ISSN 1407-7345 POWER AND ELECTRICAL ENGINEERING 2007-7345
ENERĢĒTIKA UN ELEKTROTEHNIKA

ENERGY SYSTEMS AND THE ENVIRONMENT
ENERGOSISTĒMAS UN VIDE

EVALUATION OF WIND ENERGY POTENTIAL IN LAND AND MARINE AREA OF LATVIA

SAUSZEMES UN JŪRAS TERITORIJAS VĒJA ENERĢIJAS POTENCIĀLA NOVĒRTĒJUMS LATVIJĀ

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Key words: wind power station, wind energy potential, offshore wind power installation

Introduction

An important argument for wind energy development is Latvia's involvement in global environmental policy regarding the use of renewable energy sources and the reduction of greenhouse gas emissions which create global commitment for the country.
In recent years more and more relevant role is given for research and construction of wind power stations (hereafter - WPS) in exclusive economic zone of the Republic of Latvia (hereafter - EEZ) and territorial sea of the Republic of Latvia (hereafter - TS) which is related with larger annual mean wind speed whereby will be produced more electric energy amount as well as existing limitations on land area.
Construction of wind power stations in EEZ and TS is a comparatively new and potential energy production sub-sector in Latvia, however legislation in force does not provide business opportunities as well as there is no applied research in this field.

Chosen method and results [1]

Before the evaluation and justification of explorative method used in this work, it is important to stress that during the development of this research it is not possible to use any method isolated from other research methods. There are various methods to estimate wind energy potential on land which are developed by world known scientists, for example, *Grubb and Mayer* (1993), *Fellows* (2000), *Sorensen* (1999) and Rogner (2000). Mainly all methods are based on calculations, which are made using computers.

Wind energy potential on land area of the Republic of Latvia

Further in this work are taken data from my master degree thesis and subsequent publications about it.
From the above mentioned thesis follows [1; 2]:

Assumptive physical geographical wind energy potential
Assumptive physical geographical wind energy potential in concrete district can be formulated as follows (1):

$$G_{p.i.} = S_i \cdot f_i \tag{1}$$

where:
$G_{p.i.}$ - the physical geographical potential in i district (km^2);
S_i - total land area in i district (km^2);
f_i - suitability factor for socio – geographical constraints in i district.

The f_i is calculated from the following expression as (2):

$$f_i = \frac{(S_i - S_{pils.i.}) \cdot a_i \cdot w_i \cdot b_i \cdot r_i}{S_i} \tag{2}$$

where:
$S_{pils.i.}$ - urban area in i district (km^2);
a_i - the binary weighting factor for altitude in i district;
b_i - the suitability factor for bio reserves in i district;
w_i - the suitability factor for land-use and land-cover function in i district;
r_i - the suitability for wind regime restrictions in i district.

Summing up acquired data we can conclude that the total physical geographical wind energy potential is available on 5670,5 km^2 or 8,9 % from total land area of Latvia (not including 7 biggest Latvia's cities).

Assumptive technical wind energy potential (according to annual mean wind speed and WPS power density location)
WPS power density location determines several factors, for example, necessary infrastructure, loses of permissible disturbances, available area and even visual constraints.
The mentioned potential type in this paper is viewed and calculated from two points:
1. From existing WPS power density location. In the various literature sources existing WPS power density location ranges from 17 MW/km^2 in California (USA) to 5 - 8 MW/km^2 in Europe WPS parks [1].
2. From existing WPS installed capacity ratio versus total country area.
In paper is calculated that the biggest WPS power density location on 1 km^2 is in Denmark – 0,073 MW/km^2 and in Germany – 0,058 MW/km^2. In Latvia it is 0,0004 MW/km^2. As we can observe from the first point that WPS power density location is nowhere near equal to installed WPS power density location in separate WPS parks. For example, Latvia will to achieve WPS power density location 0, 05 MW/km^2, than we need to install about 3370 MW.
The total maximal install capacity in land areas of Latvia, taking into account annual mean wind speed (> 4,0 m/s at 10 m high) by which WPS operate successful is substantially lower, because in 10 Latvia's districts annual mean wind speed is less than 4 m/s at 10 m height. The biggest potential is in the Kurzeme region in range from 133,6 MW to 10684,8 MW, but the smallest in the Zemgales region in range from 24,2 MW to 1936,8 MW.

Assumptive economical wind energy potential (according to annual mean wind speed and WPS power density location)

WPS starts work economically if wind speed is 5,1 m/s at 10 m height, wherewith is possible to identify districts in Latvia which comply with this indicator.

The total maximal install capacity on land area at wind speed 5,1 m/s at 10 m height is substantially lower than assumptive technical potential, because in 21 Latvia's region annual mean wind speed is less than 5,1 m/s at 10 m height. The biggest potential is in Kurzeme region in range from 55 MW to 4400 MW (it depends from WPS power density location), but the smallest in Vidzemes region in range from 3,5 MW to 280 MW. In Zemgales and Latgales regions are not assumptive economical wind energy potential at present.

Expected produced electrical energy volume according to possible economical potential is designated to use two different WPS - E 48 and E 82 from company *Enercon*. Firstly the produced electrical energy volume depends from WPS rotor height (70, 90 and 110 m) and secondly from WPS power density location (WPS nominal power 0,8 MW and 2 MW). The minimal expected produced electrical energy volume is 131 GWh, but the maximal – 10764 GWh.

Wind energy potential in exclusive economic zone of the Republic of Latvia and territorial sea of the Republic of Latvia

Assumptive physical geographical wind energy potential

According to legal acts marine area in which could be possible to install WPS and which would be in ownership of Latvia or its jurisdiction divide in: EEZ and TS.

2) Territorial sea

Total area of TS is:

$$S_{t.j.} = l_1 * l_2 = (498*12*1{,}852) - 330 = 10737 \text{ km}^2,$$

where:

l_1 – length of sea border, km; In compliance with Statistic yearbook of Latvia 2006 [Central Statistical Bureau of Latvia, Riga 2006], it compiles 498 km;

l_2 – width of territorial sea, km.

In compliance with legal acts width of territorial sea is 12 sea miles, if it's not defined otherwise in interstate treaties (1 sea mile = 1852 m).

2) Exclusive economic zone

Total area of EEZ is about 15300 km^2.Therefore total marine area is about 26000 km^2. Assumptive physical geographical potential is calculated from the following expression as:

$$G_p = S_{kop} - S_{d.t.} - S_{k.c.} - S_m - S_{n.k.} - S_a = 26000 - 6000 - (1640 - 300) -$$
$$-((3400 - 250) - (1170 - 570)) - 200 - 150 = 15760\ km^2$$

where:

S_{kop} - marine area, km^2;

$S_{d.t.}$ - protected area in sea, km^2;

$S_{k.c.}$ - ship way area, km^2;

S_m - military zone and chemical combat weapons area, km^2;

$S_{n.k.}$ - ship's wreck area, km^2; S_a - defence zone area, km^2.

Assumptive technical wind energy potential (according to annual mean wind speed and WPS power density location)

WPS power density location varies in large scale that depends from WPS nominal power and distance between them. WPS power density location determines several factors in common with land, for example, necessary infrastructure, loses of permissible disturbances, available area and even visual constraints.

In estimation is assumed that WPS power density location is 5 MW/km^2. Therefore according to assumptive physical geographical potential is estimated assumptive technical potential and it is $15760\ km^2 * 5\ MW / km^2 = 78800\ MW$.

Nowadays WPS from technical point of view can be installed in water at different depths: in shallow water (0-30 m) is used mono pile and cassion, in transitional depth (30-50 m) is used tripod and cassion, in deep water (>50 m) is used floating turbine concepts which are connected with continental shelf or seabed with anchors. At this moment economical valid is WPS which are installed in shallow water and transitional depth (in depth till 50 m).

Taking into account that currently WPS are installed in waters till 50 m than assumptive technical potential is 6400 MW. Possible marine areas are shown in table:

Table 1

Possible marine areas

The park	Area, km^2	Number of WPS	Nominal capacity of WPS, MW	Nominal capacity of the park, MW	Expected produced electrical energy volume, GWh	Tons CO_2/year
L1	20	20	5	100	307	110989
L2	25	25	5	125	383	138737
L3	20	20	5	100	307	110989
L4	200	200	5	1000	3066	1109892
L5	80	80	5	400	1226	443957
L6	200	200	5	1000	3066	1109892
L7	100	100	5	500	1533	554946
L8	50	50	5	250	765	277473
L9	85	85	5	425	1303	471704
L10	500	500	5	2500	7665	2774730
total	**1280**	**1280**	**5**	**6400**	**19622**	**7103309**

In Latvia's marine area wind speed measurements are not carried out, therefore real data are not available and it is necessary to do recalculation to use data from land meteorological stations. Using information from literature source N.3 we can see that wind speed at 8 m height is 5,5 – 7 m/s, which is acceptable from WPS working point of view. At the 66 m height wind speed is 8 - 9 m/s and at the 153 m height wind speed is 9,5 – 10 m/s.

Expected produced electrical energy volume according to assumptive economical potential is designated to use WPS - *5M* (nominal power 5 MW) from company *REpower*. The expected produced electrical energy volume is about 241 TWh. Expected produced electrical energy volume is about 19584 GWh, if look to water depth till 50 m.

Assumptive economical wind energy potential (according to annual mean wind speed and WPS power density location*)*

Considering that the annual mean wind speed is enough high, the assumptive economical potential is equal to the assumptive technical potential (according to annual mean wind speed and WPS power density location).
Therefore an electrical energy volume is equal as well.
The assumptive technical and economical potential which is calculated in this work is a maximal indicative estimation, in which are not included and treated substantial aspects whereby results are not defined as wind energy potential which is possible to get in reality:
1. it is not taken into account the connection to electrical grid;
2. it is not taken into account the balancing and energy storage possibilities.

Conclusions

Wind energy potential on land is very irregular, which is basically related to irregular location of forest, bog and water area.
Assumptive technical wind energy potential on land area is in range from 567 MW to 45364 MW, but assumptive economical wind energy potential on land is in range from 58 MW to 4680 MW.
Assumptive technical wind energy potential on marine area is 78800 MW, but assumptive economical wind energy potential on marine area is 78800 MW as well, from which 6400 MW are possible to install in water depth till 50 m.
In order to estimate and calculate more precise potential of wind energy it s necessary to take into account with existing political, legal, social opinion, economical, technical and detailed physical geographical aspects in the country, wherewith acquired results of the study can not considered as wind energy application potential.

References

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3. Stefan Sandström, Simulations of the Climatological Wind Field in the Baltic Sea Area Using a Mesoscale Higher-Order Closure Model, Journal of Applied Meteorology Article: pp. 1541–1552, Uppsala University, Sweden.

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Kašs R. **Sauszemes un jūras teritorijas vēja enerģijas potenciāla novērtējums Latvijā.**
Latvijas līdzdalība starptautiskajā vides politikā, kas skar atjaunojamo energoresursu izmantošanu un siltumnīcefekta gāzu emisiju samazināšanu un paredz valstij noteiktas starptautiskas saistības, ir svarīgs arguments vēja enerģētikas attīstībai. Vēja elektrostaciju būvniecība LR ekskluzīvajā ekonomiskajā zonā un LR teritoriālajā jūrā ir relatīvi jauna un potenciāla enerģētikas apakšnozare Latvijā, tomēr spēkā esošo normatīvo aktu bāze nenodrošina šāda komercdarbības veida uzsākšanu, un līdz šim nav veikti praktiskie pētījumi šajā jomā. Darbā ir

novērtēts vēja enerģijas iespējamais fizikāli ģeogrāfiskais, tehniskais un ekonomiskais potenciāls Latvijas sauszemes un jūras teritorijā. Vēja enerģijas izmantošanas iespēju novērtējuma un aprēķinu sagatavošanā izmantots autora izstrādātais maģistra darbs un jaunākā informācija šajā nozarē. Darbā izmantoto metodi un rezultātus iespējams izmantot vispārējai vēja elektrostaciju uzstādīšanas plānošanai un saražotās elektroenerģijas daudzuma aprēķināšanai. Lai novērtētu un aprēķinātu precīzāku vēja enerģijas potenciālu, ir jāņem vērā valstī esošie politiskie, juridiskie, sabiedrības viedokļa, ekonomiskie, tehniskie un konkrēti fizikāli ģeogrāfiskie aspekti, līdz ar to darbā iegūtos rezultātus nevar uzskatīt par vēja enerģijas pielietojamo potenciālu.

Kass R., Evaluation of wind energy potential in land and marine area of Latvia.
Important argument for wind energy development is Latvia's involvement in global environmental policy regarding the use of renewable energy sources and reduction of greenhouse gas emissions which create global commitment for the country. Construction of wind power stations in exclusive economic zone and territorial sea is a comparatively new and potential energy production sub - sector in Latvia, however legal acts which are in force do not provide business opportunities as well as there is no applied made research in this field. The main aim of the paper is to evaluate possible physical geographical, technical and economical potential of wind energy in land and marine area of Latvia. Data and information basically is provided author's master thesis and newest information in this field. The method and the results of the paper can be used for general planning of the wind power stations installation, as well as for calculation of electrical energy volume produced. In order to estimate and calculate more precise potential of wing energy is necessary to take into account with existing political, legal, social opinion, economical, technical and concrete physical geographical aspects in the country, wherewith acquired results of the study are not consider able as wind energy application potential.

Кашс Р., Оценка потенциала ветряной энергии на суше и морской территории в Латвии.
Важный аргумент для развитие энергии ветра - причастность Латвии в глобальной экологической политике отношению к использованию возобновляемых энергетических источников и сокращения антропогенных выбросов парниковых газов, что требует от государства выполнения определённых обязательств.. Строительство ветряных электростанций в экономической зоне ЛР и территориального моря ЛР относительно новый и потенциальный энергетический сектор в Латвии, однако действующее законодательство, не позволяет начинание подобного бизнеса и до настоящего времени не реализуются практические исследования в этой области. В работе проведена оценка возможного физико-географического, технического и экономического потенциала использования ветряной энергии в Латвии (на суше и морской территории). Для достижения цели работы был проведён анализ тематической литературы и использован метод с несколькими предположениями. Метод, применяемый в исследовании, и результаты работы могут быть использованы как для расширения уже существующих знаний, так и для детального планирования электростанций ветра или для расчётов полученного количества энергии.