Choosing rational locations for placing wind farms in Eurasia with regard to the railway transport specifics

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Abstract. On the continent of Eurasia, there is a main point of excess energy resources - a cargo point located on the territory of Western Siberia in Kuzbass. From it, both west and east, excess flows of energy resources are transmitted in the form of electricity or transported in the form of coal over long distances by rail. Electricity is an environmentally cleaner form of energy resources, since it does not pollute the environment. Therefore, in modern conditions, it is necessary to use electricity to a greater extent. There is the possibility of replacing energy-intensive technological operations: from wood and coal, as well as oil and gas to electric energy. This will be possible and advisable to be carried out in new points during the additional construction of production enterprises for the generation of electricity, as well as when replacing existing technical equipment from previously existing fuel sources with electric energy. The generation of electricity from renewable sources becomes appropriate. The placement of wind farms in both the western and eastern parts of the Eurasia continent will make it possible to reduce the transmission distance of electric power from a cargo point by 5 thousand km.

1. Introduction

In modern conditions of human life, most of the production processes began to occur using electric energy. Its practical application can significantly improve the quality of communications, provide the best economic indicators. At the same time, technical means of electricity are very complex, both in their creation and in their further operation.

In large cities, power lines occupy less territory than transport routes that previously provided the energy to the population. So, when energy resources are delivered to the CHPP, large areas are required for the construction of roads, which ensure the transportation of various types of fuel, primarily coal [1]. In general, such transport routes were usually located at the same level, which caused the need for a large territory and a significant increase in transport costs. Therefore, the transfer of large volumes of electric energy in large cities provides a significant reduction in the cost of transport facilities associated with meeting the needs of the population in energy resources. Therefore, in modern conditions of transport it is necessary to ensure both the generation and transportation of huge flows of electric energy over considerable distances.
The use of electrical energy has allowed large-scale organization of automation in the use of production processes. Its use in production and in everyday life will significantly reduce the costs associated with the generation and further consumption of electric energy both in urban and rural areas.

The use of wind engines made it possible to organize the generation of electricity in all countries of the world, and not only in a limited number of countries that have mineral fuel deposits. However, the efficiency of wind engines depends not only on their technical parameters, power and installation cost. The effectiveness of new sources of power generation largely depends on their location in Eurasia.

2. Research methods

Electricity is an environmentally cleaner form of energy resources, since it does not pollute the environment. Therefore, in modern conditions, it will be necessary to use electricity to a greater extent, both in production processes and in people's lives. However, the effectiveness of the procedure for using various types of energy resources in the practical activities of people will largely depend on the nature of the historical development of the economy of the countries of the world in the context of scientific and technological progress. In this case, to establish rational options, the following factors are evaluated that affect the efficiency in using electricity in the practical activities of people.

The use of energy resources by mankind has allowed people to quickly achieve a significant improvement in their living standards. So, for many millennia, people have used labor to support their existence. There was a market for selling excess goods. However, these factors did not ensure the growth of material well-being of society. For many millennia, the standard of living of the population remained at the beggar level and did not increase. And only in the last five hundred years, with the beginning of the widespread use of external sources of energy based on the achievements of science and technology, the volume of production of the countries of the world has increased tenfold. Therefore, at the present stage of the existence of human society, the expansion of the scale of people's use of energy is one of the main factors for the growth of the material well-being of the population in the future.

The use of coal for traction trains caused a significant increase in operating costs of railway transport. So, the ecology of the environment was violated everywhere. The efficiency of steam locomotives was only about 5 percent. Low calorific value and its slow combustion limited the power of train locomotives. This reduced the weight and speed of trains, reduced the carrying capacity of the main railway lines.

The introduction of oil into the production process has increased the efficiency of engines to 26 percent. The calorific value of oil was twice as high as coal. Therefore, the transition to diesel traction on the main lines allowed reducing the operational costs of railway transport associated with the transportation process.

At the initial stage of the functioning of technological progress, the main types of energy fuel, both in rural areas and in cities, were firewood and coal. Subsequently, to meet the needs of people with energy resources, oil and oil products, as well as gas, began to be widely used.

Practice has shown that previously used types of energy resources, especially coal, require a significant territory for laying, operation of transport lines located at the same level, creating storage facilities to ensure storage of the necessary fuel reserves associated with the peculiarity of their use due to the seasonal changes. In this case, there are big problems associated with heating rooms with coal or firewood. The subsequent use of gas caused frequent explosions in residential buildings, especially high-rise ones, for example, in Magnitogorsk and others.

Only the availability of electricity ensured the functioning of particularly large cities with a multimillion population. Electric network devices, in comparison with transport lines, are located at different levels. Therefore, the electrification of production processes has significantly reduced the territory of large cities and ensured the satisfaction of people's needs for energy resources.
Practice also showed that despite the costs of building roads and operating sources of transport with coal and oil, it was necessary to additionally carry out electric power transmission lines throughout the territory of a large city.

At the initial stage of the functioning of technological progress, electric energy was used mainly for lighting. The provision of electricity to residential premises, instead of candles and kerosene lamps, made it possible to provide people with lower costs and round-the-clock better lighting of houses throughout the entire period of the year. At the same time, the ecology in the area of large cities was further improved.

At the present stage, electric energy has been successfully used for heating residential premises. This measure was most effective in rural areas, especially for summer cottages, when people are absent for a long time.

In modern conditions, electricity has been successfully used for the practical use of more advanced and efficient technical equipment. The large-scale use of electric energy in communications during the functioning of production processes has significantly improved the economic performance of the entire economy of the world.

The order of using various types of energy resources largely depends on technical capabilities, both in creating these types of energy resources and in the order of their subsequent use in the production activity of people.

It is necessary to evaluate:

A. Opportunities of using energy resources;
B. Quality of the use of energy resources.

In terms of technical capabilities and ease of use, firewood was used at the initial stage of people's lives. At the next stage, the wind was used to the greatest extent. So, in the Middle Ages, windmills were widely used.

However, with the beginning of the Great Geographical Discoveries, wind energy began to be widely used in the navy for the development of new lands. The most massive transportation of goods and passengers, including between continents, for several centuries was carried out by sea.

Fundamental changes in the nature of the use of energy resources in people's lives have occurred since the beginning of the widespread use of coal in England. With its use in the practical activities of people, steam engines were invented and created. A new type of railway transport has become widely used. On the railroads, steam locomotives were first used as a driving force. There were steamboats, and then motor ships in the sea.

With the discovery of oil production methods in the mid-19th century, diesel locomotives were invented in rail transport and motor ships in the sea.

At the present stage of scientific and technological progress, methods for large-scale power generation were invented and put into practice, and subsequently its effective use was made. Its practical application, both for production purposes and in everyday life, had a significant impact on the efficiency in the implementation of production processes, both during the seasons and throughout the territory of a large country, taking into account urban and rural areas.

For the Eurasia continent as a whole, the effectiveness of the location of various technical means of energy resources for urban and rural areas is influenced by the presence of a cargo distribution point located in its central part. It turned out that the cargo point is located approximately in the geographical center of the country. From it, both to the west and east, the range of cargo transportation by rail to the outskirts of the continent is about 5 thousand km.

Historically, the effectiveness in the use of various types of energy resources largely depends not only on their power and specific energy consumption. The rational procedure for creating various types of power plants largely depends on the points of their location, depending on the nature of the availability of both loaded and empty directions. The effectiveness of these methods largely depends
on the presence of many time zones in the country, and above all, on the location of technical facilities for generating electricity on the continent.

In addition, when assessing various options for the development of energy devices for the future, it must be borne in mind that in the devices of electric energy, both in its generation and in transmission over considerable distances, as well as in its subsequent use on the ground, the greatest changes occurred, compared with the existing procedure for using other types of energy resources, and above all, for coal [2-5].

Until the middle of the 19th century, there was no electricity at all, and it was not used in the life of people. It was not discovered how to develop it, nor transfer it, as well as further consumption in the practical life of the population and enterprises of the country.

Therefore, from the very beginning of the appearance of electric energy, it was used only for lighting, as well as in technical communications. In rail transport, the most efficient use of electricity was only in information technology. Its use on the railways of the world made it possible, through the introduction of instant communications, to efficiently, with less delays on the route, especially on single-track railway lines, organize the passage of trains. At the same time, capital expenditures in developing the capacity of railway lines were reduced, and expenses for infrastructure facilities decreased.

Transportation of energy cargoes by rail has its own characteristics in terms of costs associated with the transportation process.

So, at the initial stage of the development of railway transport, the main efforts were aimed at increasing the average weight of freight trains. This measure, with a low initial weight, made it possible to significantly reduce the costs associated with an increase in the carrying capacity of railway lines. The costs associated with maintaining a large staff of train crews, consisting of five people, were sharply reduced: the engine driver and his assistant, the stoker, the chief and senior conductors. At the present stage, the train crew consists of only two people: the engine driver and his assistant. Therefore, at the present stage, in the context of an increase in the volume of transportation by rail, it is more expedient to build additional main routes by inserts, primarily on lines with a light profile. At the same time, the throughput of previously constructed trunk lines sharply increases. Also, the speed of trains increases by reducing the duration of their stops along the route [6-7].

The invention and implementation of electric generators and electric motors in practice made it possible to sharply increase the generation of electricity. There was an opportunity to create new power plants of high power. Ways were developed and put into practice to transfer increased volumes of electricity over long distances. At the same time, due to the reduction in coal transportation volumes, the costs associated with the need to carry out an additional empty direction of freight traffic on the railway transport reduced.

The presence of the above achievements made it possible to organize the electrification of trunk lines in railway transport. This allowed organizing and significantly reducing operating costs associated with the cost of electricity for the movement of trains. Electrification allowed increasing the throughput and carrying capacity of railway lines, increasing the technical speed of freight and passenger trains, and organizing high-speed train traffic.

Under the new conditions, it became possible to replace energy-intensive technological operations: from wood and coal, as well as oil and gas, to electric energy. It is possible and advisable to implement for two independent conditions.

A. In new points during the additional construction of production enterprises for the generation of electricity.
B. Replacing existing technical equipment previously using fuel sources with electric energy.

One of the most significant measures in railway transport in the development of increasing volumes of transportation is the electrification of railway lines. Its practical application allows reducing operating costs associated with the transportation process in the movement of trains. At the same time,
the carrying capacity of railway lines increases. A scientific methodology has been developed to assess the effectiveness of large capital expenditures in its implementation. In the existing feasibility studies, the efficiency of electrification was ensured only with increased volumes of transportation for main railway lines. For existing methods, increasing the weight of freight trains increases the cost of electrifying railway lines in the presence of long-distance station tracks [7].

At the same time, due to technological progress and rational use of energy resources, the role of mineral energy sources, especially coal, is gradually decreasing. In the production process, coal is gradually replaced by electricity. Therefore, in the future, in connection with the technological progress, it becomes more expedient to build solid second tracks at first on single-track main lines instead of increasing the weight of freight trains. After that, it becomes more expedient to ensure the development of increasing volumes of traffic due to the electrification of railway lines and the growth of traffic on them. In the future, measures associated with a further increase in the average weight of freight trains in single-track sections with diesel traction will become less appropriate. It becomes necessary to quickly switch to the electrification of railway lines in order to master the increased volumes of traffic.

Analysis and practice, as well as new scientific studies have shown that the effectiveness of new technical means for providing the population and enterprises with electric power largely depends on the power and efficiency of new technical means for generating electric power. New scientific data showed that the effectiveness of new technical means also largely depends on the construction site of new technical facilities for generating electricity. It should be borne in mind that due to technological progress, there are points of both surplus and lack of electricity in each country of the world [8].

The main points of the lack of energy resources are usually found both in large cities and in the locations of industrial enterprises that consume significant amounts of electricity. These points of the lack of energy resources are usually located on the territory of each country and have changed their location due to technological progress. Due to population growth, points of a significant lack of energy resources have appeared.

So, coal, oil, and gas are located in a limited area at points of mineral deposits. Hydroelectric power stations are usually built on rivers with the possibility of building additional hydroelectric power stations there. For the Eurasian continent as a whole, the epicenter of the availability of excess energy resources is the region of Western Siberia, where there are the richest oil and coal deposits in the Kuzbass.

For several decades, a system has been developed in Eurasia for the availability of a cargo point in the country. There is a point with the largest excess of energy resources in the central part of it. These increased volumes of energy resources are sent across the entire continent, both west and east to its borders, in significant volumes.

This figure shows that from the mineral deposits located in the central part of the continent of Eurasia, increased flows of energy resources flow to all its areas, both west and east. These energy flows can be transported either by rail or transmitted over considerable distances in the form of electricity. The rational scope of each method of transferring energy resources over long distances has changed with technological progress in the economy of the world.
At the initial stage of technological progress, most of the energy resources in the form of coal went closer to the main points of electricity consumption. The high cost of electricity transmission in that initial period, as well as small volumes made it expedient to transport energy resources, especially in the form of coal, by railways at considerable distances closer to the points of consumption of energy resources. At the same time, at these endpoints, most of the electricity was generated at local CHP plants. In rail transport, there was a significant flow of cars in the empty direction to the coal loading points located in the central part of the Eurasia continent.

At the beginning of technical development, energy resources in the form of fuel were extracted in a small area located in mineral deposits. At the same time, energy resources were used by people at all points of the country: both in large cities and in sparsely populated rural areas, including those where there were no enterprises consuming significant amounts of electricity. At first, significant flows of electricity were generated at power plants located in large cities and industrial areas at fuel fields. At the same time, electricity was not transmitted over long distances. Energy resources in the form of coal were transported over long distances by rail. In this case, the huge area of the territory, both of each region and in general for all countries of the continent, turned out to be without electricity generation points. Therefore, electricity from large production centers located in large cities was transferred to the large countryside areas where it was consumed.

The disadvantage of this system of providing the population and enterprises of the country with electricity is that electricity was transmitted in excess quantities from points of lack of fuel (from large cities) to rural settlements and over considerable distances. At the same time, in this rural area, electricity was increasingly consumed.

At the present stage of scientific and technological progress, the availability of renewable and non-renewable sources has a significant impact on the effectiveness of meeting the population’s electricity needs. The vast majority of energy is currently used from non-renewable sources: coal, oil, and gas. Their extraction requires more and more costs over time. In this case, a large number of previously effective deposits of coal and oil are depleted. Therefore, at the present stage of scientific and technological progress, the generation of electricity from renewable sources has become increasingly widely used.

Under new conditions, wind power generation plants were invented and began to be widely introduced into practice. Their large-scale implementation in practice allows for the generation of electricity from a renewable source - WIND. They have significant advantages over previously widely used coal, oil, and gas.

The use of renewable energy sources, in addition to saving mineral resources for the future, has the following advantages, which are insufficiently taken into account in the previously published scientific literature [9-11].

A. It is possible to obtain additional energy in significant volumes from renewable sources with limited mineral energy resources.

B. It may be easy to create and use renewable energy sources for practical application anywhere on land of each region or in general for all the countries of the Eurasia continent.

C. The stock of raw materials in previously developed mineral deposits is saved.

D. Improving the ecology of the environment.

E. The transmission range of electric power to the points of their consumption is reduced. These technical devices can be relatively easily created near the main points of electricity consumption. The range can be relatively easily reduced due to the rational points of their placement in the country as a whole.

F. Small specific initial costs at one point of electricity generation. So, wind farms have a small unit initial cost. These technical devices can be relatively easily installed near the main points of electricity consumption. The transmission range of electricity can be relatively easily reduced due to rational points of their placement on the territory of all countries of the continent.
G. The possibility of generating electricity in most of the territory of each country. In the vast majority of the territory of each region or even for all countries of the continent, there are no points for generating electric energy [5].

H. Renewable energy sources in the form of wind farms have additional opportunities to increase the efficiency of methods for generating additional electric energy, which are not sufficiently studied in the scientific literature.

3. Discussion

Wind power plants have significant advantages in generating electricity, compared with existing options, especially in the area of passage of transport lines, as well as in large cities.

Wind farms can be built anywhere on land. Therefore, first of all, it will be necessary to place them on those points of land in general for the whole country or even for the whole continent where the greatest reduction in the range of transportation of energy resources can be achieved. At the same time, a possible reduction in the range of transportation of energy resources can be established taking into account the presence of a cargo point on the Eurasia continent.

First of all, for the existing conditions, the transfer of fuel and electricity with its excess in large volumes is carried out from a cargo distribution point located in the central part of the Eurasia continent to any point on land of the country. The farthest transmission of electricity or transportation of fuel will be in the case of its transmission to the west or east to the outskirts of the continent. There may also be options, for example, north or south of each area.

Energy resources are currently being transferred from a cargo point on the Eurasia continent to the longest distances. For the western and eastern parts of the Eurasia continent, the transportation range is up to 5 or more thousand kilometers.

In this case, the placement of wind farms in the western part of the Eurasia continent will reduce the transmission distance of electricity by 5 thousand km. This will have a significant effect from improving the order of transmission of electricity over long distances.

Placing wind farms near the cargo point of the Eurasia continent on the main railway lines provides a smaller reduction in the distance of the transmission of electricity.

Figure 2 shows that the existing method of transporting coal is carried out from a cargo point to a thermal power plant of a CHPP located in a large city in the western part of Eurasia. From this point, the generated electricity is transmitted to consumers located throughout the territory of each country. In western countries, the increased range of transmission of energy to the point of consumption causes high costs associated with the delivery of electricity to consumers.
In the second conditional version (Figure 3), electricity is generated by new wind farms on the territory of the countries of the western part of the continent. In this option, there is no need to transport energy resources from a cargo point to consumers located in the countries of the western part of the Eurasia continent. This measure allows having a huge cumulative effect by reducing the range of transportation of energy resources by a distance of 5 thousand km.

It can be seen from the figure that in the current version of the absence of wind farms on the western border, electricity or energy resources are transmitted from Kuzbass to a distance of several thousand kilometers.

At the same time, the construction or creation of wind farms in this region allows providing these points with electricity almost without transmission over short distances.

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