Estimation of the Wind Power Plants Capacity to be Integrated in Actual Power System of Moldova

Mihai Tîrşu, Dmitrii Zaiţev, Irina Golub, Lev Calinin
Institute of Power Engineering of Academy of Sciences of Moldova
Chisinau, Moldova
tirsu.mihai@gmail.com

George Cristian Lazaroiu
Polytechnic University of Bucharest
Bucharest, Romania
clazaroiu@yahoo.com

***Abstract*— Extension of share of renewable energy sources in energy mix is a big challenge for our community. First of all we should fight against global warming by cutting emissions of GHG. Secondly we should increase energy security and reduce energy poverty. The Republic of Moldova is highly dependent on energy import (about of 90%). One of ways to reduce its energy dependence is to increase share of renewable energy. The paper addresses only electricity issue. Currently Moldova imports over 80% of its electricity consumption. On the over hand electricity produced from renewable energy sources is lower than 1% target being 10% to 2020.**

The paper present results on estimation of wind turbines capacity that can be integrated in actual electrical system without doing any reconfiguration of electrical system. The study is based on analysis of power transformer stations working on 110kV, 35kV, 10kV and 6kV. Over 350 consumption nodes through all country territory were analyzed per total. The potential of wind turbines was estimated for two heights – 50m and 100m. Results can serve as useful information for both investors and TSO/DSO.

Keywords – wind turbines; RES, power system, transformer stations, electricity.

I. INTRODUCTION

The Republic of Moldova, like many other countries, is highly dependent on electricity import. Today, Moldova electricity consumption is over 4 billion kWh from which 80% is from import. During last 5-10 years load consumption of Moldova for both winter and summer periods is respectively 850MW and 470MW. In 2010 Moldova became member of Energy Community and has to implement well established targets. One of them is to reach 20% of renewable energy in total consumption by 2020. The specific target for electricity Moldova agreed to implement by 2020 – 10% from RES. Currently electricity produced from RES is less than 1% due to different issues that we will not raise in this paper. The mentioned target can be reached using mainly three sources: biomass, solar energy and wind energy. We will address here only wind energy. The specific cost of electricity produced form RES can be different and depending on necessity to construct or not transformer stations and transport lines.

The purpose of paper is to estimate how many electricity produced by wind turbines mounted on heights 50m and 100m can be integrated in power system using existing transformer stations.

II. ESTIMATION OF TRANSFORMER STATIONS CAPACITY

In order to have whole picture of Moldova power system the distribution system and transformer stations analysis was done. The map of power system divided in 5 regions is shown on Fig.1.

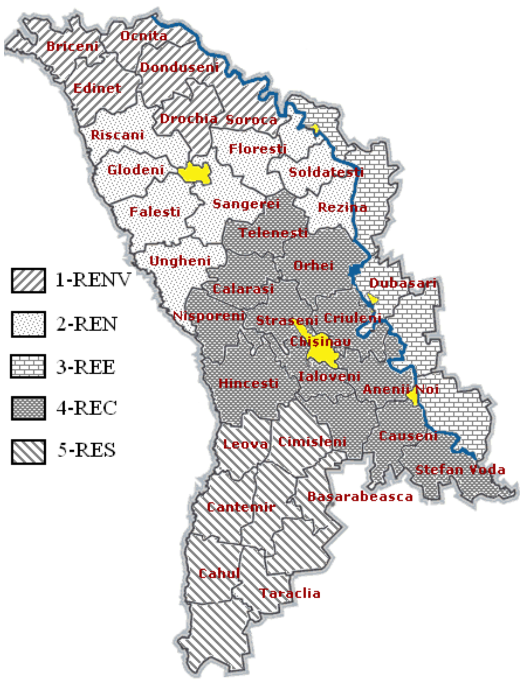

Fig.1. Moldova power system map divided in 5 regions

From fig.1 it can be seen that power system was divided in 5 regions:

RENV – North-Vest Electricity Network;
REN- North Electricity Network;
REE – East Electricity Network;
REC – Central Electricity Network;
RES – South Electricity Network;

The Transnistria is included here as well, but we will only estimate wind capacity for this region and not use in the following analysis.

The database which includes a lot of power system parameters was elaborated. Main parameters included in database are next: number of transformer station, placement (locality), nominal active and reactive power for both winter and summer periods, installed power of transformers, output voltage (110kV, 35kV,10kV or 6kV), height upon sea level, coordinates etc.

The installed capacity of transformers as well consumption load are presented in Table I.

TABLE I. MAIN PARAMETERS OF POWER SYSTEM TRANSFORMER STATIONS

			winter		summer	
№	Name	Installed power of transformers	$P_{н}$	$Q_{н}$	$P_{н}$	$Q_{н}$
		MW	MW	MVAr	MW	MVAr
1	RENV	439.2	61.5	19.1	21.5	17.8
2	RENV	1285	119.4	35.4	87.4	44.9
3	REE	1893.1	172.8	27.1	157.7	30.4
4	REC	2598.2	434.9	191.4	175	149.2
5	RES	575.7	68.1	23.3	26.9	19.2
	Total	**6791.2**	**856.7**	**296.3**	**468.5**	**261.5**

Analysis of data presented in table 1 shows that installed power of transformers is much higher than existing load. The transformers oversize results in additional energy losses. This is due to fact that industry doesn't work or is very small compare to 1990.

So, currently rated capacity of transformers is 6791 MW, including Transnistria and consumption load is 857 MW in winter period and 469MW in summer period.

III. ESTIMATION OF WIND TURBINES CAPACITY

The estimation of wind turbines capacity that can be integrated in actual power system without its refurbishment was done based on some criteria:

1. *Height of wind turbine.* It was selected two heights: 50m and 100m. For these heights were estimated rated capacities of wind turbines based on [1].

$$P = 0,5 \cdot \rho \cdot A \cdot C_p \cdot V^3 \cdot N_g \cdot N_b , \qquad (1)$$

where

ρ – air density;

A – rotor step area;

C_p - coefficient of performance;

V – wind velocity;

N_g - generator efficiency;

N_b - gear box bearing efficiency.

The air density was estimated for all consumption nodes using data provided by wind atlas [2].

The rotor step area was calculated using rotor diameter equal to height of tower.

The performance coefficient was selected equal to 0.35.

The average wind speed was taken from wind atlas for coordinates of each node.

The generator efficiency was selected equal to 0.8.

The gear box bearing efficiency was selected to 0.95.

2. *Number of wind turbines.* For each consumption nodes was estimated maximal number of wind installations possible to be integrated as rated power of transformer divided to power of wind turbine.
3. *The feeder length.* It was analysed two options: feeder of 5km length and feeder of 2.5km length. For both options was considered that area designated to placement of wind turbines is equal to area of circumference with diameter equal to feeder length.
4. *Density of wind turbines.* The distance between wind turbines was considered equal to 8 diameters of wind rotor [3]. The maximal number of wind turbines in definite area can be placed if we use arrangement as in fig.2.

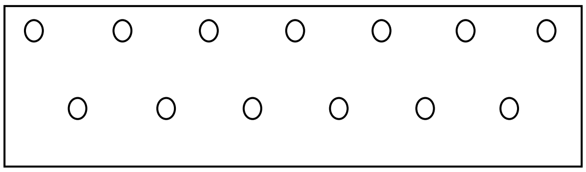

Fig.2. The placement of wind turbines

5. *Available space*. The transformer stations that are placed in cities were excluded from analysis.

The obtained results for height 100m are presented in table II.

TABLE II. THE NUMBER OF WIND INSTALLATIONS THAT CAN BE INTEGRATED IN POWER SYSTEM AT HEIGHT 100M

Name	Height 100m					
	Rated power, MW	Need area, km²	Wind turbines on 19.63km², units	Total capacity of wind turbines, MW	Wind turbines on 4.9km², units	Total capacity of wind turbines, MW
RENV	426.6	1764.61	549	130.31	137	32.53
RENV	603	2463.79	829	213.24	209	53.66
REE	1105	3983.24	997	272.10	254	69.36
REC	1541	5413.45	1425	401.73	359	101.09
RES	576	2654.72	788	178.01	199	45.29
Total	**4252**	**16280**	**4589**	**1195**	**1158**	**302**

The fig.3 shows distribution of wind turbines capacity by regions that can be integrated in power system for three cases: total available capacity of power system (FP), capacity that can be integrated than feeder length is 2.5km (P_2.5km) and capacity that can be integrated than feeder length is 5km (P_5km).

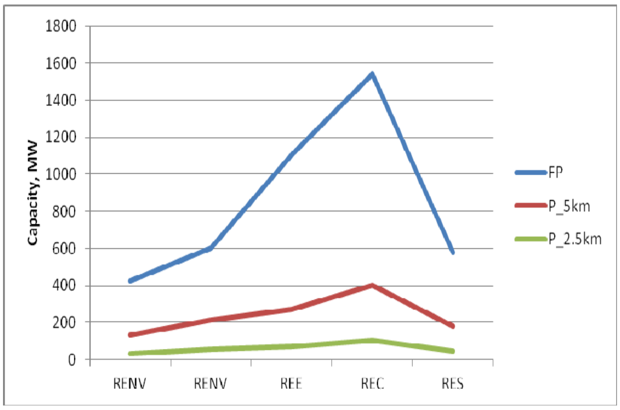

Fig.3. Capacity of wind turbines that can be integrated in each region

So, from Fig.3 it can be seen that maximal available capacity is in Central distribution network (REC), and in conditions of applied restrictions the higher capacity has also Central distribution networks (REC). On the other hand the capacity of wind turbines that can be integrated in power system is much lower than available rated capacity of transformer stations. Individually for some consumption nodes the available space is higher than imposed by restriction, but in most cases it is necessary very huge area due to relatively low wind speed. The wind turbines that can be installed in conditions of Moldova are class 3 or 4 (see Table III) [4].

TABLE III. CLASSES OF WIND TURBINES.

Class	Average Air Speed (min) m/s	Average Air Speed (max) m/s
1	0	5.6
2	5.6	6.4
3	6.4	7
4	7	7.5
5	7.5	8
6	8	8.8
7	8.8	11.9

The minimal wind speed in points of consumption nodes is 4.9 m/s and maximal speed is 7.2 m/s.

In the Table IV are presented results for height 50m.

TABLE IV. THE NUMBER OF WIND INSTALLATIONS THAT CAN BE INTEGRATED IN POWER SYSTEM AT HEIGHT 50M

Name	Height 50m					
	Rated power, MW	Need area, km²	Wind turbines on 19.63km², units	Total capacity of wind turbines, MW	Wind turbines on 4.9km², units	Total capacity of wind turbines, MW
RENV	439	1721	2106	121	526	30
RENV	1263	2492	3660	245	926	62
REE	1803	4677	1622	93	405	23
REC	2433	4625	5284	385	1348	99
RES	569	2468	3153	186	806	48
Total	**6508**	**15984**	**15826**	**1030**	**4012**	**262**

The fig.4 shows the comparison between capacities of wind turbines for heights 100m and 50m.

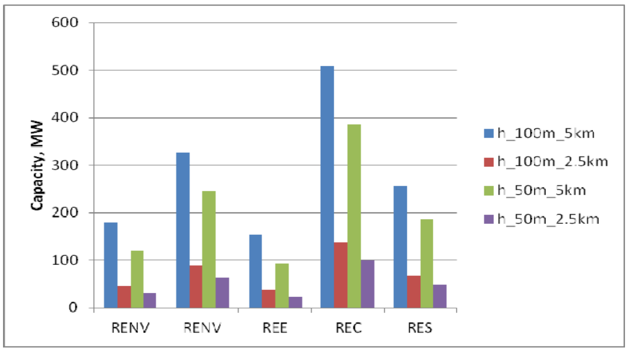

Fig.4. Rated capacity wind turbines for heights of 100m and 50m for two lengths of feeder: 5km and 2.5km

The results analysis shows that the total capacity of wind turbines installed at height 100m is about 30% higher capacity at 50m but number of wind installations differ three times.

Total capacity of wind turbines what can be integrated in power system without refurbishment is about 302MW at height 100m and 219MW at height 50m if the feeder length is 2.5km. For the feeder length of 5km the total capacity of wind turbines integrated at 100m will be 1158MW and at height 50m will be 868MW.

The total capacities of wind turbines will decrease if do not considering REE region (Transnistria). On the fig.5 it is shown total capacity of power system and wind turbines capacity for both 100m and 50m.

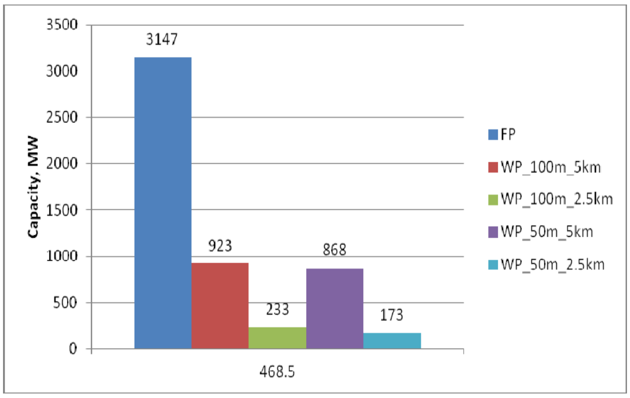

Fig.5. The capacity of wind turbines for both height: 100m and 50m for two feeders length.

The data presented on Fig.5 shows that currently power system of Moldova without Transnistria can accept integration of about 3174MW wind installations if do not take in consideration issues related to system stability. If apply restrictions that length of feeder is not more of 5km than it can be integrated about 923MW at height of100m and 868MW at height of 50m. Respectively, if the length of feeder is 2.5km than capacity of wind turbines possible to integrate in power system at height 100m will be 233MW and 173MW at height 50m.

IV. Conclusions

The paper results shows clear that Moldova has enough wind potential to ensure electricity supply of consumers. Total capacity of wind installations that can be integrated in power system without its refurbishment and excluding transformer stations from cities is estimated at 4252MW, including Transnistria with about 1105MW. It should be mentioned that issues connected to system stability due to intermittent character was not considered here.

The capacity of wind installations possible to be integrated in power system applying some restrictions, including feeder length of 5km at height 100m is estimated to be 923MW and respectively 868MW at height 50m.

If the feeder length is limited to 2.5km than wind turbines capacity at height 100m will be 233MW and respectively 173MW at height 50m.

The estimated capacity of wind turbines at height 100m is higher than both winter and summer loads.

V. Acknowledgement

The results were obtained in frame of project 16.80013.5807.12/Ro financed by HCSTD (CSSDT) of Academy of Sciences of Moldova and in frame of project 37BMPNIII-P3- 199/02.09.2016 financed by Romanian National Authority for Scientific Research and Innovation, CCCDI – UEFISCDI.

VI. References

[1] http://www.ajdesigner.com/phpwindpower/wind_generator_power.php

[2] http://moldova.awstruepower.com/

[3] http://vetrogeneratorsvoimirukami.ru/montaj.html

[4] http://windpower.generatorguide.net/wind-speed-power.html