POTENTIALS AND MARKET PROSPECTS OF WIND ENERGY IN THE PROVINCE OF VOJVODINA

by

Vladimir A. KATIĆ**, Boris P. DUMNIĆ, Nenad A. KATIĆ, Dragan M. MILIĆEVIĆ, and Stevan U. GRABIĆ

Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia

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The paper presents an overview of the wind energy potentials, technologies and market prospects in the Autonomous Province of Vojvodina, the region of Serbia with the most suitable location for exploitation of wind energy. The main characteristics of the region have been presented regarding wind energy and electric, road, railway and waterway infrastructure. The wind farm interconnection with the public grid is explained. The most suitable locations for the wind farms are presented, with present situation and future prospects of wind market in Vojvodina.

Key words: *wind energy, wind potentials in vojvodina, legal regulation, wind farms perspectives*

Introduction

Wind energy market is today one of the most prosperous and dynamic, not only in renewable energy field, but in industry sector, as a whole. There are many factors influencing this rapid growth, but one of the most important is the strategic decision of the EU to support intensive research and development in last decade of the 20th century and give generous long term incentives to "green" energy producers in the first decade of the 21st century. This was a result of the EU Directive No. 2001/77/EC [1] stated that the share of "green" energy production in overall Community energy consumption has to be increased from 6% in 1998 to 12% in 2010. New target is set in 2009 to 20% by 2020 in EU Directive No. 2009/28/EC [2]. According to available data, the share of energy coming from renewable energy sources (RES) was 11.7% in 2009 [3]. This means that the goal for 2010 has been achieved or even surpassed.

In 2011 the data show that the power capacity of renewable energy sources (excluding large hydro power) has been significantly increased since 2000. From 4% of all EU power capacity in 2000, it has reached 18% in 2011 [4]. Figure 1 presents EU power capacity mix in 2000 and 2011. It can be seen that installed power of RES has jumped from 23,037 MW in 2000 up to 157,210 MW in 2011, *i. e.* 6.8 times.

The EU directives have also stipulated that a share of RES electricity production should be increased from 13.9% to 21% in 2010, up to 37% in 2020 [1, 2]. According to latest

* Corresponding author; e-mail: katav@uns.ac.rs

analysis by the European Wind Energy Association (EWEA), the EU achieved its 2010 target [5, 6]. As official data for 2010 has not been published yet, the renewable energy produced in 2010 has been estimated between 665 and 673 TWh. This covers the 21% target of overall consumption predicted around 3,115 TWh up to 3,175 TWh for 2010 (in 2009 it was 3,041.9 TWh [5]). Such continued grow of renewable electricity production in the EU would lead to 36.4% of electricity share in 2020 and as high as 51.6% in 2030 [6]. The tab. 1 shows this trend.

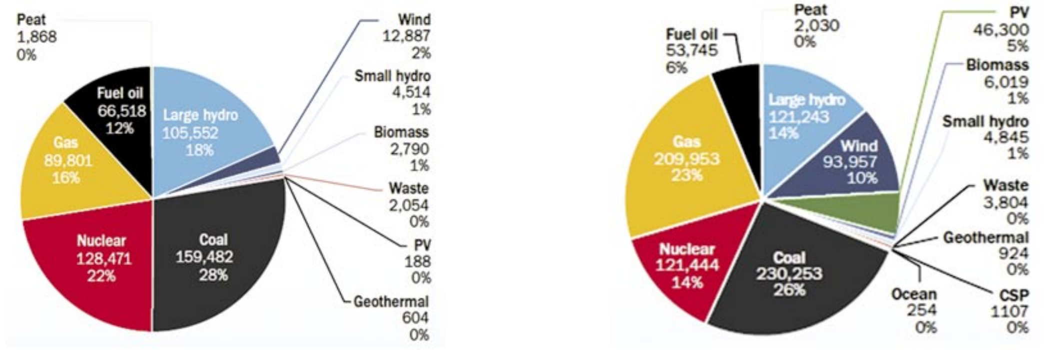

Figure 1. EU power capacity mix in 2000 (left) and 2011 (right) [4]

Table 1. Share of renewable electricity to total electricity consumption [6]

2005	2006	2007	2008	2009	2010	2020	2030
13.6%	14.2%	15.1%	16.4%	18.2%	21.2%	36.4%	51.6%

Actual situation and further projections show that RES electricity mix in 2020 will be dominated by wind (43%), either on-shore or off-shore (fig. 2) [7].

Wind potentials of EU-15 countries have been carefully recorded in well known European Wind Atlas almost 15 years ago [8]. It was the basis for large investments into wind capacities all around Europe, both on-shore and off-shore. Such orientation led to very fast growth of wind power industry in EU, comparable only to progress in computer industry. Figure 3 represents this increasing trend of installed capacities of wind power with prediction up to year 2020 and its effects on CO_2 reduction [8]. It also shows how fast rising is the wind industry, putting wind energy in the leading position among new technologies in Europe. Additional very significant effect is that wind power plants significantly reduce emission of gasses and therefore contributes to improvements of overall environment conditions.

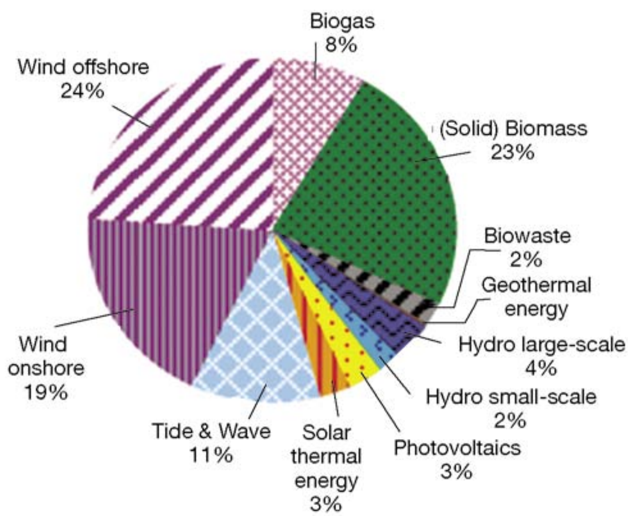

Figure 2. Additional RES distribution in EU-15 production of electrical energy up to 2020 [7]

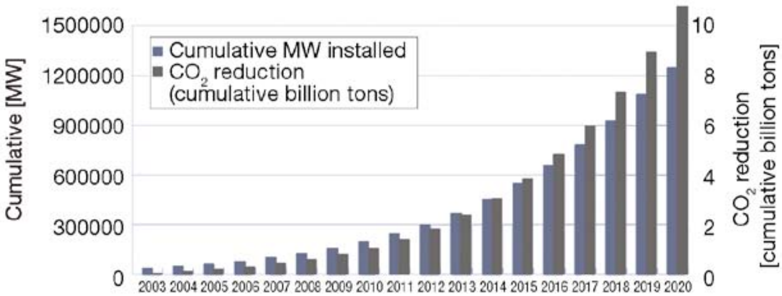

Figure 3. Installed wind power in EU, with prospects of grows up to year 2020 and effects on CO_2 reduction [8]

Figure 4 gives a look into up-to-date situation (end of 2011) regarding installed wind power capacities across the Europe, according to the EWEA [9]. The latest figures show that 93,957 MW of installed wind energy capacity was operating in the EU by the end of 2011, with additional 1,930 MW in candidate countries and 565 MW in EFTA countries, giving in total 96,607 MW, which is 11.5% higher than in 2010. Similar trends are to be observed at other continents, too. Annual figures of new wind power installation capacities for EU and global are shown on fig. 5. It can be seen that Europe is no longer the major market for new wind installation, as its share has dropped from 86.5% in 2000 to 31.3% in 2008, down to 24.5% in 2011 [10].

Figure 4. Wind power installations in Europe by end of 2011 [9]

The wind power capacity installed in EU by end of 2011 would, in a normal windy year, produce around 190 TWh of electricity, equal to about 5.8% of the EU's electricity demand,

and avoid the emission of 144.5 million tons of $C0_2$ per year, the equivalent of taking more than 66.5 million cars off Europe's roads (fig. 6 [11]). Further projections show that in 2020 wind electricity production will be almost 500 TWh or 14% of all electricity generation in EU.

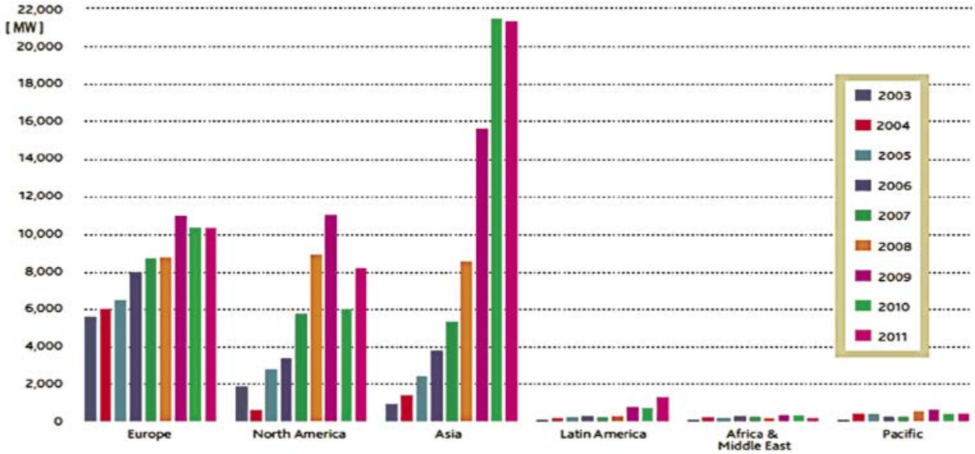

Figure 5. Annual wind power installed capcity by region 2003-2011 [10]
(color image see on our website)

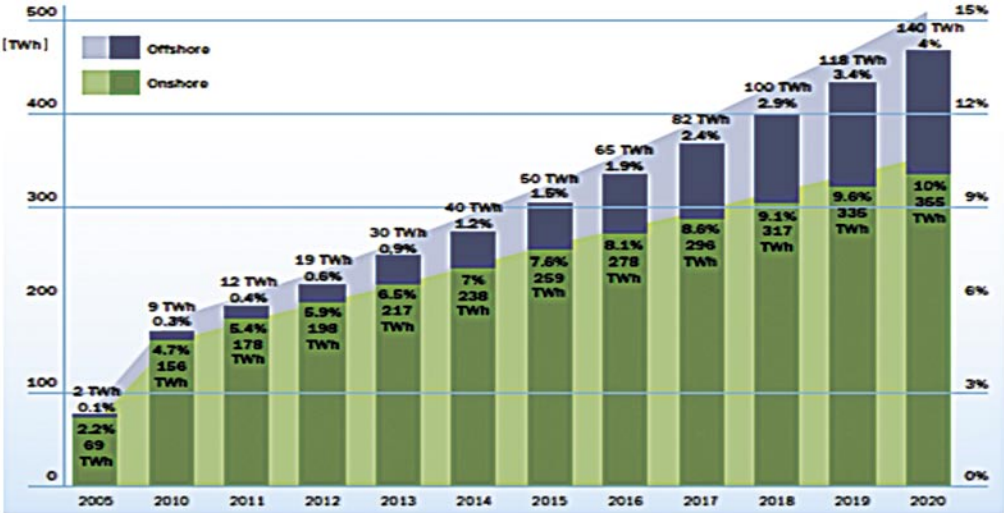

Figure 6. Wind power production in EU – TWh/share of consumption [11]
(color image see on our website)

However, the wind power electrical generation capacities are not equally spread over the continent. From fig. 4, it can be noticed that Germany, Spain, Denmark, UK, Holland and Portugal have the largest share of installed wind power capacities. At the same time, in the area of West Balkan (Albania, Bosnia and Herzegovina, FYR Macedonia, Montenegro, and Serbia), there is not a single wind power station. The development of wind power installation in wider area of central and south-east Europe 2002-2010 is shown in fig. 7.

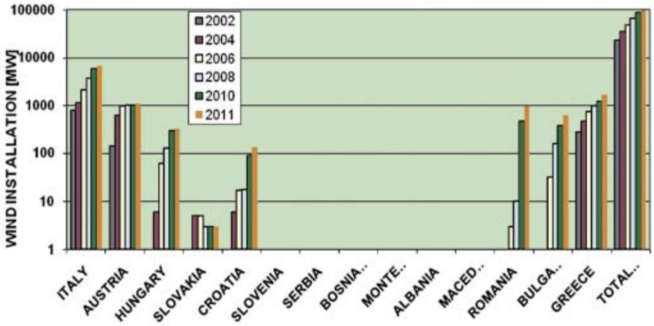

Figure 7. Development of wind power installation in central and south-east Europe 2002–2010

The aim of this paper is to present an insight of current development of wind energy potentials and market perspectives in the northern region of Serbia, the Autonomous Province (AP) Vojvodina.

Wind energy potentials in AP Vojvodina

Wind energy potential in Serbia and especially in its northern AP Vojvodina has been in focus of researchers from different institutions since year 1984 [12]. Results of several research project proved that wind energy potential is significant and that average wind power density is between 100 and 400 W/m^2 (fig. 8) [12, 13]. It can be noticed that there are three main areas very suitable for wind power installations: central Serbia, eastern Serbia and north-east Serbia or south-east of AP Vojvodina.

However, taking into account other important aspects for utilization of wind energy potentials (accessibility, electric power network, road and railway infrastructure, *etc.*), the area of south-east AP Vojvodina attracted the most attention. That was motivation for further research efforts in this field. In depth study of the wind potential in AP Vojvodina, entitled "Wind Atlas of AP Vojvodina", has verified previous results, but with more accuracy and confident [14].

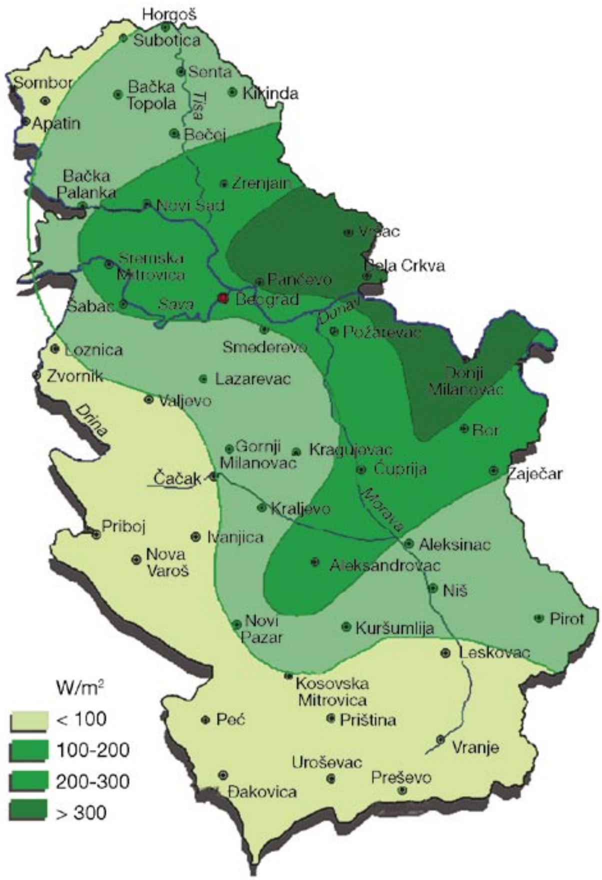

Figure 8. Wind energy potential in Serbia (100 m, yearly average power density)

The study was performed using much convenient data, *i. e.* wind metrological data from 8 metrological stations (MS) all over the territory of AP Vojvodina (Palic, Sombor, Kikinda, Zrenjanin, Novi Sad, Sremska Mitrovica, Vrsac, Banatski Karlovci) in 10 years period. Metrological data of interest are analyzed using Wind Atlas Analysis and Application Program (WAsP) developed by RISO Laboratory in Denmark.

The WAsP analyses time-series of wind data measurements in order to provide a statistical summary of the observed wind climate for each MS. The results were maps of wind speeds and wind power density of the surrounding area (40 × 40 km) of each MS. Analyzed wind data in the surrounding area of MS were converted into regional wind atlas data sets over the digitized maps of AP Vojvodina with a step 0.033° latitude and longitude. It was performed using WAsP and Surfer software with application of interpolation function which is a common procedure for this form of analysis. The results of study were detailed maps of wind speeds [ms^{-1}] and wind power density [Wm^{-2}] for whole territory of AP Vojvodina at the heights of 10 m, 25 m, 50 m, 100 m and 200 m above the ground. Figure 9 present wind speed and wind power density at height of 100 m above the ground. It can be seen that the wind potential is significant especially for the height of 100 m and above, which corresponds to the height of pillar of modern wind turbines (1-5 MW). From fig. 9 it can be concluded that South-East part of AP Vojvodina has the most significant potential for exploitation of wind energy with average annual wind speed over the 6 m/s and with average wind power density in a range of 250-400 W/m^2. A rough calculation may lead to estimation of energy production from a 2 MW generation unit in amount of 4.3 GWh per year up to 6.9 GWh per year.

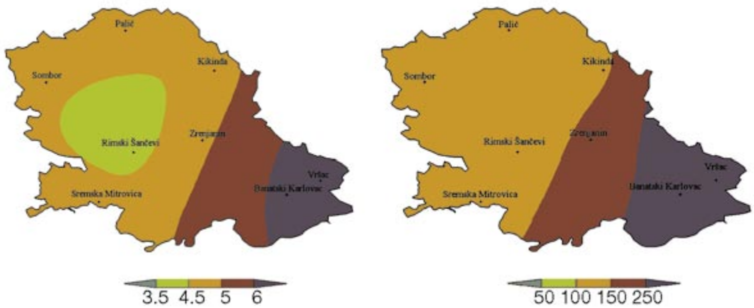

Figure 9. Average annual wind speed [ms^{-1}] (left), and average wind power density [Wm^{-2}] (right), at 100 m above the ground [14]

Environment protection restrictions in AP Vojvodina

Wind farms have relatively little impact on wildlife. During the construction of wind farms may lead to temporarily disruption of animal activities in the area, but after the establishment of wind farm normal operation, the animals may regularly use this habitat.

Endangerment of birds is often the main objection against the installation of wind turbines. There are many papers on the impact of wind farms on birds and the preoccupation with their mortality in areas where wind farms are installed. They show that there is relatively small impact of wind farms on bird mortality. However, during determination the micro-location of a wind farm, it is necessary to avoid migration corridors, and habitats of rare birds, such as those that are of international importance for birds. Institute for Nature Protection of Serbia and AP Vojvodina and have marked the birds migration corridors and resting areas for territory of AP Vojvodina, as well as protected natural areas (national parks, nature parks, landscapes of exceptional quality and other protection zones). In fig. 10, migration corridors are in gray and marked with bilateral arrows, while protected natural areas are in red.

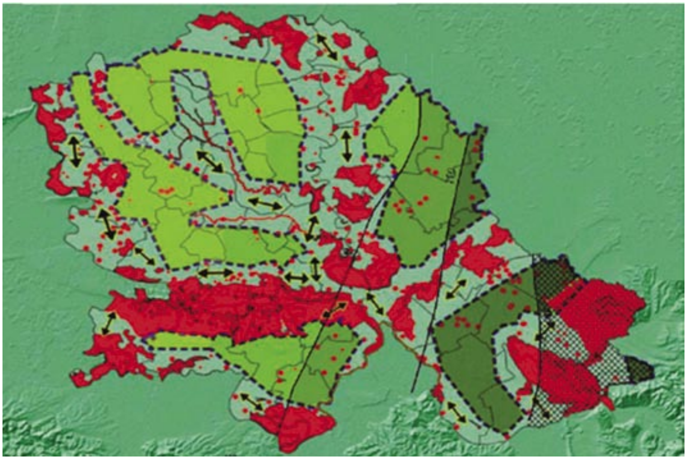

Figure 10. Overview of suitable locations for building wind farms in AP Vojvodina

The areas marked in light green and framed by dashed lines, except for the red dots on them, are the zones with a small impact on the wildlife and on birds. If this figure is overlapped with fig. 9, the most suitable areas for wind farms installation can be obtained. These areas are colored with darker shades of green. It can be seen that they are located in the extreme south-east of AP Vojvodina, around cities of Bela Crkva and Vršac. In addition to these locations, suitable ones are on the borders of National Park "Delibatska peščara" and east of city of Zrenjanin. For a more detailed description of possible locations, it is necessary to take into account the built infrastructure (electricity networks, roads, railways,...) as well as data from the Spatial Plan of Serbia and AP Vojvodina.

Electric grid and road, water, railway infrastructure

Available transportation infrastructure is of high importance for successful exploitation of wind energy. Although electric transmission network for transportation of produced electrical energy is the most important, good roads, railway, waterway and other infrastructure contributes for lower costs of wind farm construction and maintenance.

Characteristics of electric power system in Serbia and AP Vojvodina

Power grid in Serbia used to be integral part of former Yugoslavian network, so it is strongly interconnected with neighboring systems of ex-YU countries. The main transmission system characteristics are: 95 high voltage substations, 187 transformers and 18,622 MVA of total installed capacity [15].

Serbian total HVAC overhead line (OHL) network length of different voltage levels (400 kV, 220 kV, 110 kV) amounts to 9,997.98 km. Disposition of 400 kV and 220 kV OHL and available transfer capacities on the Serbian interconnections are shown on fig. 11 [16]. Transmission network in Serbia was designed to ensure power transfer from power plants to load centers.

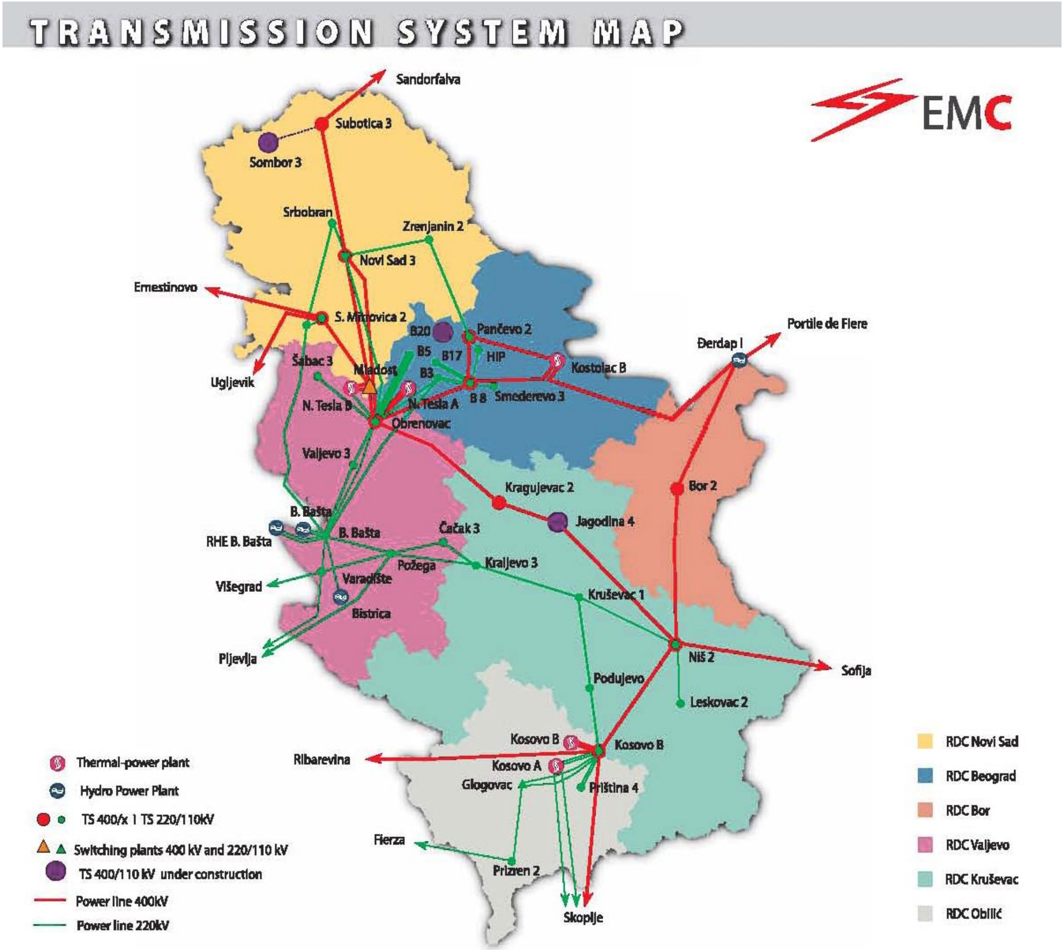

Figure 11. Transmission system map

Disposition of the HVAC-OHL at the territory of South-East AP Vojvodina is presented on fig. 12. At the moment transmission system in this area does not have possibilities for apprehending large wind plants as new generation units. There are three 110 kV OHL in the whole region as well as one 220 kV and one 400 kV on the border of the region. The 110 kV loop Pancevo 2 – Vrsac 2 – (with radial direction to B. Crkva) – Vrsac 1 – Pancevo 2, with a consumptions of about 100 MW (≈ 500 A) is outdated and critical in terms of reliability. A new 400 kV OHL, which is going to connect Pancevo with Vrsac and Resica (in Romania), will increase available capacities, significantly (fig. 12, dashed red line). It will improve voltage conditions in network, increase reliability of electricity supply, create possibility for evacuation of energy produced in wind farms and increase electricity transits through Serbian system.

Road transport infrastructure

With the total road length of about 6,000 km, out of 43,258 km in Serbia as a whole, the road network in the AP Vojvodina is well-developed, although its quality is reduced due to

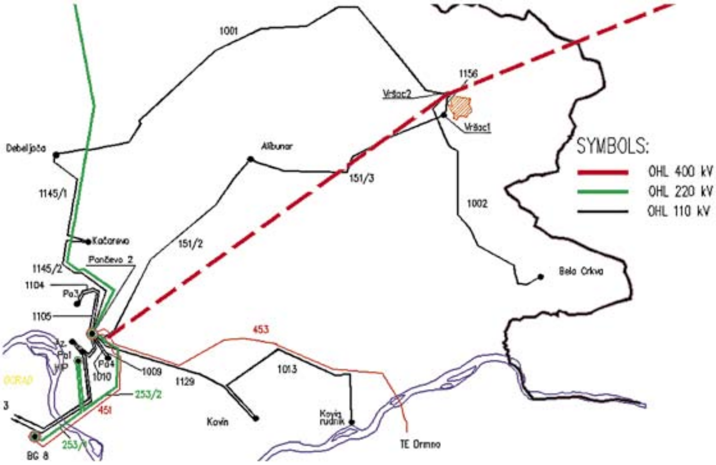

Figure 12. Electric transmission system map in south-East AP Vojvodina

insufficient investments and inadequate maintenance in the period 1990-2000 [17]. Most of the roads are well covered with hard surface roads (5,100 km), which gives good conditions for wind turbine components, equipment and manpower transportation, especially during construction phase.

Railway transport infrastructure

The total length of Serbia railway network is 3809 km and 1247 km (32.7%) are electrified. Only 7% of the lines (276 km) are double-tracked. The average network density, satisfactory on Serbia level, is very uneven and significantly decreases towards the south of the country [17]. About 45% of the railway lines in Serbia have allowed axle load of 22.5 t, while 30% is less than 16 t. Allowed speed exceeds 100 km/h on only 3.2% of the lines, and major part (about 50%) of the network allows maximum speed of up to 60 km/h.

In south-east AP Vojvodina region, an international railway line is connecting Belgrade with Vrsac and Timisoara (in Romania) and it is in a good shape, while all other lines have obsolete technical and technological parameters.

Inland waterway transport

Serbia has favorable economic and geographic features for cargo inland waterway transport (IWT). The basic elements of the inland waterway system on the territory of Serbia are the rivers Danube, Sava and Tisa (total length about 960 km), as well as the network of navigable canals within the Hydro-system Danube-Tisa-Danube (HS DTD – 600 km). The total length of inland waterways in Serbia, at the average water level, is about 1680 km [17].

Regarding the annual transport volume and capacity, the most important ports are: Belgrade, Pančevo, Smederevo and Prahovo [17]. Most of the ports on inland waterways in the Republic of Serbia are connected with main railway lines and roads or are very close, which has strategic and logistic importance. Ports in Belgrade and Pančevo have container terminals, while the other ports offer various services and are mostly specialized for general and bulk cargo. The fleet on IWT in Serbia consists of about 450 vessels, with the available transport capacity of about 435,000 tons. This presents good opportunity for transportation of long and heavy components of wind turbines.

Strategy and incentives for wind energy exploitation in Serbia and AP Vojvodina

Serbia has adopted the following legal regulations, which is relevant for the renewable energy sources:
– law on energy,
– strategy of long-term energy development of Republic of Serbia until 2015,
– program of realization of the energy development strategy of Serbia from 2007-2012,
– decree on the definition of the status of privileged producer, and
– decree on incentives for producers who have the status of privileged producers (feed-in tariffs).

Law on energy is the basis of energy policy in Serbia that has been adopted in the in 2005 and changed in its new edition in 2011 [18]. It opened the possibility for de-monopolization of the energy sector, as well as intensive use of renewable energy.

The Strategy of long-term energy development of Republic of Serbia until 2015 [19], determines the basic objectives of the new energy policy, priority directions of development in the energy sector and approve the adoption of appropriate tools program, which allows the realization of the key priorities in the work, operations and development of the whole energy system (in the manufacturing and energy consumption) of Serbia.

The Program of realization of the energy development strategy of Serbia from 2007-2012 provides three goals that define the regulatory framework for greater use of RES, adoption and implementation of financial and nonfinancial measures and activities to encourage use of renewable energy [20]. It is estimated that the energy potential of renewable energy sources in Serbia amounted to over 3.83 million toe/year (toe – tones of oil equivalent). The share of wind energy is about 5% (0.19 million toe per year). In that context, some activities from the program are directly related to wind energy, as well as activities under the third objective: "Determining the real potential of wind energy", "Creating a database and cadastre RES", "The creation of experts in the field of renewable energy", and indirectly: "Work on harmonization of national legislation relating to the field of renewable energy with the EU", "Law on Agricultural Land", and "Regulation of privileged producers of electrical and thermal energy and biofuels". Finally, the program provides plans for the construction of the first wind farm in 2009 year capacity of 2 MW and then further building of 8 MW/year by 2012 year, totaling 26 MW. It was estimated that such new capacities would contribute to getting about 110 GWh/year representing around 0.17% of electricity consumption in 2012. Unfortunately, these plans have not been realized, yet.

The Decree on the definition of the status of privileged producer defines preconditions and procedures for obtaining the status of privileged produced of electrical energy. Furthermore it gives the model of privileged producer electric power purchase agreement, which is made between the Privileged producer and EPS Public Enterprise (Electric Power Industry of Serbia).

The Decree on incentives defines feed-in tariffs for different RES producers [21]. For wind energy the feed-in tariff is 9.5 Euro cents for each kWh of electrical output during 12 years. The total of wind power capacity in Serbia subject to such incentives is limited to 450 MW. Furthermore, the decree is valid until December 31st 2012.

For the territory of AP Vojvodina additional strategic document on implementation of Energy Development Strategy of the Republic of Serbia has been adopted [22]. As a document of great importance for efficient energy use and development planning in this area, this document is composed as a series of modules covering all energy sectors. This document provides an assessment of the potential AP Vojvodina in the field of energy, proposals in the program priorities of improving the energy sector and assesses of needed investment. Renewable energy is treated in module 13 in which all the important sources of renewable energy are discussed. For wind energy it is stated that there are good potentials. It is envisaged that by 2012 the production, primarily from wind power should reach 10% electricity consumption in AP Vojvodina, which is estimated at about 1,200 GWh per year. On the basis of this data, it is estimated that 600 MW of new capacities in wind farm should be planted. This was a huge task, considering that at that moment (end of 2008) there were no any installed MW of wind power. Such projections were in 2010 re-estimated and decreased to more realistic 300 MW to be realized by 2015. Still, in April 2012 there is not a single operating wind plant.

Grid connection possibilities and power system operation

Wind farms are connected to the transmission or distribution network, depending on their power level. For power capacity greater than 15 MW, wind farms are mainly connected to the transmission network, while below 15 MW they are connected to the distribution network. One of the possibilities for organization and connection of a wind farm is presented on fig. 13. As wind farms may have significant impact on power quality and stability of power systems, its activation and operation present a significant problem. In that sense, there are rules for the network connection of wind power system – grid code.

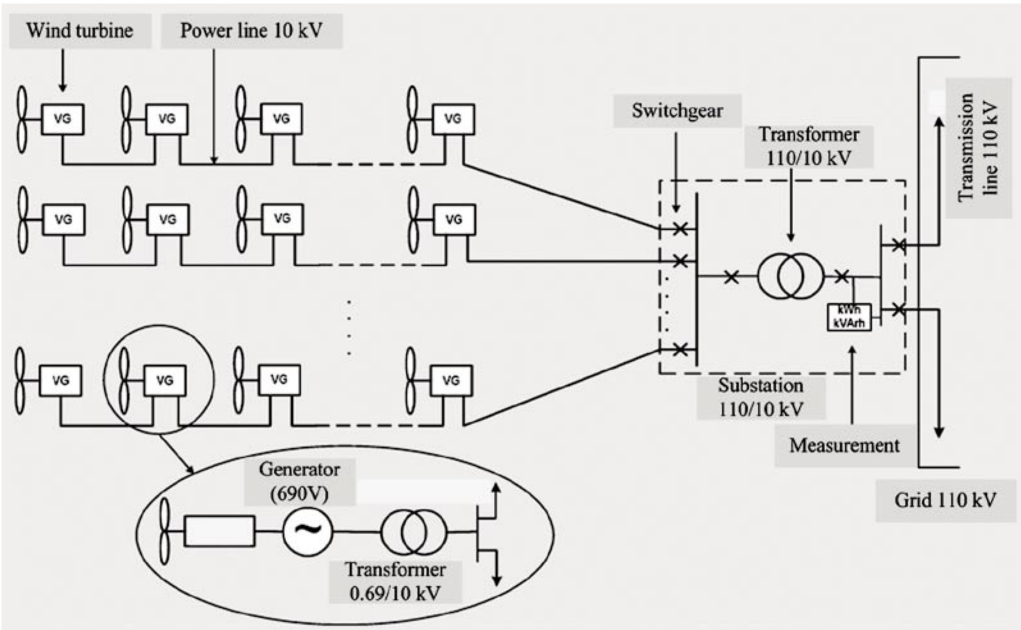

Figure 13. Connection of a wind farm to the public grid

Grid code, distribution code and wind code

Every power transmission system operates according with specific rules which define the obligations of present and future users in their work-on and connection-to the power network [23-27]. These requirements must be fulfilled by an electrical power producers, consumers connected to the power transmission network and the company that manage the network. These requirements are well known as the Grid Code.

Similar to the transmission network, distribution network determine the requirements when connecting their users (Distribution Code) [28]. Compared to the users connected to the transmission systems, users connected to the distribution network has a lower power and therefore have lower influence on the behavior of the system. Consequently, the Distribution Code requirements are usually much milder compared to the requirements of Grid Code.

The fact is that requirements of Grid and Distribution Code are constantly adapting according with technology development. This fully applies with the intensive using of wind energy conversion systems (WECS) in the last decade. This energy sources are developing very quickly and has many special features compared to the conventional power plants. Hence, in many countries the connection requirements for wind farms have a special treatment well known as the Wind Code [25].

Wind farms impact – main characteristic

The main disadvantage of WECS compared to the conventional energy sources is power production uncertainty as a consequence of frequent changes in wind speed [29]. Consequently, wind farms cannot easily meet all the requirements which high power synchronous generator fulfills. Some of examples of them are: accurate prediction of deliver energy, speed limit of power change, island work and commissioning without the support of the network (black start).

Also, different solutions of wind farms are characterized by different handling, both in steady state, and during the disturbances in the network. This largely determines how it affects the operation of the network. For example, wind turbine with squirrel cage induction generator directly connected to the network and with the limitations of the mechanical input (stall turbines) have the simplest design with no possibility to control the flow of active and reactive power in steady state and during the disturbances. During the voltage dips, induction generators additionally load the network with increased consumption of reactive power which could endanger network stability. On the other hand, wind turbines equipped with power electronic converters have much more opportunities and even the advantages compared to the conventional power plants. Their ability to quickly control the flow of active and reactive power can provide support to the operation of a network in such a way that they contribute to the regulation of frequency and voltage.

Grid code regulation – common requirements

Common requirements of almost all leading grid codes concerning wind farm connection include fault ride-through, active power regulation and frequency control, reactive power control and voltage regulation as well as power planning.

Fault ride-through

At the beginning of introduction of WECS in the power system, in case of network failure, protection-procedure for disconnects of wind farms from network was at voltage levels of 70% to 80% of nominal value [26]. Thus, the short-term disruption in the transmission system could lead to interruption of operation of wind farms over a very large area. The constant increase of wind energy share in the produced electrical energy requires that WECS must remain in operation even in the event of network disturbances. Otherwise, the loss of production from wind farms can endanger the stability of the whole network.

The grid codes issued during the last few years invariably demand that wind farms (especially those connected to HV grids) must withstand voltage dips to a certain percentage of the nominal voltage (in some cases down to 0%) and for a specified duration. Such requirements are well known as fault ride through (FRT) or low voltage ride through (LVRT). Characteristics are described by voltage vs. time characteristic, denoting the minimum required immunity of the WECS. The FRT requirements also include fast active and reactive power restoration to the pre-fault values, after the system voltage returns to normal operation levels. Some codes impose increasing of generation of reactive power by WECS during the network disturbance. In this way it is provided voltage support to the transmission system, a requirement that resembles the behavior of conventional synchronous generators in over-excited operation [30]. Figure 14 presents LVRT requirements of various grid codes.

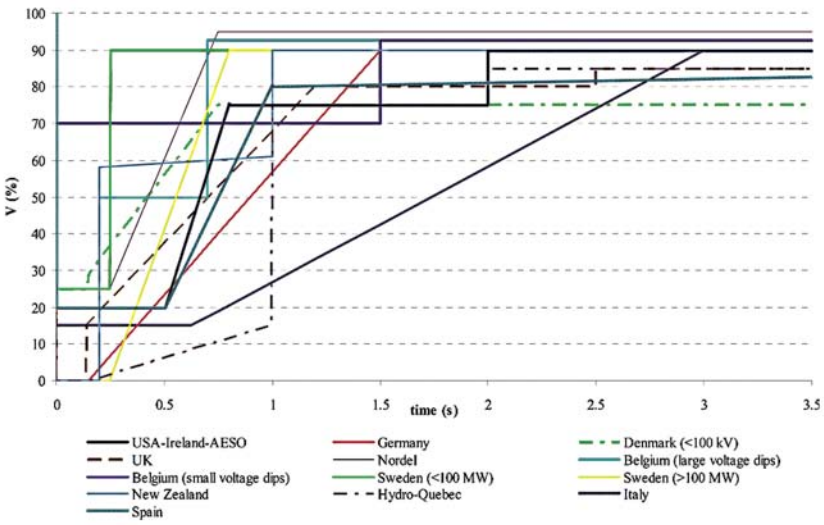

Figure 14. LVRT requirements of various grid codes

Active power and frequency control

In the power system, the frequency is an indicator of the balance or imbalance between production and consumption. For normal power system operation, the frequency has to be close to its nominal value. In the European power systems, the frequency most generally lies in the range 50 ± 0.1 Hz.

The network operator is obliged to maintain the frequency of the system according to the network policies. To avoid permanent frequency deviation outside the prescribed limits under the normal operation conditions, the generator has to have the ability to change output of active power.

At the point of common coupling (PCC), modern variable WECS are connected to the power grid through power electronics devices, which have the capability of providing a

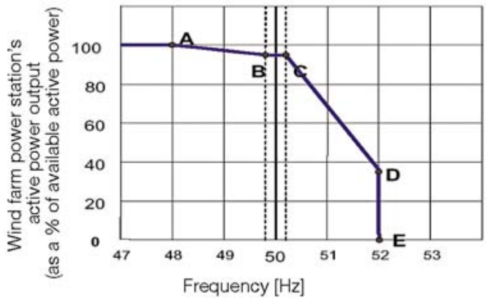

Figure 15. The requested change in wind farm output power in relation to frequency deviation

primary frequency response similar to that one of conventional generators [31]. Typical dependence of the modern wind farm output power and frequency is shown in fig. 15. The values of points A, B, C and D of this curve are adjustable.

When the frequency falls below the frequency defined with point B, wind farm control system should respond by increasing output power. When the frequency is increase above the value determined by point C, the production should be reduced to the C – D – E change. For frequencies above the D – E required output power is zero. At this point, the WECS may be disconnected from the network.

Reactive power control and voltage regulation

In order to preserve the voltage-quality of the transmission system with connected wind farms, their control system has to have ability of reactive power control. Since the influence of the reactive power injection to the voltage level is dependent on the network short-circuit capacity and impedance, the reactive power control requirements are related to the specific characteristics of each network. Figure 16 shows a comparison between some of the existing reactive power control ranges for normal operation of WECS (normal voltage domain) [32].

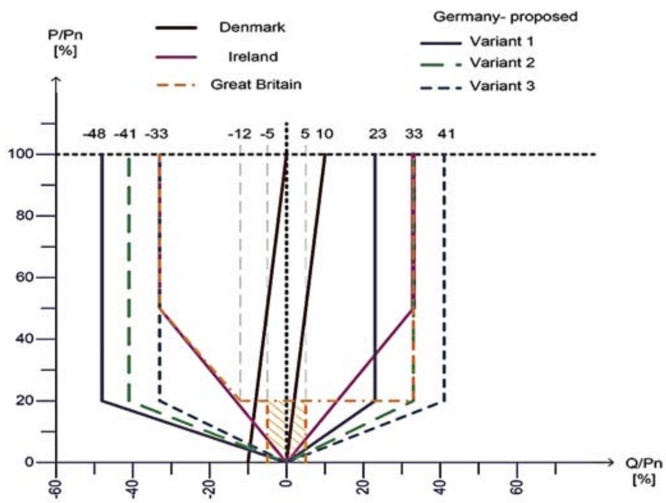

Figure 16. Reactive power control range for normal operation of WECS

Present situation and perspective for wind energy

In Serbia, and AP Vojvodina as well, at the moment, there is not a significant wind power plant that would generate electricity from wind energy. However, in previous period significant efforts have been made to investigate the possibility of exploitation of wind energy. To coordinate all activities Provincial Secretariat for Energy and Mineral Resources of AP Vojvodina has set the Council for RES – Wind Energy as a AP Vojvodina government's body to offer help and consultancy in the field of wind energy. Besides research studies, which task was to define wind energy potential in AP Vojvodina and Serbia (presented in chapter 2 of this paper), a number of companies have been established in order to set new installation for exploitation of wind energy. These companies, together with some state agencies, have initiated and performed long term wind-speed and other relevant parameters measurements on several locations all over the AP Vojvodina region. Figure 17 shows municipalities and location of wind parameters measurement (light squares) [33]. Results of measurements verified data from Wind Atlas of AP Vojvodina [14], *i. e.* proved that the best location for building of wind farms are in the south-eastern part of the Vojvodina (South-Banat District). Eleven locations have been selected for possible sites of wind farms, while five locations have been abounded. They are shown as dark squares in fig. 17 with indications of their names. For these locations a lot of planning, administrative, legal and other preparation work has been done. Energy licenses in amount of 1350 MW have been issued by the Energy Agency of Serbia, although only 450 MW are planned to be subsidized with feed-in tariffs. Six projects and locations are presented in tab. 2 as the most advanced and the most probable future installation of new wind farms.

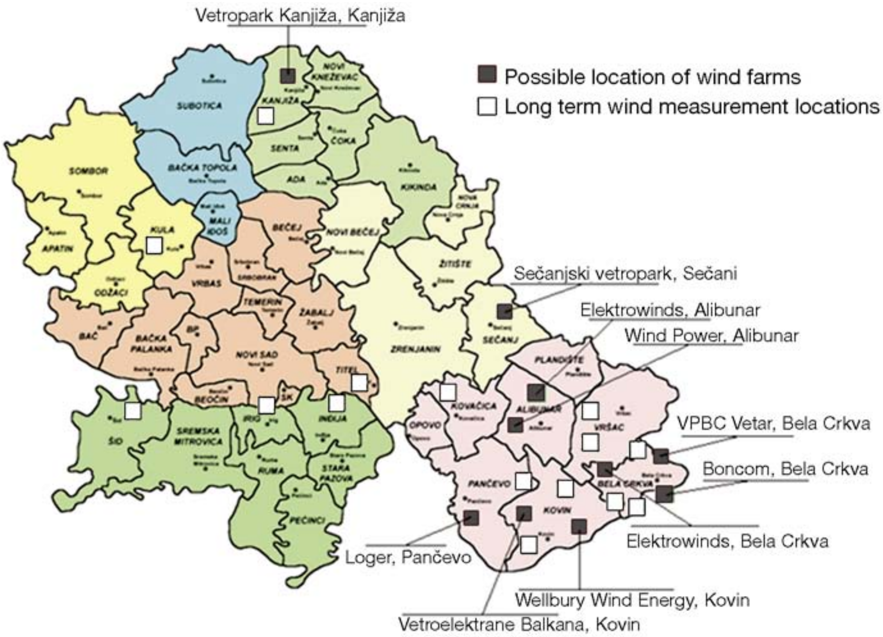

Figure 17. Long-term monitoring (light squares) and selected locations with name of wind farms (dark squares) [33]

Additional consideration is firm environment protection, *i. e.* special nature areas and protected zones are included into spatial planning of wind farm location. In this case a situation presented in fig. 18 is obtained. As it can be seen, some locations from fig. 17 overlap with areas suitable for construction, both from wind resource at the site, and from the aspect of environmental protection and built-in infrastructure (they are indicated with wind turbine symbols in fig. 18).

As an example, a construction plan of three wind farms, Bavaništansko polje, Bela Anta and Čibuk, in municipality Kovin (the southernmost site in fig. 18) is presented in fig. 19 [34]. It shows that they are all located in the area with good wind conditions. Problem may arise regarding grid stability, as they are all planned to be connected at the same point to the grid (TS Pancevo 2).

Another case is wind farm in the territory of Kanjiza municipality (the northernmost site in fig. 18), where besides lower available wind speeds, other problems may arise, as the site

Table 2. Wind farms close to realization

No.	Investing company	Name of wind farm	Power (MW)	**Municipality**
1	VPBC, Bela Crkva	Vračev Gaj	187,5	Bela Crkva
2	Welbury Wind Energy, Belgrade	Bavaništansko polje	188	Kovin
3	MK-Fintel Wind, Beograd	La Piccolina	5	Vršac
4	Windtim, Belgrade	Šušara	60	Vršac and Bela Crkva
5	Energovind, Vršac	Vršac-Alibunar-Plandište	400	Vršac, Alibunar, Plandište
6	Vetroelektrane Balkana, Belgrade	Čibuk	300	Kovin

overlap with migratory birds corridors. In future some more wind farm may be expected as nine energy licenses have been issued by the Energy Agency of Serbia. However, some more efforts need to be put in solving of problems of transporting the electricity output of these wind farms and for balancing a huge variation of input wind energy and therefore of output electrical one.

Conclusions

The paper presents current situation regarding wind energy in Serbia and AP Vojvodina. Although there are very good conditions for exploitation of this kind of renewable energy, results are still poor. There are several matured plans on 5-6 locations in Vojvodina, but construction have not started yet. Still, some preliminary preparation work have started in location near city of Plandiste, so some concrete results may be expected during or by the end of 2012.

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