DEVELOPMENT OF AN ALGORITHM FORECASTING THE GENERATION OF ELECTRIC ENERGY BY A WIND DIESEL COMPLEX

Daria Batueva

Saint Petersburg Mining University, 199106 Saint Petersburg; dasha-batueva4@rambler.ru

ABSTRACT. There are a large number of autonomous sources of power supply, which provide electricity to industrial enterprises and regional power regions in the Arctic zone operating in isolation from the united power system. Their power supply is carried out mainly from autonomous diesel power plants. Load schedule of remote areas in which there are industrial enterprises will directly depend on the cycles of electrical equipment. However, when using a wild-diesel complex as one of the sources of power supply, it is necessary to take into account the effect of climate change on the operation of a wind power plant and to predict it, together with the forecast of energy consumption of an electrical object. The data shown on the wind maps do not allow to determine the location of wind power plants in the Arctic, because, firstly, they do not take into account all the necessary parameters, secondly, the work should be based on the study of dynamic maps, the data in which are processed and analysed in real time based on neural networks and machine learning. The article develops an algorithm for optimising the software package; upon receipt of data on meteorological conditions, the programme will calculate the electricity generated by the wind power plant. When planning the load schedule of an enterprise for days or hours in advance, the ratio of electric power output of wind power stations, diesel power stations and accumulation or output of electric power from batteries will be determined.

Keywords*:* Wind-diesel complexes, reliability of power supply, load schedule, energy consumption forecasting

РАЗРАБОТВАНЕ НА АЛГОРИТЪМ ЗА ПРОГНОЗИРАНЕ НА ГЕНЕРИРАНЕТО НА ЕЛЕКТРОЕНЕРГИЯ ОТ ВЯТЪРНО-ДИЗЕЛОВ КОМПЛЕКС

Дария Батуева

Санктпетербургски минен университет, 199106 Санкт Петербург

РЕЗЮМЕ. Има голям брой автономни източници на електрозахранване, които осигуряват електроенергия на промишлени предприятия и регионални енергийни райони в арктическата зона, работещи в изолация от общата енергийна система. Захранването им се осъществява главно от автономни дизелови електроцентрали. Графикът на натоварване на отдалечените райони, в които има промишлени предприятия, ще зависи пряко от циклите на електрическото оборудване. Въпреки това, когато се използва вятърно-дизелов комплекс като един от източниците на електрозахранване, е необходимо да се вземе предвид ефектът от изменението на климата върху работата на вятърна електроцентрала и да се прогнозира, заедно с прогнозата за потреблението на енергия на електрически обект. Данните, показани на вятърните карти, не позволяват да се определи местоположението на вятърните централи в Арктика, защото, първо, не отчитат всички необходими параметри, второ, работата трябва да се основава на проучването на динамичните карти, данните, в които се обработват и анализират в реално време въз основа на невронни мрежи и машинно обучение. Статията разработва алгоритъм за оптимизиране на софтуерния пакет; след получаване на данни за метеорологичните условия програмата ще изчисли електроенергията, генерирана от вятърната електроцентрала. При планиране на графика за натоварване на предприятието за дни или часове напред, ще се определи съотношението на изходната мощност на вятърните електроцентрали, дизеловите електроцентрали и натрупването или произведената електрическа енергия от акумулатори.

Ключови думи: вятърно-дизелови комплекси, надеждност на електрозахранването, график на натоварване, прогнозиране на консумацията на елекрическа енергия

Introduction

Today, the development of the Arctic territories of Russia requires reliable sources of electricity, and the region needs new solutions and technologies, one of which may be wind-diesel complexes operating in parallel to cover the peaks of the electrical load.

"Ensuring the country's energy security, including through reliable and high-quality power supply in a number of remote regions and regions with low consumer density," is one of the main targets of state policy reflected in the energy strategy of Russia until 2035. About 70% of the territories of the Russian Federation are decentralised power supply zones and non-electrified zones.

Today, the energy supply of the Arctic regions is mostly isolated, due to the fact that the energy areas are far from each other and the energy complex cannot be used efficiently; because of this the reliability of providing electricity to the consumers is reduced. Energy supply is carried out separately in each district at the expense of diesel power stations and the fuel for them comes once a year for northern delivery. As a rule, these are diesel power plants that have low efficiency and high production costs of electricity, which reach to 80-120 rubles per kilowatt-hour, taking into account the fact that diesel fuel for them has to be delivered once a year during winter delivery. At the same time, if we take the average price of electricity in the zone of centralised power supply in the country, it will be 3-4 rubles per kWh for the end user. Wind turbine complexes will significantly reduce the cost of electricity

(due to the fuel component), ensure a payback period of the project of 3-5 years, and achieve a reduction in emissions of pollutants and CO_2.

The development of the Arctic territories of Russia requires reliable sources of electricity, and in connection with the geographical features of the region, new solutions and technologies are needed.

It is necessary to plan not only the modernisation and expansion of the existing electric grid complex, but also to use distributed generation, including renewable energy sources, to increase the efficiency of the energy complex.

For settlements that do not have industrial enterprises, the curve of electrical load is largely determined by the pumps of the village heating system - boiler plants operating on wood, fuel oil or coal. This determines the significant seasonal uneven energy consumption of such settlements. The deviation of real energy consumption from the curve of the day's workload is from 11 to 56%, with the maximum deviation occurring in the summer months. This is because there are consistently low air temperatures in winter and the average temperature changes significantly every month in the spring, summer and autumn periods, which entails a shift in the load curve. As a result, the deviation of real loads from the energy balances used in calculations for the summer regime day can be 40-50%.

As for remote areas in which there are industrial enterprises, the load schedule will directly depend on the electrical equipment operation cycles. However, when using a wind-diesel complex as a power source, the question of the impact of climate change on the operation of wind turbines remains, which also needs to be predicted in the system together with the energy consumption forecast of an electrical object.

Baseline Territory Data

The parameters that must be considered during the construction of a wind farm on the territory of the Arctic practically do not differ from the parameters for the territories in the middle lane. However, it is necessary to pay special attention to some of them, due to extreme and unstable weather conditions. Below is a complete list of parameters that are important when choosing a place:

1. Average wind speed.
2. Wind direction
3. Minimum wind speed.
4. Maximum wind speed.
5. Power density.
6. Average temperature.
7. Average humidity.
8. Average pressure.
9. Altitude above sea level.
10. Distance to water.
11. Height difference.
12. Smooth height differences.
13. The maximum difference in the area of 5-10 km.
14. Percentage of trees or plants in the area (roughness).
15. Distance to the settlement.
16. The distance of the pre-industrial facility.
17. The average number of inhabitants in the area.
18. Distance to the road (sea, air).
19. Distance to the electricity network.
20. Protected areas: reserves, etc.

Operation mode of the wind turbine and diesel generator

Characteristic of system

The wind-diesel complex should incorporate an automatic system that will take into account external climatic changes (this work takes into account only the change in wind speed) and change the operating modes of the diesel generator and wind turbines. The change in power of wind and diesel generator sets depending on the change in wind speed is shown in Figure 1.

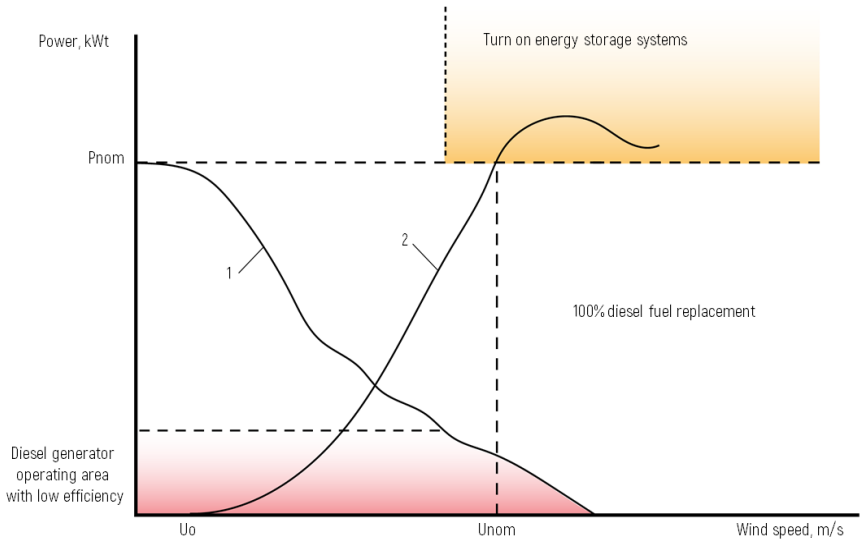

Fig. 1. Operation mode of the wind turbine and diesel generator

Algorithm for choosing the mode of operation

The procedure is described in the form of an algorithm, on the basis of which the automatic system will make a decision on the choice of the operating mode of a wind-diesel complex under changing climatic conditions. The algorithm is based on the presence of a wind turbine, a diesel generator set and a battery in the system, wind speed readings. After selecting the mode of operation of the power supply sources for the object of research, the production and consumption of electricity as well as how much energy is accumulated in the battery are calculated. The algorithm is shown in Figure 2.

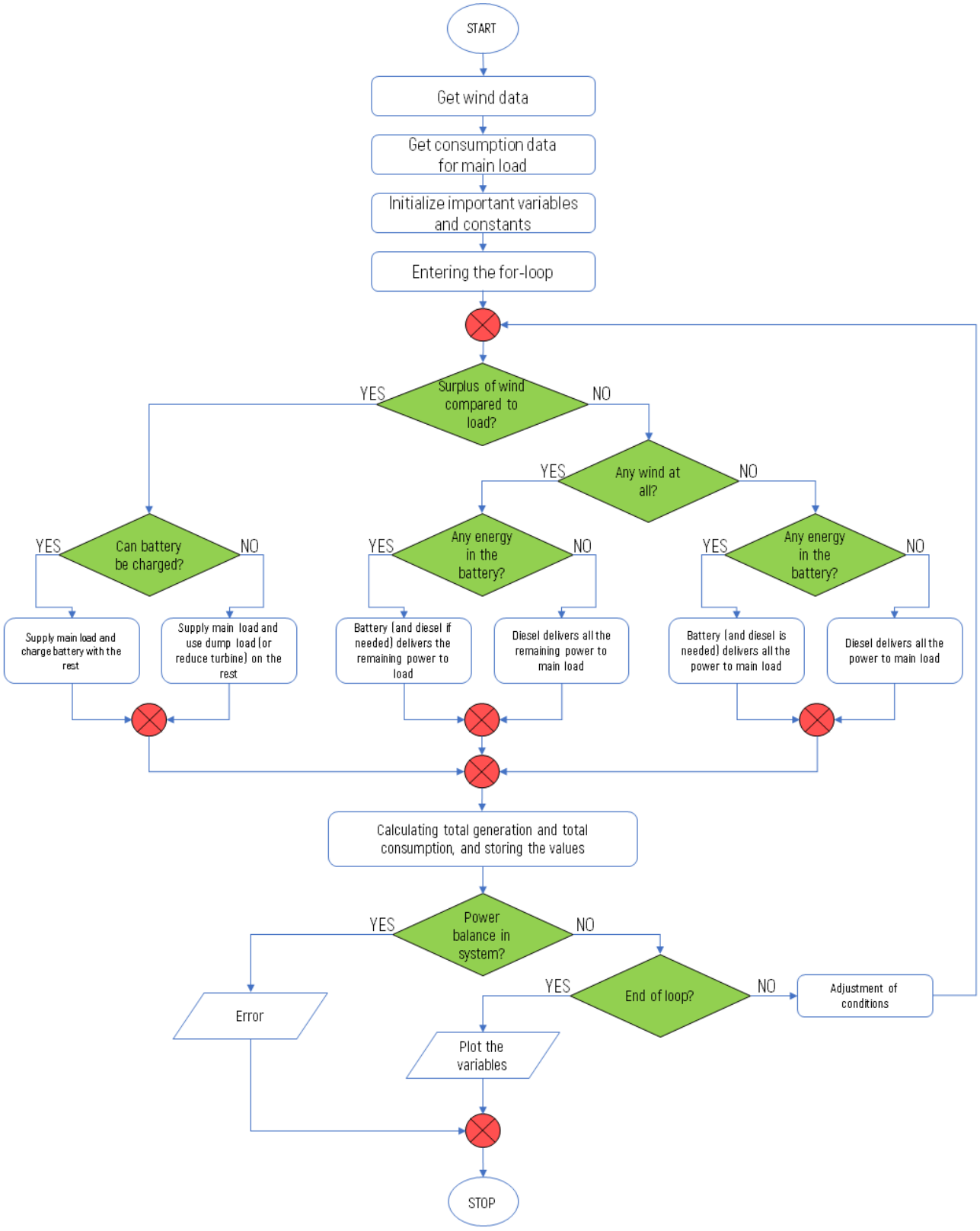

Fig. 2. Algorithm for choosing the mode of operation of wind turbines and diesel generator

Neural network prediction

The next step in the study will be to create a model based on neural networks. The databases of statistical data from the points indicated in the chapter earlier will be used to forecast the generation by the wind-diesel complex. A simplified structure of the model is presented in Figure 3.

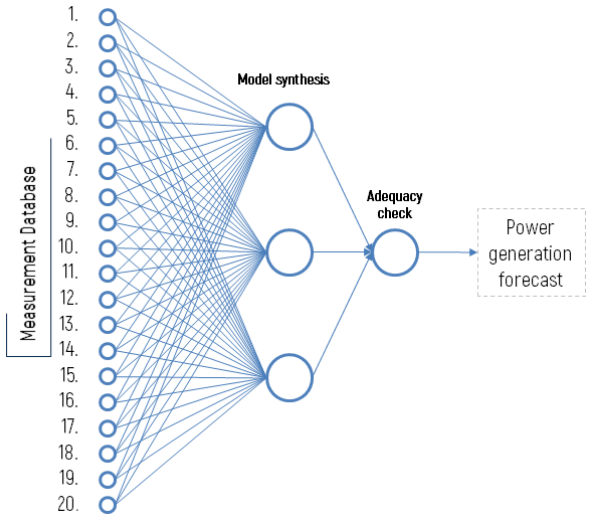

Fig. 3. Model of neural network prediction

It should be noted that the more factors will be taken into account, the more accurately it will be possible to form a forecast of electricity generation. Knowing the projected graphs of loads of objects that are supplied from the wind-diesel complex, it will be possible to determine with high precision the operating modes of the wind-diesel complex and batteries for energy storage.

Conclusion

The article describes the main problems of areas with decentralised power supply, including dependence on the supply of expensive fuel and high specific fuel consumption at diesel power plants, as well as the deviation of real energy consumption from the load schedules of the day.

A description of the algorithms that will allow to predict and automatically select the operating modes of wind-diesel complexes to cover the peaks of the electrical load is presented.

The necessary information is indicated, on the basis of which it is possible to analyse and identify the dependence of electricity consumption on climate change and predict the operating modes of the wind-diesel complexes to cover the peaks of the electrical load.

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