofar as perspectives for future development of renewable energy sources in Poland. 4 112 certificates of origin were issued in 2006, covering energy volume of 449 960,354 MWh[1] .

At the end of 2006 Ministry of Economy increased the levels of obligation to purchase energy from renewable sources for years 2007 – 2014 – in accordance with the new Ordinance the share is to increase to 10,4% in 2010. Successful implementation of the certificates of origin system for green energy became a basis for development of other support schemes – e.g. energy from co – generation.

An attempt to estimate future development scenarios for the renewables sector is a much more task. Estimating wind energy feasible for installation and defining country's potential in generating wind energy requires collecting many qualitative and quantitative data that currently either does not exist or is not publicly available. Unfortunately, in Poland there are no – unlike in other countries like the United Kingdom, Germany or Spain – professional governmental and scientific studies concerning the potential of particular RES technologies. What is worse, there are also no credible analyses of effects /financial, technical, economic, etc./ of development of these sources. Rare existing studies are not publicly available.

In PWEA's assessment basic factors determining the wind energy development potential will be analyzed. Boundary value determined on the basis of factor introducing most limitations will be proposed as feasible wind energy penetration in year 2020. Therefore, by assumption the scenario developed by the Association is to be very conservative. One has also to emphasize that

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it is only an initial estimate of wind energy development opportunities in Poland, not considering offshore capability or technological progress in capacity and productivity of individual wind turbines.

Due to an early phase of life of the sector in Poland and small market penetration – approximately 216 MW of installed capacity and approximately 142 installed turbines (as of 10th of May 2007) – one cannot use domestic experience to anticipate future development of these sources. Therefore the basis for estimating development potential of wind energy until 2020 will be the experience and conclusions from other countries, where wind energy today has a significant share in meeting the demand for electricity. The development scenario has been developed with regard to domestic technical and geographical conditions and under the assumption that currently existing barriers as well possible future ones, stemming from bad legal regulations, will be successively eliminated.

2. Baseline

Development of the wind energy sector in 2020 must be related to anticipated condition of the entire energy sector in this time perspective.

Current status (2005 data):

a. Total generating capacity installed in the system – approximately 35 000 MW,
b. Gross electricity production – approximately 157 TWh,
c. Electricity consumption – approximately 144 TWh, ,
d. Maximum use of installed capacity - approximately 65 %,
e. Average yearly efficiency of current system generating capacity (from items a and c) - approximately 49 %,

Assumed indices

a. Average GDP growth until 2020 - 5,1% p.a. (5,4% p.a. in 2006 - 2010),
b. Average growth of demand for electricity – 0,8 GDP (0,8 – elasticity index)[i],
c. Energy consumption in 2020 – 267 TWh, (calculated on the basis of GDP growth calculations from item a, assuming elasticity factor at the level of 0,8),
d. Share of renewable energy /in the energy volume for final consumers/ in 2014 – 10,4%.

3. Assessment of wind energy growth potential

To estimate wind energy growth potential analysis of currently known and rationally definable constraints affecting the sector's potential will be performer. Primary constraint areas include:

- Number of wind sources safe for the National Power System,
- Constraints stemming from siting possibilities on the area of Poland (land availability),
- Possibilities for development of operators' power systems until 2020.

Analysis of constraints to development of renewables related to price barrier stemming from increase in energy costs borne by final consumers under the assumed wind enregy growth has been omitted purposefully. Strategic documents of the State, including the "Poland's Energy Policy until 2025", lack reference to anticipated future electricity prices. The Association also does not posses credible data concerning:

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- Anticipated electricity generation costs in year 2020,
- Anticipated operational costs of RES support schemes /if any/ in 2020.

Lack of such data disallows for using the price barrier criterion for estimating possible wind energy growth rates.
The study also does not consider constraints stemming from the existence of the NATURE 2000 ecological network and development of other surface nature conservation forms. Studies currently performed by PWEA and representation of ornithologists will allow in the perspective of two – three years for assessment of actual impact of wind turbines on birds and verification of minimizing and compensating measures taken; we hope that this will result in the very existence of NATURE 2000 areas not excluding the possibility for wind farm construction on a particular area. Moreover, due to lack of completed update of list of NATURE 2000 areas and indetermination of final boundaries of already approved areas there is no way to determine how large areas are potentially, as we assume only temporarily, excluded from the possibility to be used as wind energy sites.

Also, PWEA may not in full estimate wind energy development opportunities on the area of Polish territorial sea and exclusive economic zone. The reasons are plentiful, with key being:

- Lack of political will to develop offshore wind energy,
- Lack of action towards establishment of procedures for investment realization on NATURE 2000 areas designated within the Polish territorial sea,
- Lack of regulations concerning selection of subjects entitled to design and realize such projects (licensing process),
- Problems with spatial development of maritime areas and lack of spatial development plans for these areas.

Construction of offshore wind farms is currently the main development direction of European wind energy. Most European countries that may, like Poland, use their territorial waters (and/or exclusive economic zone) to build wind turbines developed strategies in this field. For construction of offshore wind farms is much complicated task, requiring more state involvement, as well as establishment of additional support schemes for offshore projects due to their higher costs. Use of maritime areas for siting wind turbines allows for achieving higher productivity and significant capacity growth.
Considering the potential stemming from use of offshore areas may significantly change the present estimation of Poland's potential insofar as installed capacity and production of electricity from wind.

3.1. Safety of the National Power System - indices

Basic differences between power systems in particular countries cause that simple indices allowing for unambiguous assessment of wind generation on safety level in the power grids do not exist. The very diversity causes also that experience and observations of one operator do not give unambiguous answers concerning future effects of high penetration levels in other operators' grids. However, to assess the development of wind energy in different countries two indices are commonly used[ii]:

- *Penetration* defined as the share of wind energy in total electricity generated in a system,
- *Capacity penetration* defined as the ratio of wind capacity to total generating capacity in a system.

Both theoretical analyses and actually recorded situations[iii] confirm the possibility for a significant (30% to 50%) penetration of wind energy in the system without particular negative effects of wind sources on the power system. With regard to safety margin, approximately 20% penetration is considered safe. Determination of higher safe penetration levels for assumed reliability and security levels in the system is based on simulations and model analyses of a particular power grid. Such analyses use complex power system models, consider actual wind turbine characteristics, precisely define allowable electric values reflecting allowable effects of wind generation on the system. From available publications it stems that in Poland no such complex analysis of a "safe" for the system wind

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penetration was made. Also the Association for obvious reasons /for instance due to lack of data concerning the system/ is incapable of commissioning such analyses.

Therefore to preliminarily estimate wind capacity that may be installed in the National Power System one proposes to use a very conservative index at the level of 20% to reflect assumed capacity penetration. The index is easy to define and "softer" for the system due to differences in generation efficiency between conventional power plants and wind turbines. Also practical experience from a number of countries and regions /Denmark, Spain, northern areas of Germany, the USA/ confirm correctness of such assumption. Wind energy development plans in particular countries indicate the possibility for a significant increase over the proposed 20% as a safe capacity penetration index without jeopardizing stability and reliability of the grid (Table no. 2).

Table no 2. Wind energy penetration indices assumed by different countries (Source: on the basis of Garrad Hassan data)

Country	Assumed penetration
Germany	2012: 39%
Spain	2010: 54%
United Kingdom	2010: 13%

Much higher penetration levels than proposed 20% are safe due to grid implementation of complex wind generation control and supervision systems as well as by defining strict requirements for newly installed wind turbines. Similar provisions exist in Polish legal regulations /binding Transmission Grid Traffic and Maintenance Instruction and a draft of the system ordinance/, however due to insignificant number of wind sources the provisions are not being implemented in practice yet.

3.2. Estimation of safe wind energy capacity in the NPS in accordance with power penetration factor

Assumed indices for 2020

In the study data for year 2020 discussed in Paragraph 2 were assumed as the basis. The base year is 2005.

I) Assumed energy consumption in 2020

– 267 TWh

Linear growth of system generation, proportional to increase in energy consumption, is assumed. Due to the fact that today's energy production is based mainly on conventional /thermal/ generation, the amount given in Item II corresponds to approximated power of total generation dominated by conventional sources operating with approximately 50% efficiency (Item f).

II) Equivalent /without regard to displacing part of conventional sources by wind / total generation capacity in conventional sources in year 2020

– 62 000 MW

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Assumptions

III) Generation efficiency for wind turbines
– 20 to 35 %

For further calculations 25% efficiency for wind turbines is assumed.

IV) Maximum wind capacity penetration in the NPS in 2020
– 20 %

Calculations

Assuming that in 2020

- Efficiency of conventional sources in the system will be 50 %,
- Efficiency of wind sources will be 25 %,
- Wind capacity penetration will be 20 %,

then:

V) Capacity of wind generation in the system by 2020 may amount to
– approximately 13 600. MW

VI) Total capacity of conventional generation in the system by 2020 may amount to
– approximately 54 000 MW

VII) Total system generation capacity by 2020 may amount to (VI+VII)
– approximately 67 600 MW

Discussion of results

Most important simplifications in the above calculations include:

- Assuming linear growth of energy consumption and system capacity. Available documents[iv] assume construction of new capacity in the order of 21 to 23 thousand MW by 2020; however, these studies do not consider increasing wind energy potential,
- Assuming that total effectiveness of conventional generation in 2020 will be at the level of base data (today approximately 50%). Assuming conventional sources efficiency at the level of approximately 60 %[v] wind capacity fore assumed penetration level decreases by approximately 2000 MW.

Comparing the results with installed capacity in Germany or Spain and wind energy development plans in the USA or Great Britain one may deem them completely accurate and feasible.

Determination of amount of electricity generated in wind turbines by 2020

On the basis of amounts calculated in Item VI and assuming 25% generation efficiency in wind turbines (Item IV) one may determine:

IX) Amount of energy generated in wind turbines in 2020
- approximately 30 TWh

CONCLUSION

For assumed wind energy capacity penetration in the system /20%/ total installed capacity in wind turbines may reach the level of approximately 13 600 MW. With these values the amount of electricity generated by wind turbines in 2020 will amount to 30 TWh.

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3.3. Siting opportunities

The next element analyzed in this study is the issue related to siting constraints encountered by wind energy. The question, how many turbines /or how many MW in wind in total/ may be located on the area of the country with regard to economic, legal and social factors is the least analyzed issue in the few years' of wind energy development history in Poland. Meanwhile, these are the factors that directly determine the possibility to build particular number of wind turbines with particular capacity.

- Economic factors – locations available to wind energy allowing for achieving economic results satisfying for the investor strictly depend upon: wind resources, connection costs and lease costs. All these elements are highly variable. Today's accepted windiness is much lower than a couple of years ago due to use of higher and more efficient wind turbines. This means that not only shore areas, but also inland sites may benefit from wind energy development. Dispersing wind energy on larger area also decreases unitary connection costs. Larger potential area of wind energy penetration entails relatively lower lease prices. Therefore the investors' pressure to locate projects not only in northern Poland is increasing. Such a development path is currently observed in Germany, a country having wind conditions similar to Poland.
- Legal factors – legal regulations of wind turbines development significantly limit the areas available for the projects locations. It concerns, in particular, environmental restrictions /surface forms of nature preservation, standards concerning noise emission /.
- Social factors – social acceptance of wind energy may be decreased due to dispersing the turbines on particular country's areas. It will also have an influence on limiting the potential areas for wind energy.

3.3.1. Analytical assessment of determining the potential of wind turbines locations

Poland is a country with the area of 312,685 square kilometers. Vast majority of its territory is excluded from the possibility of locating the wind farms investments as it is covered with urban areas, including building developments, roads, airports, ports, railroad infrastructure, factories and industrial plants, as well as forests, rivers, lakes, marshy areas or with geographical structure preventing the location of the wind turbines. Additionally, many of these areas are located in the immediate vicinity of building developments, forests or are settled in depressions, which restrict their usefulness for wind energy.
Estimating the area available for the investments of wind farms building, the following areas shall be excluded from overland area: lands under water, forestlands and tree- and shrub-covered areas, built-up areas, and urbanized areas. Considering additional, simplifying assumption of the area's detailed function separation (i.e. assumption that, for example, the preserved areas are totally separated from forests), on the basis of the Main Statistical Office statistical data included in Table 3, it can be calculated that only about 9080155ha of the overland area, that is about 29.8% of the country's area may theoretically be used for the development of wind energy. Additionally, subsequent areas should be excluded due to the vicinity of forests, building developments or the occurrence of a specific lie of the land (depression areas or inaccessible mountain areas).

Table 3: Structure of land exploitation in Poland – selected positions:

Land	Area in ha	The land's share in the country's territory in %
The country's territory (overland area with inland waters and part of the inner sea waters)	31 268 500	100%
Water area	822 000	
Land area	30 446 500	

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Areas under water	647 000	2,1%
Areas legally preserved	approx. 10 047 345	approx. 32%
Forestlands, tress- and shrub- covered lands, including forests	9 214 000 8 942 000	29,5% 28,6%.
Area of farmlands (arable lands, orchards, meadowlands and permanent pastures, built-up farmlands, areas under ponds, areas under ditches), Including arable lands, meadows and pastures	19 241 000 16 899 300	61,5% approx. 55%
Built-up areas and urbanized areas, including: Housing areas, Industrial areas Communication areas.	1 458 000 188 000 94 000 933 000	4,7%. 0,6% 0,3% 3%
Estimated areas potentially available for wind energy	9080155	29,8%
Estimated area with favorable wind conditions vi	2 724 047 (calculated as 30% of the area potentially available for wind energy)	8,9%
Estimated area with remarkably favorable wind conditions vii	454 007,8 (calculated as 5% of the area potentially available for wind energy)	1,4%

Source: One's own calculation based on the MSO data.

Lack of wind atlas for Poland, and, what follows, lack of information about the country's areas on which specific average wind speed occurs, prevent assessing what part of these potentially available areas may be really used for the development of wind energy with respect to windiness. Basing on the Institute of Meteorology and Water Management data, stating that the areas with favorable wind conditions constitute about 30% of the country's territory, it may be calculated that approximate area on which it is possible and worthwhile to develop wind energy on land for Poland would amount to about 2 724 047ha, that is 8,9% of the country's overland area. If wind energy were to develop only on the areas qualified by the IMWM as remarkably favorable (5% of the country's territory), this area would even be smaller and would amount to 454 007,8ha.

Such a calculation is a large generalization, as the availability of the area does not have to be correlated with the occurrence of favorable wind conditions. Additionally, this estimation does not take into consideration the occurrence of closed military and aerial grounds, etc., and the fact that the land is not a monolith, and is divided by communication infrastructure, forests, building developments, etc. Legal regulations impose obligation of maintaining some distance, e.g. from housing areas, many areas also contain the jacket, in which realization of the wind investments is often legally prohibited (e.g. in case of the occurrence of strict forms of nature preservation or architectural preservation) or inadvisable due to wind plants productivity (as it is in case of forests or large obstructions, from which, due to the speed disturbance, specific distance is maintained). This estimation also does not include the assumed increase of the country's forest area, as well as its further urbanization and planned development of preserved areas, including Ecologic Network Nature 2000. Additionally, the restriction resulting from availability and proximity of the energy infrastructure, including high-voltage line, was omitted in the calculation.

Assuming that, in average, about 10ha should be reserved for 1 MW of the installed capacity, on the account of the impact zone and the area occupied by the technical infrastructure, and all factors

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mentioned above limit the area with favorable wind conditions to 50% of the area available for wind energy, the land on which the projects could be realized would amount to 227 000ha. **On the basis of**

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this estimation it could be stated that, assessing only the availability of land and taking into account present development of technology, it is possible to install nearly 23 000MW of wind energy in Poland.

3.3.2. Comparative assessment of indicating the potential of wind turbine location

For the sake of verification of calculation conducted in section 3.3.1, theoretical calculation from this section was related to the capacity installed presently in Germany. Current state of market development in Germany was compared to the location potential in Poland and this way the estimated possibilities of the wind energy locations were verified.

In principle the wind turbines on mainland are located on arable lands. As it was mentioned above, owing to technological progress, including the use of higher towers, the projects may be located in sites characterized by less favorable wind conditions, which results in the fact that more wind farms are built in the interior.

It is assumed that owing to dynamic technological development and the increase of the installed unitary power of devices that occurred during last 25 years, the turbines with significantly higher unitary power as compared to German market /by about 50%/ will be installed in Poland. Currently, the basic unit built in Poland is the turbine with the capacity of 1,5-2,0 MW. The area occupied by the wind turbines converted into the installed capacity is approximately identical for the turbine with the power of several hundred kW and the turbines of MW class (about 10ha per 1MW). It results from the necessity of maintaining appropriate distance between the turbines, which should be from 4 to 8 diameters of the turbine propellers.

I.	The area of arable land in Germany amounts to	- approx. 17 million ha
II.	The area of arable land in Poland amounts to	- approx. 15,9 million ha
III.	Current number if wind farms in Germany	- approx. 20 000.
IV.	Average size of the turbines installed in Germany	- approx. 1 MW
V.	Average size of the turbines which will be installed in Poland	- approx. 1,5- 2,0MW
VI.	Capacity of wind farms possible to be installed in Poland indicated on the basis of the index of land used for the turbine from the German market	- 18 800 MW.

Conclusion

The carried out analyses indicate that the availability of land for wind turbine location is not a significant restriction of the wind energy development in Poland. Additionally, as it was mentioned before the study does not include the possibility of using sea area for building wind farms due to currently existing barriers in the scope of offshore development of wind energy, resulting, among other things, from establishing the area of Natura 2000 on almost entire area of territorial waters or introducing high fees for promise of a concession for settling artificial island in the Exclusive Economic Zone. According to the Association, building the wind farms at sea creates significant possibilities for further development of wind energy. The use of sea area may significantly increase /up to 30%/ the capacity possible to be installed in wind energy by 2020 as well as the amount of energy generated by the wind farms.

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3.4. Possibilities of expansion of power systems of the operators by 2020

As it was mentioned, there are few[viii] generally available analyzes and publications concerning the effects of the wind energy development which include significant (20%) share of energy generated from wind in satisfying the demand for energy. In particular, there is lack of governmental studies analyzing various variants of scope and costs of the necessary network expansion and other elements of electro energy system with possible significant development of wind sources. One of the few is the study[ix] commissioned by PSE S.A. in 2003, concerning the scenarios of the wind energy development. Unfortunately, only the summary or fragments of this study are available. In 2005 the revision of the study was conducted but the OSP did not make any information from the study available to the public.

Below, information from the study from 2003 are presented. The tables include the list of essential investments in transmission system for various levels of wind energy development. Table 4 demonstrates the costs of modernization and expansion of electro energy system of transmission operator and distribution companies for particular stages of electro energy system modernization.

Stage no.	Investment details	Wind capacity [MW]
1.	• Modernization of 110 kV Kąty Rybackie – Nowy Dwór line devices, • Construction of a 110 kV Resko – Łobez line and further from Żarnowiec station to connection point for 138 MW of wind capacity between Opalino and Wicko, • Upgrading 9 series of 110 kV lines from 120 mm^2 to 240 mm^2 conductors on the area of: Energetyka Szczecińska, ZE Koszalin, ZE Słupsk and ZE Gorzów, • Construction of a 220 kV Recław station (changing operating voltage of the existing Morzyczyn – Recław line to 220 kV and adding a 250 MVA transformer in the Recław station),	3 224
2.	• Increasing capacity of the 220 kV Krajnik – Vierraden connection by 81%	3 654
3.	• Construction of a new 330 MVA 400/110 kV transformer in the Dunowo station • Construction of a new 330 MVA 400/110 kV transformer in the Słupsk station	3 927
4.	• Construction of a new 250 MVA 400/110 kV transformer in the Krajnik station	4 094
5.	• Changing voltage of the Krajnik – Vierraden connection from 220 to 400 kV	5 902
6.	• Upgrading 5 series of 110 kV lines from 120 mm^2 to 240 mm^2 conductors on the area of: Energetyka Kaliska, ZE Białystok and Energetyka Poznańska, • Construction of a 400 kV Dunowo – Żydowo – Piła Krzewina – Plewiska line (replacing the 220 kV line), construction of new Żydowo and Piła Krzewina stations with 330 MVA 400/110 kV transformers,	6 805
7.	• Replacing current transformers on the 400 kV Krajnik – Dunowo – Żarnowiec, Gdańsk Błonie – Grudziądz and Gdańsk Błonie – Olsztyn Mątki lines	7 731
8.	• Construction of a second 400 kV Krajnik – Dunowo – Słupsk – Żarnowiec line and the 400 kV Piła Krzewina – Bydgoszcz line with a 500 MVA 400/110 kV transformer in the Bydgoszcz station, • Increasing carrying capacity of the 400 kV Piła Krzewina – Plewiska line to 1200 MVA	9 482

List of grid investment costs related to wind energy development **Table 4**

	Investment costs per stage [thousand PLN]								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Total**
Distribution companies	192 075	0	0	0	0	83 990	0	0	276 065
PSE SA	38 100	2 240	43 000	19 000	15 300	521 140	3 000	685 850	1 327 630
Total	230 175	2 240	43 000	19 000	15 300	605 130	3 000	685 850	1 603 695

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Assessment of the feasibility of the investments listed in the Table from legal, administrative or social point of view is rather difficult. The system investments, especially in the scope of the high and the highest voltage lines, may continue for years /5-10 years/, and sometimes cannot be completed due to social or environmental reasons. The fact that the study was conducted at the time when the restrictive nature preservation regulations /Nature 2000/ were not in effect is an additional obstruction, which may hinder realization of some of the listed stages.
Even so, the scope of the modernizations proposed in the Table is, in the opinion of the Association, possible to be conducted, taking into account almost 13-year long time horizon. Eventual problems with its realization may result from belated initiation of actions aimed at realization of necessary modernizations and expansion of the system or may occur when the indicated scope will significantly differ from the real investment needs.

The lists presented indicate that connecting wind generation with the capacity of up to 9 500 MW to the system will require several operations, the cost of which was estimated at about 1.6 billion PLN. Important information can be derived from the estimation that for the connection of capacity of up to 5 900 MW the required total modernization cost of the transmission and distribution operators will not exceed 310 millions PLN. With the assumption of the wind energy construction cost at the level of 1 – 1.2 million €/MW it means the increase of wind project realization costs by about 1.3%. These are not amounts which may significantly change the investment decisions.

Also the assessment of the influence of the costs of further system modernization and expansion for the purpose of connection of wind energy to the level of 9 500 MW, suggests the conclusion that they are not critical. The modernization costs at the level of 1.6 billion up to 2 billion PLN (after taking into account the increase of investment costs) cause the increase of the realization costs of wind projects by 4 up to 5%, which also for large number of wind projects, especially those located in northern regions of the country, should not result in the investors decisions to cease the realization of the investments due to economic reasons.

The analysis of the above data enables to conclude that the expansion and modernization costs of the system are not serious obstructions for the wind energy development to the level of about 10 000 MW. According to the Association, the increase of this level even to 15 000 MW should not increase significantly the unitary costs of system modernization, thus significantly limit the subsequent wind project. It should be remembered that in years 2007-2013 substantial means for funding infrastructure investments will be available from various Union funds.

CONCLUSION

In this situation it should be assumed that the necessity and conditions of the expansion of the transmission system and distribution system do not create a serious restriction /neither technical nor legal nor financial/ of the potential of the wind energy development to the level of 15 000MW.

4. FINAL CONCLUSIONS

Summing up the results of the assessments in three fields: system safety, connection restrictions and location restrictions, it may be stated that the level, safe for the system, of wind energy penetration in the system will be the primary technical obstruction of the renewable sources progress. It may be concluded from the assessments that, taking into consideration current technical and technological conditions, entirely possible, safe and real level of wind energy

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development in Poland by 2020 is installation of 13 600 MW and achieving the production of electric power from wind farms at the level of 30TWh.

It is, according to the Polish Wind Energy Association, the minimum quantity, calculated on the basis of conservative assumptions, not taking into account the potential in the scope of the offshore project development or technological changes and the change of the formula of individual turbine capacity, which will occur within next 14 years. The construction of 13600MW will require further elimination of legal and administrative barriers. It shall be remembered that in the period 2007-2020, i.e. next 14 years, approximately 13 400 MW were to be put into operation (it would mean the need to build about 900-1000MW annually). The experience of many countries (Germany, USA, Spain) where the annual increase of capacity exceeded 2000MW and countries such as France, Great Britain or Portugal, where the increase of capacity amounted to over 700MW, indicate that it is possible.

Development of wind energy during last years proves that the restrictions in the scope of the use of wind farms and the assumptions concerning development of the sector are systematically overcome. What was impossible yesterday, today becomes reality, and continually increasing number of wind turbines in energy systems and the growth of the share of wind energy in satisfying the consumers demand clearly prove it.

[i] One of the method of forecasting the increase of the demand for electric power is to assume the so-called indices of flexibility of the gross electric energy consumption increase with reference to the gross domestic product increase. The flexibility index established for the "Domestic Plan of Distribution of Entitlement to CO2 Emission for years 2008-2012 (project May 2007) amounts to 0.8. Such an index was accepted for the assessment of the increase of the electric energy demand. Source: http://www.mos.gov.pl/she/prace_nad_kpru/kpru/KPRU_II_projekt_2007_18052007.pdf,

[ii] The impact of large scale wind power production on the Nordic electricity system - Holttinen, H, 2004

[iii] Developments in wind turbine technology and energy forecasting for high wind penetration - Andrew Garrad and Paul Gardner, Garrad Hassan and Partners

[iv] Long-term forecast of the fuels and energy development until 2005 – The Energy Market Agency, 2004

[v] WHY NUCLEAR ENERGY IN POLAND? -Stefan Chwaszczewski, The Nuclear Energy Institute, Otwock-Świerk

[vi] Term comes from the windiness map of Poland elaborated by the IMWM. In this elaboration the areas with favorable wind conditions are estimated at 30% of the land area.

[vii] Term comes from the windiness map of Poland elaborated by the IMWM. In this elaboration the areas with remarkably favorable conditions are estimated at 5% of the land area.

[viii] Study of Integration Possibilities of Wind Energy with the Polish Power Grid.- R. Janiczek, K. Madajewski, B. Sobczak: European Wind Energy Conference, Madrid 16÷19 June 2003

[ix] Study of the influence of the wind energy development on the work and development of National Power System – study prepared by PSE SA, 2003

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