Development of Wind Energy in European Union

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Abstract: Nowadays, the European Union and the world as a whole find themselves in front of a crossroad concerning the future of the energy. Today's environmental policies are largely devoted to fostering the development and implementation in European Union of renewable energy technologies. This paper analyses the wind energy development in European Union in terms of legislative framework, wind potential and development trends. The aim of this paper is to analyze the wind energy development in European Union, evaluating current situation and proposing new opportunities for the process improvement. The wind energy actual situation in Romania is also analysed in order to propose some actions to develop wind energy in Romania. Further, the paper presents an overview of cost and benefits of wind energy production.

Key words: wind energy, wind technical potential, investments, wind power generation costs, benefits.

1. Introduction

In the complex picture of energy policy, the renewable energy sector is the one energy sector which stands out in terms of ability to reduce greenhouse gas emissions and pollution, exploit local and decentralised energy sources, and stimulate world-class high-tech industries [1].

Wind energy is an environmental friendly and renewable source, and its utilization can help in reducing the dependency on fossil fuels with limit reservation [2].

Wind-power is the world's fastest-growing energy source, with installations increasing by about 30% a year. During the last 25 years the size of the state-of-the-art wind machine has been increasing systematically but the actual technology of horizontal-axis wind turbines would ultimately reach its limits [3].

Among the various sources of renewable electricity, wind energy has been a clear success in European Union. With a growth in wind capacity of 150% since 2001, the European Union is the established leader in the field and has a 60% share of the global market [4]. Examples of countries experiencing high growth and respectable shares of wind power in their energy mix include Germany, Spain, Denmark and Ireland [5]. There are multiple reasons for such an increase of wind generation capacity: opening of electricity market, favourable feed-in tariffs for wind energy producers, rapid development of wind technology that let to a decrease of investment costs to 1000 EUR/kW, short construction period (one year), low operation and maintenance costs, no fuel costs, relatively simple preparatory works and location assessment and low environmental impact [6, 7]. The more important reason is the decreasing production cost of wind energy caused by the remarkable development of wind power technology [2].

The main disadvantages of wind power are intermittency and generation variability caused by the variable nature of wind. Although the variability of wind can be largely predicted, it still affects the operation of the power system [6, 7].

2. Comparative approach of wind energy development in European Union

Europe is the world leading market for wind energy development. However, in half of the European Union, wind is not sufficiently harnessed, due to delays in authorisations, unfair grid conditions and slow reinforcement and extensions of the electric power grid. These continue to pose a threat to the future growth of wind energy. The industry has set a new target of 75,000 MW by 2010. This capacity would provide approximately 160 TWh, representing between 4% and 6% of the 2010 European electricity consumption. For this deployment to be achieved, more countries must use wind energy. The offshore market will most certainly be a key element in wind energy development in the next few years. The growth of the global wind energy market has been

accompanied by a phase of industrial reorganisation of the sector. This reorganisation has deeply modified the wind power industrial situation since 2002. There has been considerable industry consolidation, with fewer, larger players, particularly in the global market. Medium and smaller sized firms still play a role, though, at a more regional market level [4].

In 2006, the European Union has seen another record year with installations above 7,000 MW, thereby reaffirming its undisputed status as the world's biggest wind market. Although there are still many barriers to wind energy development in most EU countries, the figures demonstrate a healthy underlying trend in the market.

The value of wind turbines installed in Europe in 2006 was approximately 9 billion Euros [8]. The cumulative wind power capacity operating in the European Union increased by 19% in 2006 compared to 2005, and now exceeds 48,000 MW (table 1). In an average wind year this will produce approximately 100 TWh of electricity, equal to 3.3% of total European Union electricity consumption [9].

Among the other European Union countries, we can note the dynamism of Germany, which increased its wind power capacity by 2,233.1 MW in2006, of Spain, which installed 1587.16 MW, and of France, which installed 810 MW, more than in the entire history of the French market.

The top five European wind energy markets in 2006 were Germany, Spain, Denmark, Italy and the UK. However, the European wind sector is gradually becoming less reliant on these few key markets in Europe, and other countries such as France, Portugal, Austria and the Netherlands have recently demonstrated strong growth.

Germany is the world's leader in terms of wind installed capacity. The total share of wind energy in the total electricity consumption in Germany now stands at approximately 5.5%. In the longer run it is also expected that the industry will profit from the developing offshore business [8, 10].

Since 2000, under EEG regulations electricity produced from renewable energy sources is given priority for connection to the grid, the priority of purchase, of transmission, and for payments. Grid operators are obliged to feed in electricity produced from renewable energy and buy it at a minimum price within their supply area. In order to allow for technological progress and continuous cost reduction, the compensation rates are subject to nominal annual degression. Another important regulation is the German Federal Building Code which treats wind energy plants as privileged projects. Local authorities are supposed to designate specific priority- or preferential zones for wind energy utilisation.

Table 1 European Union Wind Capacity

Countries	Total end 2005 capacity (MW)	Installed 2006 capacity (MW)	Total end 2006 capacity (MW)
Austria	819	145.6	965
Belgium	167.4	26.3	193
Bulgaria	10	22	32
Cyprus	0	0	0
Czech Republic	28	22	50
Denmark	3,128	11.5	3,136
Estonia	32	0	32
Finland	82	4	86
France	757	810	1,567
Germany	18,414.9	2,233.1	20,622
Greece	573.3	172.5	746
Hungary	17.5	43.4	61
Ireland	495.5	249.9	745
Italy	1,718	417	2,123
Latvia	27	0	27
Lithuania	6.4	49.05	55.5
Luxembourg	35.3	0	35
Malta	0	0	0
Netherlands	1,219	356	1,560
Poland	83	69.3	152.5
Portugal	1,022	494.4	1,716
Romania	**1.69**	**1.3**	**3**
Slovakia	5	0	5
Slovenia	0	0	0
Spain	10,028	1587.16	11,615
Sweden	509,5	62.15	572
United Kingdom	1,332	634.4	1,963
EU-27	**40,511**	**7,611**	**48,062**

For onshore wind farm development, the amount of sites commissioned is decreasing while repowering is proceeding at a slow pace. Repowering could play a stronger role in Germany today, but numerous Federal States have issued recommendations concerning vicinity and height restrictions and therefore hindering the use of a large number of suitable sits can no longer be used for the installation of modern turbines.

A recent study published by the Ministry of the Environment includes a projection for 1,100 MW offshore wind capacity by 2010, and as much as 12,000-15,500 MW by 2020. More than

60,000MW of projects have been proposed by various companies and consortia [10].

In **Spain**, one major step for renewable energy was the approval of the „Plan de Energias Renovables en Espana, 2005-2010" (PER) in the Council of Ministers in August 2005. The PER sets new targets for installed power and electricity production. In the determination of the specific new targets, the wind energy potential in Spain is clearly recognised with 20,155 MW. Spain holds the second position for installed wind power capacity with 11,615 MW. In 2006 the output of Spanish wind farms exceeded the figure of large hydroelectric power plants [10].

In **Italy**, at least 22% of the electricity supply should come from renewable sources by 2010 [11]. Both geothermal and hydroelectric energy is widespread in Italy but they have reached their saturation levels and have limited possibilities for further development. The photovoltaic market is progressing, but the target of new installations is limited. Wind and biomass energy are the only renewable energy sources which can be exploited to reach the EU targets in reasonable time scale and at competitive cost [10].

The growing Italian market has brought about the arrival of several new domestic players as well as growing interest from foreign developers, even if the wind resource is rather limited. Potential sites outside the traditional areas in the Southern Italian mainland are more and more at stake. But the main barriers to the development of the wind sector remain the regional authorization hurdles, local acceptance and grid connection difficulties.

United Kingdom has the best wind regime of any country in Europe, but the growth of its market has been hampered in the past by a mixture of opposition to development at a local level and lack of clear government policy [11]. The UK experiences a seasonal maximum in wind power availability during winter, and an increase in wind power availability during the day compared to overnight. Low wind speed events have a limited impact on the UK, and high wind speed events are extremely rare [12].

The UK government has a target for 10% of the country's electricity supply to be provided by renewable sources in 2010 [11]. The ability of wind power to reliably contribute to UK electricity supplies is fundamentally related to the characteristics of the UK wind resource, and how characteristics such as seasonal weather patterns correlate with electricity demand [12]. If the 2010 target is to be achieved, an important contribution is expected to be made by wind farms built around the UK's coastline. These have been encouraged by two successive rounds of sea bed lease allocation, both organised by the Crown Estate, which controls activity in coastal waters. In the first round, projects with the potential for more than 1,500 MW of capacity were allocated leases. Three of these have already been built in 2006. The potential of the second offshore round is enormous [10].

Analysing the European Union wind capacity in 2006 (Table 1) we can see that **Romania** is far away from other member states in this field. With 1.3 MW installed during 2006, a 78% increase compared to 2005, Romania has now 3 MW wind power capacity. This is a very small value compared to other European Union member states, but is an important step ahead for Romania.

3. Wind energy in Romania: present state and prospects for the future

As a member state of the European Union, Romania needs to increase the wind energy generation and consumption, in order to achieve its objectives regarding the renewable energy field.

Romania's wind technical potential is evaluated up to 100000 TJ/year. There are such favourable areas where the wind speed outpaces 6 m/s and the ratio between the investment value and the yearly amount of produced energy is quite attractive (0.32-1.90 USD/KWh).

The general map of Romania's wind potential was elaborated taking into consideration wind energy potential at medium height (elevation) of 50 m, based on geographical and weather data collected since 1990 [13]. Talking about wind potential, *it should be signaled that not so reliable statistical wind data are available from the standard meteorological network*. Few professional measurements according wind energy projects procedures were performed up to now.

There are in Romania five wind energy zones (I-V) established taking into consideration the existing wind potential, the climatic conditions and the geographical conditions (table 2) [13]. Wind potential in Romania is fit for wind energy applications on the Black Sea littoral, the off-shore and the mountainous area. In the mountains, the compromise to find suitable roads and grid connections, defines the most interesting area at 900 to 1200 m altitude. Recent studies have shown that the South-East part of Romania is an area with an economically relevant wind potential. Good sites for wind farms offer mean wind speeds of 6 /m/s and more, at WT hub heights above ground level.

Table 2 Technical-economical elements of wind energy zones energetic potential exploitation in Romania

Zone/ speed, energy	High mountain (m/s; W/m^2)	Open sea (m/s; W/m^2)	Seacoast (m/s; W/m^2)	Flat grounds (m/s; W/m^2)	Hills and plateaus (m/s; W/m^2)
I	>11,0; >1800	>9,0; >800	>8,5; >700	>7,5; >500	>6,0; >250
II	10,0-11,5; 1200-1800	8,0-9,0; 300-800	7,0-8; 400-700	6,5-7,5; 300-500	5,0-6,0; 150-250
III	8,5-10,0; 700-1200	7,0-8,0; 400-600	6,0-7,0; 250-400	5,5-8,5; 200-300	4,5-5,0; 100-150
IV	7,0-8,5; 400-700	5,5-7,0; 200-400	5,0-6,0; 150-250	4,5-5,5; 100-200	3,5-4,5; 50 – 100
V	<7,0; <400	<5,5; <200	<5,0; <150	<4,5; <100	<3,5; <50

Analysing and evaluating the collected data it shows up that in Romania wind installations can be set up with a total power that can rich 14000 MW, which means a contribution of almost 23000 GW/year of electric power. Based on the preliminary evaluation near the shore, the medium and short-term wind technical potential is about 2000 MW, with an average amount of electric power of 4500 GWh/year [14, 15].

Currently, there is an operational yet a legislative and financial environment to help wind energy projects, according documents (Governmental Decision 443/2003 or GD 1535/2003) wich built the general conditions. Because the tradable green certificates have been implemented in several countries in Europe [16], the Ministry of Economy and Commerce promotes a specific financial mechanism to encourage RES, based on a quota system and a Green Certificates market. A tradable green certificates is a market-oriented instrument to achieve targets for renewable electricity generation in deregulated electricity markets [16]. The basic idea of green certificates is to create a support system where the market decides the level of support given to electricity from renewable energy sources. In a green certificate system producers of renewable electricity receive a certificate for each pre-defined unit of electricity produced [17]. One of the goals of a tradable green certificates market is the promotion of a diverse mix of renewables, some of which may be more attractive from a socio-economic and ecological perspective [16]. The first rationale for implementing a green certificate system is to give incentives for further investments in electricity production from renewable sources, thus towards building a sustainable electricity production system [17].

Wind energy commercial projects are in progress and several developers are ready to start investments. The researches regarding the wind energy equipments (aerodynamic structure or power generation) had as a result designing, testing and producing some wind generators with horizontal axle and a power of 300 KW in Semenic Mountains, and with vertical axle (Darrieus type) and a power of 100 KW at Redi Hill in Tulcea. In Romania was also designed a wind energy system in the open Black Sea, with an estimated collecting wind potential of 12200 KWh/year. The global collecting efficiency is 0.39. It results that the effective collecting wind energy is 4758 KWh/year [18]. Into the industrial park of Ploiesti is also working a wind power station of 0.66 MW.

In order to valorise Romania's wind energy potential, we propose some investments projects in the South-East part of Romania. Their main goal is to assure [14]: wind energy potential valorisation in conditions of high energetic efficiency; identification of technical and functioning performances of wind equipments that are connected at national energy system; technologies and equipments transfer from other European Union member states; implementation of applicative management programs and technological transfer programs; building new power wind production capacities for rural zones, medium and long term.

Until 2010 new power wind generation capacities of 120 MW will be build in Romania. That implies a 120 million Euros total investment effort, and 314000 MWh wind energy generation. During 2011-2015 period will be build new power wind generating capacities of 280 MW. Wind energy production will be 1001000 MWh in 2015. The total investments effort will be of 280 million Euros in this period [14, 15].

The data mentioned above leads us to the conclusion that in Romania wind energy must be taken into consideration in the energy planning. Wind power should continue to grow in Romania in the next years. It offers the possibility to be used as individual electric energy supply source, especially in the rural areas.

The various locations of wind energy resources in Romania may lead to a diversification of the energy production sites and to increasing employment opportunities in less economically developed areas [19]. Several actions are suggested now, in view of future commercial opportunities: identification by preliminary study and analyses of advantageous wind farm sites; securing the sites by concession or pre-concession arrangements; starting professional wind energy measurements close to the selected sites, to acquire necessary wind data for the output and cost of energy calculations.

4. Overview of costs and benefits of wind energy production

Onshore and offshore wind power must be treated as different technologies, due to the large differences in investment and operation costs. Generation costs for onshore wind power are in the range of 40-64 Euros/MWh. The lower value corresponds to investment cost of 1150 Euros/kW at an average wind speed of 9.5 m/s. The higher value is for 800 Euros/kW at 6 m/s. The cost range for offshore wind energy amounts to 71-96 Euros/MWh, for projects of 1800 Euros/kW at windy sites. In this case wind speeds are between 8 and 10 m/s. Near-shore projects in sheltered waters have lower investment costs (1250-1400 Euros/kW) [20].

The actual technological development reduces the investment and exploitation costs. The minimum value of wind energy investment and exploitation costs is our days comparable with the value of classical power generation that use coal as a fuel.

The costs of wind power decreased by about 30 percent and 60 percent between 1990 and 2000 [21]. Wind power generation costs will also reduce considerably in the coming decades. Offshore generation cost reductions for the years 2010 and 2020 will be larger than those for onshore wind, not least because of the significant expected drop in electrical interconnection costs and the installation of larger turbines. Onshore generation costs are expected to decrease by 20-25% by 2020, and offshore generation costs by up to 40%, compared to present [20].

The main challenge is to continue reducing the cost/kWh of wind power through continued technology improvement, research and development and economies of scale.

The main key advantages of wind power are the following [22]:

- It is a clean energy, with no resulting carbon dioxide emissions;
- It has low cost and at optimum locations, wind can be competitive with nuclear, coal and even gas, on a level playing field;
- Rapid deployment, being modular and quick to install;
- Fuel is free, abundant and inexhaustible;
- It provides a hedge against fuel price volatility;
- Wind energy contributes to the security of supply, avoiding reliance on imported fuels;
- Provides bulk power equivalent to conventional sources;
- It is land friendly, meaning that agricultural and industrial activities can continue around it.

The economic benefit of wind becomes even larger when the benefits of CO_2 emissions reduction and other environmental benefits are taken into account [9]. If the environmental and social costs of power generation were included in electricity prices, wind power would already be cheaper than any other electricity generating technology.

Because of its advantages, wind energy has an important role to play in the energy scenario. In the past 15 years, the cost of wind energy has more than halved, and its production per unit of capacity has more than doubled. At any given site, a single modern wind turbine produces, on an annual basis, 180 times more electricity, at less than half the cost per kWh than its equivalent 20 years ago [5].

In order to continue growing, wind energy needs research and development. Wind energy technology has made considerable progress, but it has not exhausted its potential for further technological development. The main research and development priorities are the development of offshore wind, cost reduction and research on environment issues especially for offshore, as well as the need to adapt the electricity networks to new technological, economic, environmental and political realities [23].

4. Conclusion

Wind energy has successfully been used in European Union during the last decade because of its ecological nature and, also, because of the possibility to be used as individual electric energy supply source, especially in the rural areas. At the same time, wind energy development is limited as a consequence of the discontinuous wind flows and because of the variable wind speed. Also, with the increasing impact of wind energy, the electric systems will have to face new challenges.

Wind energy will never be internationally traded and hence will insulate the European economy from escalating energy costs and periodic fuel shortages. The long term implication is that the economic future of Europe can be planned on the basis of fixed price electricity derived from an indigenous energy source free of all the security, political, economic and environmental disadvantages associated with oil and gas [24].
In our opinion, wind energy will be able to compete on costs in the very near future. That is why Romania needs to install new capacities and to produce more wind energy. The support for implementing wind power generation projects (under the new Sectoral Operational Programme "Increase of Economic Competitiveness") would allow further development of this area.

References:

[1] *Renewable Energy Road Map Renewable Energies in the 21st Century: Building a More Sustainable Future*, Brussels, 10.1.2007, Commission of the European Communities, COM (2006) 848 final.

[2] Shanming W., Schaefer U., Design and Optimization of 8MW Directly Driven Surface Mounted Permanent Magnet Wind Generators, *Proceedings of the Seventh IASTED International Conference on Power and Energy Systems*, IASTED, ACTA Press, 2007, p. 97.

[3] Ponta F.L., Seminara J. J., Otero A. D., On the aerodynamics of variable geometry oval trajectory Darrieus wind turbines, *Renewable Energy*, Volume 32, Issue 1, Jan. 2007, p. 36.

[4] *Green Paper Follow-up Action Report on Progress in Renewable Electricity*, Brussels, 10.1.2007, Commission of the European Communities, COM (2006) 849 final.

[5] European Wind Energy Association – EWEA, *Strategic Overview of the Wind Energy Sector*, 2007, http://www.ewea.org/index.php?id=194.

[6] Jaksic D., Tot M., Maricic S.A., Long Term Impact of Wind Generation on Development of Croatian Power System, *Proceedings of the Seventh IASTED International Conference on Power and Energy Systems*, IASTED, ACTA Press, 2007, p. 79.

[7] European Wind Energy Association, *Large Scale Integration of Wind Energy in the European Power Supply: Analysis, Issues and Recommendations*, EWEA, December, 2005.

[8] Zervos Arthouros, Europe Sets the Renewables Standard, *Wind Directions*, EWEA, March/ April 2007, pp. 5.

[9] Van Hulle Frans & al, *EWEA Report Large Scale Integration of Wind Energy in the European Power Supply: analysis, issues and recommendations*, Executive Summary, EWEA, December 2005, pp. 23-24.

[10] Global Wind Energy Council, *Global Wind 2006 Report*, GWEC, 2007.

[11] *Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market*, European Commission, September 2001.

[12] Sinden G., Characteristics of the UK wind resource: Long term patterns and relationship to electricity demand, *Energy Policy*, Volume 35, Issue 1, January 2007, p. 112-127.

[13] Energy Research and Modernizing Institute – ICEMENERG, www.icemenerg.ro

[14] *G.D. no. 1535/18 December 2003 regarding the approval of the renewable energy sources valorisation Strategy*, published in Monitorul Oficial, Part I no. 8 from 7 January 2004.

[15] *Road Map for Energy Sector of Romania*, Government of Romania, 2004, p. 10.

[16] Ford A., Vogstad K., Flynn H., Simulating price patterns for tradable green certificates to promote electricity generation from wind, *Energy Policy*, Volume 35, Issue 1, January 2007, p. 91-111.

[17] Nilsson M., Sundqvist T., Using the market at a cost: How the introduction of green certificates in Sweden led to market inefficiencies, *Utilities Policy*, Volume 15, Issue 1, March 2007, p. 49-59.

[18] Plumb I. & al, *Economia ramurilor*, Tribuna Economică Publishing House, Bucharest, 2001.

[19] *Sectoral Operational Programme Increase of Economic Competitiveness*, Official Proposal, Government of Romania, Ministry of Economy and Trade, February 2007

[20] Pfaffenberger Wolfgang, Jahn Karin, Djourdjin Marta, *Renewable energies – environmental benefits, economic growth and job creation, Case Study Paper*, Bremer Energie Institut, Bremen, February 2006

[21] Gan L., Eskeland G. S., Kolshus H. H., Green electricity market development: Lessons from Europe and the US, *Energy Policy*, Volume 35, Issue 1, January 2007, p. 144-155.

[22] EREC & EWEA, *Wind Energy*, EWEA, 2006

[23] Kjaer Christian, Taking Control of our Energy Future, in *EU Power*, Issue 2, published by EWEA, 2006, p. 23-25.

[24] Millais C., The Leading Role of Wind Energy in Europe, in *EU Power*, EWEA, 2005, p.9.