Resources adequacy – Analysis of renewable generation variability

Ing. Michaela Lachmanová,
Faculty of Electrical Engineering, Czech Technical University, Department of Economics, Management and Humanities,
michaela.lachmanova@fel.cvut.cz

Overview

The enormous increase in the integration of renewables (RES) into the energy system with the system of subsidies (in particular the guaranteed purchase price, ie. Feed-in tariff) had serious consequences in the energy markets and the operation of the electrical system. The current way of supporting renewable energy sources and market mechanisms caused a surge supported sources, a significant change in the mix (conventional plants and operationally expensive resource are pushed out – called merit order effect) and last but not least, a significant increase in electricity prices for end users.

One of very important terms related to RES integration is Resources (generation) adequacy. Generation adequacy is the ability of the sources in the power system to match the load on the power system at all times. Developing this definition more broadly and focusing on generation side, we can consider this definition as a looking for the optimal structure of sources for electricity generation considering all economic, environmental and technical aspects of all types of sources. Importance of generation adequacy analysis increases with wide RES development. Unpredictable variability of renewable production dependent on natural conditions requires adequate sources to cover so called residual load. This electricity generation should be reliable and as much as possible cost effective.

This paper aims to analyse short-term variability of renewable generation. The results are used to state characteristics of backup sources needed to provide stable and secure electricity supply. These characteristics can be used to establish optimal economic environment for achieving of an optimal structure of sources from technical-economic point of view.

Methods

The Czech Republic has installed capacity of 21 989,0 MW with 83 301,9 GWh generation in 2016 [1]. Renewables has the share of 13% on final consumption of energy. The most significant problems are with short term variability of sources.

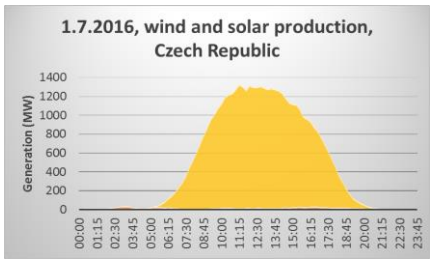
We analysed a dataset production of whole renewables throughout Czech Republic (aggregated) [2]. We focused on intermittent sources, 15 min production of wind sources and also of photovoltaic. We provided, as a beginning of the research, statistical analysis to provide basic characteristics of renewable production in the Czech Republic. So we focused on mean, median, 95% confidence interval, standard deviation.

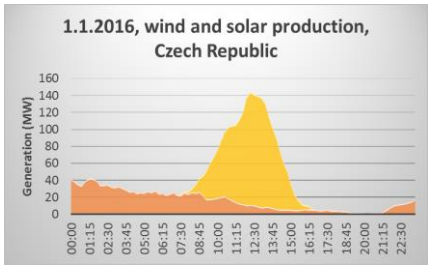
Then we focused on very important characteristic of renewable production – capacity factor, calculated as a generation divided by installed capacity (and plotted in time) [3],[4].

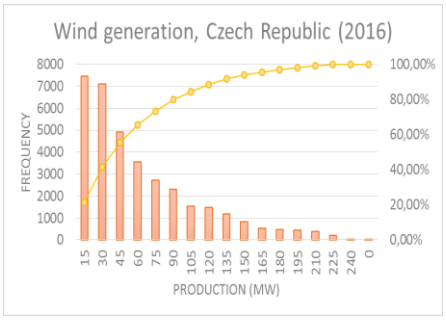
Main aim of this paper lies in analysis of 15 min gradients, which provides probability of 15 min changes in RES generation. This results can be used to obtain characteristics of short-term variability, mainly used to grid management.

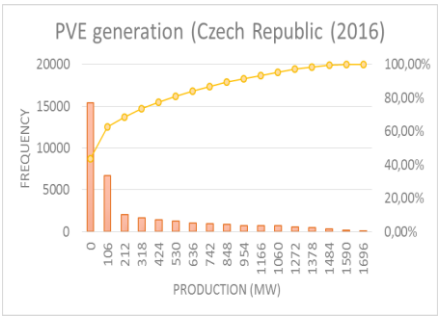
Results

The data are plotted in following charts.









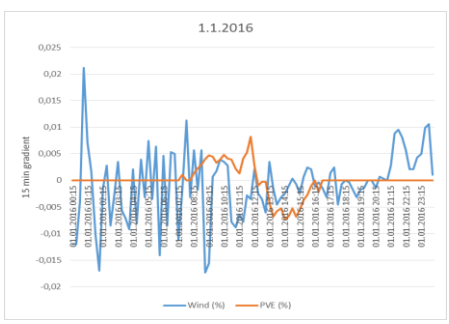
	Wind generation	PVE generation
Minimum	0,000	0,000
Maximum	0,839	0,829
Mean	**0,163**	**0,76**
Standard deviation	0,171	0,187
95% confidence interval top	0,000	0,000
95% confidence interval bottom	0,474	0,425

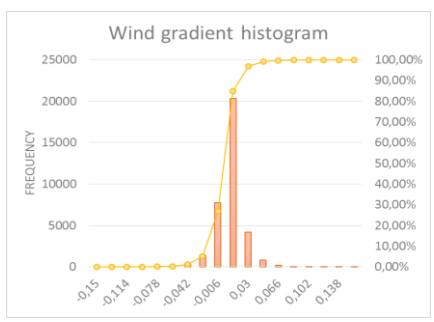
Fig. 1-4., Tab 1. Characteristics of renewable generation of Czech Republic [2]

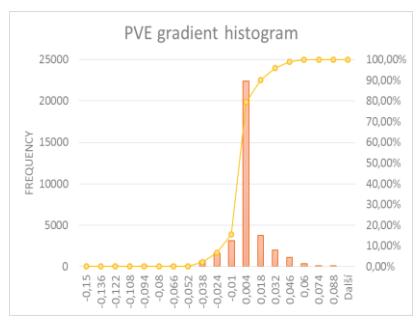
On Fig.1-4 we can observe basic characteristics of renewable production in the Czech Republic. Two days from the befinning of the year 2016 and the beginning of the summer are plotted in first two charts. We can see, that wind production is very low on the beginning of the summer and solar generation is much more weak in the beginning of the year of 2016. Also we can see on the next two probability charts, that in the case of wind generation 80% of generation is under one third of installed capacity. Also PVE generation is producing ih n 80% of time under one sixth of installed capacity. Last table shows us capacity factor, provided by mean generation (line 3). We can see, that capacity factor of wind generation is 17% and 7,6% for PVE production. Also we can conclude, that with 95% confidence both type of sources are providing less than 47% (wind) and 42% (PVE).

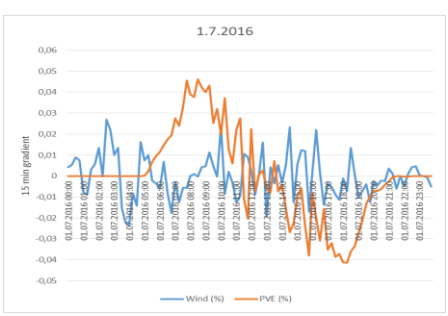
More interesting results come from 15 min gradient analysis. These gradients were calculated as a 15 min changes in generation.

The results are plotted in the following charts.









	Wind generation	PVE generation
Minimum	-0,148	-0,130
Maximum	0,140	0,087
Mean	0,000	0,000
Standard deviation	0,015	0,015
95% confidence interval top	-0,025	-0,025
95% confidence interval bottom	0,025	0,025

Fig. 5-8, Tab2. Characteristics of 15 min gradients [2]

As we can see, 15 min gradients are not so high, wind generation fluctuates between 15% of installed capacity up and down, and PVE generation 13% down and 8,7% up. Also with 95% probability, renewable generation will not

fluctuate more than 2,5%. Following table shows the probabilities of fluctuation of RES generation. We can see, that with 65% probability (wind) and 69% probability (PVE) the generation will not change more than 1%.

Probability of fluctuation			
Range		Wind	PVE
-1%	1%	64,39%	69,02%
-5%	5%	98,76%	99,27%
-10%	-10%	99,94%	99,99%

Tab 3. Probability of fluctuation of RES sources.

Conclusions

This paper deals with first analysis of whole production of RES in the Czech Republic. Maximum generation of wind is 83% of installed capacity and 82,9% of installed capacity of PVE. Capacity factor is very low – 7,6% PVE, 16% wind.

After first observation of dataset we focused on hourly gradients analysis. Hourly (15 min) gradients vary up to 15% up and down for wind generation and between -8% and 13% for PVE generation. That we can conclude, that hourly variability is high, but hourly gradient is not as high.

In the following research we would like to focus on detailed analysis of this dataset, which will be used for model of RES development and for dimensioning of backup sources, using also demand response.

References

[1] Roční zpráva o provozu ES ČR 2016. ERÚ (Czech Regulatory Office) [online]. Praha, 2017 [cit. 2017-06-17]. Dostupné z: https://www.eru.cz/documents/10540/462820/Rocni_zprava_provoz_ES_2016.pdf/800e5a09-a58a-4a73-913f-abc30cda42a5

[2] ČEPS, a.s. (Czech TSO) [online]. Praha [cit. 2017-06-17]. Dostupné z: http://www.ceps.cz/CZE/Data/Vsechna-data/Stranky/Default.aspx

[3] CIPRA, Tomáš. Finanční ekonometrie. (Financial Econometry)1. Print Ekopress: , 2008, 538 s. ISBN 978-80-86929-43-9.

[4] RNDr. KATEŘINA HELISOVÁ, PH.D. ČVUT, FEL. Mathematics for Economy: Materials for the course [online]. 2011-11-07 [cit. 2017-06-20]. Available from: <http://math.feld.cvut.cz/helisova/01MPE zapisky.pdf>