EVALUATING THE SUCCESS OF GERMANY'S STATE ENERGY POLICY

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Abstract: *Now the energy policy of Germany has changed and this is a new stage in its development. It is associated with sustainable development, environmental friendliness of energy production. First, the structure of Germany's fuel and energy balance is changing dramatically. We are facing a rejection of the use of nuclear energy, coal and oil fuels. On the contrary, alternative energy sources and natural gas are widely used. Secondly, the spatial-organizational structure of the electric power industry is set in motion. The number of companies that generate electricity from alternative sources has increased. This contributed to increased competition and a decrease in the share of production costs in the price of electricity for the end user. We set out to investigate the success of public policy measures. We compared changes in the fuel and energy balance structure with changes in the regulatory framework. It became obvious that the legislation in Germany was constantly changing, adjusting to the current situation. It was necessary to promptly solve unpredictable problems that appeared. It is shown that the main result of the measures of the energy policy of Germany is the improvement of the quality of life of the population, including the rural one.*

Key words: *alternative energy, Germany, energy policy, energy balance, energy transition*
JEL codes: *Q42, Q58, G18, G52*

1. Introduction

In 1998, the SPD and the Greens won the elections. They formed a coalition and became the head of the German government for the first time. They changed the vector of state policy in the country, imposed society environmental protection and sustainable development.

The purpose of this article is to study the effectiveness of measures of state support for certain areas of development of the German energy sector. We consider it necessary to analyse the main regulatory legal acts adopted by the German authorities, then - to compare them with changes in the fuel balance, and finally - to identify the correlation between these phenomena.

Today, the topic of sustainable development is exciting the minds of scientists around the world. Scientific research helps to better understand the role of each country in achieving the global sustainable development goal. Conditions, reasons for success are analysed. Forecasts are being built [Shuvalova et al. 2018; Rüdiger, 2014]. Ma and others [Ma, et al. 2021] talk about the importance of preserving the environment and reducing greenhouse gas emissions. A huge number of countries have joined the Paris Agreement to the United Nations Framework Convention on Climate Change. The countries of the European Union are implementing the initiative of their organization – the European Green New Deal initiative of the European Commission. It is known that industrialization leads to an increase in emissions, while an increase in household incomes leads to a long-term reduction in emissions. However, it is also clear that government policy, including policy on the development of alternative energy and support for the use of energy efficient technologies, can also affect the reduction of emissions. The author assumes that the economy will not suffer from these measures, but emissions will decrease. In the article [Kovalev et al. 2019] says that the problem of climate change due to human activities is a global problem and they can only be solved together. In recent years, the UN has held 22 events dedicated to the sustainable development of the planet.

A lot of attention in the literature is paid to the behavioural aspect [Woznica, 2019; Degterev, 2020; Raźniak, et al. 2021; Stryjakiewicz et al. 2014; Wang et al, 2020] because the effectiveness of promoting alternative energy and the success of projects in this area depends on the attitude in society. For example, the development of nuclear power is usually met with resistance from residents. However, the development of renewable energy sources favorably affects both the economy and tourism, and residents often favor the development of alternative energy.

Many articles deal with individual energy policy mechanisms [Bertsch et al. 2018; Fischer et al. 2021; Growitsch et al. 2015; Horschig et al. 2017], with international cooperation [Novikova et al. 2018; Ziolo et al. 2020]. In this article, we have conducted a comprehensive study on another topic, trying to assess the effectiveness of public policy. Usually laws are not always enforced. And for Germany, whose inhabitants are distinguished by organization and

diligence, it is extremely important that the Laws correspond to the time, technology and the needs of society.

2. Methodology and Data

We started writing this article by looking for statistics. Fortunately, it was easy to find, just like 15 years ago. The main source for the German energy sector is the Fuel and Energy Balance Working Group – «Arbeitsgemeinschaft Energiebilanzen» (www1).

Next, we started looking for a regulatory framework. The energy policy of the German Government was expressed in support measures. They developed and proposed laws to Parliament. Parliament approved them. Let's list some of them.

• 1991 – was adopted the Law on the priority supply of electricity generated from renewable energy sources to the power system – «Stromeinspeisungsgesetz».

• 1996 - was adopted European Union Directive 96/92/EU on the internal electricity market, replaced by Directives 2009/72/EU and 2019/994 on the liberalization of the electricity and gas markets.

• 1998 - was adopted a key document for the energy industry - the new Energy Law – «Gesetz ueber die Elektrizitaets- und Gasversorgung» in other words – «Energiewirtschaftsgesetz», which regulates the basic mechanisms of the functioning of the energy economy in Germany (the previous one was in force since 1935). The law was revised several times – in 2003, 2005, 2008 and 2011.)

• 1999 - was introduced an environmental tax for most of the energy industries.

• 2000 - was adopted the Law on Subsidizing Renewable Energy – «Erneuerbare-Energien-Gesetz». The law was revised several times – in 2004, 2009, 2012, 2014, 2017, 2021.

• 2001 –was concluded an agreement between the government of Germany and the operators of the nuclear power plant on the phasing out of nuclear energy – «Vereinbarung zwischen der Bundesregierung und den Energieversorgungsunternehmen». In addition, the law on nuclear energy – «Atomgesetz» has been changed.

• 2002 – was ratified the Kyoto Protocol the Paris Agreement to the United Nations Framework Convention on Climate Change.

• 2003 – was adopted the Law on Trading in Allowances to Emit Greenhouse Gases – «Treibhausgas-Emissionshandelsgesetz».

• 2005 – was adopted Ordinance on charges for access to electricity supply networks – «Strom- und Gasnetzentgeltverordnung».

• 2009 - was adopted Act on the extension of the transmission lines – «Energieleitungsausbaugesetz».

2009 – was adopted European Union Directive 2009/28/EC on the promotion of the use of energy from renewable sources

• 2010 - was adopted. National Renewable Energy Development Plan – «Energiekonzept für eine umweltschonende, zuverlässige und bezahlbare Energieversorgung».

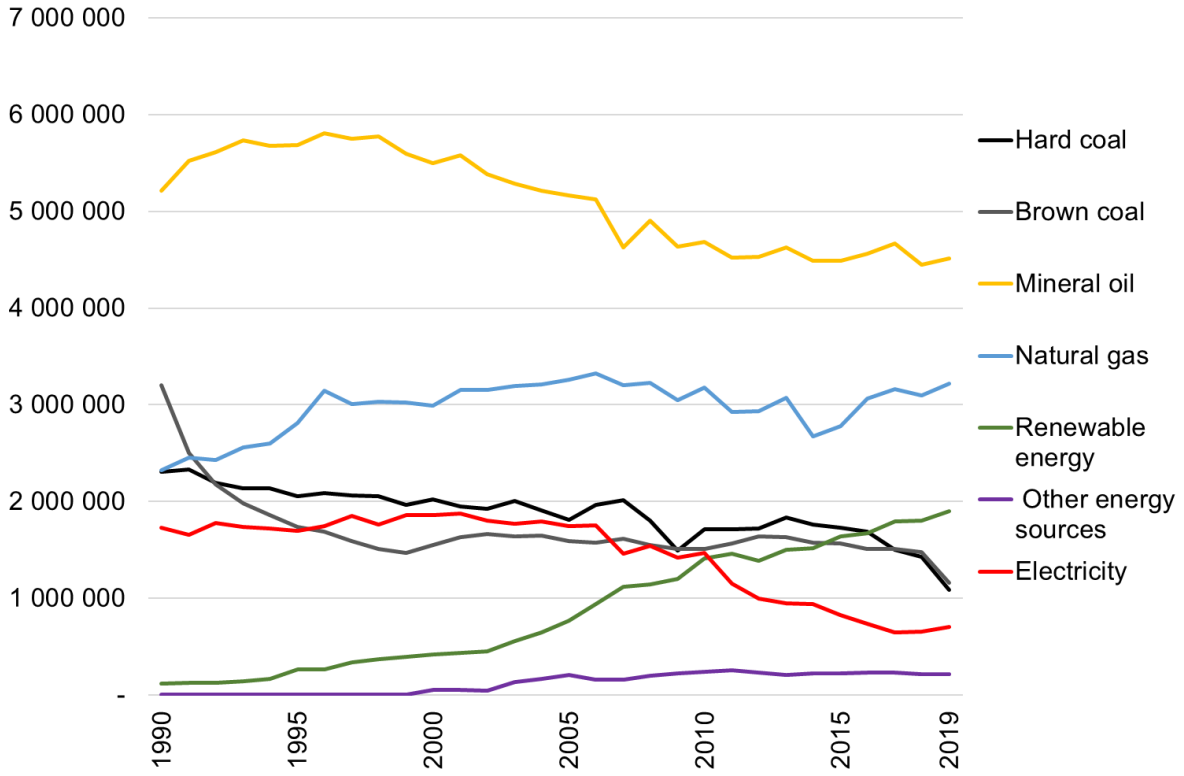
• 2010 – was adopted the Energy Strategy of Germany until 2035.

• 2013 – was adopted the Law on the State Target for Ensuring a Reliable Energy Supply – «Gesetz über den Bundesbedarfsplan».

• 2020 – was adopted the National Renewable Energy Development Plan of the German Government – «Nationale Energie- und Klimaplan der Bundesregierung».

Let us state the following fact. The accepted programs have been implemented. This becomes evident when analysing changes in the fuel and energy balance of Germany (Fig. 1, 2 and 3).

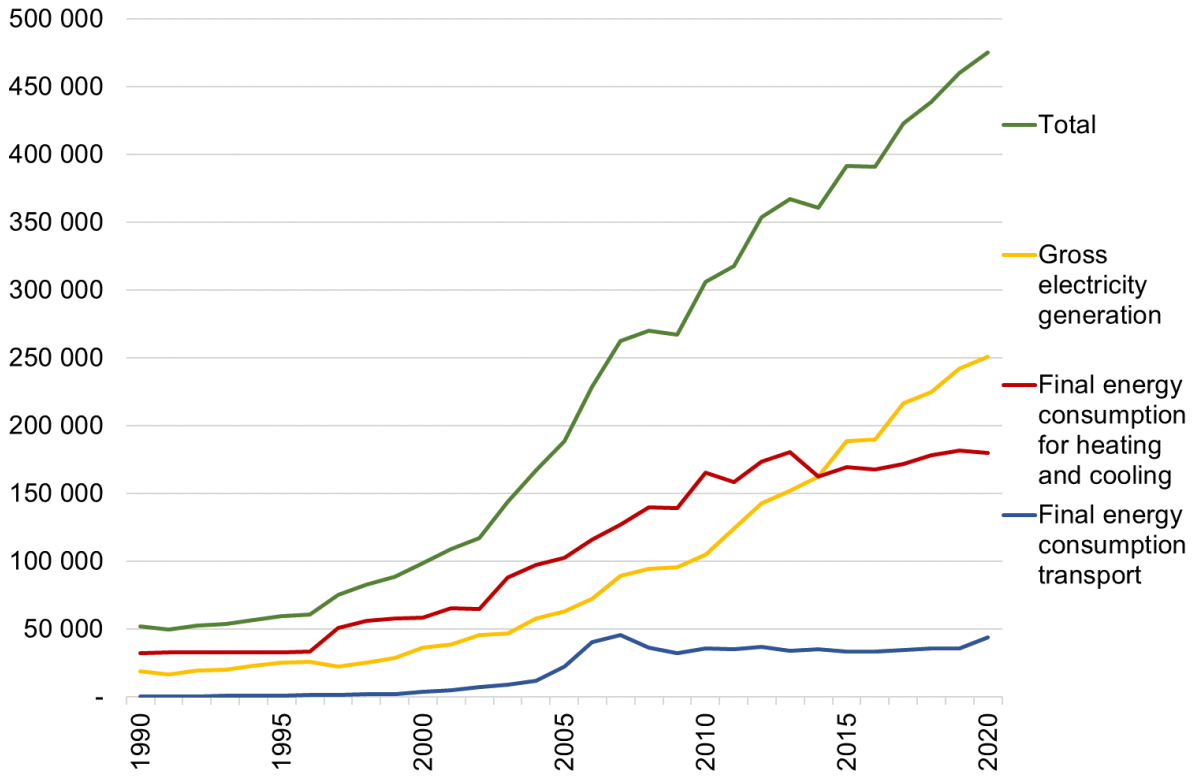
Fig. 1 Changes in the structure of consumption of primary energy sources in Germany, TJ



Source: (www1)

"Changes in the structure of consumption of primary energy sources in Germany" is illustrated in Fig. 1. The outstripping growth in natural gas consumption in the early 1990s is obvious, while oil consumption, on the contrary, has been steadily declining since 2000. One cannot fail to mention the use of coal - a traditional source of energy for Germany - in fact, the only fossil energy source in the country that is available in abundance. Perhaps, the decline over the past 30 years in the consumption of brown coal, mined primarily in East Germany, cannot be compared with any other source of energy. This decline was colossal - especially in the early years after the reunification of the Federal Republic of Germany and the German Democratic Republic.

Fig. 2 Change in the use of renewable energy sources for different needs, kW*h



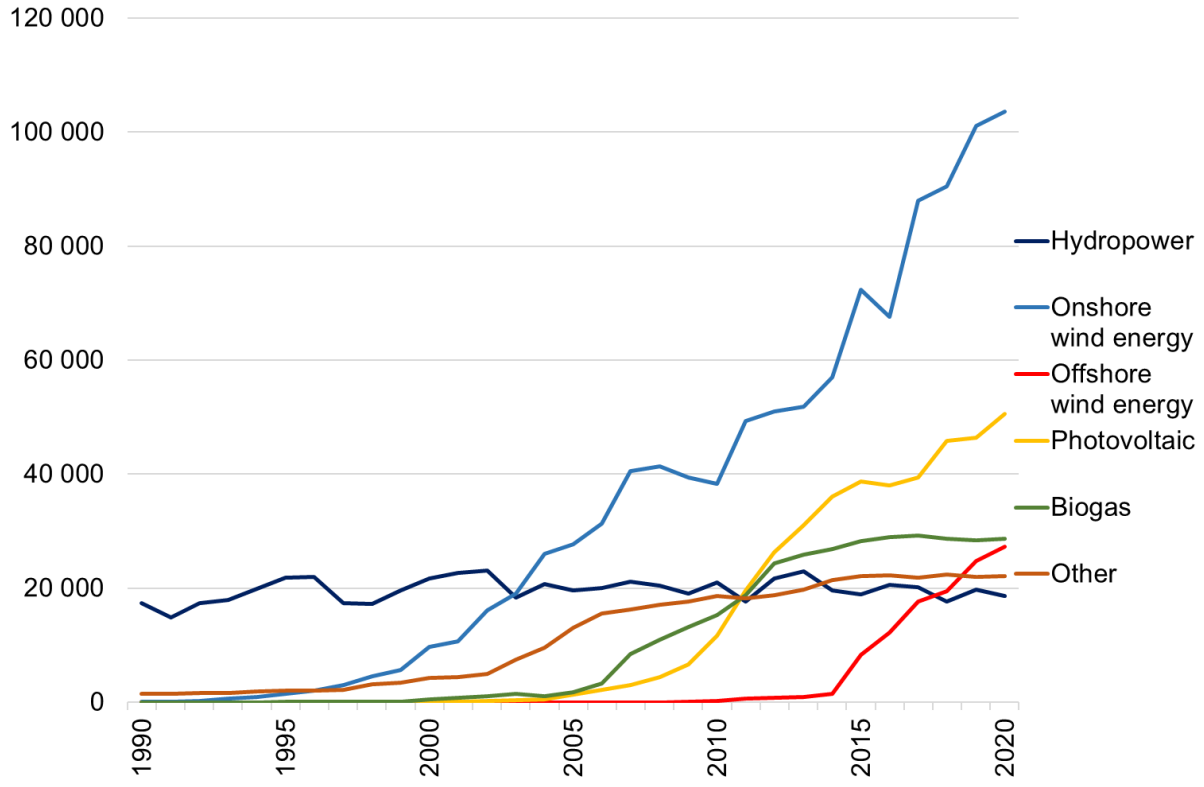
Source: (www1)

In recent years, the decline in consumption of brown coal has slowed down and goes in parallel with a decrease in the production of hard coal (the main fossil energy resource in West Germany). Thus, the adoption of strict environmental restrictions during this period affected the fact that the fuel base of the German electric power industry changed and switched from coal to environmentally cleaner, harmless natural gas. Electricity generation at nuclear power plants is included in the indicator "Electricity and other types of energy". Since 2008, the

production and consumption of nuclear energy has been inevitably reduced and tends to zero. In East Germany, all nuclear power plants were closed immediately after reunification. Currently, only a few previously built nuclear reactors continue to operate in all of Germany. But in 2022, not a single nuclear reactor will operate in Germany.

The main innovative energy source in Germany is renewable energy sources. 2003 to 2009 there was an increase in the use of renewable energy sources. The situation is illustrated in Fig. 2 ("Change in the use of renewable energy sources for different needs"). It is recorded that until 2014, most of the renewable energy sources were used for heat production. Since 1997, the positive dynamics of this process has continued. But 2014 was a watershed year. The first place among the main consumers of renewable energy sources is taken by the electric power industry. Since 1990, these industries have shown steady growth. Previously, the main renewable source of electricity in Germany was only hydropower. The maximum increase in electricity production using renewable energy sources was observed in the period 2004-2015. The use of renewable energy sources in transport in Germany has not yet achieved significant results.

Fig. 3 Structural changes шт epy electricity generation based on the use of alternative energy sources, GW*h



Source: (www1)

Over the past 30 years, hydroelectric power plants have produced approximately the same amount of electricity (Fig. 3). And hydropower is now the last on the list of renewable energy sources. Innovative energy sources in Germany are wind, solar and biogas fuels. 1990 to 2020 there is an increase in the production of electricity at wind farms. Wind power showed the highest rates of development from 1992 to 2005. (the growth rate is about 60% per year). And now the growth rates of electricity generation based on wind power plants operating on land are very significant (more than 10%). Since 2015, there has been a significant increase in electricity generation from innovative, expensive offshore wind farms. The first experimental wind turbines on the shelf of the North and Baltic Seas in Germany were built back in 2009. Support for the industry, clear legislative acts had a significant impact on the massive construction of power plants at sea. And its pace is not decreasing. Wind energy, converted into electricity onshore and offshore, remains the mainstay of renewable energy development in Germany today.

However, the fuel balance of electric power plants operating on alternative energy sources is gradually diversifying. Since 2005, there has been an increase in the production of electricity from solar power plants operating on photovoltaic cells. 2010 to 2014 the generation of electricity from photovoltaic modules of solar panels has grown the fastest.

A particular interest is caused by an increase in the production of electricity using biogas fuels obtained by fermentation. Period 2005 - 2012 is distinguished by increased values of the growth of this indicator. Of all types of biofuels in Germany, biogas is used primarily for electricity generation. There are few forests here; deforestation is almost completely prohibited. Therefore, crop production is used to generate energy, including electricity. A huge number of fields in Germany are sown with rapeseed. It is mainly used for making liquid biofuels. Only from cake - biogas. Good raw materials for biogas production are corn, rye, beets. If not for legal restrictions, perhaps all fields in Germany would be sown with industrial crops from which biofuels can be produced. But then the food security of the country would suffer. And the German authorities cannot allow this.

3. Results and Discussion

With our research, we tried to characterize and evaluate the effectiveness of state policy measures in the energy sector.

To do this, we compared, in chronological order, changes in the energy sector, primarily in the fuel structure within Germany, with changes in the regulatory framework (Fig. 4). As a

result, certain patterns crystallized. So in 1991, Germany adopted a law on the priority supply of electricity to the power system, generated on the basis of the use of renewable energy sources. This law started working at full capacity but did not become effective immediately. Experimental wind turbines were first built. The development of wind energy has brought about a major structural transformation in the German energy sector. The massive construction of onshore wind turbines to generate electricity on an industrial scale was particularly active from 1995 to 2005. However, the fastest introduction of alternative energy sources required the introduction of a number of additional regulations.

Tab. 1 Periods of extreme growth or decline (on an industrial scale) in the use of various energy sources (blue - growth, red - decline)

Indicators	Consumption of primary energy sources						Change in consumption of renewable energy sources for production of			Change in electricity generation using various renewable energy sources			
Energy source	oil	natural gas	brown coal	nuclear energy	hard coal	renewable energy	heat	electricity	auto fuel	wind energy onshore	photovoltaic	biogas	wind energy offshore
1990													
1991 - was adopted the Law on the priority supply of electricity generated from renewable energy sources to the power system													
1990-1995													
1996-2000													
2000													
1999 - was introduced an environmental tax for most of the energy industries 2000 - was adopted the Law on Subsidizing Renewable Energy 2003 - was adopted the Law on Trading in Allowances to Emit Greenhouse Gases 2005 - was adopted Ordinance on charges for access to electricity supply networks													
2001-2005													
2006-2010													
2010													
2010 - was adopted. National Renewable Energy Development Plan 2010 - was adopted the Energy Strategy of Germany until 2035													
2011-2015													
2016-2020													
2020													

Source: (www1)

In the late 1990s, the elections were won by the SPD / Green parties and they formed a coalition government. They raise the issue of improving the environmental friendliness of energy production. The above law played an important role in this matter. Investors began to develop clean energy production. From 1990 to 2000, natural gas consumption began to grow at a maximum rate.

This is not to say that the fuel structure in Germany changed only under the influence of state policy. Changes also occurred due to decision-making, events at the level of individual regions of the country. Thus, in the first years after the reunification of Germany, less and less brown coal was mined in the Middle German and Lusitz Basins. They are located in East Germany. West Germany experienced a coal mining crisis back in the 1960s. After the reunification, the economy of East Germany was rebuilt according to the West German model. At the same time as the consumption of brown coal fell in East Germany, the use of natural gas expanded. In the GDR, natural gas was practically not used for energy purposes. It was a valuable imported chemical raw material - natural gas was imported from the USSR. But as we can see, after the reunification, the concept of energy development in the Eastern states of Germany has changed.

In 1999, most of the energy industries were subject to an environmental tax. In addition, in 2000, the law on subsidizing renewable energy sources comes into force. In 2002, Germany ratified the Kyoto Protocol of the Convention on Climate Change, in 2003, the German law on the mechanism of emission of harmful substances was adopted. In other words, it becomes clear that the further development of the energy sector will be in line with these laws. As it turned out later, the policy was effective and results appeared.

First, since 2000, there has been a significant decline in oil consumption in the energy sector. Oil was the main source of energy in the German economy after the end of World War II (in the 1950s), when it was very cheap on the world market. The country imported oil. It was on cheap oil that the economic recovery of West Germany went.

Secondly, the 2000s saw the greatest growth in the use of renewable energy sources - especially in the heat power industry. Heat power engineering is a technologically simple process that does not require significant investments. However, in 2015, district heating through the use of renewable energy sources slowed down. Mechanisms of state support for other alternative energy sources began to work. In other words, from now on, most of the renewable energy sources in Germany are used to generate electricity, not heat. Electricity production, in contrast to heat production, is more expensive and more high-tech. It has a greater effect on the

country's economy. The fact that in Germany renewable energy sources are the main resource for generating electricity, and not heat, strikingly distinguishes this country from neighboring Eastern European countries, where renewable energy sources are most often used in simpler technological processes - for generating heat.

In 2005 was adopted Ordinance on charges for access to electricity supply networks, providing for the introduction of a new tax. The creation of a large number of small electric power industries, primarily wind power plants, has changed the structure of the energy system. If earlier the current was supplied to the consumer from large power plants, now there is a dispersed network of small power plants. They had to be integrated into the power system - connected to high-voltage power lines. It was impossible to develop the energy sector without an additional regulatory legal act related to supporting the development of the network. Since 2005, there has been a very active rise in the production of electricity from renewable energy sources. At the same time, the structure of electricity production began to diversify. The graph (Fig. 4) shows that since 2005, biogas fuel has been actively used for electricity generation in Germany. And since 2010, solar power plants have been built on an industrial scale.

In 2005, 2009 and 2013, plans were adopted for the development of the German energy system - power lines. There is a renewal, and in fact, the revision of existing laws. In particular, these national plans provided for the construction of four trunk lines from the north of Germany, where large offshore wind farms will soon be located, to the south of Germany, where the main consumers of electricity are located.

The adoption of these regulations led to the following events. The culmination of the development of alternative energy in Germany has been the construction of wind power parks on the shelf of the North and Baltic Seas since 2015. These investment-costly projects require a huge amount of documentation, approvals, the use of high technologies, sales forecasting, etc. These investments, all these aspirations would have been impossible to realize if a clear regulatory and legal framework had not been developed. It was supplemented by comprehensive documents and comprehensive energy development programs in general. In 2010, Germany adopts such documents as the National Renewable Energy Development Plan and the German Energy Strategy until 2035.

But there were also tragic events in other countries that influenced the development of the energy sector in Germany. In 2011, there was an accident at the Fukushima nuclear power plant in Japan. Since 2001, the German government has been consistently pursuing a policy of abandoning the use of nuclear energy domestically. However, the question of the possibility of

operators extending the service life of nuclear reactors was considered. The accident at the Japanese nuclear power plant "Fukushima" and social protests in society forced the German government to virtually abandon the production of electricity at nuclear power plants.

4. Conclusions

The concept proclaimed by the first Federal Chancellor of the Federal Republic of Germany, Konrad Adenauer, is still valid. To address social issues, the state redistributes income within the country. Sustainable development, energy security of the country are also important goals that contribute to the prosperity of society. The authorities have a certain influence on the economy. True, at present it seems that the state is taking away from ordinary citizens - after all, the development of alternative energy is financed by the Germans from their own pockets. So much money is not taken from industrial enterprises, because industry ensures the country's competitiveness The population of Germany has financial well-being, due to which it was possible to implement large-scale programs for the development of renewable energy. But it cannot be said that projects for the development of alternative energy in Germany were implemented without a hitch. Government authorities reacted to the problems and promptly changed legislation.

Also, do not forget that Germany, developing alternative energy, pursued not one, but several goals. Germany is a recipient of energy resources. It cannot provide its needs with fossil fuels in time. By developing renewable energy, it is trying to get rid of energy imports. There are other positive aspects of the development of renewable energy. This is a huge experience in restructuring the entire energy system and energy infrastructure. The development of alternative energy has contributed to technological progress. Germany has always been famous for its high-quality technological solutions. In the energy sector, there is an all-encompassing reallocation of capital. This is worth mentioning separately. After all, the change in the fuel base of power plants has led to changes in the ownership structure of electric power facilities. Large vertically integrated companies in Germany are selling fossil fuel power plants and buying and building offshore wind farms.

At this stage of development, the promotion of alternative energy has made a great contribution to the elimination of the natural monopoly. Large vertically integrated companies began to change the profile of their activities. They began to focus on the most profitable business areas that receive government support. This is a dealer network and sales business, electricity generation using alternative energy sources. The network distribution business

associated with the transmission of electricity through high-voltage transmission lines over long distances was taken away from them. At the same time, the distribution of electricity and its sale turned out to be no less, but rather even more profitable under the new conditions.

In other words, we traced a direct correlation between the actions of the authorities, including the adoption of regulatory legal acts, and changes in the energy sector, including changes in the fuel and energy balance. But the main effect of the modern energy policy in Germany is to improve the quality of life, increase the stability of the economy. Not only the quality of life of urban residents (of which there are more than 75% in the country), but also of rural residents has improved. After all, environmentally "dirty" power plants have always been outside the cities (that is, in the countryside). In the cities, however, only those industries remained that required proximity to the consumer, for example, heat production. Therefore, it is believed that rural residents received the greatest benefit from the development of alternative energy. They themselves participated in the development of alternative energy. Landowners have built wind farms, solar power plants. This business brings them additional income. Power plants require maintenance, connection to power lines and other services. All this revitalizes the life of rural areas and even makes it possible to facilitate the resettlement of the population there from cities.

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