**Competitiveness Economic Assessment of Russian Natural Gas and Electricity Supplies for China under Inter-Fuel Competition**

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**Abstract.** Calculations to assess the effectiveness of inter-fuel competition between natural gas, coal and electricity for the production and consumption of thermal energy in China are presented in the article. The analysis of electrical capacity, the structure of the electrical balance, and the dynamics of production and consumption of energy resources (electric and thermal energy, coal, gas) is conducted. Environmental problems due to carbon dioxide emissions at coal-fired power plants in China are revealed. The advantages of using electricity for electric heating for Russia and China are outlined, and the efficiency of the prospects for exporting renewable (nonpolluting) electricity that is generated after the construction of a cascade of hydroelectric power plants in Southern Yakutia for electric heating is evaluated. Effective mechanisms of attraction, formation and use of Russian and foreign investments for projects of construction of HPP cascades with the expected efficiency of invested funds by public and private investors for both countries are proposed.

1. **Introduction**

Energy is the basic foundation for the sustainable functioning and development of the economy and the social sphere in any country.
The demand for energy consumption depends not only on the intensity of the economy sectors, social sphere and population, but also it depends on the rapid development and introduction of energy and resource efficiency technologies by producers and consumers of energy, and alternative, non-traditional and renewable energy.

All these energy-efficient measures with the development of digital industries, production processes, the distribution and marketing of energy reduces the energy intensity of energy and fuel consumption and ultimately reduces the efficiency of the economy and its transformation into a digital economy and increases the standard of living of the population.

Electric-power and heat power industries are platforms for inter-fuel competition, which create a competitive environment between different primary energy carriers such as coal, natural gas, fuel oil, gas condensate and electricity for electric heating, and prospects for the development of alternative, non-traditional and renewable sources of energy.

Thus, the further diversification of the fuel basket depends on the efficiency of the energy carriers, the cost of their delivery and the price of the fuels for the production of electrical and heat energy. The industrial and transport sectors are the most sensitive to changes in prices for replacement fuels, while households and the electric power industry are the least sensitive [8].

The relevance of this study is to assess the efficiency of exports of Russian energy resources such as natural gas and electricity for electricity consumption in China, taking into account the priorities of the long-term Energy Strategies of the Russian Federation and the People’s Republic of China.

2. Research methods and methodology

At present, there is a sufficient number of scientific papers and analytical materials by energy specialists in the field of assessing the inter-fuel competition between coal and gas, especially in view of the environmental cost of delivery to the electricity and heat producers, and the availability of effective technologies in the choice of fuel types.

Two methods for evaluating the energy and economic efficiency of using electricity as electric heating in two ways are proposed. In the first method, the volume of energy resources for generating a unit of Gcal of thermal energy is calculated on the basis of the calorific value of the fuel types. In the second method, the volume of energy resources for generating 1 Gcal of heat energy is calculated taking into account the efficiency of boilers of heat power plants. As a result, the efficiency of electricity use for electric heating in the provinces of China and for the regions of Southern Yakutia was revealed.

The novelty of the research consists in justifying the methods of indicators assessment of energy and economic efficiency of energy use for electric heating by two methods which lead to environmental and social performance of the country.

Materials of specialists and scientists, such as Stern D. I. (2009); Yang Yufeng (2015); Mitrova T. A., Galkina A. A. (2017); Mastepanova V. M., Tomberg I. R., (2018); Ruban L. S., Grib N. S., (2020); Elyakova I. D., Kondratev O. I., Karataeva, T. A., Danilova L. I., Khristoforov A. A., Elyakov A. L. (2017) in the field of inter-fuel competition in the energy sector, the development of methods for assessing the efficiency of fuel use is of great importance in the competitive fuel market (primary energy carriers) to improve the development of more efficient and integrated solutions for the production of electric and heat energy (secondary energy carriers).

3. Results and discussion

Even in the most difficult conditions of the slowdown in the global economy due to COVID-19, China retains the second place in terms of GDP among the largest economies in the world. According to the International Monetary Fund and the World Bank, China ranks first in terms of GDP per capita, taking into account purchasing power parity, which is a characteristic that determines the level of economic development of the country (Table 1).
Table 1. The place of countries in terms of GDP per capita

| Place | Country    | GDP per capita, US $ according to the IMF | GDP per capita, US $ according to the World Bank |
|-------|------------|------------------------------------------|--------------------------------------------------|
| 1     | China      | 127837                                   | 121764                                           |
| 2     | Luxembourg | 118004                                   | 120490                                           |
| 3     | Singapore  | 100092                                   | 101458                                           |
| 4     | Qatar      | 93880                                    | 95108                                            |
| 5     | Ireland    | 86444                                    | 91959                                            |
| 7/8*  | USA        | 63056                                    | 65254                                            |
| 53/50*| Russia     | 27317                                    | 28184                                            |

Source: https://ru.wikipedia.org/wiki/ *According to the World Bank (WB)

As it was planned in 2019, the installed capacity of China's power plants amounted to 2010 GW. The volume of electricity production increased by 4.7% and amounted to 7325.3 billion kWh. (Table 2).

Table 2. The main indicators of electricity production by power plants of the People's Republic of China in 2019

| Installed capacity of China's Electric Power Industry (GW) | | |
|-----------------------------------------------------------|---|---|---|
| | 2018 | 2019 | Annual growth (in %) |
| TPP (Thermal Power Plant) | 1144 | 1190 | 4.1 |
| HEPP (Hydro-Electrical Power Plant) | 352 | 356 | 1.1 |
| NPP (Nuclear Power Plant) | 44 | 49 | 9.1 |
| WPP (Wind Power Plant) | 184 | 210 | 14 |
| SPP (Solar Power Plant) | 174 | 205 | 17.4 |
| TOTAL: | 1900 | 2010 | 5.5 |
| China's Electric Power Generation Capacity (billion kWh) | 2018 | 2019 | Annual growth (in %) |
| TPP (Thermal Power Plant) | 4924 | 5045 | 2.4 |
| HEPP (Hydro-Electrical Power Plant) | 1232 | 1302 | 5.7 |
| NPP (Nuclear Power Plant) | 295 | 349 | 18.6 |
| WPP (Wind Power Plant) | 366 | 406 | 10.9 |
| SPP (Solar Power Plant) | 177 | 224 | 26.5 |
| TOTAL: | 6994 | 7325 | 4.7 |

Source: National Bureau of Statistics, China

The generating capacity was 7417 billion kilowatt-hours in 2020, which is 2.7 percent more than in the previous year [1].
China ranks first in the world in terms of electricity production and overall energy consumption, with an electrical demand capacity of more than 7 trillion kWh in 2019 (Table 3).

**Table 3. Dynamics of electricity production and consumption in China for 2001-2019**

| Year | Electricity production, billion kW / h | Electricity consumption, billion kW / h | Year | Electricity production, billion kW / h | Electricity consumption, billion kW / h |
|------|----------------------------------------|----------------------------------------|------|----------------------------------------|----------------------------------------|
| 2001 | 1481                                   | 1452                                   | 2011 | 4713                                   | 4653                                   |
| 2002 | 1654                                   | 1597                                   | 2012 | 4988                                   | 4901                                   |
| 2003 | 1911                                   | 1889                                   | 2013 | 5432                                   | 5317                                   |
| 2004 | 2203                                   | 2190                                   | 2014 | 5794                                   | 5709                                   |
| 2005 | 2500                                   | 249                                    | 2015 | 5815                                   | 5767                                   |
| 2006 | 2866                                   | 2808                                   | 2016 | 6133                                   | 6059                                   |
| 2007 | 3282                                   | 3097                                   | 2017 | 6604                                   | 6597                                   |
| 2008 | 3467                                   | 3357                                   | 2018 | 7112                                   | 7091                                   |
| 2009 | 3715                                   | 3678                                   | 2019 | 7325                                   | 7460                                   |
| 2010 | 4207                                   | 4100                                   | 2020 | 7417                                   |                                         |

Source: National Bureau of Statistics, China

The volume of electricity production in China is 7 times more than in Russia, including electricity production from renewable energy sources that amounted to 629.5 billion kWh, which is comparable to 60% of the annual volume of electricity production in the Russian Federation. The share of renewable energy sources in 2019 was - 8.6%, and taking into consideration hydroelectric power plants it was 26.4% [3,4].

The total capacity of wind and solar power plants which is the fastest growing segment of the Chinese electric-power industry exceeded 410 GW. They jointly generated 629.5 TWh of electricity. For comparison: This is approximately 60% of the total annual electricity generation in Russia. The total share of solar and wind in electricity production in China has reached 8.6%.

The power capacity of China is 2 times higher than in the United States [7]. The growing demand for electricity consumption is mainly influenced by two main factors: the high rate of economic development and the large number of the country's population.

In 2020, the structure of energy consumption in China was: coal - 60%, oil - 20%, natural gas -9%, primary electricity - 12%. In the forecast dynamics of 2050 it will be respectively: coal - 34%, oil - 16%, natural gas -16% and primary energy - 33%, [7]. Primary electricity includes the production of electricity from renewable energy sources and nuclear power plants.

As it is shown in Figure 1, the structure of energy suggests that China is not in a hurry to abandon the use of coal in power plants for the production of electricity and heat. It occupies the main share in the energy balance - 64.7%, natural gas - 3.2%.

According to the Energy Strategy until 2050 which was adopted in 2018 under the name “Energy System for a beautiful China”, the following should happen there:

- economic growth and transformation of the energy system into an environmentally friendly one;
- GDP per capita should grow by 3.8 times to the level of 2016 and it should amount to $ 30,765 / person when calculated for the same population;
- demand reduction for electricity due to the transformation of the economic structure [5].

At present, China is the largest source of harmful emissions. The country uses more coal than the rest of the world as a whole. Until now, the Chinese authorities have committed to reach a peak in emissions no earlier than 2030.

Table 4 shows the volume of coal production and consumption in China for 2015-2019.
Table 4. Coal production and consumption in China for 2015-2019, million tons

| Year | Production | Consumption |
|------|------------|-------------|
| 2015 | 3747       | 4210        |
| 2016 | 3670       | 4300        |
| 2017 | 3411       | 4490        |
| 2018 | 3684       | 4640        |
| 2019 | 3970       | 4860        |

Source: National Bureau of Statistics, China

Although there is a decrease in China in the consumption of coal and fuel oil; in the production of electricity and heat by thermal power plants (the share of thermal power plants is decreasing from 71.1% (2017) to 68.9% (2019)), but nevertheless, CO2 emissions exceed the global average due to the use of coal mainly in the structure of electricity production (65%) according to the International Energy Agency (IEA).

The reduction in the share of coal consumption is due to the development and introduction of renewable energy sources and the re-equipment of coal-fired power plants with modern energy units.

Coal consumption in China by 2050 should be reduced to 846-534 million tons of reference fuel; coal consumption for electricity generation should be reduced to 310 g/kWh, and for new power plants – below 300 g/kWh according to the Energy Strategy of the People's Republic of China.

The volume of thermal energy production in 2001-2019 was increased by 36.1% (Table 5).

Table 5. Dynamics of thermal electricity production in China in 2001-2019

| Years | Heat production, thous. Gcal | Years | Heat production, thous. Gcal |
|-------|-----------------------------|-------|-----------------------------|
| 2001  | 2811                        | 2011  | 9157                        |
| 2002  | 3170                        | 2012  | 9298                        |
| 2003  | 3775                        | 2013  | 10144                       |
| 2004  | 4289                        | 2014  | 10509                       |
| 2005  | 4890                        | 2015  | 10233                       |
| 2006  | 5660                        | 2016  | 10598                       |
| 2007  | 6504                        | 2017  | 11356                       |
| 2008  | 6466                        | 2018  | 12119                       |
| 2009  | 7124                        | 2019  | 12468                       |
| 2010  | 7958                        |       |                             |

Source: National Bureau of Statistics, China

In view of the difficult environmental situation, particularly in the capital, Beijing and the South-Eastern provinces of China, where there is more carbon dioxide emission in the atmosphere, the main trends in the development of energy is the reduction of coal use to 58% and the use of efficient technologies in coal-fired power plants which is reflected in the energy policy of the country and in the Energy strategy of China up to 2050.

The baseline scenario of China’s Energy Strategy up to 2050 provides for a slight increase in natural gas consumption from 269 billion cubic meters in 2019 to 238 billion cubic meters in 2050. That means, according to the environmental scenario, the reduction in natural gas consumption predicts a decline in demand by almost half – to 123 billion m3 in 2050.

Chinese electric power plants will continue to use coal as fuel for power plants due to the large coal reserve in the country, but they will plan to reduce its share in the fuel structure for electricity generation.

“China has banned organizations from building new coal-fired power plants near the three largest cities – Beijing, Shanghai and Guangzhou due to the deterioration of the environmental situation.
China's rapid economic rise based on coal-fired power over four decades has had a significant impact on the environment and public health. In general, due to poor air quality, the average life expectancy in China is reduced by almost 25 months” is revealed by Mastepanov V. M. and Tomberg I. R. [1].

China is currently studying and formulating the country's “14th Five-year plan”, and according to previous studies, China's coal consumption ratio will fall to 40% by 2035, and the share of clean energy will increase significantly.

Under the slogan “Make the Chinese sky blue again” in China, natural gas, along with hydropower and renewable energy, can become the cleanest energy resource in the fight against air pollution, so natural gas is assigned a small but significant role in China's energy strategy to solve environmental problems [6].

The share of natural gas in the Chinese energy sector, as of 2020, was a low share of 9% in the electric balance and will grow to only 16% by 2050 [10].

Table 6 shows the volume of natural gas production and consumption in China for 2015-2019.

| Year | Production | Consumption |
|------|------------|-------------|
| 2015 | 131        | 198         |
| 2016 | 137        | 225         |
| 2017 | 142        | 234         |
| 2018 | 145        | 251         |
| 2019 | 151        | 269         |

Source: National Bureau of Statistics, China

The plan of China is to make a transition from coal-fired power plants to eco-friendly power plants running on natural gas and to develop “green energy”. Therefore, the volume of natural gas production at the Chayandinsky oil and gas condensate field in the Republic of Sakha (Yakutia) is increasing with reserves (B1+B2) from the category of unique more than 1.2 trillion cubic meters of gas and 61.6 million tons of oil condensate, as well as large reserves of helium in the category of ABC1+C2 is 1,400 million m3. The main gas pipeline “Power of Siberia” with a design capacity of gas supplies up to 38 billion cubic meters per year for 30 years has also been built. “Power of Siberia” will operate at full capacity in 2025. The contract amount is US $ 400 billion.

According to the calculations of the Institute of Energy Research of the Russian Academy of Sciences, Energy Center of the Moscow School of Management SKOLKOVO, gas, as alone from fossil fuels, will increase its share in global energy consumption from the current 22 % to 25-27 % by 2040 [4].

Table 7. Gas consumption and production in China for 2020-2040, billion m3

|      | 2020 | 2030 | 2040 | Growth rate 2040/2020, % |
|------|------|------|------|-------------------------|
| Consumption | 324  | 502  | 585  | 180                     |
| Production  | 180  | 267  | 379  | 210                     |
| Import      | 144  | 188  | 206  | 143                     |

Source: compiled by the authors according to data of the Institute for Energy Studies of Russian Academy of Sciences

The growth rate of gas consumption, production, and especially imports slows down every decade in China, but also increases due to the demand for this type of energy carrier.

As for electricity, as it can be seen from the dynamics analysis of electricity consumption, they are growing, and higher growth rates are predicted due to economic growth and the growth of the country's population.
Russia has signed a long-term contract for the supply of 100 billion kWh of electricity in China until 2036. The supply of electricity for export to China from the Amur Region is carried out by “Inter RAO”, a subsidiary of PJSC “RusHydro”. They buy electricity from power plants in the Far Eastern region and pay the cost of its transmission through electric networks since 2009. The change in the volume of electricity exports to China can be seen in Figure 1.

The dynamics of electricity export supplies is shown in Figure 1.

![Figure 1. Diagram of electricity export volumes to China for 2009-2020](image)

The volume of deliveries is 3.62 billion kWh is only 0.04% of the annual energy consumption of the whole China. Tariffs for electric energy are equal to 2.9 rubles/kWh and the amount of export revenue is about 9 billion rubles.

In order to solve the problems of this study, an estimate of electricity demand in the northern provinces of China is given (Table 8).

### Table 8. Electricity production and consumption in the territory of North-Eastern China, billion kWh

| Provinces of China | Production 2019 | Consumption 2019 | Deficit/ Surplus (+) |
|--------------------|-----------------|------------------|----------------------|
| Liaoning           | 199,6           | 240,1            | -40.5                |
| Jilin              | 94,6            | 78               | 16.6                 |
| Heilongjiang       | 105,7           | 99               | 6.7                  |
| Total              | 399,9           | 417              | 17.1                 |

Source: National Bureau of Statistics, China

As a result, there is a large electricity shortage in the northern province of China (Liaoning), which amounts to - 17.1 billion kWh.

The demand for electricity exports to the Northern provinces and to China in general will increase due to the demand of industrial sectors such as oil and gas chemical corporations, steel and engineering companies.

As it can be seen from above and according to the Table 5, China annually buys electricity from the Russian Far East at least 50-60 billion kWh.
And we need to offer them to buy electricity not only for its consumption, but also electricity for electric heating. This is beneficial for both Russia and China. It is necessary to offer China to build high-tech electric-boiler power plants, thereby achieving the most environmentally friendly electricity production, and for Russia is necessary to attract investment and technology for the construction of the South Yakut hydropower cascade Complex of large hydroelectric power plants in South Yakutia with a total capacity of more than 9,000 MW with an average annual output of about 40 billion kWh. Cascade of hydroelectric power stations is suggested to build on the southern rivers of the Republic of Sakha (Yakutia), the Uchur River, the Timpton River, the Aldan River and the Olekma River.

This complex should include 9 hydroelectric power plants. The reservoir area of the Kankunskaya HPP will be located in the Aldan and partially Neryunginsky districts of Southern Yakutia in a narrow river valley of the canyon type [7].

In our opinion, first of all, the construction of the South Yakut hydroelectric power plant cascade is necessary and economically feasible for the Russian Federation itself with cheap and environmentally friendly electricity:

- to create an energy-efficient economy and ensure energy security in the context of its digital transformation;
- to create a large center of the metallurgical and machine-building industry, taking into account the complex of technological processes associated with the use of coke concentrate, and therefore the development of the Elginsky field and other coal mining companies in the Southern Yakutia;
- for the extension of the development and industrial project of the Elkon uranium deposit for the development of nuclear energy in order to provide consumers with decentralized energy in the Arctic and northern territories of the Republic of Sakha (Yakutia).

At present, scientists have no doubts that global warming exists and that it will radically change the Earth's climate if the increase in average annual temperatures cannot be kept at 1.5-2 °C. This is confirmed by data from climate satellites, thousands of weather stations and ocean buoys, as well as various computer models of the climate.

“High levels of air pollution are an urgent social and public health problem in China. According to the International Institute for Applied Systems Analysis and the International Energy Agency, polluted air causes about 1 million premature deaths. In addition, household air pollution (household pollution) causes an additional 1.2 million premature deaths. In general, due to poor air quality, the average life expectancy in China is reduced by almost 25 months” as V. M. Mastepanov and I. R. Tomberg wrote in their article [1].

The key factors for generators when making a decision to invest in certain installations are primarily the fuel component and the price of CO2 [2].

The import of electricity from hydropower plants of the South Yakut hydropower complex is effective and expedient for China:

- due to the use of cheap, clean and uninterrupted power to ensure the energy security of the provincial deficit in electricity and thermal energy for sustainable development of industrial facilities and social sphere;
- due to environmental problems in the country and due to carbon dioxide emissions from coal-fired power plants, but nitrogen oxide emissions are also harmful emissions into the atmosphere due to the use of natural gas by gas turbine and thermal power plants;
- due to the economic benefits of using electricity as electric heating, because of the lower operating costs of electric boilers and electric grid facilities than the construction of main and distribution gas pipelines and their maintenance costs;
- due to the social efficiency, which is the convenience of using electricity as electric heating and the population of the country, but also electric power equipment and electric boiler installations;
- due to the efficiency of inter-fuel competition between coal, gas and electricity for electric heating.

The assessment of the energy and economic efficiency of the use of electricity as electric heating is carried out in two ways. In the first method, the amount of energy resource for generating 1 Gcal is
calculated from the calorific value of the fuel type. In the second method, the volume is calculated taking into account the efficiency of the boilers (Table. 9 and 10).

**Table 9.** The first method of economic efficiency of electricity exports for electric heating to China, taking into account the calorific value of fuel types

| Fuel type          | Calorific value | The volume of energy resources for the production of 1 Gcal | The cost of a unit of energy, US dollars | Cost of 1 Gcal, US dollars |
|--------------------|-----------------|---------------------------------------------------------|------------------------------------------|---------------------------|
| Natural gas        | 7600 kcal/m³    | 131.6 m³                                                | 0.35                                     | 46.1                      |
| Coal               | 7000 kcal/kg    | 142.9 kg                                                | 0.0357                                   | 5.1                       |
| Electric power for electric heating | 864 kWh/kcal | 1157.41 kWh | 0.029* | 33.6 |

* The forecast tariff for electric heating was adopted taking into account the price of electricity exports to China

**Table 10.** The second method of economic efficiency of electricity exports and electricity for electric heating to China, taking into account the efficiency of boilers

| Indicators                               | Units     | gas  | coal | electric power |
|-----------------------------------------|-----------|------|------|----------------|
| Boiler efficiency                       | %         | 85*  | 55*  |                |
| Specific consumption of conventional fuel | Kg of reference fuel/Gcal | 168.1 | 259.7 |                |
| Nominal fuel consumption                | ton of reference fuel  | 0.17 | 0.26 |                |
| Conversion factor                       | Index     | 0.82 | 1.24 |                |
| The volume of energy resources for the production of 1 Gcal | Ton of fuel | 0.14 | 0.32 | 864 |
| The price of fuel and electricity per ton of fuel | US dollar/ton of fuel | 350 | 44 | 0.029** |
| The cost of generating 1 Gcal of heat  | US dollars | 48.5 | 14.0 | 25.1 |

* The forecast tariff for electric heating was adopted taking into account the price of China’s electricity exports

** The average values of boiler efficiency for this type of fuel are accepted

As a result of the inter-fuel competition between coal, gas and electricity for electric heating in the production of thermal energy in China, coal-fired power generation is economically profitable due to the low price of coal and the production of thermal energy on it. But taking into account environmental safety and social efficiency, the most profitable for China is electric heating, even in comparison with the thermal energy generated by thermal power plants using natural gas.

Thus, in our opinion, for China, especially for the northern and north-eastern provinces, in order to provide reliable and safe electric and thermal energy, it is necessary and less expensive to import electricity from the Far East and Russia, including the Republic of Sakha (Yakutia) than build high-voltage power lines from the west of the country.
4. Conclusions

The advantages of electricity export for the Russian Federation from the Republic of Sakha (Yakutia) to the People's Republic of China are:
- hydroelectric power works on almost inexhaustible water resources and has the ability to recover the invested funds in the construction of hydroelectric power stations in short time [8].
- provision of cheap renewable electricity from South Yakut hydroelectric power plants for the development of priority sectors of the economy in accordance with the Economic Strategy of the Republic of Sakha (Yakutia) until 2050 and the subjects of the Far Eastern Federal District;
- environmental safety of electricity production at hydroelectric power plants for the environment, than the use of energy coals in GRES, and in the future natural gas at gas turbine power plants;
- energy efficiency comes from the special operation of hydraulic structures – due to the need for constant loading of hydroelectric power plants in the presence of excess capacity;
- preservation of depleted natural gas at the Chayandinskoye field in the Republic of Sakha (Yakutia) instead of exporting it to China in the context of low gas prices in the global energy markets of the Asia-Pacific region;
- development of its own petrochemical industry in the Republic of Sakha (Yakutia) and in its neighboring territories and export of its products to the People's Republic of China;
- attracting foreign direct investment, high-tech equipment of hydroelectric power plants and hydraulic structures for the construction of the cascade hydropower stations in the South Yakut hydropower complex and high-voltage power lines to China.
- the long-term supply of electricity to China in future, rather than hydrocarbon fuel. It can be called an absolute achievement and success in terms of strategic prospects for cooperation with China.

The advantages of electricity export for the People's Republic of China from the Republic of Sakha (Yakutia) are:
- meeting the deficit and demand for electricity and heat consumption through electric heating in the northern provinces of the People's Republic of China;
- reducing dependence on coal for electricity and heat generation;
- reduction of harmful emissions to the environment at coal-fired and gas-turbine power plants for the production of electric and thermal energy at electric boilers;
- reduction of environmental penalties for exceeding the limit level of emissions of harmful substances, especially carbon dioxide CO2;
- cost-effectiveness due to the low cost of construction of high-voltage power lines and the cost of their operation, than the cost of construction of main, distribution gas pipelines and the cost of their maintenance;
- low tariffs for electricity produced at hydroelectric power plants and electricity for electric heating,
- the emergence of the possibility of developing the production of electric vehicles and its refueling with electricity in the northern provinces of the People's Republic of China.

For the efficient operation of underutilized capacity of Far East and Eastern Siberia hydroelectric power station, it is advisable to export electricity to the States of northeast Asia (China, Mongolia, Democratic People's Republic of Korea and Japan) and contribute to the formation of the Unified energy system of the North-East Asia by construction of interstate energy relations.

Thus, the construction of HPP cascades in Southern Yakutia should become the state task of the strategic direction of electricity escort in the coming years, and not just the plan of one energy company, PJSC “RusHydro”, and then not in the near future as in 2030.

When we all wait for the country to achieve sustainable economic development after the global financial crisis (2008), the currency crisis with the imposition of EU and US sanctions (2014), the stabilization of the economy after the recession due to COVID-19 (2020), and when we postpone for many years such effective projects as the construction of a cascade of hydroelectric power stations in Southern Yakutia – Each time we will abandon the current and strategic plans for structural diversification of the economy, which brings great benefits to the country and ensures the most
sustainable economic growth, we will remain for many years a less developed country with an undeveloped natural resource potential and a low standard of living for its population.

We must not forget that the electric power industry is the basic industry that provides not only the vital activity of the national economy and the life support of the population, but also ensures the progressive development of the entire economy and social sphere, which requires certain deadlines for the return of investments, but also reliably supplies electricity to consumers for many years.

As a result of the research of the relevant topic and for the sustainable development of the economy, we offer:

- develop a state program for the construction of a cascade of South Yakut hydroelectric power plants;
- allocate funds for the state program from the National Welfare Fund to the Russian Direct Investment Fund (RDIF);
- to interest and attract the largest potential consumer of electricity exports, such as China, and to draw up a state contract with it for the long-term supply of electricity, taking into account the supply of electricity for electric heating;
- attract or borrow funds from Russian and foreign private large businesses;
- to create a Fund for the development of Hydropower in the Republic of Sakha (Yakutia) and attract funds from sovereign wealth funds of foreign countries, with the subsequent distribution of shares among shareholders and the creation of effective mechanisms for the return on investment.

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