ELECTRIFICATION AS A METHOD TO IMPROVE ENERGY EFFICIENCY

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Abstract

Increase the level of economic and social development of a country or region, it is necessary to provide energy supply with a high share of electricity. The article considers the issues of increasing the share of electricity in the structure of final consumption of energy resources in order to improve the energy efficiency of the economy.

Keywords: *electricity consumption, energy efficiency, energy resources, total final consumption, electrification*

1. INTRODUCTION

Before the formation of international statistics using the concepts of gross domestic product (GDP) and gross national product (GNP), experts used the indicator "specific electricity consumption per capita" to assess the level of economic development of a particular country. Indeed, there is a fairly stable correlation between these values. Figure 1 shows the relationship between GDP and specific electricity consumption in different regions in 2018 according to the International Energy Agency (hereinafter - IEA) [1].

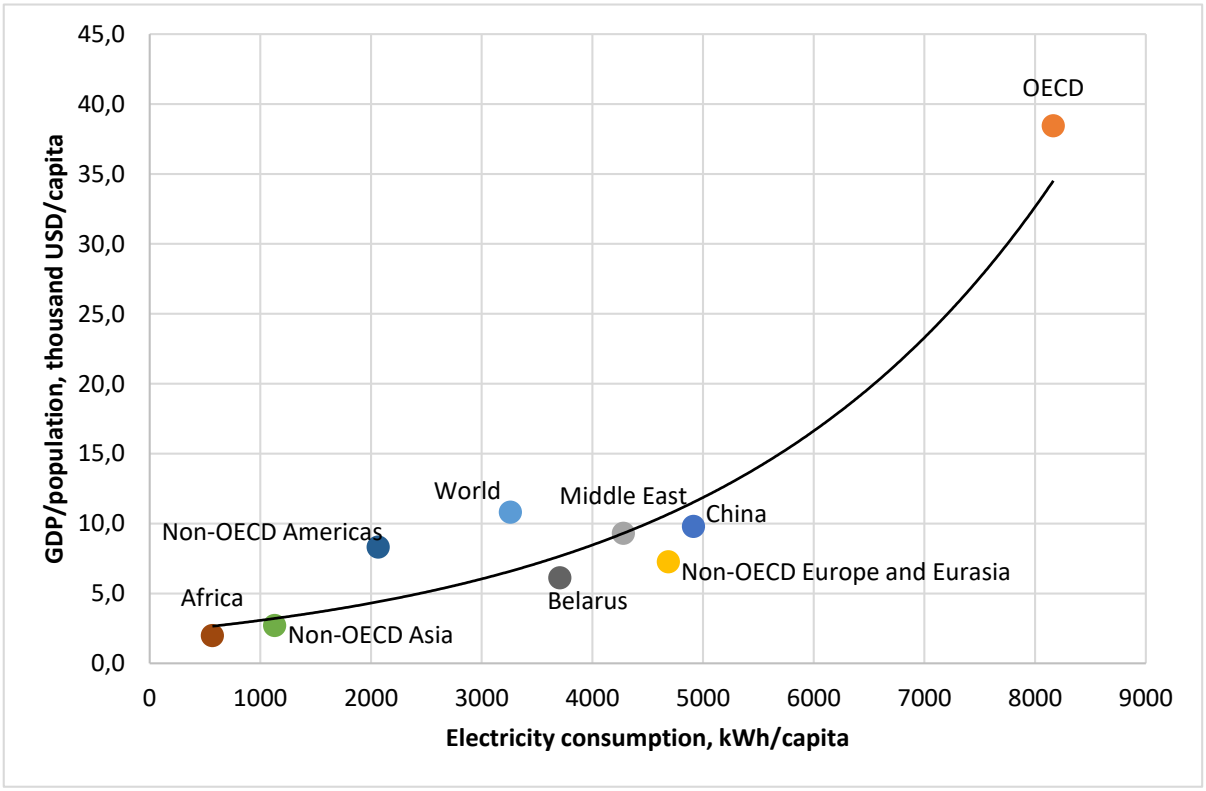


Fig. 1. Dependence of specific GDP on electricity consumption for different regions and countries, 2018 year (Source – International Energy Agency)

2. BENEFITS OF ELECTRIFICATION

From the data presented above, it follows that in order to increase the level of economic and social development of a country or region, it is necessary to provide energy supply with a high share of electricity. Electricity has significant advantages over other types of energy:

- Possibility of branching and transmission over long and short distances with relatively low losses;
- Implementation of energy flow control, regulation and automation and, as it is now fashionable to say, digitalization with high precision;
- Environmental cleanliness and absence of greenhouse effect for nuclear and renewable energy sources;
- Achievement of a high level of technical safety by simple and reliable means;
- Achievement of comfortable conditions for the consumer, etc.

Therefore, the share of electricity in final energy consumption is constantly growing at a higher rate compared to other energy sources (Figure 2) [2].

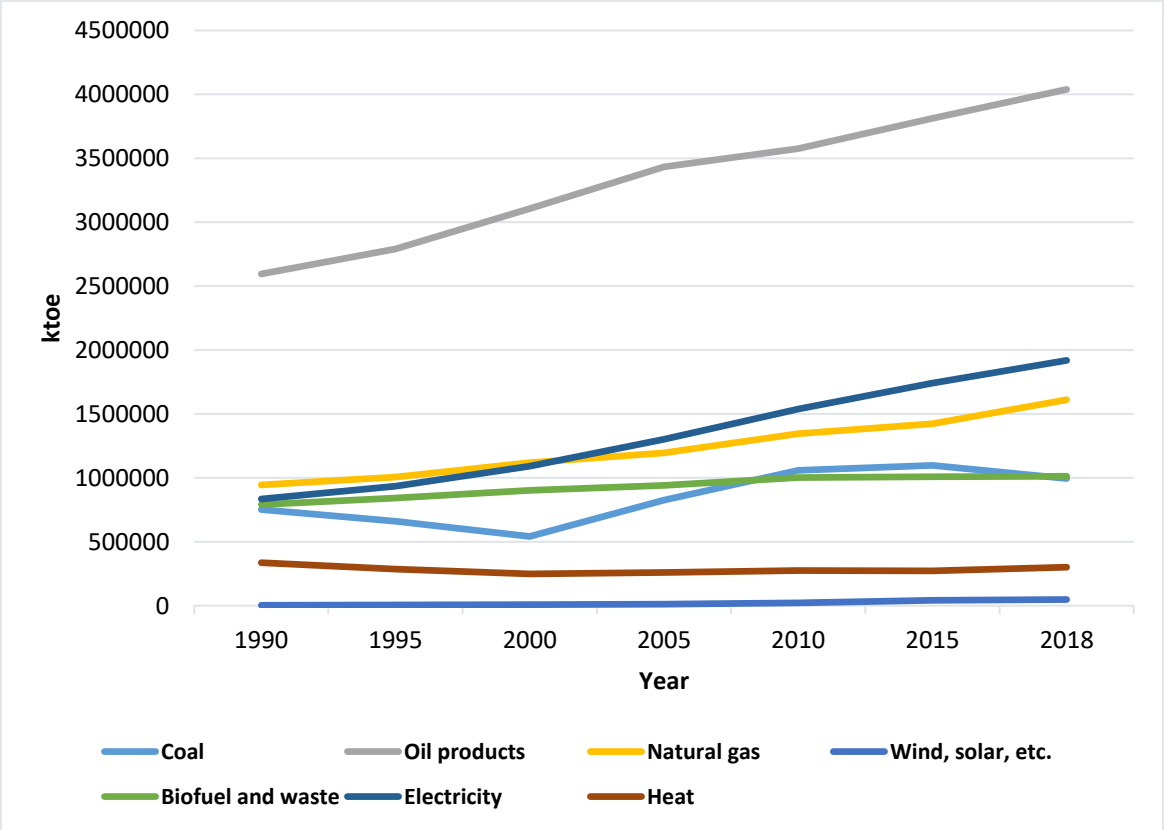


Fig. 2. World total final consumption by energy resource, 1990 – 2018 year
(Source – International Energy Agency)

According to the IEA, in 2018, electricity came in second place after oil and oil products in terms of final consumption, both in the world and in developed OECD countries.

Probably, in the next decade, electricity, bypassing oil, will take the leading position both in developed countries and on average in the world. It should be kept in mind that according to the World Bank in 2018, 13% of the world's population (about 1 billion people) did not have access to electricity - the

inhabitants of Africa, Central and South Asia. But in India, for example, about 30 million people get access to electricity every year.

3. SITUATION IN THE REPUBLIC OF BELARUS

The Republic of Belarus as part of the USSR was one of the economically developed republics. Specific electricity consumption in 1990 was 4850 kWh/capita, as in advanced European countries. Moreover, as shown in Table 1, during 15 years (1975 - 1990) the growth of specific electricity consumption in Belarus was higher than in the USA and the USSR as a whole, but mainly due to the fact that new power plants were built in other neighboring republics. As a result, during the first 15 years after gaining independence, Belarus became power deficient and had to import from 20 to 30% of the consumed electricity by the neighboring countries. Specific electricity consumption has fallen to a level of 3600-3700 kWh/capita in recent years.

Table 1. Annual power consumption and capacity per capita in Belarus, Former USSR and USA

Indicator		USA	USSR	Belarus
Electricity consumption, MWh/capita	1975 year	9,9	4,1	2,4
	1990 year	12,2	6,45	4,8
Ratio 1990/1975, %		1,23	1,57	2,0
Capacity of power plants, kW/capita	1975 year	2,47	0,86	0,56
	1990 year	3,04	1,34	0,66
Ratio 1990/1975, %		1,23	1,56	1,18

In 2008, it was decided to build its own nuclear power plant in Belarus. Currently, the process of commissioning of the first unit for commercial operation is being completed, and at the end of next year it is expected to reach the full capacity of two units, each with a capacity of 1200 MW. The Belarusian NPP will annually produce 18 billion kWh of electricity, with the current consumption of about 37 billion kWh per year. Therefore, the key problem for the Belarusian energy sector is to increase the share of electricity in the structure of final consumption.

4. THEORETICAL POTENTIAL OF ELECTRIFICATION

The theoretical potential for growth in electricity consumption can be determined from the fuel and energy balance of the Republic of Belarus. In 2019, the country produced and consumed 40,5 and 38,1 billion kWh of electricity, respectively. Exports amounted to 2,4 billion kWh. [3]

To assess the current (i.e., currently available) theoretical potential to increase the share of electricity, let us consider the structure of final consumption of energy resources in the Republic of Belarus in 2019. (Figure 3).

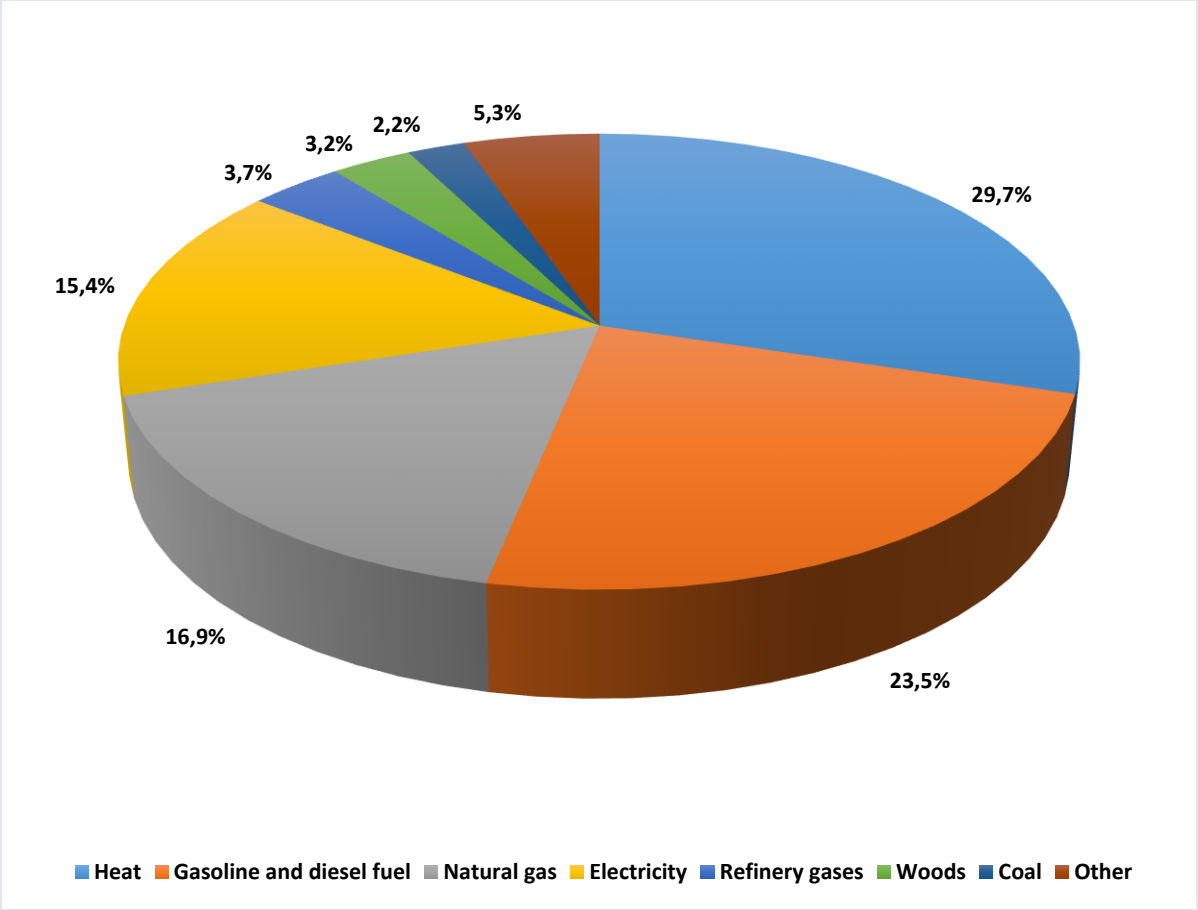


Fig. 3. The structure of final consumption of energy resources in the Republic of Belarus, 2019 year (Source – Energy balance of the Republic of Belarus)

Of the total consumption of 18,5 Mtoe of fuel and energy resources, almost one-third is used in the form of heat, followed by oil products (23,5%) and natural gas (16,9%). Electricity takes a modest fourth place on the list, with a share of only 15,4% [3]. If the first three energy sources, which together make up 70% of energy consumption, are replaced by electricity in the four most energy-intensive sectors (industry, residential, transport, and services), this would theoretically require nearly 120 billion kWh of additional electricity, given the corresponding efficiency factors. (Table 2)

Table 2. Theoretical potential of electricity final consumption increasing in the Republic of Belarus

Type of economic activity	Replaceable energy resource	Value, Mtoe	Theoretical potential, TWh
Industry	heat	2,06	23,9
	natural gas	1,07	12,4
Transport	gasoline and diesel fuel	3,48	28,2
Residential	heat	2,21	25,7
	natural gas	1,5	17,4
Comm. and public services	heat	1,03	12,0
Total		**11,35**	**119,6**

Naturally, the technically available value of this transformation, as will be shown in the next section, taking into account the experience of advanced countries, will be much smaller, but scientific and technological progress will contribute to further electrification in the economy and social sphere.

5. TECHNICALLY AVAILABLE POTENTIAL OF ELECTRIFICATION

Technically available potential of electrification in Belarus was assessed by the authors from The Institute of Power Engineering of the National Academy of Sciences of Belarus. For this purpose the share of electricity in the structure of final energy consumption in Belarus and other EU and CIS countries was compared. The countries, for which the study was carried out, were divided into groups: developed EU countries (Germany, France, Finland, Sweden were considered), EU countries - former members of the Council for Mutual Economic Assistance (Czech Republic, Slovak Republic, Poland). To compare consumption between countries, data from the International Energy Agency for 2016 [4] were used.

In the developed European countries the largest specific weight in the sphere of industry in terms of the use of fuel and energy resources has iron and steel; chemical and petrochemical industry; machinery and transport equipment; food and paper industry. In the transport sector, the most energy-intensive sector is road transport, but rail transport accounts for the largest share of electricity use. In the non-production sphere, a very important consumer of fuel and energy resources and electricity is the residential sector.

In Central European countries, the structure of fuel and energy consumption is generally similar to that in Western Europe, but the share of electricity used by industry is somewhat lower.

It should be noted that for many types of activities the level of electricity consumption in the Republic of Belarus is lower than the global average. The difference is especially noticeable in the production of non-metal products, machinery, food, paper and textile and leather industries, transport (especially railway transport), and the residential sector. An even greater difference is observed in comparison with the EU countries. At the same time, the greater the difference in the share of electricity in the structure of total consumption of fuel and energy resources between developed countries and the Republic of Belarus for each type of activity, the higher the potential for its increase.

Based on the analysis, the following types of economic activity were identified as the most promising for increasing the consumption of electricity in the country: residential sector, comm, and public services, railway transport, food industry, production of various non-metallic products, petrochemical production, machinery and transport equipment.

The technically available potential of increasing the share of electricity in the structure of final consumption by these types of economic activity is presented in Table 5.

Table 3. Calculation of technically available electricity consumption by type of activity [4]

Type of economic activity	Electricity consumption					
	Current consumption, ktoe	Current consumption, GWh	Current consumption structure, %	Perspective structure, %	Technically available consumption, GWh	Growth, GWh
1	2	3	4	5	6	7
Total final consumption	2526	29377	13,7	21,9	46961	17584
Chemical and petrochemical	295	3431	30,7	33,0	3688	257

Non-metallic minerals	96	1116	10,3	17,5	1897	780
Transport equipment	31	361	33,3	54,3	588	227
Machinery	115	1337	40,2	56,2	1870	532
Food and tobacco	137	1593	19,6	33,6	2731	1138
Rail	48	558	21,3	77,4	2029	1470
Residential	575	6687	11,3	25,4	15032	8344
Comm. and public services	688	8001	33,4	45,4	10876	2875
Total						**17584**

Thus, the possible increase in the share of electricity in the structure of consumption of fuel and energy resources by the selected types of economic activity to the level of developed European countries can amount to 17,5 billion kWh and additionally load more than 2 GW of generating capacity. At the same time, only the residential sector, the service sector and railroads provide more than 70% of the resulting growth value. The food industry and the non-metallic industrial sector can provide significant growth.

The most affordable and economically feasible way to increase electricity consumption in the country is the construction of fully electrified housing, i.e. residential buildings with heating and hot water systems based on electricity use.

CONCLUSIONS

Until mankind invents a new energy resource that is more efficient than electricity, the further electrification of our lives is inevitable. In addition to the advantages already discussed, this process has another important advantage. Figure 4 shows the correlation between the specific electricity consumption and energy efficiency (or energy intensity) of the economy for a number of countries [1], from which it follows that electrification is one of the methods of solving the global problem: increasing energy efficiency and reducing the impact of energy processes on the environment.

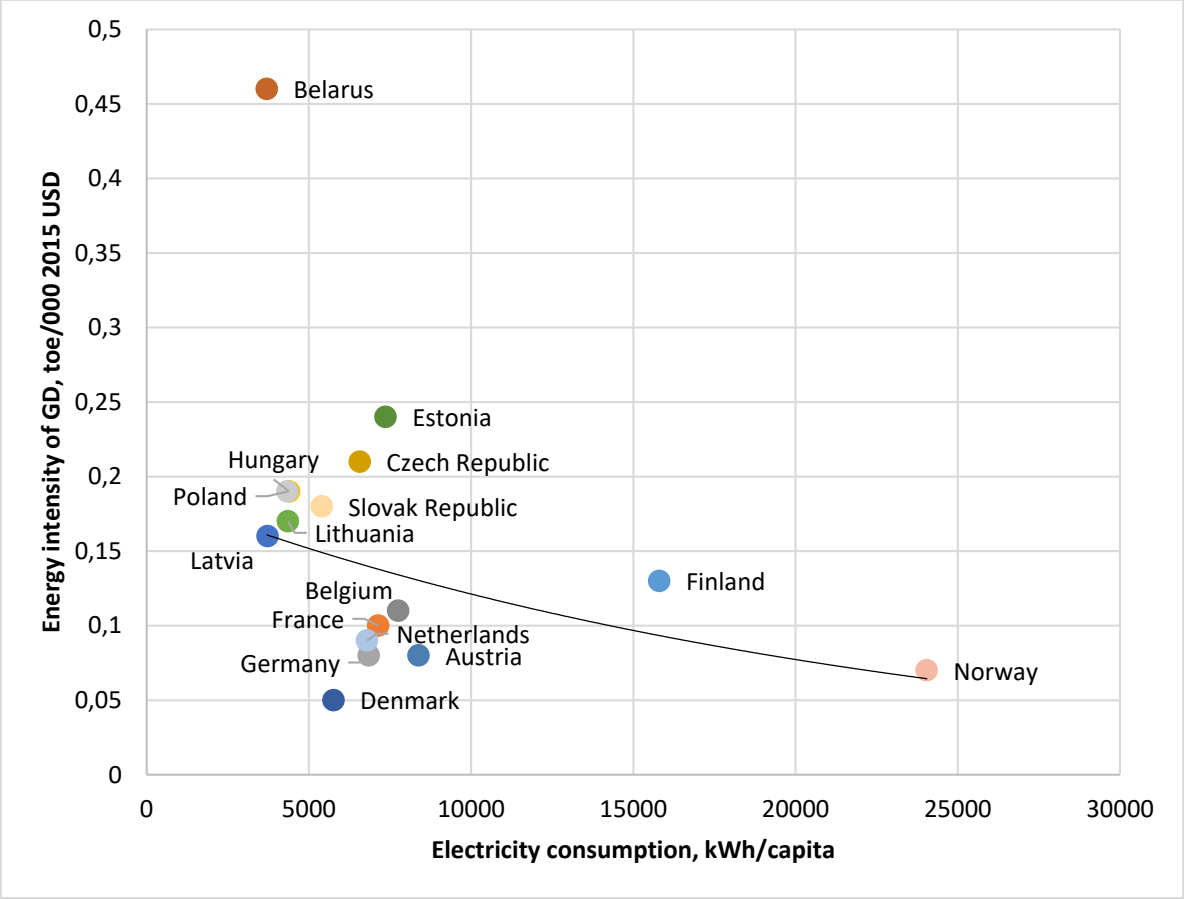


Fig. 4. Dependence of Energy intensity of GDP on electricity consumption for different countries, 2018 year (Source – International Energy Agency)

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