Centrum Rzeczoznawstwa Budowlanego

Open Access Journal
Modern Engineering 1 (2020) 1-5
journal homepage: http://mengineering.eu

Electric vehicles as the best energy storage solution for unpredictable household renewable energy sources

Viachaslau CHARVINSKI * [1] and Helene KOSTUKEVICH[2]

[1]Belarusian National Technical University, Belarus
[2]Institute of Integrated forms of education and monitoring, Belarusian National Technical University, Belarus

Keywords: renewable energy sources, vehicle to home (V2H), charging, household demand profile, energy storage

Summary. One of the main problems of renewable energy source - RES (such as wind or sun) is their unpredictability. Cooperation of such sources with energy storage has a very positive effect on the correct use of renewable sources. One of the ideas for home energy is storage of energy in the batteries of electric vehicles engines (V2H). The purpose of this work is to analyze electricity losses and power system performance depending on the shape of the load schedule. The work includes identifying the dependence of the required degree of load balancing on the shape factor of the load curve, heating factor and energy losses. In anailed cases, it was shown that the best solution for a single-family house with a passenger car used for everyday needs would be a wind turbine with a diameter of 6 [m]. The battery capacity that would have to work with this system was estimated at 542 [Ah].

1 Introduction

The production of electricity from renewable energy sources (RES) and the process of its consumption almost always disagree in time [1, 5, 6]. The correct combination of these processes for autonomous energy consumption systems depends on the possibility of wind and solar energy accumulation or the ability to adapt energy consumption for its production in renewable energy systems. In order for all system components to be well selected at the project level, a user energy consumption schedule should be created in addition to the anticipated production schedule. For individual users (e.g. single-family homes), this schedule is almost always irregular. For both autonomous (off-grid) and central energy consumption, the irregular energy consumption schedule reduces the energy efficiency of electricity generation and transport. Electrical equipment of the power system operates in a different mode than the nominal one. This problem has been widespread since the beginning of the existence of power networks, it is the cause of increased energy losses in electrical networks [9, 10]. It is also worth noting that the amount of losses increases with the level of irregularity of consumption [2, 8, 11].

2 Methodology

To smoothing the schedule of the electric load of the consumer is the use of energy storage devices [7]. This is typical for both large enterprises and small households. Here it is necessary to develop the concept of matching the storage capacity for renewable energy of a certain installed capacity to power the irregular load of the consumer. The main idea of such concept consists in the maximum smoothing by the accumulator of the schedule of unbalance of electric power in the resulting mismatch of the generated electric power by RES sources and the power consumed by the load. The accumulator may be an electric vehicle battery [12].

One of such problematic RES is the wind power device. The energy received from the wind turbine, by definition, is uneven. It is proportional to the cube of the wind speed.

For calculation there was used MATLAB software. A program in MATLAB [3, 4] was created for the rapid calculation of the energy generated by the wind turbine and remaining available for accumulation after energy consumption by the house. An electric vehicle may be one of the consumers of surplus electricity. The diameter of the wind turbine

*Corresponding author: E-mail address: chervinskey@mail.ru (Viachaslau CHARVINSKI)

Received 11 January 2020
Available online 15 March 2020
ISSN 2450-5501
Published by Centrum Rzeczoznawstwa Budowlanego

blades was set as a parameter for this program. The speed of the wind flow varies randomly during the day. The program graphically displays the zones of excess and insufficient energy. The load of the house was set according to the actual schedule of the electric load in Fig.1, based on the approximate composition of consumers at home and the schedule of their commutation.

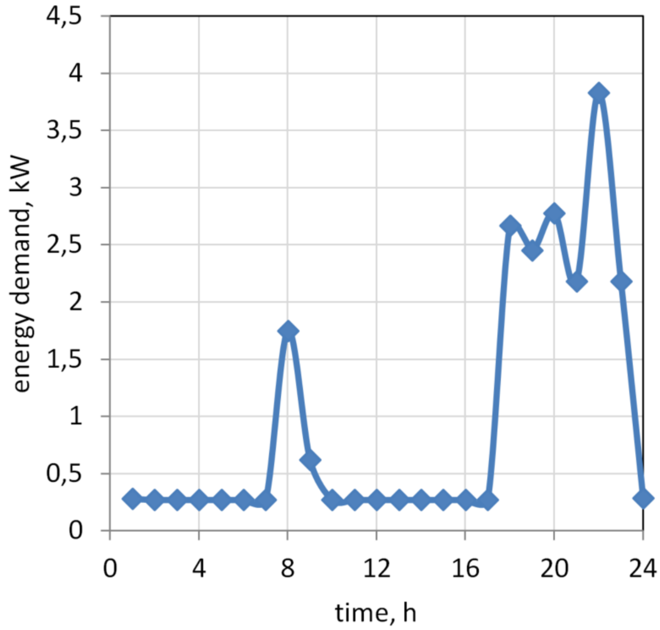

Figure 1. Daily load used for the calculation

The composition of consumers of electric energy is as follows: incandescent and led lamps, refrigerator, freezer, iron, TVs, computers, washing machines, coffee machine, microwave, vacuum cleaner, phone chargers, food processor, grinder, drill, etc. The installed capacity of all devices was 16.03 kW, and the average daily consumption of electric energy is equal to 24.8 [kWh].

The calculation results for the radius of the blade L=1 [m] are shown in Fig. 2. According to the program assumption, the daily energy demand of the house is 24.85 kWh. The daily energy generation from the wind turbine is 3.16 kWh. Energy stored in the accumulator is 0.12 kWh. It can be seen that in this case, the daily energy to charge the drive is insignificant compared to the daily energy demand by the house. So it is necessary to increase the energy received from the wind turbine.

In the figure 3 there are shown results for blades diameter equal to 4 [m] (radius L=2 [m]). The daily energy consumed by the house is the same – 24.85 kWh, the daily energy generated from the wind turbine respectively increased into 11.2 kWh. The energy for the storage unit also increased into 3.41 kWh. In order to accumulate such energy storage capacity of batteries (with a voltage of 12 V) in Ampere-hours, will be:

$S = 3.41 \cdot 1000 \cdot 1.3/12 = 369$ [Ah]

where, the factor 1.3 was introduced to take into account the need for a maximum battery discharge level of up to 30%. In case of full discharge, its service life will be significantly reduced.

Next step of calculation is diameter of the wind turbine equal to 6 [m] (blade radius: L=3 [m]). Calculation results are shown in Fig. 4. The calculated daily energy consumed by the house remained the same – 24.85 kWh, the daily energy from the wind turbine respectively increased into 15.95 kWh, the energy for the storage unit also increased into 5.0 kWh. In order to accumulate such amount of energy the capacity of batteries in Ampere-hours, will be:

$S = 5.00 \cdot 1000 \cdot 1.3/12 = 542$ [Ah]

It is obvious that the use of wind turbines with blades of 3 [m] length is more preferable to meet the energy requirements of the house than with blades of shorter length. Accordingly, for such blades, an appropriate wind generator and appropriate energy storage are designed or purchased. The application of this program allowed to calculate for the known power consumption schedule of the consumer with a daily energy consumption of 24.85 kWh, the proper radius of the wind wheel equal to 3 [m] and the storage unit capacity of 542 [Ah].

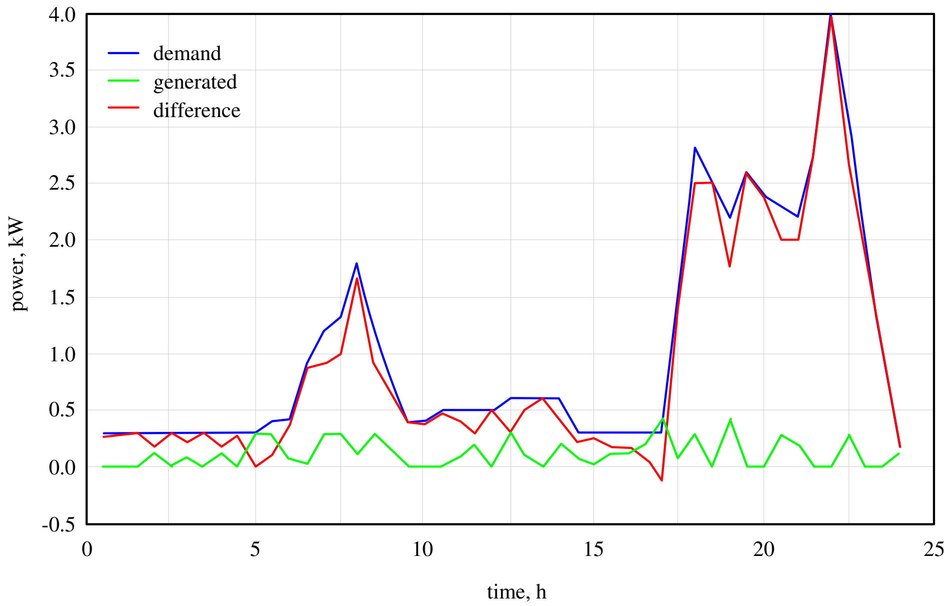

Figure 2. Results obtained for blade length L=1 [m]

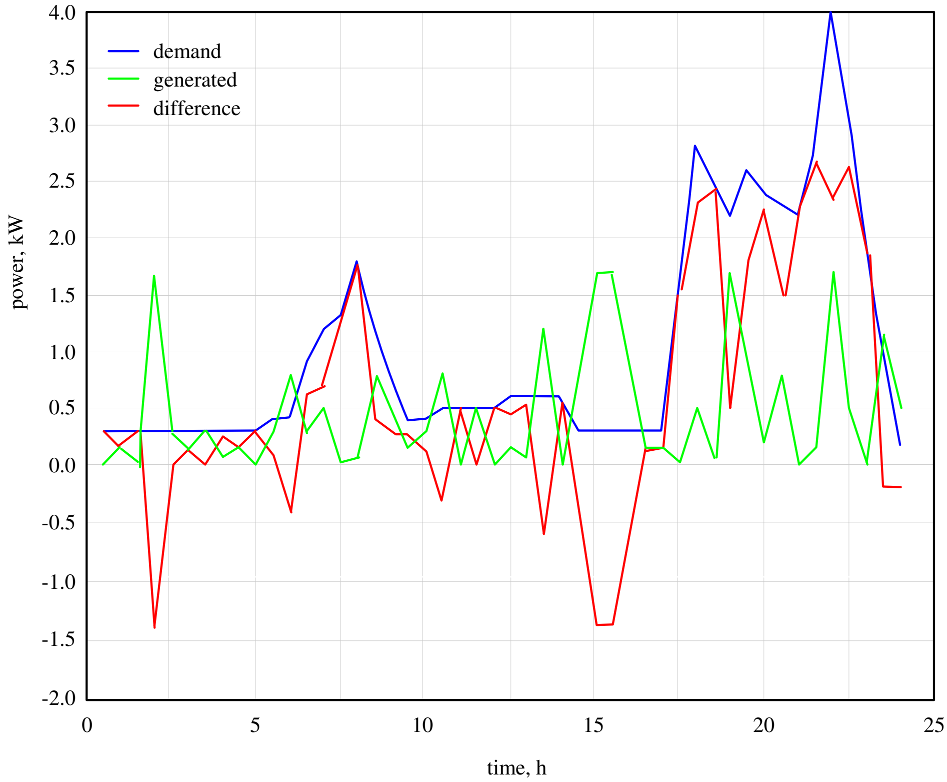

Figure 3. Results obtained for blade length L=2 [m]

3 Conclusion

The research work presents an algorithm for using an electric car (V2H) as a reservoir of electricity produced by a home wind turbine. MATLAB software was used for calculations. The analysis was carried out for three different sizes of wind turbines (blade length: 1, 2 and 3 m). The analysis was made in terms of the known energy consumption characteristics of the car user, as well as the building's total electricity demand. Wind intensity was adopted for the conditions occurring in Belarus. The analysis showed that for longer wings it is possible to better cover the

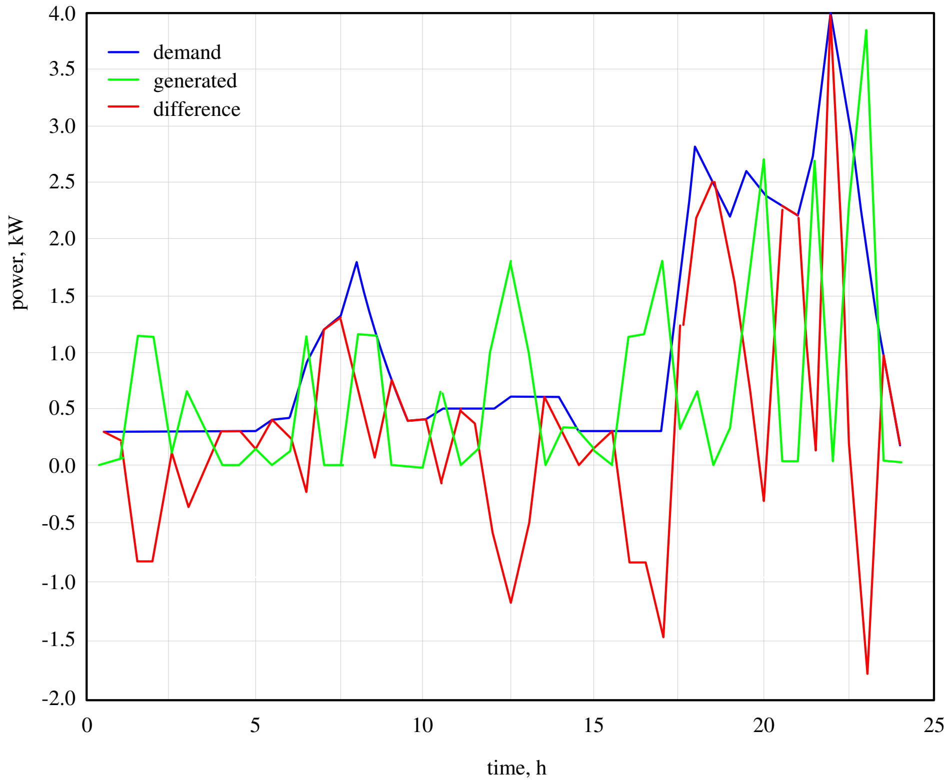

Figure 4. Results obtained for blade length L=3 [m]

demand (but also with high energy overproduction). However, the size of the turbine may not be acceptable from a construction law perspective for small houses.

References

1. Bi, Y., Zang, G., Qin, L., Li, H. & Wang, H. Study on the characteristics of charging/discharging processes in three-phase energy storage coupling in solar air conditioning system. *Energy and Buildings* **204,** 109456. ISSN: 0378-7788 (2019).
2. Charvinski, V., Kostukevich, H. & Rusowicz, A. Possibility of the electric vehicle-to-home charging using renewable energy sources. *Rynek Energii* **146,** 76–78 (1 2020).
3. Eshkabilov, S. *Beginning MATLAB and Simulink: From Novice to Professional.* (2019).
4. Gilat, A. *MatLab. An Introduction with Application* 6th ed. (Wiley, 2017).
5. Grzebielec, A., Rusowicz, A., Jaworski, M. & Laskowski, R. Possibility of using adsorption refrigeration unit in district heating network. *Archives of Thermodynamics* **36,** 15–24 (3 2015).
6. Han, X. *et al.* Weather index insurance for wind energy. *Global Energy Interconnection* **2,** 541 –548. ISSN: 2096-5117 (2019).
7. Laskowski, R. Relations for steam power plant condenser performance in off-design conditions in the function of inlet parameters and those relevant in reference conditions. *Applied Thermal Engineering* **103,** 528–536 (2016).
8. Liu, Y., Wu, X., Du, J., Song, Z. & Wu, G. Optimal sizing of a wind-energy storage system considering battery life. *Renewable Energy* **147,** 2470 –2483. ISSN: 0960-1481 (2020).
9. Ruciński, A. Energochłonność systemów wytwarzania chłodu w obiektach hotelowych. *Inżynieria Bezpieczeństwa Obiektów Antropogenicznych.* ISSN: 2450-1859 (3 2019).
10. Ruciński, A. & Rusowicz, A. Thermoelectric generation of current - theoretical and experimental analysis. *Archives of Thermodynamics* **38,** 3–13 (4 2017).
11. Stropnik, R., Koželj, R., Zavrl, E. & Stritih, U. Improved thermal energy storage for nearly zero energy buildings with PCM integration. *Solar Energy* **190,** 420 –426. ISSN: 0038-092X (2019).

12. Yukita, K., Kobayashi, Y., Duy-Dinh, N., Matsumura, T. & Goto, Y. Suppression of PV output fluctuation using EV in a electric power system. *IFAC-PapersOnLine* **52.** IFAC Workshop on Control of Smart Grid and Renewable Energy Systems CSGRES 2019, 93 –98. ISSN: 2405-8963 (2019).