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Climate Protection and German Energy Security in the Second Decade of the 21st Century

Introduction

The fight against global warming has entailed several modifications in the sphere of energy, the environment, industry, and agriculture. This issue is clearly related to innovation, and the transfer of technology, as well as security, migration and structural changes in regions affected by climate change. Climate policy, in turn, is a type of political activity conducted on both internal and international levels, and is aimed at reducing, or at least stalling, the progress and effects of global warming.

Climate protection requires the rebuilding of the energy system towards a greater use of renewable energy sources instead of coal, oil, or natural gas, which, in turn, translates into reducing greenhouse gas emissions. That is why the energy policy has over the last couple of years been mainly focused on achieving the objectives related to environmental and climate protection, followed by enhancing the security of energy supply, or developing competitiveness.

The reliability of supply is a measure of energy security with economically justified price levels and a limited impact on the environment and climate. In the case of the security of supply – or rather the security of energy supply – a distinction is usually made between its three components: technical, technological, and political[1]. The first component concerns the extent to which the energy system is able to provide

[1] K. Pittel, 'Das energiepolitische Zieldreieck und die Energiewende', *ifo Schnelldienst*, 2012, Vol. 65, Iss. 12, p. 22.

uninterrupted energy, and to respond to technical disruptions. This means that the technical infrastructure of the energy management of a given state is sufficient, reliable, well exploited, and does not pose a threat to energy security. The second component maintains energy quality standards: the economy uses new technologies and new energy sources, and research and implementation ensure access to new technologies. Political security, on the other hand, concerns the effects of dependence on energy imports. It includes issues related to the access to energy sources, transport routes, and energy conversion installations[2].

The security of energy supply requires limiting dependence on imports of energy resources from politically unstable countries, because it carries the risk of interruption of supply, which, in turn, could have a negative impact on the economy, and everyday life. Reducing fossil fuel consumption is essential to achieving two goals: increasing energy security, and protecting the climate. Nevertheless, actions taken to increase energy security and environmental and climate protection may be mutually exclusive. For example, there may be a preference for using individual carbon resources, but its combustion releases CO_2. A major solution to reduce a significant amount of CO_2 emissions is the carbon capture and storage technology (CCS)[3]. Replacing solid fuels with natural gas in electricity production is intended to reduce greenhouse gas emissions. However, in the case of small own resources it may increase the import of raw material from abroad. In turn, the advantage of nuclear energy over other energy sources is that the electricity produced from it can be supplied at any time. Although it is a low-carbon source of energy, the problem is the storage of radioactive waste generated from the fuel used and the costs of possible failure of nuclear reactors. The development of renewable energy sources has the effect of reducing dependence on fossil fuel imports, thus increasing the level of the security of energy supply, as well as greenhouse gas emissions[4].

The energy transition in Germany – admittedly a process of transition from high-carbon forms of economic development – is a response to the challenges related to ensuring the security of energy supply, environmental protection, and climate. This means that as regards energy production, it is based on renewable energy sources, and in the process of its use on saving and increasing energy efficiency. However, the reconstruction of the energy economy has specific implications for society, the domestic economy, but above all for the security of Germany's energy supply.

The aim of this paper is to outline the linkages between the issue of climate protection and Germany's energy security in the second decade of the twenty-first century. It briefly discusses the development of Germany's sustainable energy policy initiated in the 1990s, and includes statistical data showing changes in energy efficiency, the development of renewable energy sources, and the reduction of greenhouse gas emissions. It also looks at the main problems related to ensuring the security of Germany's energy supply in the energy transformation process, especially

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2 G. Bartodziej, M. Tomaszewski, *Polityka energetyczna i bezpieczeństwo energetyczne*, Warszawa-Racibórz 2009, pp. 77–78, 96.

3 F. Müller, 'Klimapolitik und Energieversorgungssicherheit: zwei Seiten derselben Medaille', *SWP-Studie* 2004, S 14, p. 7.

4 B. Molo, *Die Energiepolitik Deutschlands im 21. Jahrhundert. Determinanten – Ziele – Maßnahmen*, Berlin 2014, pp. 45–46.

against the backdrop of the climate protection requirement. The paper rests on historical-comparative analyses, as well as elements of decision-making and (institutional)-legal methods, and it is based on primary sources, studies, and the author's individually conducted research[5].

Towards a sustainable energy policy (energy transition)

The objectives of the energy policy of the state include: security of supply, competitiveness, and sustainability. Although Germany classifies these three goals as equivalent, traditionally competitiveness or sustainable development have been prioritised in the process of implementing specific energy policy solutions. This approach, in relation to the goal of sustainable development, its origins in the 1980s. At that time, in a relationship including with the public debate in the Federal Republic of Germany on forest degradation, an environmental protection requirement was added to the concept of energy policy. On the other hand, in the late 1990s, the objectives of energy policy were supported by national and international efforts to shape the structure of energy supply in connection with reducing greenhouse gas emissions[6].

Significant changes in Germany's energy policy were initiated with the creation of the coalition government SPD/Alliance 90/The Greens in 1998. The "Ecological modernisation" focused on reforming the energy sector, and several watershed decisions were made. In addition to increasing energy efficiency, and taking into account environmental protection requirements in energy supply, the main objectives of the energy policy were the development of renewable energy sources, and the abandonment of nuclear energy. The amended Atomic Energy Act of 2002 provided for a gradual phasing out of nuclear power plants by 2022 and imposed electricity production limits for each of the reactors operating at that time. The development of renewable energy sources was to be supported by the Renewable Energy Sources Act (*Erneuerbare-Energien-Gesetz*, EEG) of 29 March 2000. The policy of ecological modernisation rested, among others, on energy saving and the development of electricity and heat cogeneration installations. In April 2002, the federal government adopted national sustainable development strategy "Perspectives for Germany – Our Strategy for Sustainable Development" (*Perspektiven für Deutschland. Unsere Strategie für eine nachhaltige Entwicklung*), which was to link energy policy with climate protection. The policy of the two governments of the SPD/Alliance 90/The Greens coalition (1998–2002[7], 2002–2005) is currently perceived as an indicator of the development trend of Germany's energy and environmental policy in the subsequent years[8].

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5 *The research was co-financed from funds allocated for the statutory activity of the Faculty of Law, Administration and International Relations of the Andrzej Frycz Modrzewski Krakow University no. WPAiSM/DS/1/2019.*

6 See: F. Illing, *Energiepolitik in Deutschland. Die energiepolitischen Maßnahmen der Bundesregierung 1949–2015*, Baden-Baden 2016.

7 L. Metz, *Ökologische Modernisierung und Vorreiterrolle in der Energie und Umweltpolitik? Eine vorläufige Bilanz*, [in:] Ch. Egle, T. Ostheim, R. Zohlnhöfer (eds.), *Das Rot-Grüne Projekt. Eine Bilanz der Regierung Schröder 1998–2002*, Wiesbaden 2003, pp. 329–350.

8 See: K. Dobersalske, *Die rot-grüne Energiewende. Nachhaltige Energienutzung in der Entwicklungszusammenarbeit unter Rot-Grün*, Marburg 2010.

On the whole, the CDU/CSU/SPD coalition government that was in power from 2005 to 2009 continued to develop a sustainable energy policy, especially in the context of the debate on international climate protection, including at the EU forum. In August 2007, Angela Merkel's government adopted the Key Elements of an Integrated Energy and Climate Programme (*Eckpunkte für ein integriertes Energie- und Klimaprogramm*). The 29 points of the document measures whose implementation was to result in reduced energy consumption in plants, home appliances, individual heating of houses and flats, and vehicles, and as a result a reduction of negative changes in the natural environment. The goal was to increase the share of renewable energy in electricity production to 25–30 percent and heat production to 14 percent by 2020. In turn, the biogas share was expected to increase to 10 percent, which would reduce the dependence on natural gas imports. The federal government also intended to introduce more ecological coal combustion technologies, i.e. to build and launch two or three pilot power plants equipped with carbon capture and storage (CCS) systems and to create the right conditions for the development and use of this technology[9]. On December 5, 2007, the federal government adopted a package of proposals for changes to existing laws and ordinances, which were adopted in 2008. They were all a reflection of the similar standpoints of the coalition partners on the inclusion of environmental and climate protection requirements in the energy policy. The issue of the future of nuclear energy, however, remained open, because the coalition partners represented different stances: the SPD opposed the extension of the deadline to abandon nuclear power, and the CDU/CSU was in favor of extending the period of operation of nuclear power plants in order to achieve climate policy goals[10].

The emphasis within the energy policy of the CDU/CSU/FDP coalition, which was in power from 2009 to 2013, was, alongside the development of renewable energy sources, placed to strengthen competition in the energy market (in the case of electricity and natural gas), save energy, create a modern and effective energy infrastructure and developing a sustainable energy mix. Measures to modernise the energy sector were broadly in line with previous government programmes, and the key difference was the use of nuclear energy. It was decided to extend the life of the nuclear power plants by 8 or 14 years, depending on their age, which meant that the last one would be shut down in 2036. The energy concept adopted by the Federal Government on September 28, 2010 was a scheme for a comprehensive change of the energy sector in the perspective of 2050. Targets were set for reducing greenhouse gas emissions, developing renewable energy sources, and increasing energy efficiency[11]. The disaster at the Fukushima-Daiichi Nuclear Power Plant in March 2011

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9 *Eckpunkte für ein integriertes Energie- und Klimaprogramm*, http://www.bmwi.de/BMWi/Redaktion/PDF/E/eckpunkt-fuer-ein-integriertes-energie-und-klimaprogramm,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf [accessed: 10.01.2019].

10 See more: A. Sohre, *Strategien in der Energie- und Klimapolitik. Bedingungen strategischer Steuerung der Energiewende in Deutschland und Großbritannien*, Wiesbaden 2014.

11 *Energiekonzept für eine umweltschonende, zuverlässige und bezahlbare Energieversorgung*, 28.09.2010, http://www.bundesregierung.de/Content/DE/_Anlagen/2012/02/energiekonzept-final.pdf?__blob=publicationFile, [accessed: 10.01.2019].

contributed to taking expeditious steps aimed to modify Germany's energy policy concept, including a plan to phase out nuclear power plants by 2022[12].

The CDU/CSU/SPD coalition government of 2013–2017 continued the energy transition process[13]. The Renewable Energy Sources Act, amended in 2014, introduced an annual limit on new renewable energy installations. The changes in the support system for renewable energy sources were to stabilise the increase in the capacity of new installations, reduce support costs, and initiate the marketization of the renewable energy sector. However, the amendment to the 2016 Act assumed a partial release of the renewable energy market, including the abandonment of most guaranteed tariffs, and the introduction of tenders in their place. Since January 1, 2017, the tender system has covered all investments in renewable energy sources, except for the smallest solar power plants installed by private individuals. Angela Merkel's government has intensified efforts to increase energy efficiency. The National Action Plan on Energy Efficiency (*Nationaler Aktionsplan Energieeffizienz*, NAPE) was adopted by the federal government on December 3, 2014, and the Energy Efficiency Strategy for Buildings (*Effizienzstrategie Gebäude*, ESG) was launched on November 18, 2015. Achieving the goal of reducing greenhouse gas emissions by 40 percent by 2020 was supposed to serve the Climate Action Programme 2020 (*Aktionsprogramm Klimaschutz 2020*), adopted by the federal government on December 3, 2014. It contains a list of activities that should lead to a reduction of 62 to 78 million tonnes of equivalent CO_2 until 2020[14]. So far, over 70 percent of the measures provided for in the document have been implemented. The Climate Action Plan 2050 (*Klimaschutzplan 2050*), which was adopted by the federal government on November 14, 2016, points the way to a climate neutral economy. The Climate Action Plan 2050 links the achievement of national greenhouse gas emission reduction targets with the provisions of the Paris Agreement to the United Nations Framework Convention on Climate Change of 12 December 2015. In order to reduce greenhouse gas emissions by at least 55 percent by 2030 compared to 1990 levels, sector-specific reduction targets have been set: for the energy sector – 61–62 percent, for construction – 66–67 percent; for transport – 40–42 percent, for industry – 49–51 percent, and for agriculture – 31–34 percent. The importance of forests mitigation potential (by absorbing carbon dioxide) was highlighted too[15].

The CDU/CSU/SPD coalition, which has been leading the country since 2018, has to face the difficulties of achieving ambitious energy and climate policy goals. Activities are continued to create an energy system based on renewable energy sources,

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12 Ch. Huß, *Durch Fukushima zum neuen Konsens? Die Umweltpolitik von 2009 bis 2013*, [in:] R. Zohlnhöfer, Th. Saalfeld (eds.), *Politik im Schatten der Krise. Eine Bilanz der Regierung Merkel 2009–2013*, Wiesbaden 2015, pp. 521–553.

13 A. E.Töller, *Kein Grund zum Feiern! Die Umwelt- und Energiepolitik der dritten Regierung Merkel (2013–2017)*, [in:] R. Zohlnhöfer, Th. Saalfeld (eds.), *Zwischen Stillstand, Politikwandel und Krisenmanagement. Eine Bilanz der Regierung Merkel 2013–2017*, Wiesbaden 2018, pp. 569–590.

14 *Aktionsprogramm Klimaschutz 2020*. Kabinettsbeschluss vom 3. Dezember 2014, https://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Aktionsprogramm_Klimaschutz/aktionsprogramm_klimaschutz_2020_broschuere_bf.pdf [accessed: 10.01.2019].

15 *Klimaschutzplan 2050. Klimaschutzpolitische Grundsätze und Ziele der Bundesregierung,* November 2016, https://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Klimaschutz/klimaschutzplan_2050_bf.pdf [accessed: 10.01.2019].

energy efficiency, accelerated development of electricity networks, and the reduction of energy production from fossil fuels. Accelerating the development of renewable energy sources is of key importance to meet the demand for electricity, as well as achieving the goals of reducing greenhouse gas emissions in the transport, construction and industry sectors. In order for Angela Merkel's government to make progress in reducing greenhouse gas emissions, it is necessary to adopt a plan to shut down coal-fired power plants, the implementation of which will not result in energy supply deficits. The Commission on Growth, Structural Change and Employment, appointed by the federal government, published a final report on January 26, 2019, in which it recommended closing the last coal power plant by 2038 at the latest. In 2032, the possibility of accelerating the closure of all lignite mines and lignite power plants is to be explored, i.e. until 2035. The Commission has also taken into account the faster start of the so-called "coal exit": it proposed that 12.5 GW of coal power plants' power should be shut down (they currently have a capacity of about 45 GW) by 2022. These are power plants that should be closed due to their advanced age. However, the Commission report did not mention any specific coal-fired power plants that should be excluded. According to the Commission's recommendation, only 20 GW of coal-fired power plants will work in 2030 (8 GW of hard coal and 9 GW of brown coal). The implementation of these recommendations would imply large contributions to achieving the goal of reducing greenhouse gas emissions by 2030. In addition, over the span of 20 years, the German Länder will receive EUR 40 billion for restructuring. The funds are to be used to finance early retirement for brown coal sector employees, and for the development of regions affected by the closure of mines and coal power plants[16]. In connection with ensuring the implementation of climate policy objectives, work was initiated on the preparation of the Climate Protection Act (*Klimaschutzgesetz*). The bill presented by the Minister of the Environment Svenja Schulze in February 2019 contains a provision that greenhouse gas emissions will be gradually reduced compared to 1990: 1) at least 40 percent by 2020, 2) at least 55 percent by 2030, 3) at least 70 percent by 2040, 4) at least 95 percent by 2050. To achieve the above goals, emission reductions have been set for the following sectors: 1) energy sector, 2) industry, 3) transport, 4) construction, 5) agriculture, 6) waste management, and others[17].

Achieving energy and climate protection goals (statistical data)

The goal of implementing a sustainable energy policy is to strive to maintain a balance between energy security and the protection of the environment and climate

[16] *Abschlussbericht Kommission „Wachstum, Strukturwandel und Beschäftigung"*, *Beschluss vom 26.01.2019*, https://www.greenpeace.de/sites/www.greenpeace.de/files/publications/abschlussbericht_kommission_wachstum_strukturwandel_und_beschaeftigung_beschluss.pdf [accessed: 28.02.2019].

[17] *Referentenentwurf des Bundesministeriums für Umwelt, Naturschutz und nukleare Sicherheit, Bundes-Klimaschutzgesetz (KSG)*, https://www.klimareporter.de/images/dokumente/2019/02/ksg.pdf [accessed: 28.02.2019].

against the negative impact of energy-related activities, in addition to meeting social needs and the competitiveness of services in the sector. Energy efficiency and renewable energy sources are the pillars of the sustainable energy policy. The development of renewable energy sources should contribute to increasing energy security by reducing dependence on imports of fossil fuels and to achieving climate policy goals, i.e. reducing greenhouse gas emissions in energy production and management processes.

Energy efficiency

According to the energy concept of the Federal Government, the final energy productivity in the period from 2008 to 2050 is to be increased by 2.1 percent annually. At the same time, primary energy consumption should decrease by 20 percent by 2020, and by 50 percent by 2050, compared to 2008[18].

In the period from 1990 to 2017, primary energy consumption fell by 9.3 percent (1990: 14906 PJ, 2017: 13525)[19]. Final energy consumption in Germany has fallen by 3.4 percent since the beginning of the 1990s until 2016 (1990: 9472 PJ, 2016: 9152). In the long-term trend, energy consumption has increased in the transport sector, while it has declined in the industrial, trade, commerce, and services sectors. In 2016, the sectoral shares in final energy consumption of transport were around 29.5 percent (2,696 PJ), industry 28.2 percent (2,581 PJ), private households 26.2 percent (2,394 PJ) and the sector of trade, commerce and services at 16.2 percent (1,480 PJ)[20].

In terms of primary energy consumption, energy productivity increased by 65.2 percent in the period that spans from 1990 to 2017. Energy productivity in 2017, once again, improved by 1.4 percent over the previous year. In terms of primary energy consumption, the average growth rate of energy productivity stood at 1.8 percent per year[21].

Final energy productivity increased by 51.7 percent in the period from 1990 to 2016, which corresponds to an average growth rate of 1.6 percent per year. From 2008 to 2016, the annual increase in final energy productivity averaged around 0.9 percent. While gross domestic product grew by 46.6 percent since 1990, final energy consumption fell by 3.4 percent[22].

Final energy productivity increased by 9.6 percent from 2008 to 2017 according to preliminary results, corresponding to an average annual increase of 1.0 percent This means that the target of an annual average increase of 2.1 percent by 2050 has not been reached yet. Compared with the previous year, energy productivity in 2017 even fell by 0.9 percentage points. This was due to the fact that final energy consumption in each sector, except for private households (+ 2.2 percentage, compared to the previous year), increased proportionately faster than the gross domestic

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18 *Energiekonzept für eine..., op. cit.*

19 'Energieeffizienz in Zahlen. Entwicklungen und Trends in Deutschland 2018', BMWi, p. 14, https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/energieeffizienz-in-zahlen-2018.pdf?__blob=publicationFile&v=5 [accessed: 10.01.2019].

20 *Ibid*., p. 19.

21 *Ibid*., p. 24.

22 *Ibid.*, p. 26.

product. Although primary energy consumption was lower than in 1990, it increased slightly compared to the previous year. According to preliminary results, in 2008–2017 primary energy consumption decreased by 5.5 percent If the trend remains the same as in previous years, the goal will not be met by 2020[23].

Increasing energy efficiency can be obtained by undertaking a number of technical, technological, organisational and educational activities in various areas of social and economic endeavours. The problem of improving the efficiency of the use of fossil fuels by energy-intensive sectors of the economy in Germany is becoming a priority for maintaining sustainable development.

Renewable energy sources

So far, the energy transition in Germany has been an electricity transformation (*Stromwende*)[24]. Renewable energy sources have become one of the salient sources for electricity production. However, the supply of electricity is of key importance to the success of the energy transformation, as electricity is increasingly used in connecting sectors for heating and cooling as well as in transport.

In 2018, electricity production from renewable sources amounted to 225.7 billion kWh (2017: 216.3 billion kWh). Electricity production from PV installations increased to 46.2 billion kWh (2017: 39.4 billion kWh). In 2018, the PV system was expanded by 2,938 MW, i.e. an increase of 77 percent, compared to 2017: 1,660 MW. At the end of 2018, PV installations had a total capacity of 45,277 MW[25].

Onshore and offshore wind farms generated 111.6 billion kWh of electricity in 2018 (2017: 105.7 billion kWh). The share of gross electricity production from wind energy in gross electricity consumption was 18.6 percent. Onshore wind electricity production stood at 92.2 billion kWh (2017: 88.0 billion kWh). In 2018, the added capacity of on-shore wind turbines amounted to 2 273 MW (2017: 5 009 MW). This is the lowest value since 2013. At the end of 2018, onshore wind turbines had a total net power of 52 565 MW (2017: 50 292 MW). The added offshore wind turbine capacity was 990 MW (2017: 1275 MW). At the end of 2018, the total installed capacity of offshore wind turbines increased to 6,417 MW (2017: 5,427 MW). The increase in the capacity extension, which, however, was only realised in the second half of 2018, and favourable wind conditions led to a significant increase in offshore electricity production – 19.3 TWh (2017: 17.7 billion kWh)[26].

Approximately 51.3 billion kWh of electricity was generated from biomass in 2018 (2017: 50.9 billion kWh). Biogas had the largest share in the total value with 29.5 billion kWh. Electricity from biomass covered a total of about 8.6 percent of total gross electricity consumption. As a result of drought, electricity production in hydropower

[23] 'Nachhaltige Entwicklung in Deutschland. Indikatorenbericht 2018', Statistisches Bundesamt (Destatis) 2018, p. 50. https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Nachhaltigkeitsindikatoren/Publikationen/Downloads-Nachhaltigkeit/indikatoren-0230001189004.pdf?__blob=publicationFile [accessed: 10.01.2019].

[24] O. Edenhofer, M. Jakob, *Klimapolitik. Ziele, Konflikte, Lösungen*, Bonn 2017, p. 100.

[25] 'Erneuerbare Energien in Deutschland**.** Daten zur Entwicklung im Jahr 2018', Hintergrund,// März 2019, Umweltbundesamt, p. 8, https://www.umweltbundesamt.de/sites/default/files/medien/1410/publikationen/uba_hgp_eeinzahlen_2019_bf.pdf [accessed: 30.03.2019].

[26] *Ibid.,* p. 9.

plants fell by around 18 percent compared to 2017 (20.2 billion kWh), and with a volume of 16.5 billion kWh was the lowest since 1991. The share of hydropower in total electricity consumption gross fell below 3 percent. In 2018, about 7 MW were added, mainly by increasing the capacity of existing plants. With 172 million kWh, geothermal energy generated about 5.5 percent more electricity than in the previous year (163 million kWh). However, the proportion of geothermal energy continues to be less than 0.1 percent of total gross electricity consumption in Germany[27].

According to the energy concept, the share of electricity from renewable sources in gross electricity consumption should increase to at least 35 percent by 2020, to at least 50 percent by 2030 and to at least 80 percent by 2050. In 2018, the share of electricity generated from renewable sources in gross electricity consumption rose to 37.8 percent (2017: 36 percent). Thus, the target set for 2020 has already been achieved in 2017. The share of renewable energy in heat consumption increased to 13.9 percent in 2018 (2017: 13.4 percent) and amounted to 170.9 billion kWh. With a share of just over 86 percent, biomass remains the most important source of heat – around 147.3 billion kWh (2017: 149.5 kWh)[28]. In 2018, the share of renewable energy sources in final energy consumption in the transport sector amounted to 5.6 percent (2017: 5.2 percent), i.e. 35.9 billion kWh. In addition to biofuels, electricity consumption in the transport sector, combined with the growing share of renewable energy in the German energy mix, also contributes to energy transformation in the transport sector. The use of electricity from renewable sources in the transport sector increased to almost 4.3 billion kWh (2017: 4.0 billion kWh). The share of electricity produced from renewable sources in transport increases more than the share of biofuels[29].

In 2018, the share of renewable energy sources in total primary energy consumption went up to 14 percent, and in gross final energy consumption to 16.7 percent. The main reasons for this increase were the development of renewable energy sources in the electricity sector (especially wind energy and PV), increased use of biofuels, as well as a decrease in total energy consumption in the heating and cooling and transport sectors[30]. The federal government's goal is to increase the share of renewable energy in gross final energy consumption to 18 percent by 2020, 30 percent by 2030, and 60 percent by 2050.

Greenhouse gas emissions

In the years 1990–2018, greenhouse gas emissions in Germany gradually decreased from 1,251 million tonnes of equivalent CO_2 to nearly 905 million tons of equivalent CO_2 in 2017 and 865.6 million tonnes of CO_2 equivalent in 2018 (-30.8 percent). In

[27] *Ibid.*, p. 10.

[28] *Ibid.*, p.11.

[29] *Ibid.,* p. 13.

[30] 'Die Energiewende im Stromsektor: Stand der Dinge 2018. Rückblick auf die wesentlichen Entwicklungen sowie Ausblick auf 2019', Agora Energiewende, Januar 2019, p. 5, https://www.agora-energiewende.de/fileadmin2/Projekte/2018/Jahresauswertung_2018/125_Agora-JAW-2018_WEB.pdf [accessed: 30.03.2019].

2018, greenhouse gas emissions from the energy sector amounted to 310.5 million tonnes of CO2 equivalent (a 33.4 percent reduction from the 1990 levels), and industry to 196 million tonnes CO_2 equivalent (a 31 percent reduction from the 1990 levels), 162 million tonnes of CO_2 equivalent (a 1percent reduction compared to 1990), 117 million tonnes of CO_2 equivalent (a 44 percent reduction compared to 1990), 69.8 million tonnes CO_2 equivalent (reduction by 22.3 percent compared to 1990)[31].

Through the use of renewable energy sources in 2018, emissions savings amounted to around 184 million tonnes of equivalent CO_2, including about 141 million tonnes of equivalent CO_2 within the electricity sector; in the heat sector this index stood at about 35 million tons of equivalent CO_2, and thanks to the use of biofuels about 8 million tons of equivalent CO_2[32].

The development of renewable energy sources has significantly reduced the CO_2 emission factor. Other reasons for the decrease include the increase in the share of natural gas, which has a lower CO_2 emission factor than coal, and better efficiency in electricity generation of newly connected conventional power plants. CO_2 emissions per kWh of electricity consumed in Germany are falling. The kWh of electricity produced in 1990 emitted 764 g of CO_2, while in 2016 – 523 g of CO_2, and in 2017 – 486 g of CO_2 and an estimated value of 474 g CO_2 / kWh in 2018 confirms the downward trend. However, in 2011–2013 (2011: 568 g/kWh, 2012: 573 g/kWh, 2013: 572 g/kWh), increased energy production from coal due to the construction of new power plants fired with this fuel led to an increase in absolute and specific carbon dioxide emissions in energy production. Since 2014, a decrease in electricity consumption and a further increase in energy production from renewable sources has resulted in a reduction in absolute and specific CO_2 emissions. Production of electricity based on renewable sources, reduction of surplus of electricity exports, transition to low-emission fuels, development of combined heat and electricity generation and increase of energy production efficiency are of key importance to reducing overall CO_2 emissions[33].

To achieve the assumed level of greenhouse gas emissions in 2020, i.e. 753 million tonnes of equivalent CO_2, emissions should be reduced in 2019 and 2020 on an annual basis by 55 million tonnes of equivalent CO_2[34]. The paradox is that although Germany is developing renewable energy sources, there is a risk that national climate protection goals are not only for 2020 (reducing greenhouse gas emissions by 40 percent by 2020 compared to the 1990 levels), but also the goal of reducing greenhouse gas emissions by 55 percent by 2030 will not be met. Greenhouse gas emissions in Germany have not decreased significantly over the past eight years, which

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31 'Klimaschutz in Zahlen. Fakten, Trends und Impulse deutscher Klimapolitik', Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit, Stand: Mai 2018, p. 44, https://www.bmu.de/fileadmin/Daten_BMU/Pools/Broschueren/klimaschutz_in_zahlen_2018_bf.pdf [accessed: 20.01.2019].

32 'Erneuerbare Energien in... *op. cit.*, p. 16.

33 'Entwicklung der spezifischen Kohlendioxid- Emissionen des deutschen Strommix in den Jahren 1990-2018', *Climate Change* 2019, no. 10, Umweltbundesamt, p. 22, https://www.umweltbundesamt.de/publikationen/entwicklung-der-spezifischen-kohlendioxid-5 [accessed: 30.04.2019]; 'Die Energiewende im Stromsektor..., *op. cit.,* p. 5.

34 'Energieverbrauch in Deutschland im Jahr 2018', AGEB 2019, p. 44.

was mainly due to the production of energy from coal. According to experts, the federal government should apply additional climate protection measures, such as accelerating the closure of coal-fired power plants and combined heat and power plants. Climate change policy goals will not be achieved without the so-called "coal exit", as will the conversion to an electricity system based on renewable energy sources[35].

German energy security in the age of climate protection

Germany's energy security depends on internal factors – i.e. the volume of resources and reserves of energy raw materials, production capacity to cover its own energy demand – and due to the import of fossil fuels and electricity, also on the development of the energy market across the European Union, and the situation on international energy markets. In the process of energy transformation, the challenge is to ensure a well-functioning energy system and reliability of energy supply.

In the context of energy efficiency, it is clear to see that the greatest potential for reducing energy consumption occurs if energy production at nuclear power plants is completely replaced by renewable energy and/or imported electricity. Nevertheless, in 2018 the production of electricity from wind, water and solar radiation, as well as the balance of electricity exchange increased by about 6 billion kWh, while the production of electricity in nuclear power plants slightly decreased compared to 2017 (2018: 76 billion kWh , 2017: 76.3 billion kWh). In 2017 and 2018, the share of nuclear energy in gross electricity production was 11.7 percent and 11.8 percent, respectively[36].

Following the decision to accelerate the decommissioning of nuclear energy in Germany, the issue of import of electricity produced in nuclear power plants outside Germany has become debatable. Ultimately, however, Germany imports and exports electricity that is produced from various energy sources, such as natural gas, coal, and uranium. In 2018, 82.7 billion kWh of electricity went abroad (2017: 83.4 billion kWh), while electricity imports reached 31.5 billion kWh (2017: 28.4 billion kWh). The surplus in electricity exchange amounted to 51.2 billion kWh. A large proportion of cross-border electricity flows are not contractual supplies, but rather transit volumes and ring flows. The largest amounts of electricity originated from France (8.4 billion kWh)[37]. It remains an open question whether, in the medium and long term, Germany will decide to import nuclear energy for political and social reasons.

The main argument for the energy transformation cited in the context of energy security is to reduce dependence on imported fossil fuels. In 2018, crude oil, natural gas and coal had a 79.3 percent share in primary energy consumption. 70 percent of primary energy demand is covered by imported fossil fuels. The main suppliers of energy raw materials are Russia, Norway, the Netherlands, the UK, Kazakhstan, Libya,

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35 C. Kemfert, *Klimaziel 2020 verfehlt: Zeit für eine Neuausrichtung der Klimapolitik*? „ifo Schnelldienst" 2018, no. 1, p. 3. L. Göke et al., 'Erfolgreicher Klimaschutz durch zügigen Kohleausstieg in Deutschland und Nordrhein-Westfalen', *DIW Wochenbericht* 2018, no. 33, pp. 701–711.

36 'Energieverbrauch in Deutschland…, *op. cit.*, pp. 8, 30.

37 *Ibid.*, pp. 31–32.

USA, Nigeria, Iraq, Australia and Colombia[38]. Germany's dependence on imports of individual energy carriers was as follows: mineral oils 98 percent, natural gas 93 percent, hard coal 93 percent, uranium 100 percent[39]. Despite import dependence, Germany is characterised by a significant diversification of energy raw material suppliers. Germany treats its suppliers as reliable partners who have not reduced or threatened to stop the supply of fossil fuels, especially natural gas. Geopolitics is not important for the security of energy supply, unlike the technical aspect. According to Christian Hübner, thanks to the use of renewable energy sources and energy savings, the share of imported fossil fuels could drop to a level below 30 percent by 2050, and thus reduce dependence on energy imports[40].

However, in the process of energy transition, fossil fuels take over the bridging function in place of nuclear energy until they switch to renewable energy sources; are to increase the security of Germany's energy supply. The growing share of renewable energy sources in electricity production leads to supply, which is largely dependent on meteorological fluctuations. Therefore, there is a need to equalise the demand for electricity by non-renewable energy sources. Conventional power plants are important in the process of energy transformation, especially increasing the use of natural gas as a low-emission energy source. The advantage of gas power plants is their ability to balance fluctuations in solar and wind energy production and stabilise the network. Production of electricity from natural gas has fluctuated in recent years – from 89.3 billion kWh in 2010, through a decrease to 62 billion kWh in 2015, to a further increase to 86.7 billion kWh in 2017, and a slight decrease to 83.4 billion kWh in 2018[41]. An unexpected effect accompanying the energy transition was the displacement of natural gas from the electricity market. In particular, the lower profitability of gas-fired power plants resulted in a reduction in gas consumption in electricity production. The reasons for this decline were also the use of coal-fired power plants, as well as increasing energy efficiency and the development of renewable energy sources.

It is estimated that, in the medium term, natural gas consumption in Germany will remain stable; however, with increasing dependence on Russian gas imports. Russia is perceived as a credible partner in energy cooperation, while the Nord Stream 2 gas pipeline, which is to be a direct connection to the West Siberian deposits, should strengthen the security of natural gas supplies to Germany, and the European Union.

The challenge posed for energy security related to renewable energy sources concerns the creation of specific conditions for their development, in particular the integration of renewable energy sources in the transmission network and the electricity market. This also applies to the construction of high voltage power networks that

[38] 'Energie für Deutschland Fakten, Perspektiven und Positionen im globalen Kontext', 2018, Weltenergierat – Deutschland e.V., p. 111, https://www.weltenergierat.de/wp-content/uploads/2018/05/81040_DNK_Energie2018_D.pdf [accessed: 10.01.2019].

[39] 'BGR Energiestudie 2018, Daten und Entwicklunegn der deutschen und globalen Energieversorgung', März 2019, p. 17, https://www.bgr.bund.de/DE/Themen/Energie/Downloads/energiestudie_2018.pdf?__blob=publicationFile&v=10 [accessed: 20.04.2019]

[40] Ch. Hübner, 'Beschleunigte Energiewende in Deutschland. Einordnung und Analyse', *KAS Analysen&Argumente*, Juni 2012, p. 7.

[41] 'Energieverbrauch in Deutschland…, *op. cit.*, p. 30.

transport electricity from the north to the south parts of Germany, as well as local distribution networks. In the event of excess supply of electricity generated from renewable sources, the ability to store energy will play a major role in managing energy systems. In this context, issues of storage capacity, storage security and access to stored energy resources, as well as greater use of electricity storage outside Germany (e.g. in Norway) are gaining momentum.

An alternative to dealing with fluctuations in renewable energies is the development of innovative technologies for converting energy into gas (Power-to-Gas, P2G), which could be used by using excess electricity generated from renewable sources. In Germany, 35 power-to-gas plants with a total output of 30 megawatts are currently in operation. Most of them are pilot scale, or demonstration projects on a small scale for research purposes. In Hamburg, however, the first industrial plant with a capacity of five megawatts is already producing green gas for a refinery. A total of 16 plants are currently being planned. About one third of these should have a capacity of more than five megawatts, and two of them even more than 100 megawatts. Their total output of 273 megawatts will then reach nine times the number of plants installed today[42].

The development of transmission networks in Germany does not go hand in hand with the development of renewable energy sources. Of the more than 1,800 kilometres of new electricity transmission routes (*Energieleitungsausbaugesetz*, EnLAG Act), taking into account the third quarter of 2018, approximately 1,200 kilometres were spent permit, and 800 kilometres were completed, i.e. 45 percent of the total length. Another approximately 570 kilometres are undergoing approval, and spatial planning procedures. At the same time, the overall length of the network under the Federal Requirement Plan Act (*Bundesbedarfsplangesetz*) is currently 5,900 kilometres. Taking into account the third quarter of 2018, building permits were issued for about 600 kilometres, of which about 150 kilometres were completed[43].

The power system in Germany is rated as reliable. Unplanned power shortages remain very low; sufficient resources are available to meet electricity demand at all times. In 2010, interruptions in the supply of electricity to the consumer amounted to 14.9 minutes, and in 2017 – 15.14 minutes. Shorter failures and breaks less than three minutes were not included[44].

As has already been mentioned, the issue of continued use of fossil fuels is controversial in relation to the goal of reducing greenhouse gas emissions. The abandonment of the use of nuclear energy – a low-emission source – paradoxically results in the use of fossil fuels for the production of electricity, in particular coal, which is why environmental protection requirements conflict with the significance of this

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42 R. Diermann, 'DVGW veröffentlicht aktualisierten Überblick über Power-to-Gas-Anlagen in Deutschland', 24.04.2019, https://www.pv-magazine.de/2019/04/24/dvgw-veroeffentlicht-aktualisierten-ueberblick-ueber-power-to-gas-anlagen-in-deutschland [accessed: 30.04.2019].

43 *Netz- und Systemsicherheit*, https://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/Versorgungssicherheit/Netz_Systemsicherheit/Netz_Systemsicherheit.html [accessed: 20.04.2019].

44 *Bericht. Monitoringbericht 2018*, Bundesnetzagentur, Bundeskartellamt, p. 8, https://www.bundesnetzagentur.de/SharedDocs/Downloads/DE/Allgemeines/Bundesnetzagentur/Publikationen/Berichte/2018/Monitoringbericht_Energie2018.pdf?__blob=publicationFile&v=3 [accessed: 10.01.2019].

highly emissive raw material in energy supply and hinder the achievement of the climate protection goal. In the context of the "coal exit", it is debatable whether the system will have enough reliable production capacity to exclude the possibility of blackout. At the end of 2017, the installed capacity of the power plant amounted to 215 846 MW (net), including renewable energy installations 118.844 MW, gas power plants 29 645 MW, hard coal power plant 25 341 MW, brown coal power plant 21 033 MW, nuclear power plants 10 799 MW, other to the conventional elector 4474 MW, and pumped storage power plants 5,710 MW[45]. According to the federal government, the shortfall in supply will be offset by better energy efficiency, a steadily growing supply of solar and wind energy, and electricity imports. However, German operators of four transmission systems estimate that there may be a 5.5 GW shortfall between peak power demand in 2021, and thus even before the closure of most coal-fired power plants[46].

Conclusions

Sustainability, one of the basic goals of energy policy, has been interpreted in recent years in terms of reducing greenhouse gas emissions, an important climate action.

Climate protection implies a fundamental transformation of the energy system: a process of phasing out fossil fuels for energy from renewable sources. The development of renewable energy sources, a gradual decrease in the supply of energy from fossil fuels and the improvement of energy efficiency are of key importance to both energy security and achieving the goals of reducing greenhouse gas emissions in the medium and long term.

The standpoint on energy transformation in Germany is truly ambiguous. On the one hand, the objectives for the development of renewable energy sources are significantly exceeded; on the other hand, the reduction of greenhouse gas emissions, the development of the transmission network and reduction of fuel consumption does not follow the schedule, which may prevent the achievement of energy and climate policy goals 2020, and thus threaten the achievement of the goals set for 2030, or 2050.

Activities to ensure the security of energy supply should be intensified. The increased share of renewable energy sources in energy production increases the demand for supply and demand balance mechanisms, such as demand management, the creation of a reserve power plant, and the expansion of the network or energy storage. A major issue discussed nowadays in Germany in the context of climate protection and ensuring energy security is the supply of energy from fossil fuels, needed in the process of transition to renewable energy sources. Abandoning the use of coal, alongside nuclear energy, may imply the acceleration of the construction of gas-fired power plants, and the need to import electricity from abroad to meet the growing demands of customers. In addition, it has economic and social consequences, which is why it is so important to accurately define the instruments for carrying out the "coal exit".

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45 'Energie für Deutschland…, *op. cit.*, s.113.

46 Details: www.bmwi.de.

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Ochrona klimatu a bezpieczeństwo energetyczne Niemiec w drugiej dekadzie XXI wieku
Streszczenie

Opracowanie prezentuje zależności między wyzwaniami ograniczenia zmian klimatu a bezpieczeństwem energetycznym Niemiec w drugiej dekadzie XXI wieku. Zapewnianie bezpieczeństwa energetycznego następuje w sytuacji ograniczania negatywnych skutków oddziaływania na środowisko naturalne i klimat na wszystkich etapach gospodarowania energią, czyli pozyskiwania nośników energii, ich przetwarzania, transportu i konsumpcji. Przedstawiono główne kierunki rozwoju polityki energetycznej Niemiec od końca lat 90. XX wieku oraz uwzględniono dane statystyczne dotyczące efektywności energetycznej, rozwoju odnawialnych źródeł energii i redukcji emisji gazów cieplarnianych. Ponadto w artykule omówiono główne problemy zapewniania bezpieczeństwa zaopatrzenia energetycznego Niemiec w procesie transformacji energetycznej i ochrony klimatu. Istotne jest poszukiwanie i wdrażanie rozwiązań służących jednocześnie ochronie klimatu i poprawie bezpieczeństwa energetycznego.
Słowa kluczowe: Niemcy, ochrona klimatu, bezpieczeństwo energetyczne, efektywność energetyczna, odnawialne źródła energii, emisja gazów cieplarnianych

Climate Protection and German Energy Security in the Second Decade of the 21st Century
Abstract

The study presents the linkages between the challenges of reducing climate change and Germany's energy security in the second decade of the twenty-first century. Energy security is guaranteed whenever the negative effects on the environment and climate are reduced to a minimum at all stages of energy management, i.e. the acquisition of energy carriers, their processing, transport and consumption. The paper looks at the main directions of the development of Germany's energy policy since the late 1990s, and discusses the statistics on energy efficiency, the development of renewable energy sources, and the reduction of greenhouse gas emissions. It also outlines the major issues related to safeguarding the security of Germany's energy supply in the process of energy transformation and climate protection, highlighting the importance to seek and implement relevant solutions that simultaneously protect the climate and improve energy security.
Key words: Germany, climate protection, energy security, energy efficiency, renewable energy sources, greenhouse gas emissions

Klimaschutz und Energiesicherheit Deutschlands in der zweite Dekade des 21. Jahrhunderts
Kurzfassung

Die Studie zeigt den Zusammenhang zwischen den Herausforderungen der Eindämmung des Klimawandels und der Energiesicherheit Deutschlands in der zweite Dekade des 21. Jahrhunderts. Die Energieversorgungssicherheit ist gewährleistet, wenn die negativen Auswirkungen auf Umwelt und Klima in allen Phasen des Energiemanagements, d. h. der Beschaffung von Energieträgern, ihrer Verarbeitung, ihres Transports und ihres Verbrauchs, verringert werden. Die Hauptrichtungen der Entwicklung der deutschen

Energiepolitik seit Ende der neunziger Jahre wurden vorgestellt und Statistiken zur Energieeffizienz, zur Entwicklung erneuerbarer Energiequellen und zur Reduzierung der Treibhausgasemissionen aufgenommen. Darüber hinaus werden die Hauptprobleme der Gewährleistung der Energieversorgungssicherheit Deutschlands im Prozess der Energiewende und des Klimaschutzes erörtert. Es ist wichtig, Lösungen zu suchen und umzusetzen, die gleichzeitig das Klima schützen und die Energiesicherheit verbessern.
Schlüsselwörter: Deutschland, Klimaschutz, Energiesicherheit, Energieeffizienz, erneuerbare Energien, Treibhausgasemissionen

Защита климата и энергетическая безопасность Германии во втором десятилетии XXI века
Резюме

В статье рассмотрены существующие зависимости между действиями направленным на борьбу с глобальным изменением климата и энергетической безопасностью Германии во втором десятилетии XXI века. Обеспечение энергетической безопасности государства осуществляется в ситуации снижения негативных последствий воздействия на окружающую среду и климат на всех этапах получения энергии, то есть: добычи энергоносителей, их переработки, транспортировки и потребления. Приведены основные направления развития энергетической политики Германии с конца 90-х годов. Указаны статистические данные касающиеся энергоэффективности, развития возобновляемых источников энергии и снижения выбросов парниковых газов. Кроме того, в статье рассмотрены основные проблемы обеспечения безопасности энергоснабжения Германии в процессе энергетической трансформации и защиты климата. Важное место занимают проблемы поиска и внедрения решений, направленных одновременно на защиту климата и повышение энергетической безопасности.
Ключевые слова: Германия, защита климата, энергетическая безопасность, энергоэффективность, возобновляемые источники энергии, выбросы парниковых газов