Master Thesis

The impact of solar and wind energy on the gas relations between Germany and Russia.

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Executive summary

The global geopolitics of developed countries in the twentieth century was highly shaped by energy geopolitics, which is outmost dependent on the supply and demand of coal, oil and gas. The development and diffusion of renewable energy technology may reshape the geopolitical power in the world. In the past 30 years there has been established an intense gas trade relation between Germany and Russia, which is constantly changing and evolving. Although it is of high importance to understand, whether the established relations are affected by the rapid increase of solar and wind energy in Germany. Therefore, the main research question of this research goes as follows:

How does the development of wind and solar energy in Germany affect the current gas trade relations between Germany and Russia?

In order to answer this question, the study creates a framework of analysis that can logically connect the geotechnical characteristics of renewable energy with the patterns of cooperation between Germany and Russia that are based on gas trade. The framework is using four consistent and interconnected steps, analysing the geotechnical characteristics of wind and solar energy, the impact of these characteristics on the German energy security and gas trade patterns, and finally discussing the implications of these changes on the patterns of cooperation between Germany and Russia.

A literature review of both German and Russian energy sectors, the main gas trade patterns and historical patterns of RE development in both countries was performed. Such structure has allowed to analyze consistently from the situation to the complication, detailing the main actors and creating an in-depth comprehension of the variables before actually making the logical links between them. The literature review performed was done in the timeframe of approximately 20 years, starting from 2000. This timeframe was chosen due to the fact that since the 2000s the increasing Russian fossil fuel production facilitated a large expansion in the quantity of gas supplied to the European market.

During the literature review the most significant changes and trends in the German energy sector were discussed, an understanding of the state of energy security was formed and the historical development of renewable energy sector was outlined. Moreover, two main changes in the gas relationship between Germany and Russia were identified, which are the changes in gas contracts and the overall gas trade intensification.

After having created an understanding of all the necessary variables, the analysis continued by structuring the obtained knowledge in a logical sequence in accordance with the theoretical framework. It was proven, that numerous geotechnical characteristics of renewable energy impact the energy security of Germany in such a way, that the gas imports from Russia are forced to increase in order to not let the level of energy security decrease. This leads not only to the process of gas intensification, but also creates a pattern of cooperation between the countries, that is taking place on both economic and political levels. No logical connection between the changes in gas contracts and renewable energy development was found. In order to prove the absence of interconnection between these processes, a contextual variable was identified, that is fully responsible for this change. Moreover, numerous contextual variables were found for the gas trade intensification. This shows, that even though the development of RE is one of the causes for gas intensification, the situation is embedded in a complex environment with multiple factors and actors.

After having conducted the research, this study looks critically at the methods that were used as well as the framework that was applied. Strengths and weaknesses of the used approach were identified and recommendations for future framework application were made. The research ends with conclusions and policy recommendations for Germany and Russia, that are aimed at improving the energy security of these countries and increasing the mutually beneficial relations.

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Chapter 1

Introduction

1.1 Geopolitics from the energy perspective

The global geopolitics of developed countries in the twentieth century was highly shaped by energy geopolitics, which is defined as the way countries influence one another through energy supply and demand (Paltsev, 2016). For many decades the geopolitics of energy has been a synonymous for the geopolitics of coal, oil and gas. The reason for it is the fact that fossil fuels have been playing a primary role in every aspect of our lives from technology and transportation to energy production. For this reason, fossil fuels are a primary factor in the process of asserting and maintaining political dominance and control. The strategic importance of fossil fuels is critical to the functioning of our global economy.

An extremely illustrative and up-to-date example of the importance of fossil fuels to the global market and geopolitics is the Saudi Arabia oil price cut by means of boosting oil output, which happened 9 March 2020. The decision to increase production was made by Saudi Arabia as a political and economic response to the fact that Russia rejected an agreement with OPEC on cuts in oil. The severe price drop causes damage not only to big oil companies but will also have intense economic consequences on oil-dependent countries, such as Venezuela, Iran and Russia.

Yet the geopolitics and the global energy economy are changing at a relatively high speed due to the exponential growth of renewable energy technology. As new renewable ways of energy generation emerge, fossil fuels are being squeezed out of the global market and thus less geopolitical power will be dependent on fossil fuels. The energy transition that is currently taking place at a high pace, has an impact not only on the economics, policies and technological development, but also on the energy geopolitics. As renewables displace fossil fuels, new political interdependencies emerge. The world's primary energy mix will consist for more than one-third of non-fossil sources (McKinsey 2016), which leads to a completely new distribution of energy power in the world.

The reason behind the structural change in geopolitics stems from the fact that the geographical and technical characteristics of renewable energy systems drastically differ from conventional energy (Scholten 2018). Renewable energy sources are not as scarce and geographically constrained as fossil fuels. Solar and wind energy are highly intermittent both daily and yearly, which implies for new solutions in energy security, such as energy storage or continental grids. Moreover, the manufacturers of wind power plants and solar panels heavily rely on rare earth materials. These and many other factors could be a reason for a mere shift in the energy geopolitics of a country that decides to replace a significant part of fossil fuels with renewable energy.

One of the countries, that has made a significant change in the energy mix in the past 20 years and is currently following a highly outlined and detailed plan to minimize the dependency on fossil fuels and become carbon-neutral, is Germany. The German Energiewende is a legislative transition plan towards a low-carbon nuclear-free economy, where a target of reaching 80% share of renewable energy from gross final electricity consumption is set. The policy document that outlined the Energiewende was published by the German government in September 2010, while the actual transition started a decade before. According to the Federal Ministry for Economic Affairs and Energy (BMWi), during the period in 1999 until 2010 Germany's share of gross electricity consumption from renewables almost tripled. As early as in 2000, Germany implemented the Renewable Energy Sources Act, which supported the large-scale buildup of renewables under an expensive feed-in-tariff scheme. Germany was among European pioneers in renewable energy development which now results in more than 37% share of gross electricity consumption from renewable energy (BMWi, 2018).

A possible consequence of the implementation of the Energiewende could be a mere shift in the energy relations and mutual interdependence with Russia. The reason for such an assumption is

based on the fact that approximately one third of the German gas is currently imported from Russia. The last official year when Germany made these numbers publicly available was 2015, when 35% of German gas was imported from Russia (BAFA 2016), which made Germany the largest buyer of Russian natural gas (Institute for Energy Research, 2018) and thus highly dependent. The actual figures as of 2020 are not publicly available, because Germany's Federal Office for Economic Affairs and Export Control (BAFA) stopped publishing import volumes in 2016 due privacy regulations. The impact of the growing mix of renewable energy could have an impact on the mutual interdependence. As renewable energy increases, the need for the import of Russian gas could decrease, which in turn will affect the interstate energy relationship.

At the same time Russian economics is highly dependent on fossil fuels and unlike Europe, Russia has no plans and intentions to switch to renewables. Russia's recent public discourse on climate change shows, that fossil energy will continue being the main political and economic basis of Russia's power status (Veli-Pekka Tynkkynen and Nina Tynkkynen 2018). The German switch to renewable energy could become a disaster for the economics of Russia and might have serious consequences for the geopolitical relations between these countries. According to Sharples (2013), "Security of export is a significant component of Russian conceptions of energy security, which reflects Russia's status as a hydrocarbon exporter and the multifaceted value of gas exports for Russia."

Overall it is clearly visible that Germany and Russia are diversifying from each other in terms of energy trade which is most likely a consequence of the Energiewende. Although at the same time we can observe that the Russian "North Stream 2" is in the final phase of construction. This raises questions, how the future interdependency between these countries will develop. The situation becomes even more complicated taking into account that the Russian gas and German RE are simultaneously competitive and complementary on the German energy market, as some experts argue, that natural gas can be an intermediate solution if a country is aiming to become carbon-neutral in the long-term. Important questions arise, how the shift to RE in Germany has affected the mutual interdependency with Russia in terms of energy and monetary flows? How is the domestic energy security changing? How will the interstate energy policies develop? What political and economic steps will the countries take in order to improve the domestic energy security and yield maximum benefits from the gas trade? How does the state of mutual energy interdependency evolve? What opportunities and challenges are the countries facing in this regard? These questions are vitally important for both Germany and Russia and the purpose of this research is to find answers, that could help both countries develop in the right direction.

1.2 Research objective

The main purpose of the thesis is to analyze how the geographical and technical characteristics of renewable energy systems, particularly solar and wind energy, affect the interstate gas trade relations between Germany and Russia and the related patterns of conflict and cooperation. Speaking broadly, the topic of the research could be classified as geopolitics, although it is of high importance to define what exact aspects of relations will be studied, since this term is very broad and hard to define properly. In this research I focus on the international gas trade patterns and Germanies governmental decisions, that stem from the development of renewable energy in Germany and are aimed at improving domestic energy security. Such a way of narrowing down the interstate energy relations still leaves some space to discuss which policies do have a straight impact. Moreover, it is necessary to underline, that the energy trade flows which are analyzed in this research will be focused on gas explicitly.

In order to conduct an in-depth research, a framework of analysis must be created. Both dependent and independent variables must be reasonably introduced, and a clear logical connection should be created. Gas trade flows and energy security are used as an intermediate "bridge" between the dependent and independent variables, which is discussed in Chapter 2. Therefore, one of the important objectives is to find actual evidence, how the development of renewable energy in Germany has affected the energy security in Germany. The research will be concluded with outlining the possible opportunities and challenges for both Germany and Russia and recommendations for the countries how to take the best possible advantage of opportunities and

mitigate the challenges. Expert interviews will be held in order to validate the conclusions and recommendations.

1.3 Research questions

In order to conduct an in-depth and logically structured research, and develop the best applicable research framework, the research question must be not only clearly defined but all the sub-questions must be outlined and discussed. For this reason, they are formulated as following:

How does the development of wind and solar energy in Germany affect the current gas trade relations between Germany and Russia?

1. *What framework of analysis would be the most suitable in order to systematically approach and investigate the research question?*

2. *How did the energy sectors in Germany and Russia evolve in the past 20 years and what main trends in the current gas relations can be identified?*

3. *If the changes in the gas trade relations exist, are they a consequence of the geographical and technical characteristics of renewable energy development and if so, what impact do they have on the patterns of conflict and cooperation between Germany and Russia?*

1.4 Relevance

The interstate of energy relations between countries is often a key not only to the energy security of a country but also to political and economic stability. The current scientific literature has only barely studied the geopolitical implications of the global transition to renewable energy. The amount of academic research on the renewable energy geopolitics is incomparably less than on the economic modelling of solar and wind energy diffusion, policy implications and technical development. According to Vakulchuk et al. (2020), among the publications on the topic of geopolitics of renewable energy there exists a lack of attention to the countries that heavily rely on coal, among others Germany. While research has been conducted in this field in the last 10 years, limited research with predictive models and forecasting has been performed. The difference between the amount of research in these fields is illustrated in Table 1.1, where some results of queries in Google Scholar and Scopus are presented. It is clearly visible that the literature on energy geopolitics that exists mainly focuses on fossil fuels such as oil and gas. The reason for it is the fact that fossil fuels have been the primary energy resource for more than a century and even with the shift to renewable energy that is currently taking place, oil and gas will still be dominating the global market for decades.

	Geopolitics AND oil & Geopolitics AND gas	Geopolitics AND renewable energy	Ratio
Google Scholar	128,700	31,600	0.25
Scopus	1162	100	0.086

Table 1.1

This research has a specific focus on the case of Germany – Russian relations for the following reasons. Firstly, the European Union is highly divided both in terms of energy relations with Russia and the renewable energy promotion. For this reason, I believe that choosing just one country for the analysis could give more concrete results, rather than studying the whole EU. Secondly, Germany is one of the most important countries in Europe for economic reasons with the highest GDP (International Monetary Fund 2019). Finally, Germany holds one of the strongest positions in the world for the development of renewable energy and implementing renewable policies. Moreover, Germany is highly interdepended with Russia in energy and economic terms, as discussed previously.

This research could be highly beneficial to both Germany's and Russian authorities. A clear understanding of how the development of RE could create new opportunities and challenges for both countries in the mutual economic interdependency is of high importance. Knowing these opportunities and challenges could help the countries create a stronger economic and political pathway towards a renewable future with a high level of energy security, which is one of the key components of the future social welfare.

1.5 Research approach

In order to understand how the development of solar and wind energy in Germany affects the interstate energy relations between Germany and Russia, a qualitative research method will be applied. The first step in the research is creating a comprehensive framework which suits the best for the case study of energy relations between Germany and Russia. Numerous researchers have addressed this topic from different angles before, so it is of high importance to conduct an extensive literature research to bring the existing knowledge together to a theoretical framework that analyses this question from different perspectives. The research framework of Scholten (2018) will be used as an initial starting point with different adjustments, which will be discussed more in-depth in Chapter 2.

The next step is analyzing the main variables in accordance with the created framework as well as conducting an extensive literature review on the past gas relations and RE development of the countries in the timeframe of approximately 20 years. The main changes in the gas relations that are taking place currently are briefly outlined. This timeframe is chosen due to the fact that since the 2000s the increasing Russian fossil fuel production facilitated a large expansion in the quantity of gas supplied to the European market. By taking this as an initial starting point, the research addresses only the modern era of Russia and cuts off the turbulent years of the 90s.

The next step is to create a logical connection between all the outlined variables and create an understanding, whether the changes in gas relations that were identified previously are related to the geographical and technical characteristics of RE in Germany. This analysis will be performed based on the knowledge obtained in the previous step. Therefore, the framework created in Chapter 2 is applied both in Chapter 3, where an historical analysis of the variables is performed, as well as in Chapter 4, where logical connection between the variables is created and justification of the changes in energy relation is made. Impact of these implications on the energy relations between the countries is analyzed. At this step interviews with experts in the field of renewable energy geopolitics, international relations and international political economy are conducted in order to validate the findings and the created logical connections.

The final step of the research brings together all the gathered knowledge and the future potential energy relations are discussed. Conclusions are outlined and recommendations for both Germany and Russia are suggested. The schematic representation of the main research steps is depicted on Figure 1.1.

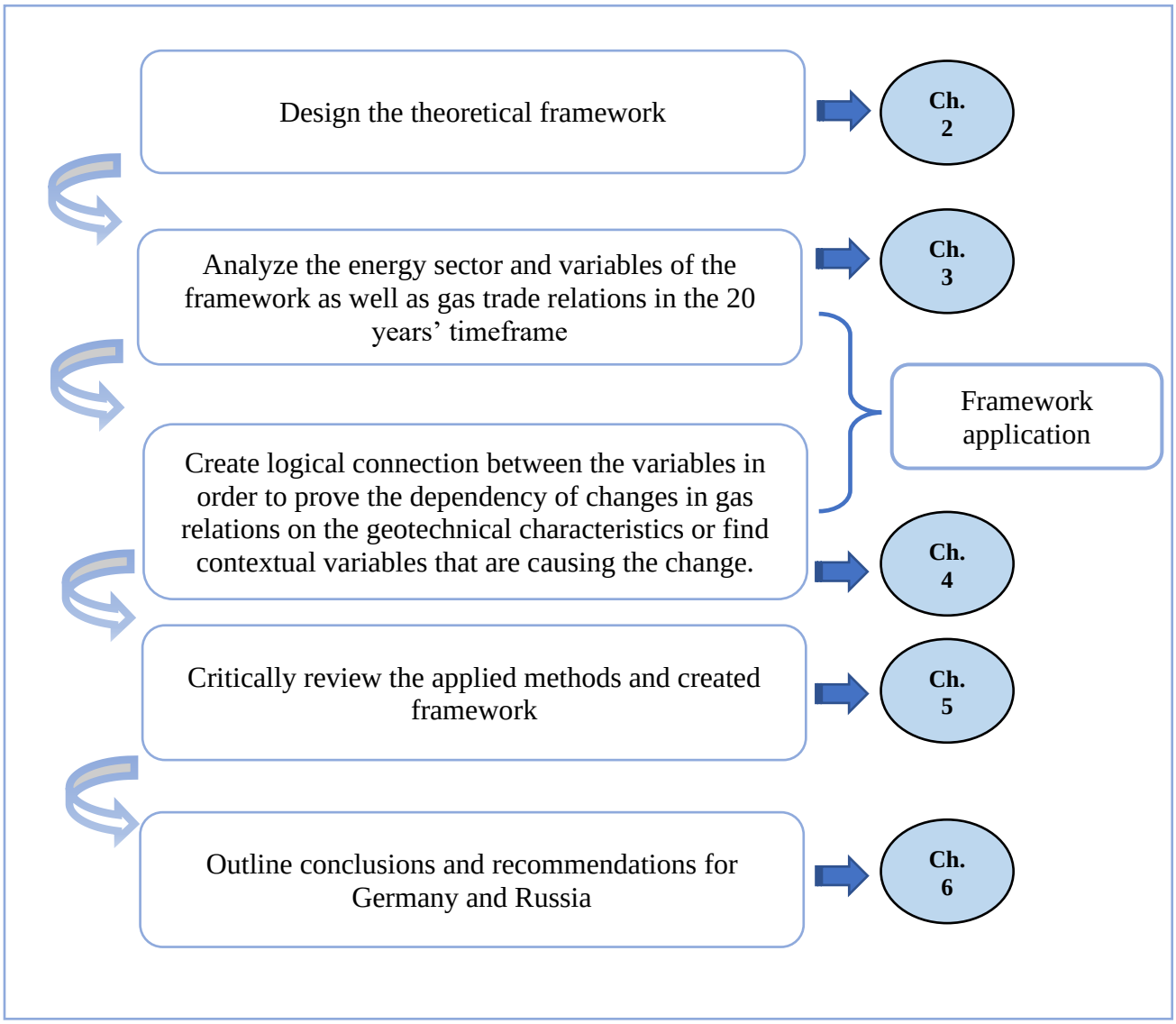

Figure 1.1 Research steps

1.6 Research methods

1. **What framework of analysis would be the most suitable in order to systematically approach and investigate the research question?**

In order to answer this question, a comprehensive research framework must be created. All the concepts used in the framework will be operationalized. A literature review will be performed in order to bring together different research approaches on this topic. The review will be done using mainly Scopus and Science Direct with keywords "renewable energy geopolitics", "energy security", "renewable energy security" and "geotechnical characteristics of renewable energy". The literature review of the listed above topics will help operationalizing all the core concepts of the research and help creating a comprehensive theoretical framework that simultaneously combines approaches from different research areas, such as renewable energy geopolitics, energy security, international relationships and international political economy. The created research framework will further be applied in chapters 3 and 4.

2. **How did the energy sectors in Germany and Russia as well as the interstate gas relations evolve in the past 20 years?**

After identifying what variables are of importance to the research, we continue with a literature review on the necessary variables as well as the overall energy sector development and gas relations mainly in the timeframe of the past 20 years. At this step the created framework is already being applied by means of understanding the dynamic evolution of the framework's variables, as well as the overall energy sector. The main changes in gas trade relations that are currently occurring are identified. The timeframe of 20 years is chosen due to the fact that in the 2000s the increasing Russian fossil fuel production facilitated a large expansion in the quantity of gas supplied to the European market.

As like in the previous sub-question, Scopus and Science Direct will be used with keywords "Gas trade between Germany and Russia" and "Germany – Russia energy interrelations". Russian literature will as well be reviewed on the same topics. Literature and governmental policy papers will be reviewed and analyzed in order to find actual implications of renewable energy on the energy security in Germany and analyze how these implications affect the international gas trade flow. The gathered information will help finding patterns in the past energy relations between Germany and Russia. An understanding of the development of the energy sectors, energy relations and mutual interdependency will be created. This knowledge will be then applied in order to answer sub-question 3.

3. **Are the changes in the gas trade relations a consequence of the geographical and technical characteristics of renewable energy development and if so, what impact do they have on the patterns of conflict and cooperation between Germany and Russia?**

At this stage of the research the main changes in gas trade relations, that were identified in sub-question 2 are analyzed using the knowledge of dynamic evolution of the framework's variables. Logical connection between the variables will be made, which will create a comprehension, whether the changes in gas trade relations, that were identified earlier, stem from the geotechnical characteristics of renewable energy in Germany or from other contextual factors. In the final step of the research I will draw conclusions whether the geographical and technical characteristics of solar and wind energy in Germany affect the gas trade relations with Russia as well as the patterns of conflict and cooperation between them.

Interviews were held with scientists in the field of renewable energy geopolitics, international relations and international political economy that focus on Germany and Russia. The knowledge and experience of the respondents was used to validate the identified relations. The interviews were conducted with the purpose of obtaining expert opinions on the subject of the current and future German – Russian energy relations and mutual interdependency. Moreover, the conducted interviews were also used to formulate policy recommendations, as the experts had a clear vision for the future necessary steps for both Germany and Russia.

While the initial goal was to conduct interviews with scientists as well as governmental workers from Germany and Russia, the escalation of political conflict (poisoning of Navalny) between the countries made it impossible to include the latter group. In total 4 experts have been interviewed; all interviews were conducted via Zoom. The table below summarizes the information about the respondents.

Name	Date	Organization	Function
Jack Sharples	10.09.2020	The Oxford Institute for Energy Studies	Research fellow
Anna Mikulska	06.10.2020	Kleinman Centre for Energy Policy, University of Pennsylvania	Senior fellow
Roman Vakulchuk	07.10.2020	Norwegian Institute of International affairs	Senior research fellow
Michael Bradshaw	21.10.2020	The Oxford Institute for Energy Studies	Senior visiting research fellow

All the interviews were semi-structured with the questions defined by the research area of the expert. The interviews were recorded with permission and later coded. A brief summary of the interviews was sent to the respondents, which they approved after editing minor details. This was done in order to avoid inaccuracies and misunderstandings. Citations and opinions of the interviewed scientists are mainly included in chapter 4. The full summary of the questions and responses can be found in Appendix 1.

Chapter 2

Theoretical Framework

Introduction

Since the study of renewable energy geopolitics is just an emerging topic with little research performed, a comprehensive framework of analysis must be built in order to conduct an in-depth research and perform a case study. In order to do so, a proper and logically structured correlation between the shift to renewable energy in Germany and the German – Russian energy interrelations must be found. The only way of analyzing this complex topic is breaking it down into more manageable pieces that will eventually help forming a clear picture. Numerous researchers have addressed this topic from different angles before, therefore a literature research is conducted in order to bring the existing knowledge together to a theoretical framework that analyses this question from different perspectives. The research framework of Scholten (2018) is used as an initial starting point with multiple adjustments. The framework provides a comprehensive way of connecting the dependent and independent variables with a logical bridge, by means of which the research becomes structured and logically interconnected at all stages. The framework designed by Scholten was initially made with global energy relations in mind, not necessarily to be rigidly applied to a specific country. Therefore, tit is chosen as a starting point in order to create a new, more specified and detailed approach.

The structure of this chapter goes as follows. Section 2.1 looks into different frameworks that deal with geopolitics of renewables and provides a brief overview of some of the research areas that are of importance to the framework creation. In Section 2.2 a step further is taken, and a framework of analysis based on the knowledge obtained from the previous section is created. In the end of this section the reader can find an explanation of how the created framework is applied in the following chapters. Finally, Section 2.3 critically examines the framework and outlines the possible drawbacks and weaknesses.

2.1 Theoretical Background

Since the main topic of this study is the geopolitics of renewables, it is of high importance to give a definition of geopolitics itself. According to Overland (2019), “Geopolitics is about the influence of geography on the power of states and international affairs, with emphasis on the strategic importance of natural resources, their location, transportation routes and chokepoints”. Although, this study focuses on a very specific area of geopolitics, which is the geopolitics of RE, particularly how the development of wind and solar energy in Germany affects the gas trade patterns between the countries. As Scholten (2018) points out, “Geopolitics of renewables in specific, is about how the geographic and technical characteristics of RES form interstate energy relations between countries”. Now having defined the essence of the study we can move on and discuss in the following paragraphs the different theoretical frameworks on this subject and the related concepts.

Numerous research papers and articles have addressed the issue of renewable energy geopolitics. While some argue, that this scientific topic is just emerging (Goldthau et al. 2019), the first studies in this field date back to the 1970s. The reports of the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) (NSF/NASA, 1972), contain an in-depth discussion on how renewable energy could serve to the USA as possible means of avoiding international energy crises. California Academy of Science (1980) published a report on a common topic, discussing how the development of renewable energy could lessen the US energy vulnerability and the likelihood of war. Several scientists in the 1980s have discussed the possibility of renewable energy to affect the political relations between countries and lessen the geopolitical power of fossil fuels (Williams 1974, Omo-Fadaka 1980, Shea 1988). Although no analytical framework had been created in that time period that could be of any means applicable to this study. The reason for it is the fact that RE was not yet widely implemented, which led to a very

abstract analysis not backed up by any facts and evidence, while the goal of this research is to find actual evidence of how RE affects the energy relations between Germany and Russia.

Multiple scientists have tackled the topic of renewable energy geopolitics since then, although according to Vakulchuk et al. (2020) "the geopolitics of renewable energy has received increasing attention from the expert and academic communities from around 2010 onwards". Taking a closer look on the academic works from the last decade, the amount of literature on conventional energy geopolitics clearly dominates. The reason for it is the fact that fossil fuels have been the primary energy resource for more than a century and even with the shift to renewable energy that is currently taking place, oil and gas will still be dominating the global market for decades. The topic of renewable energy geopolitics has lately been studied mainly by researchers from Northern Europe, particularly scientist from Germany and the Netherlands (O'Sullivan, Meghan and Overland, 2017). Authors such as Criekemans (2011), Scholten and Bosman (2013,2016), Sweijs et al. (2014), O'Sullivan, Meghan and Overland, (2017), Overland (2015) and Paltsev (2016) could be named as the most well-known and cited works on the topic of the renewable energy geopolitics. Criekemans (2011) discussed how the role of the locations of energy carriers (fossil fuels vs. renewable energy) could affect the global position of political and economic powers. Scholten and Bosman (2013, 2016) conducted a thought experiment where they addressed the new strategic reality that producer, transit and consumer countries could face in a 100% renewable future. Sweijs et al. (2014) investigates the impact of the EU decarbonization policy on political and economic relations with EU's energy partners, among which is Russia. Overland (2015) provides an overview of how the climate policies might affect the relationship between oil and gas importing and exporting countries. Paltsev (2016) compares different aspects of fossil fuels and renewable energy, discussing which geographical and technical characteristics of renewables might shape the low-carbon energy geopolitics of the future.

While all the listed above authors have made a significant impact in the field of renewable energy geopolitics, one drawback is common for these studies, which is the lack of a concrete case study of the relationship between two countries. Moreover, according to Köhler et al. (2019), the transition of the energy system from fossil fuels to renewables represents a transdisciplinary subject, which calls for a comprehensive framework that tackles this problem from various angles. Although the relationship between international politics and the energy transition still remains unclear. Therefore, the framework for this study is very hard to outline. It must be simultaneously broad enough to tackle all the listed above subjects and aspects of the problem, and deep enough to find the answer to the main question and not be led away during the research. The only framework created so far that suits most of the needs of this research, is the framework of Scholten (2018), who managed to combine and structure different scientific approaches and topics in such a way, that the theoretical framework with multiple adjustments can be applied to this "hands-on" analysis.

Scholten managed to systematically break down the topic of the geopolitics of renewables to manageable pieces, accounting for many complex factors. The key to success was outlining the dependencies between the geographical and technical characteristics of renewable energy systems (dependent variable) and the interstate energy relations (independent variable) using an intermediary step, which can be clearly seen on Figure 2.1. Such an approach not only makes the report more readable, but also creates a clearer understanding of the processes involved and structures the reasoning.

The framework of Scholten uses four consistent steps. The first charts geographical and technical characteristics of energy systems, which can be regarded as independent variables. The second, intermediary step, analyses the economic impact that the energy system has on the domestic market and among related countries. The third step investigates in-depth the dependent variable, which is interstate energy relations. Finally, the last step reflects on the relationship under study in light of contextual developments.

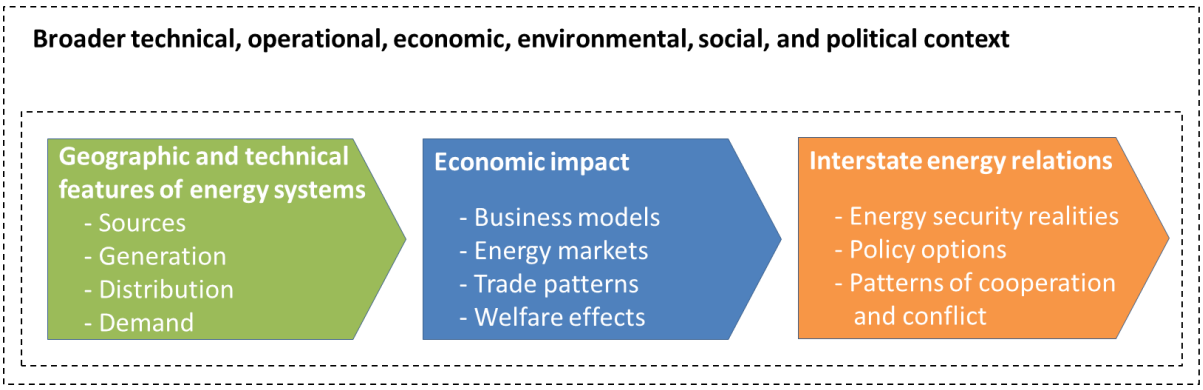

Figure 1.1 Theoretical framework of Scholten
Resource: Scholten (2018)

Having discussed some main literature in the topic of RE geopolitics, we now can move further and discuss the topic of energy security. Numerous scientists point out that the rapid development of RE will inevitably have an impact on domestic energy security (Dalby 2016; Dhaka 2009; Selby & Hoffman 2014). Although the term "energy security" is widely used, a quick glance at the scientific literature in this field shows, that there is no consensus on a definition of energy security. Chester (2010) points out, that the nature of energy security is very polysemic and multidimensional. According to Sovacool & Mukherjee (2011), 45 different definitions exist, some of which are implicit. An explanation for this fact could be that the scientific background of researchers drastically differs. Moreover, the definition of energy security is highly contextual dependent. As Sovacool & Mukherjee (2011) point out, "this multitude of definitions serves some strategic value: it enables policy actors to advance very different notions to justify their actions and policies on energy security grounds". This research sticks to the definition of the World Energy Council (2008): energy security is "an uninterruptible supply of energy in terms of quantities required to meet the demand at affordable prices", since this definition is widely accepted. Moreover, most of the works in this field point out that the security of supply will be harder to maintain when switching to renewable energy, especially in the short- and mid-term. According to Dhaka (2009), Germany will "seek to spread their energy security through technology-centered geopolitical pluralism". Overall, the scientists also agree on the fact that energy security is highly related and interdepended with energy geopolitics in our modern globalized world.

Given the number of definitions, even more ways of operationalizing energy security and classifying its various dimensions exist. Among numerous conceptions, the most widely used and citated in research articles are the 'five Ss' - surety, survivability, supply, sufficiency and sustainability (Kleber, 2009), the 'four As' - availability, accessibility, affordability and acceptability (APERC, 2007) and the 'four Rs' - review, reduce, replace, restrict (Hughes, 2009). Although the prevailing majority of the framework and studies of energy security are dedicated to conventional fossil fuels. Moreover, another issue that reveals with a closer look, is the fact, that most of the existing frameworks do not quantify energy security by any means. One of the most widely used approaches to quantifying energy security, taking into account different sustainability factors and renewable energy, is the approach created by Sovacool & Mukherjee (2011). In this study the scientist identified five key dimensions of energy security (availability, affordability, technology development and efficiency, environmental and social sustainability and regulation and governance) and clustered them into 372 different indicators, that can be used to analyze and compare national performance on energy security.

Taking a closer look at the topic of energy geopolitics relations between the European Union and Russia, this topic has been studied from various views. For example, Sharples (2016) predicts, that the amount of imported gas from Russia will not significantly drop until 2030, because the EU is considering gas as a transition fuel towards green energy. Salzman (2016) supports this point of view, pointing out that the EU – Russia political relationship is far more affected by the ongoing crisis in the Ukraine rather than by the EU's climate policies. On the other hand, Sharples (2013) predicts that the development of the EU internal gas market and the climate-change policies pose a big threat to the Russian's energy security. At the same time the Russian analysts consider the EU market to become an economically challenging environment due to uncertainties in the possible

energy diversification. Kuzemko (2013) argues that EU is a divided actor in energy transition, which is noticed by Russia, which "actively utilizes divisions to undermine the EU's negotiating position".

Moving on to international economic and relations, we see, that international conflict and cooperation in energy relations may be observed worldwide on a daily basis. Any kind of economic links in form of energy trade between countries can be seen as a form of cooperation, where both actors are seeking to increase the domestic welfare. Many scientists have already studied the economic benefits of gas trade between Germany and Russia. Most of these studies have used classical macroeconomic approach, accounting for the trade and welfare in plain numbers (Bouwmeester and Oosterhaven 2017; Sziklai et al. 2020; Ozawa et. al. 2019). At the same time, geopolitical conflict may appear in numerous forms, such as sanctions and tariffs, travel bans or warnings, embargo's or even military conflicts. According to Al-Rawashdeh (2017) "The phenomenon of international conflict differs from other phenomena of international relations as a very complex dynamic phenomenon, due to its multiple dimensions, the interplay of its causes and sources, the interplay of its direct and indirect effects, and the varying levels that occur in it in terms of scope, intensity and violence". Although these types of energy related conflicts are especially often observed in the geopolitics of conventional fossil fuels and are not representative for renewable energy. The current gas interrelations between Germany and Russia cannot be discussed from this perspective, since no armed conflicts happened for many decades. Moreover, energy policy remains a relatively cooperative field of EU-Russia relations (Judge, Maltby and Sharples 2016). One reason for this could be the level of economic interdependence achieved in the previous decades and the consequences of each side's policies for the security of the other acted as a strong incentive for maintaining dialogue and a certain level of cooperation (David and Romanova 2015; Yafimava 2015). Therefore, this research is focusing on the patterns of conflict and cooperation only from an economical gas-trade perspective and the related policies.

2.2 Requirements for the framework

After having discussed the different theoretical frameworks on the topic of renewables geopolitics it is necessary to clearly outline all the requirements for the framework for this research. In order to be able to answer the main research question the framework must fulfill the following needs. Firstly, the research is theoretical, which calls for a desk approach. All the information should be available on the internet. Secondly, a clear logical connection between all the variables should be established. This calls for an approach with an intermediate step, since the logical connection between the geotechnical characteristics of RE and the gas trade patterns is complicated. The next requirement is the broader look on the whole system. Since geopolitics is a very complex topic with multiple factors affecting it, we should not only establish a relationship between the RE development and changes in gas trade patterns, but also discuss the situation from a broader perspective. This will help to understand, to what extent the renewable energy development can be held accountable for the changes. Finally, despite the fact, that the framework is being created for a specific case study, it should be easily applicable to other countries with minor adjustments. Bearing all these requirements in mind, we can now move on to the last step and discuss the creation of the framework.

2.3 Framework Creation

In the previous section we have operationalized all the necessary concepts and discussed different research approaches that could be of help designing the actual framework. As discussed earlier, the scope of the research is very vast and therefore it is impossible to just pick an existing framework and blindly apply one to this study. Although, the framework that has inspired the author for this way of thinking and structuring was developed by Scholten (2018) using four consistent and interconnected steps. As Scholten mentions, the framework designed by him was initially made with global energy relations in mind, not necessarily to be applied to a specific country. It is hence used as a starting point to create a new, more specified framework. Therefore, the goal of this section is to take a step further and create a framework of analysis that is based on the knowledge obtained from the previous section.

Since the approach of Scholten is used as a starting point for this research, this framework will as well be based on four consistent steps, using dependent, independent and intermediate variables. Moreover, contextual variables are included in the scope of the research. This is done in order to be able to analyze other possible reasons for the changes in the patterns of conflict and cooperation within the framework of analysis. Such an approach allows to search broader for the reasons, which could be necessary for proving, that the observed changes stem from other factors.

The scheme of the theoretical framework is depicted on Figure 2.2 We will now proceed by discussing each of the logical links at a time, clarifying the choice of each and operationalizing all the related concepts.

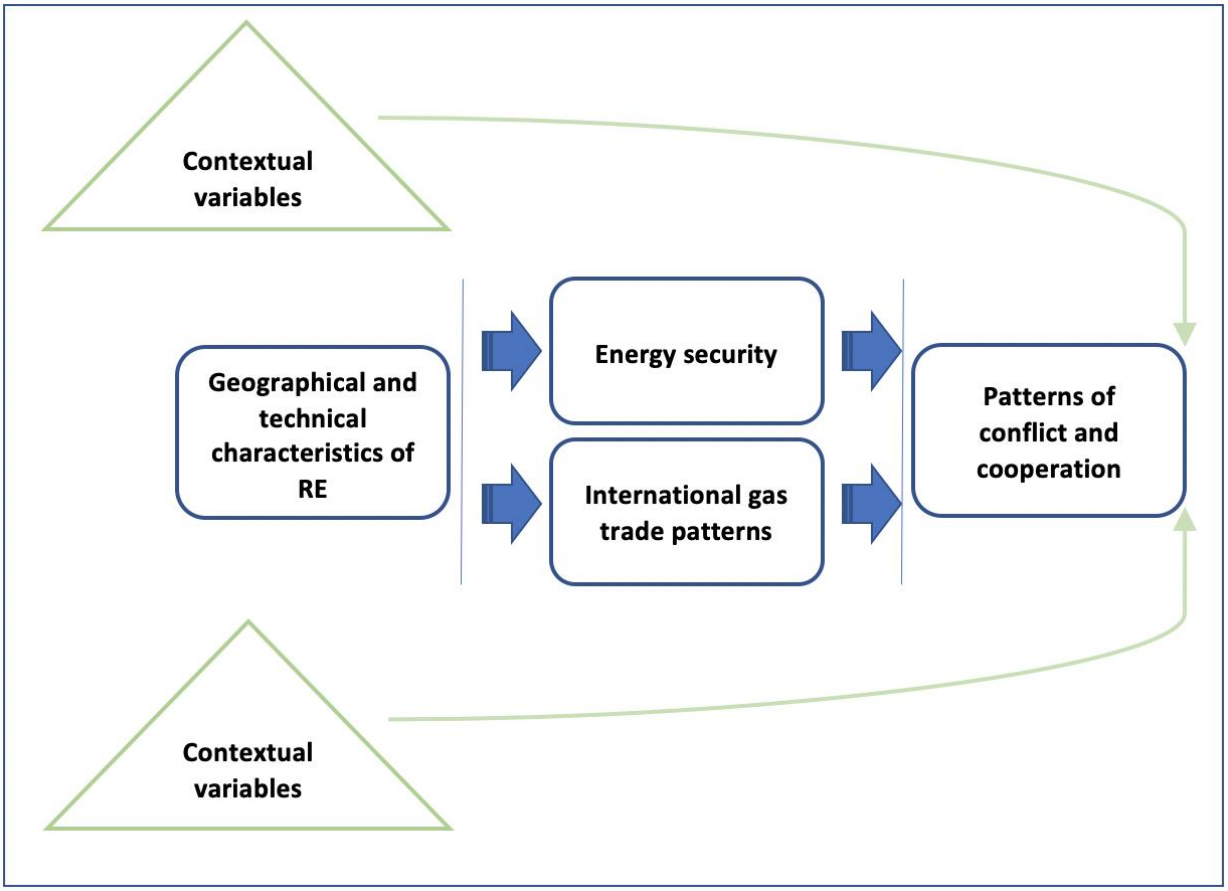

Figure 2.2 Framework of analysis

2.2.1 Independent variable

The independent variable comprises the geographical and technical characteristics of energy systems. Geographical characteristics determine the natural context in which the technical system is embedded and shaped and can be divided into three main components: sources, generation and distribution. Each of the components can be described by three characteristics, which can be observed on Table 1.

Sources of solar and wind energy can be described by the location of the power plants installation, the stability or intermittency of the resource and the potential demand meeting. The location of power plants can be either onshore/offshore or inside/outside the country border. Moreover, the location of RE systems heavily depends on the geographical conditions such as average wind speed and annual solar irradiation. The intermittency of RE is the daily and seasonal predictability, which is one of the current biggest issues of RE technology. The potential demand meeting looks at whether the installed capacity is capable of meeting the consumer needs and how much of land is needed for it, taking into account the geographical constraints.

The next component is the generation of renewable energy, which is heavily dependent on the use of rare materials, the central or decentral nature of generation and the necessity for storage. According to multiple studies, the usage rare materials is critical for RE energy technology manufacturing chain (Karen Smith Stegen, 2015; Månberger and Johansson, 2019). For example, indium, silica and gallium are often used in PV cells production, while dysprosium, neodymium and praseodymium are commonly used in both onshore and offshore wind turbines. The central or decentral generation looks at the distribution of power facilities throughout the country, taking into account the so-called prosumers. The necessity for storage is also one of import implications of RE systems, that stems from intermittency of wind and solar energy.

The third characteristic of energy is the distribution which relates to the transportation options (e.g. electricity, liquid hydrogen etc.), grid reinforcement and new smart control systems. Due to the different losses in energy transportation and the overall viability of them, different transportation options exist, that can be applied. The need for grid reinforcement stems from the often-decentralized electricity production and the new connections between areas with different wind/solar conditions. Smart control systems are also related to the decentralization, since the new consumers are often prosumers, which leads to the increased problem of grid stabilization.

Characteristics	**Independent variables**		
Sources	Location	Stability	Demand meeting
Generation	(De)central generation	Need for storage	Rare materials
Distribution	Transportation options	Grid reinforcements	Smart control systems

Table 2.1 Independent variables
Resource: Scholten (2018)

Due to the time limits of the research it is barely impossible to focus on all the 9 independent variables equally in-depth. Therefore, this framework contains a superficial analysis of the geographical and technical characteristics of renewable energy in Germany, identifying the independent variables, that contribute the most to this particular study. Such an approach could help identifying what specific geographical and technical characteristics of RE in Germany have the most impact on the energy relations with Russia, which could be of high academic knowledge, since this topic has not been researched yet.

Since no applicable method to quantify the independent variables exist, the analysis will be based on a literature research, that will reveal how much the independent variables have changed with the rapid solar and wind energy development in Germany.

2.2.2 Dependent variable

The next step in the framework creation is clarifying and operationalizing the dependent variable, which is an extremely important and difficult task, taking into account, that the term “energy relations” is broad and multidimensional. As discussed in the previous section, this research focuses more on geo-economics rather than on geopolitics as a whole. The dependent variable comprises the patterns of conflict and cooperation between Germany and Russia, that stem from the development of RE in Germany. Moreover, it is necessary to mention, that the patterns of conflict and cooperation studied in this research have the intention of strengthening the domestic energy security and reaping economical and geopolitical benefits of gas imports for Germany. Defining the dependent variable in such a way creates an opportunity to analyze how the Energiewende has affected the gas relations between Germany and Russia from the German perspective both in terms of economic impact and domestic policy responses. In order to shorten the dependent variable name, we will refer to it as patterns of conflict and cooperation, bearing in mind the explanation given in this paragraph.

Having outlined the scope of the independent variable, it is now necessary to propose a way of analyzing and quantifying the dependent variable. This framework of analysis proposes three following indicators, with the help of which it is possible to describe the economic aspects of the patterns of conflict and cooperation between Germany and Russia.

- Time
- Intensity
- Governmental response

The time indicator provides an insight into the duration of the conflict of cooperation. While it is possible to distinguish between long- and short-term, the purpose of this research is not to clearly divide the duration of the conflict or cooperation, rather understanding the core. The definition of long or short term is not only vague, but also depends on the exact conflict and situation. Therefore, I intentionally do not give a strict definition with an intention of analyzing how long or short-term the conflict or cooperation is for every concrete case.

The intensity indicator gives an overview of the potential economic impacts of the conflict or cooperation. While there exist other potential impacts, such as political, social, military etc. this research focuses explicitly on the economic impact of the conflict/cooperation based on gas interrelations, as already mentioned before. This indicator will be analyzed with the use of two parameters: direct economic impact and foreign direct investments (FDIs).

Starting with the latter, FDI, according to the Financial Times Lexicon, can be defined as an investment in the form of a controlling ownership in a business in one country by an entity based in another country. According to The Oxford Handbook of the economics of peace and conflict (2012) FDIs are one of the standard ways of measuring economic involvement. The FDIs are among other factors dependent on the patterns of conflict and cooperation between countries and can thus represent how the energy-based tensions or cooperation between Germany and Russia affects the international investments. It represents transactions that increase the investment that foreign investors from the source country have in enterprises resident in the reporting economy. Although the analysis of the shift in FDIs might not always be representative, since they may be affected by many other forms of conflict and cooperation, that do not stem from the international gas trade. Since it is impossible to clearly separate all the possible reasons for the change in the FDIs flows, it is necessary to critically examine the possible reasons of change in the FDI flows.

The direct economic impact indicator shows in monetary terms, the amount of benefit or detriment to the country from the conflict or cooperation. While at first sight such an approach looks similar to the FDIs analyses, in fact it drastically differs. By referring to the term “direct economic impact” this research analyses the amount of benefit/damage for the country from the conflict or cooperation in monetary terms. For example, discussing possible cooperation as a new gas contract, the economic impact for both countries in monetary terms will be analyzed.

The last indicator analyses how the German official authorities’ response to the patterns of cooperation or conflict. Political responses could occur in many forms, such as governmental official statements or policies that were adopted by the government as means of a response on the conflict or cooperation based on gas interrelations. As an example, could serve the political and thus financial support of LNG implementation in Germany, which could be discussed as a way of diversifying away from the Russian gas. Or the statements that Angela Merkel made towards Donald Trump, who has lately threatened Russia with sanctions for building the Nord Stream 2. Analyzing German official responses that deal with the Russian gas imports allow gaining information on related conflict or cooperation and the German official attitude to them.

2.2.3 Logical connection between the variables

Having defined both the dependent and independent variables, an intermediate step is now necessary to logically bind the variables and make the research more structured. While in the framework of Scholten (2018) economic impact is considered as the “bridge”, this research proposes two “parallel” intermediate steps between the variables: German domestic energy

security and gas trade patterns between Germany and Russia. It is important to point out that while the logical bridges may be interconnected with each other and even overlap in some of the topics, both of them are on one side dependent on the RE development in Germany and simultaneously form the ground for patterns of conflict and cooperation.

While it is arguable, that the international gas trade patterns can also be discussed in the context of domestic energy security of export/import, in this research I will be differentiating between these 2 terms. Such an approach allows not to just stick to the concepts of energy security, but also leads to a more comprehensive discussion on the topic of actual economic and geopolitical implications for Russia. Moreover, the distinction between German energy security and economical profitability for Russia provides an opportunity to create two logical connections between the dependent and independent variables, that will be in detail discussed in the next section.

As discussed in the previous section, the term energy security is broad and multidimensional and different scientific approaches to this concept exist. Since the frameworks needs some type of quantifiable indicators for energy security, we will stick to the framework created by Sovacool & Mukherjee (2011), who identified five key dimensions of energy security (availability, affordability, technology development and efficiency, environmental and social sustainability and regulation and governance) and clustered them into 372 different indicators. that can be used to analyze and compare national performance on energy security. Such an approach provides a workable and illustrative way to assess the changes in the German energy security that stem from RE development and could impact the interstate energy relations with Russia. From the 372 indicators proposed by Sovacool and Mukherjee, 10 indicators were chosen (and some adjusted) in order to link the development of wind and solar energy in Germany with the interstate gas relations between Germany and Russia. The metrics chosen for this study are listed in Table 2.

№	Dimension	Component	Indicator
1	Availability	Security of supply and production	Self-sufficiency (% demand met by domestic production)
2			Total electricity demand
3		Dependency	Natural gas import dependence rate
4			Balance of export and import of electricity
5		Diversification	Diversification on total primary energy supply
6			Geographic dispersion of renewable energy facilities
7			Share of solar and wind in electricity demand
8	Affordability	Price stability	Transmission and distribution cost for electricity
9			Gas price volatility
10	Technology development and efficiency	Safety and reliability	Duration of electricity blackouts or supply interruptions

Table 2.2 Energy security indicators from Sovacool & Mukherjee (2011) with adaptations

While the choice of some of the metrics is obvious, other indicators need reasoning and clarification. Indicators 1 and 2 reflect on the security of supply of the energy overall and electricity in particular. The analysis of them will provide an understanding of the self-sufficiency of the German energy sector as well as the national changes of electricity demand throughout the years. Indicators 3 reflects the dependency of Germany on the natural gas imports from Russia, while indicator 4 creates a comprehension, whether the produced electricity is enough for supplying the

German needs or exceeds them. Indicators 5,6 and 7 provide a more sophisticated analyses of RE. The diversification on total primary energy supply can show how dependent Germany is on both gas and RE. The geographical dispersion of energy facilities gives an insight into the (de)central generation, which is one of the independent variables, as discussed above. The decentralization of energy generation is an important consequence of RE development (McKenna, 2017), which might be affecting the Germany's energy security. The share of solar and wind energy in the total electricity demand gives an insight on the state of RE development. Indicator 8 is closely related to the technical characteristics of transportation and grid reinforcements, while indicator 9 shows, how the gas prices changed over time, which is very important for the German import rates. Finally, indicator 10 provides an understanding, of how the reliability of the German electricity grid changed with the growing share of RE. The analysis of the chosen indicators can make it possible to assess the interrelationship between the changes in the geographical and technical characteristics of RE and the patterns of conflict and cooperation by means of an insight into the various dimensions and indicators of the German energy security.

The second link between the variables, is the international gas trade patterns. Such an approach from an economical point of view will reveal, how strongly the development of RE affects the gas interdependence between the countries, which in turn leads to a better understanding of the patterns of conflict and cooperation, since they are highly economic based. To investigate the economic impact of geographical and technical characteristics of RE on the interstate energy relations it is necessary to take a closer look on how strongly the countries are gas-interdependent and how the gas trade has changed over time with regard to the growing share of RE in Germany. Although, it will be necessary to discuss, how far our observations will be an actual consequence of RE development. The following characteristics will be analyzed:

- The share of gas in the Germany's energy mix.
- The share of German gas imports from Russia from the overall gas imports.
- The share of Russian gas exports to Germany in the total gas production.
- The share of Russian gas exports to Germany from the overall gas exports.

Analyzing the listed above variables together with scientific literature on the interdependency between Germany and Russia will reveal how strongly the Russian economics is based on the gas imports to Germany. Accompanied by the analysis of the independent variables and the German energy security, an understanding will be formed, what the consequences of RE development in Germany might be for the Russian economics. Such an approach will create a comprehension, how RE affects the patterns of conflict and cooperation between Germany and Russia.

2.2.4 Contextual variables

Since the research deals with the patterns of gas trade relation, numerous factors could be responsible for the changes. Therefore, while the main goal is to analyze, whether the geotechnical characteristics of RE energy have an impact the changes, we should keep in mind, that the gas trade relations are part of a much broader picture and numerous factors have an influence. Therefore, the framework should as well account for the possible technical, operational, economic, social, environmental and political context. While this research does not include an initial analysis of these contextual variables, they must be included in the framework for the following reason. The research is structured in such a way, that the changes in the gas trade relations are first identified and then analyzed on the fact, whether the geotechnical characteristics of RE can be held accountable for them. Therefore, in order to have a possibility to prove, that the RE is not related to the changes, we should find an explanation for these changes in contextual variables.

2.2.5 Application of the framework

The analysis based on the created framework will be done in two steps, which are performed in two different chapters. Firstly, Chapter 3 provides an overview of the dynamic changes in the main variables of the framework along with a discussion of the overall renewable energy sectors both in Germany and Russia. Such an approach allows to analyze the case consistently from the situation to the complication, detailing the main actors and understanding the dynamic development of the

variables throughout the years before making the actual logical connections between the variables. Moreover, the main trends and changes in the current gas relations between Germany and Russia will be outlined.

The main goal of Chapter 4 will be to continue applying the created framework by means of finding explanation for the identified changes in gas trade relations, which requires a deeper and more contextual analysis. This will be done by understanding the importance of other contextual variables as well the main variables in the framework. The creation of logic connections and reasoning in Chapter 4 will be based on the knowledge obtained in Chapter 3.

2.3 Framework Drawbacks

The adapted from Scholten (2018) framework has many advantages, which are in detail discussed in the previous sections. Looking from a wide perspective, no particular drawbacks can be observed, since the framework suits the needs of the research, logically binding the development of RE in Germany with the gas-based patterns of conflict and cooperation between Germany and Russia by means of analysis of the domestic energy security and international gas trade patterns. At every step of the framework the concepts are operationalized and analytically examined. Such an approach not only reveals how established bilateral energy relations between Germany and Russia are affected by the geotechnical characteristics of RE, but also creates a clear logical structure with a comprehensive analysis at each stage. Nevertheless, no ideal framework exists and therefore the goal of this section is to take a step back and critically examine the created framework in order to find possible drawbacks and points for future improvement.

Starting with one of the logical connections between the dependent and independent variables, one of the drawbacks of this framework is the way energy security is analyzed. As discussed in section 3.3, the framework uses 11 energy security indicators in order to measure how the RE development has affected the energy security in Germany. While such an approach allows to dive deeper into some particular implications of energy security, it would be more beneficial to fully apply the framework of Sovacool to the analyses of energy security. Although due to the broadness of the energy security concept and the extremely high number of indicators, such a research would be extremely time consuming and could be regarded as an apart research. Therefore, just 11 indicators have been chosen, which I believe are of most importance for this particular study.

Proceeding to the dependent variable, possible issues might appear when analyzing the intensity of the conflict. As discussed in section 3.2, two different indicators are proposed for measuring and quantifying the intensity of the conflict: national economic impact and FDIs. Both of these indicators are highly complex. The economic impact of any cooperation might can be studied extremely in-depth, since any form of economic conflict or cooperation does trigger a long chain reaction, affecting different industries, which makes the full economic impact extremely hard to calculate. Therefore, this study focuses just on the “upper-level” impact, analyzing just the direct economic benefits or losses and not tracing the impact down on a national level. Another issue lies in the approach to the FDI flows. Since FDIs are a widely accepted method of measuring economic activity, it is necessary to discuss how far the observations in changes are a consequence of the conflict or cooperation that is studied. Therefore, it is necessary to analyze other patterns of conflict or cooperation between countries, since the change in the FDI flows might not be related to the gas conflict or cooperation.

The last but not least drawback of this framework is the absence of interviews with interested parties from Germany and Russia, such as employees of the German Federal Ministry for Economic Affairs and Energy, employees of the Ministry of Energy of the Russian Federation and employees of Gazprom. While the initial goal was to include respondents from this group in the interviews, it has become impossible due to the escalation of political conflict between the EU and Russia in September 2020, which is related to the poisoning of Navalny.

Chapter 3

German and Russian Energy Sectors

Introduction

In order to create a comprehension, how the development of RE in Germany has affected the gas trade relations with Russia it is necessary to not only follow the steps of the created framework, but also create a more global understanding of the system. Therefore, this chapter performs the first 2 steps of the framework, discussing the geotechnical characteristics of RE and the chosen energy security indicators. Moreover, another important purpose of this chapter is to create a global comprehension of the German and Russian energy sector and the gas trade relations between them. Looking from the perspective of the theoretical framework, this chapter performs the first 2 steps, while at the same time provides information that is necessary to make all the logical links in Chapter 4 and outline conclusions and recommendations in Chapter 5 and 6.

The structure of this chapter goes as follows. Section 3.1 focuses on Germany, firstly describing the overall structure of the energy sector and the related policies in sub-section 3.1.1. Having created a global understanding the energy sector, the chapter continues with the framework application in sub-sections 3.1.2 and 3.1.3. Sub-section 3.1.2 discusses the geotechnical characteristics of RE and what implications they might have on the energy security and gas consumption of Germany. Sub-section 3.1.3 analyses the previously chosen 10 indicators of German energy security along with the 4 indicators of gas trade patterns. Section 3.2 continues with an overview of the Russian energy sector as well as the state of RE development in Russia. This information is important to understand the structure and needs of the system, which is critical to give recommendations for future development in Chapter 6. Finally, Section 3.3 includes an historical overview of the gas-trade relations in the past 20 years as well as the main changes that have occurred in the past years. This timeframe is chosen due to the fact that since the 2000s the increasing Russian fossil fuel production facilitated a large expansion in the quantity of gas supplied to the European market. By taking this as an initial starting point, the research addresses only the modern era of German – Russian gas relationship and cuts off the turbulent years of the 90x. The analysis of the changes and the discussion of their RE dependency is left for Chapter 4, where the second step of the theoretical framework is performed.

The structure of this chapter allows the reader to systematically go through all the necessary information as well as the more descriptive parts of the framework, while the more analytical part is left for the next chapters. This allows the reader to systematically analyze the problem from the situation to the complication.

3.1 Germany

3.1.1 German energy sector and policies

Over the past 50 years, the German energy sector, has undergone significant changes, turning from both coal and nuclear energy to sustainability. The official start of the new energy policy in Germany was given in 2000 with the adoption of the law on support for renewable energy (EEG). Later this document was amended several times, but its essence remained unchanged – dismantling NPPs and increasing the share of renewable energy in the overall mix. During the time period between 2000 and 2010 the demand for electricity slightly increased, while the demand for primary energy sources for producing heat significantly decreased. This fact occurred due to the governmental financial subsidies for energy-efficient technologies in the industry sector and abandoning of coal usage for household heat. Before 2010 nearly 50% of domestically produced energy stemmed from hard coal and lignite, although the situation radically changed with increasing RE development and abandoning NPP. Hard coal production has substantially declined, although is still the largest in Europe and accounted for 10% of Germany's primary energy use in 2018. Overall the German coal and lignite production sector seems to be more a monopoly rather

than a free market. There exists only one company in Germany producing hard coal and the prevailing majority of lignite production is dominated by just one producer (Renn and Marshall, 2016).

Until 2010 roughly 50% of domestically produced energy was produced from coal and lignite, while the other half stemmed from a mix of gas, nuclear and renewables (Renn and Marshall, 2016). Although since 2010 the primary energy mix has significantly changed. In 2011 Germany announced legislative plans to phase out NPPs by 2022 and reduce the amount of fossil fuels in total primary energy consumption from 80% to 20% by 2050 by gradually expanding renewable energy technology. In 2011, the German Energy concept included a commitment to generate 80% of electricity from renewable sources by 2050. This commitment should reduce carbon dioxide emissions by 80-95 % from 1990 levels. In November 2016, the German Federal government approved the Climate Protection Plan 2050, according to which the country will reduce greenhouse gas emissions by at least 55% by 2030 compared to 1990, by at least 70% by 2040, and by at least 80% by 2050. The implementation of these tasks is possible due to the gradual closure of coal plants by 2038 and the transition to renewable energy sources. Overall the German energy transition that occurred in the past 20 years has mainly had a “green” direction.

At the moment, due to the implementation of the Energiewende, the total primary energy consumption in Germany continues to decrease. Demand for primary energy in Germany in 2019 decreased by 3% compared to the previous year (in the European Union, the decrease was noted at the level of 0.5%). Amid the implementation of the energy efficiency program, inter-fuel competition continues to increase. It is worth noting that the severity of inter-fuel competition is not fully determined by market conditions [BP Statistical Review of World Energy, 2019].

As concerning the natural gas, it is considered to be the “cleanest” of all conventional fossil fuels (UCUSA, 2014) although it’s positions in the German energy strategy are unclear. In most of the listed strategic documents, including the current energy concept of 2010, natural gas is almost not mentioned, which has given rise to various versions of developments in this sector and high uncertainty of forecasts. At the end of 2019, the "Gas dialogue 2030" (GAZ - 2030) came to its end, as a result of which a New German gas strategy was adopted [BP Statistical Review of World Energy, 2018]. It is obvious that the release of such a document had a significant impact on the balance of forces, as it clearly demonstrated the interest of the German government in the gas market. The document itself also paid attention to the consequences of the lack of regulation of the gas market at the previous stage. To assess the impact of the New gas strategy on the German gas sector, it is worth analyzing its current state [BP Statistical Review of World Energy, 2019].

Below are listed some of the possible positive factors for natural gas development in Germany:

- Abandoning nuclear energy and coal can create space for the growth of the share of natural gas in the fuel and energy balance;
- Lowest carbon footprint among all hydrocarbon fuels.
- A reliable energy resource with constant generation is needed in order to ensure the country’s energy security.
- In case of peak temperatures and emergencies, an energy stabilizer is needed, which is currently natural gas and may remain so for future periods.
- The presence of a potentially rich transport market requires hydrocarbon fuels, the most environmentally friendly source of which may be natural gas.

Taking a closer look at the consumption of natural gas in the past 20 years, we may observe some changes. Although Figure 3.1 shows, that while some in some of the year’s fluctuations were higher, the overall picture seems to be pretty stable. The share of natural gas in German power generation increased by 32.5% from 2002 to 2019 but decreased by 20.8% compared to the maximum generation in 2008. Moreover, Figures 3.2 and 3.3 reveal, that Germany has been constantly reducing domestic gas extraction since 2000 and relying more on gas imports.

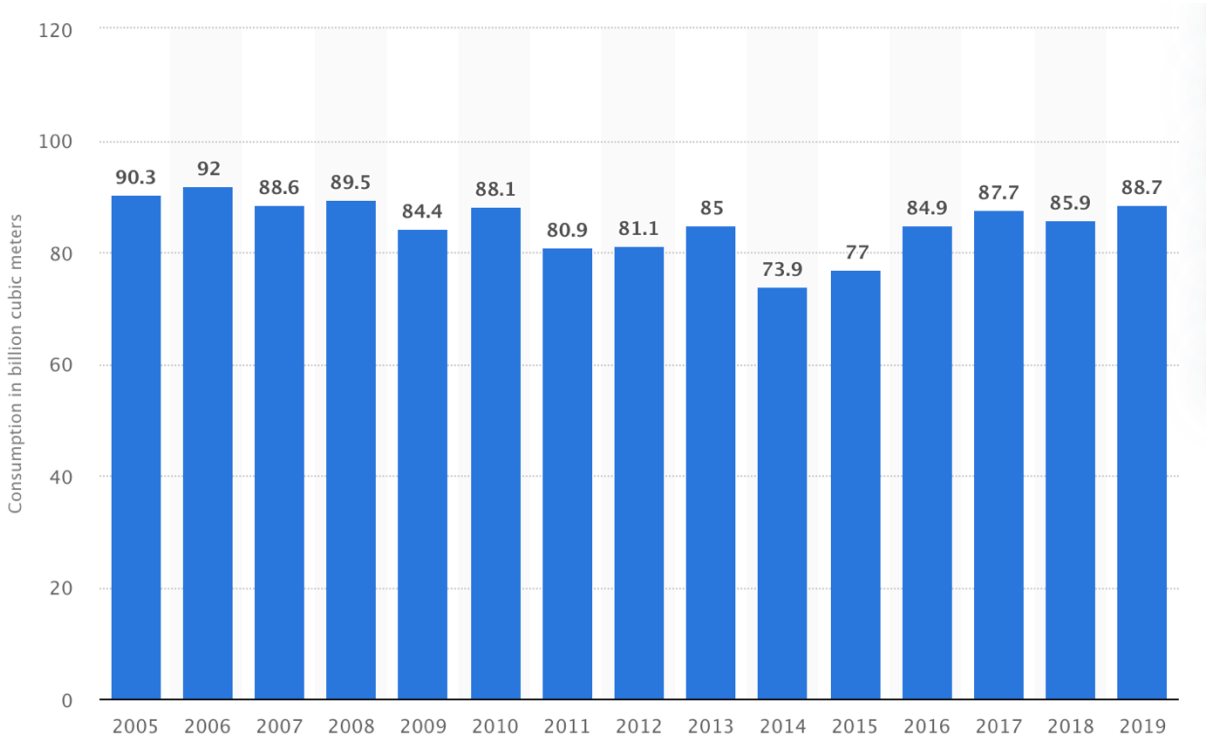

Figure 2.1 German natural gas consumption
Source: Statista 2019

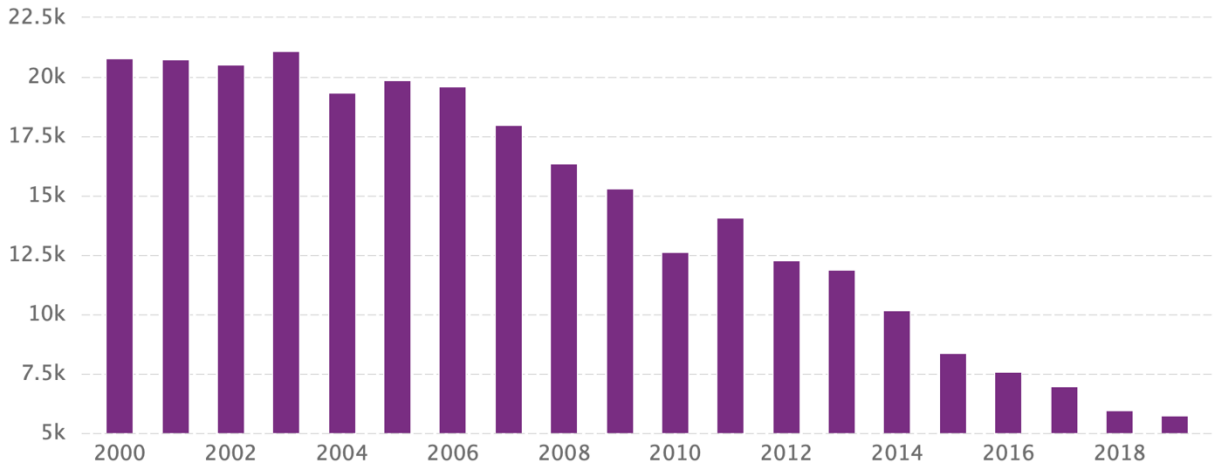

Figure 3.2. German domestic natural gas production.
Source: CEICDATA 2019

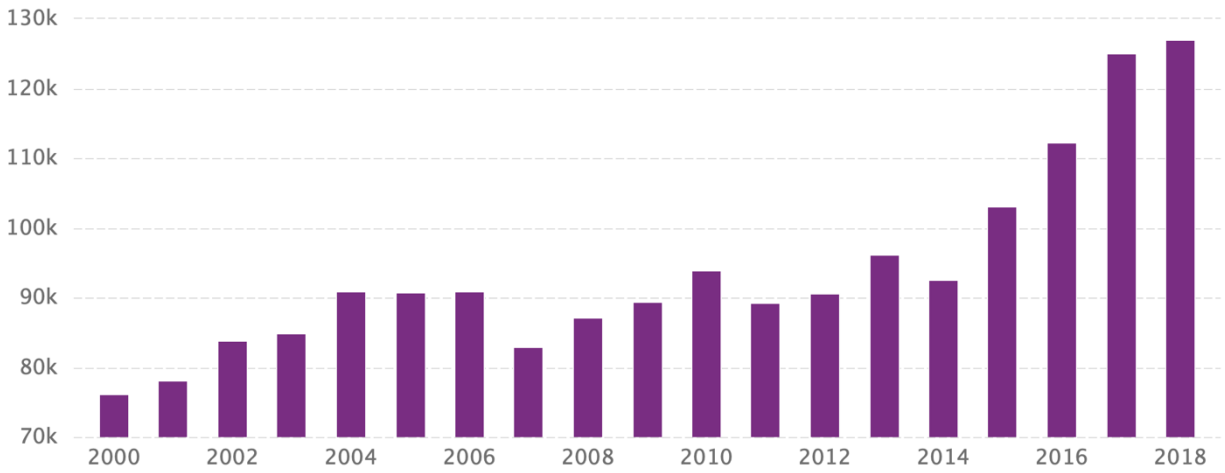

Figure 3.3. German natural gas imports.
Source: CEICDATA 2019

For the German and European energy security in the medium and long term, Germany's gas infrastructure is essential, as Germany, as the center of gas supply and transit to Europe, plays a significant role in diversifying supply routes and sources of energy resources for its European neighbors. The German gas sector is as like the coal sector the largest in Europe, although is on contrast very complex and economically developed. According to Renn and Marshal (2016), it can be described as a multi-tiered, decentralized structure with a number of privately and municipally owned companies. Since German domestic natural gas resources are very limited, more than 90% of natural gas demand is imported, which makes Germany highly dependent on a reliable natural gas supply, having mainly 3 countries, from where the import occurs: Russia, Netherlands and Norway. According to the IEA report (2020), the natural gas consumption is likely to increase in Germany in the coming years due to two factors. Firstly, natural gas is currently used as a back-up fuel source for wind and solar energy, which are expanding at a high pace. Secondly, natural gas use in electricity generation is increasing, especially during peak demand. Moreover, Germany's domestic gas production is declining. Combining this fact with the termination of Groningen gas field by 2022 and the current final phase of the Nord Stream 2 construction, we may see an increasing share of Russian natural gas on the German domestic energy mix.

Considering the German electricity production, Figures 3.4 and 3.5 reveal the changes that occurred in the past 20 years. We may observe, that the overall consumption has increased from 548 to 613 billion KWh. The use of both natural gas and RE has increased, while the nuclear and coal energy has significantly decreased. In 2001 all RE production accounted for just 7%, while in 2018 25.4% of electricity was produced from PV and wind.

An important turnover in the European and in particular Germanies internal gas and electricity market occurred in 2011, when the Third Energy Package for Gas became a law in Europe. The goal of this document was to create a single liberalized EU gas market, transforming dome of the previous gas directives and regulations. The third package is not applicable to non-EU suppliers, although changed the rules of the game for Russia in terms of exporting gas. One of the main goals was to unbundle transmission assets (separating ownership of transmission network and ownership of gas) (Mikulska, 2020).

In 2019 amendments were made in the Gas Directive in order to further extend rules governing third-party access, unbundling and tariffs to new import pipelines running from non-EU countries. This could have a major impact on the Nord Stream 2, which is currently in the last phase of construction and is expected to start running in the end of 2020. Under the new EU directive, the Russian state-controlled Gazprom will not be able to have access to the pipeline's full capacity, which will substantially affect Russian gas import plans. Although in May 2020 the German Federal Network Agency (BNetzA) has granted the Russian Nord Stream independency from the new amendments due to the fact that it is not threatening EU energy security.

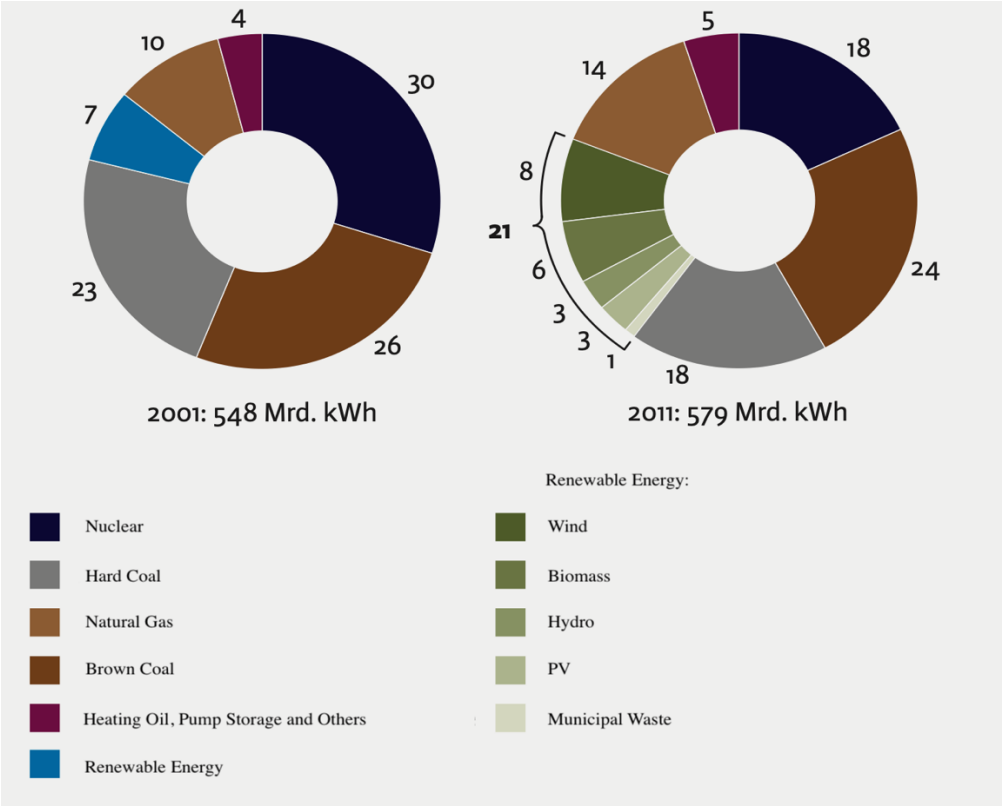

Figure 3.4. Mix of German electricity production in 2001 and 2011
Source: BDEW, 2012

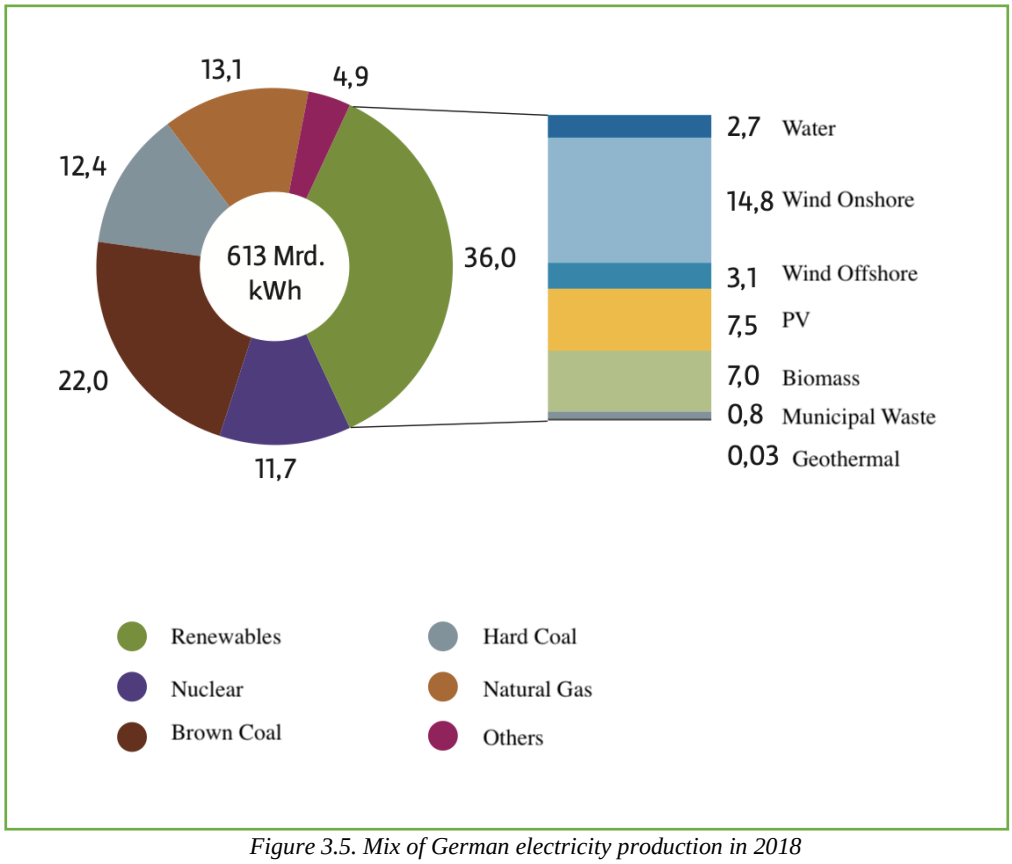

Figure 3.5. Mix of German electricity production in 2018
Source: BDEW, 2019

Considering the German energy legislation, both federal and state governments are involved in policy making. According to Hatch (1986), all the energy legislation is planned and adopted on the federal level, although state-level governments are responsible for implementing federal laws and can also develop their own energy programs. On federal level four main actors exist: Federal Ministry of Economics and Technology (BMWi), Federal Ministry of Environment, Nature Conservation and Nuclear Safety (BMU), German Energy Agency (DENA) and the Federal Cartel Office (FCO). The BMWi is responsible for the domestic energy policies and all the energy-related research and development. The BMU stands in charge for all the environmental policies and the impact of fossil fuels combustion. DENA guides the questions regarding the energy conservation and energy efficiency. Finally, FCO regulates the liberal competition on the energy and electricity markets.

3.1.2 Geographical and technical characteristics

Having discussed the German energy system, we can start our analyses from the geographical and technical characteristics of renewable energy, that are impacting the Germany's energy security. The purpose of this section is to create an understanding, which of the geotechnical characteristics, that were introduced in section 2.2.1, have the most impact on the German energy security and can thereby affect the gas relations with Russia.

Firstly, it is necessary to underline, that the weather conditions in Germany have resulted in a very uneven geographical distribution of the current energy production. Looking at Figure 3.6, we may observe, that the prevailing majority of wind turbines is constructed in the very northern areas of the country, while most of the PV energy is harvested in the southern part of Germany. Simultaneously, the most demand comes from the southern and western areas, where most of the metropolitans and industries are located. The industry takes place 24/7, which leads to a necessity for electricity at night, which the PV panels situated in the south cannot provide. Moreover, Figure 3.7 shows, that the installed capacities of wind and solar energy don't differ drastically with 60.7 GW and 50 GW respectively.

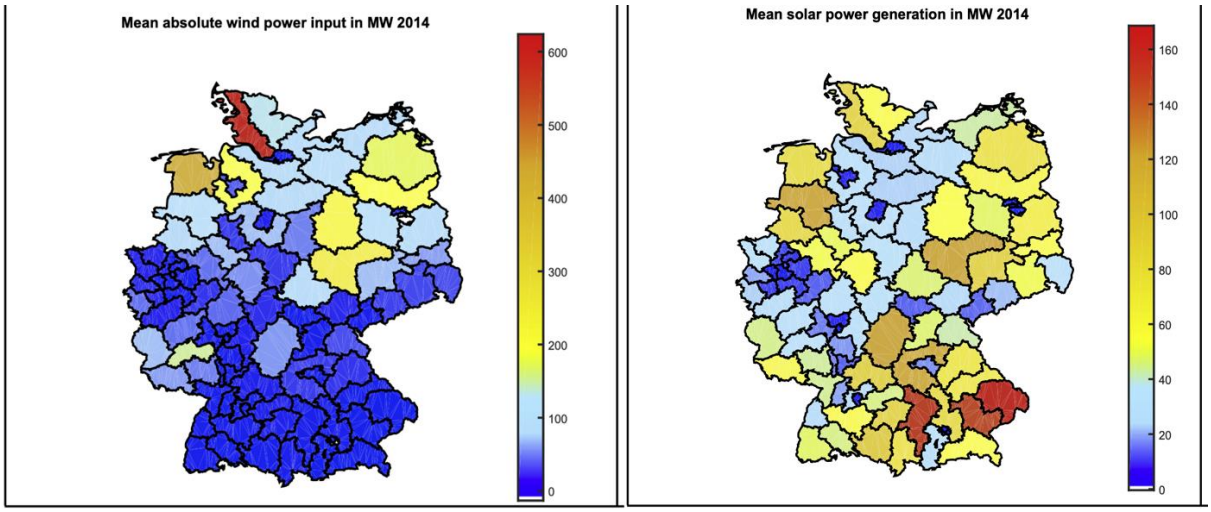

Figure 3.6 geographic distribution of PV and wind energy generation in Germany
Source: Renken et.al, 2018

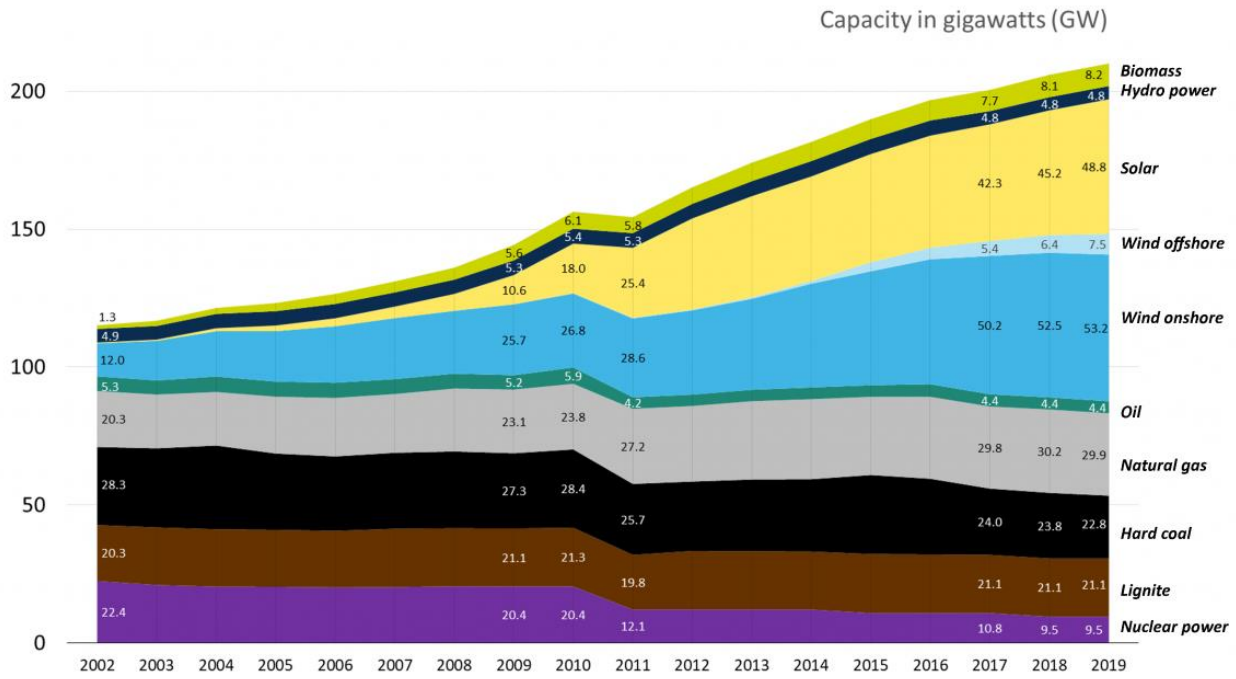

Figure 3.7. Germany.
Source: Statista, 2019

Although according to Figure 3.5, the combined on- and off-shore wind generation accounted for almost 18% of the produced electricity in 2018, while just 7.5% of the electricity was produced from using PV panels. This clearly demonstrates the problem for meeting the demand during the night, since the PV panels do not produce anything at nighttime. Therefore, in order to use renewable energy to keep the industries running during the night, the electricity from the northern wind parks has to be distributed to the southern and western parts of Germany. According to multiple studies (Matchoss et. al, 2019; Steinbach, 2013), a massive grid connection from the northern part of the country, where the windmills are situated to the western and southern regions is needed. According to the IEA (2020) the grid expansion is a stated priority for the German government. Due to the absence of this grid the gas consumption for electricity generation, that is needed for the industry, has not seen a decline. Overall this problem clearly illustrates the issues of the geographical location of the solar and wind energy as well as the need for grid expansion.

A possible solution to the grid expansion would be a technological and economical way of transferring the energy from the north and convert it to electricity already onsite. Currently R&D is performed into liquid hydrogen that could be transported via pipelines or using special trucks. Despite the conversion losses (electricity – hydrogen - electricity) such method could still be more economically feasible in comparison to a new grid through the whole country. Although at the moment the technology is far from ready for implementation with many technological issues still to overcome. Therefore, the absence of feasible transportation options of renewable energy also leads to the increased gas usage by the industries.

Another issue that is related to the necessity of gas is the intermittency of the solar and wind power. According to multiple publications (Wagner, 2014; Swider & Weber, 2006; Grave, Paulus and Lindenberger, 2012), the volatility of wind and solar power is a fundamental problem, which leads to the necessity of gas-powered power plants that are used for back-up. The open-cycle gas turbines are an ideal solution to the intermittency due to the low start-up and shut-down costs. The issue of intermittency goes hand-in-hand with the problem of storage, which could possibly solve the intermittency of RE. Although at the moment Germany is not able to deal with it, forcing the power surplus into the adjacent grids of neighboring countries, and obliging other countries to compensate for German intermittencies (Sturm, 2016). According to Markò et. al, 2017, the minimum grid load in Germany is exceeded, which leads to export of surplus energy to the neighboring countries. Therefore, due to the absence of economically and technically feasible technology for energy storage the use of gas cannot decrease.

In order to illustrate the findings, table 3.1 summarizes which of the geographical and technical of solar and wind energy in Germany lead to energy security issues and can have an impact on the gas relations between Germany and Russia.

Characteristics	**Independent variables**		
Sources	Location	Stability	Demand meeting
Generation	(De)central generation	Need for storage	Rare materials
Distribution	Transportation options	Grid reinforcements	Smart control systems

Table 4.1 Geographical and technical characteristics of RE

3.1.3 Energy security & gas trade

The following step is to analyze how the geotechnical issues that were identified above affect the 10 energy security indicators, that were chosen in Chapter 2 and the four gas trade patterns. Starting with the latter, tables 3.2 and 3.3 provide an overview of the gas trade patterns between Germany and Russia, that were calculated using the annual BP Statistical energy reviews and the German energy balances.

	Share of gas in the Germany's energy mix	Share of German imports from Russia
2001	20%	42%
2005	21%	40%
2010	22%	37%
2015	22%	44%
2018	25%	55%

Table 3.2

As we can observe, a very important feature is the increasing share of gas in the Germany's energy mix. At the same time, we can see, that the German gas imports from Russia have been growing at a very similar rate. In both indicators we see an increase in 2018 in comparison to 2000. During this period the installed capacity of solar and wind energy increased roughly sevenfold. We can conclude, that the issues of sources, generation and distribution of RE have had a visible impact on the amounts of gas imports from Russia.

Having obtained an understanding, that the geotechnical characteristics are causing an increase in the gas imports to Germany, we will now look at the situation from the perspective of Russian security of export. The following table 3.3 provides some important information about the Russian gas exports to Germany.

	Share of Russian gas export to Germany from the total gas extraction	Share of Russian gas export to Germany from the overall gas export
2001	6.1%	26%
2005	6.1%	24%
2010	6.5%	18.5%
2015	9%	22%
2018	9.6%	25%

Table 3.3

The data above clearly shows, that the gas export to Germany has been increasing in importance for Russia in the past 20 years. Currently almost 10% of the gas extracted in Russia is exported to Germany, which accounts for a quarter from the overall gas exports. We can also observe, that the share of Russian gas export from the global gas exports has stayed on the same level compared to 2000. The reason for this is the fact that Russia is exploring new gas export markets, predominantly in Asia. Therefore, while gas imports to Germany have been increasing in economic and geopolitical value for Russia, Russia has also been diversifying its import channels, in order to not become too dependent on Germany alone.

Moving on to the energy security indicators, that were chosen in Chapter 2, we will now analyze the changes and their relation to the geographical and technical characteristics of RE. Table 3.4 provides an overview of the main changes of the energy security indicators.

№	Dimension	Component	Indicator	Change in 2000-2018
1	Availability	Security of supply and production	Self-sufficiency (% demand met by domestic production)	Slightly increased
2			Total electricity demand	Unchanged
3		Dependency	Natural gas import dependence rate	Significantly increased
4			Balance of export and import of electricity	Increasing yearly
5		Diversification	Diversification on total primary energy supply	Increase in RE and gas, decrease in coal and nuclear
6			Geographic dispersion of renewable energy facilities	See Figure 3.15
7			Share of solar and wind in electricity demand	See Figures 3.4 and 3.5
8	Affordability	Price stability	Transmission and distribution cost for electricity	Slightly increased
9			Gas price volatility	See Figure 3.9
10	Technology development and efficiency	Safety and reliability	Duration of electricity blackouts or supply interruptions	Significantly decreased

Table 3.4

1. The demand met by domestic production slightly increased from 26% to 29% during the past 20 years. This mostly relates to the fact, that the electricity from renewable sources squeezed out the coal-generated electricity, which was partly relying on coal imports. Although it is reasonable to suggest, that the improvement could have been bigger if not for the increasing gas usage, that is mostly being imported. Therefore, even though the self-sufficiency of the German energy sector improved due to the Energiewende program, the increased use of gas caused by the geotechnical characteristics of RE has downplayed this.

2. The total electricity demand of Germany remained almost unchanged in the past 20 years. Despite the growing number of inhabitants, the technological development has led to improvements in energy efficiency, which in turn led to a stable electricity demand.

3. The natural gas import dependency has significantly increased in the past 20 years. In 2000 Germany natural gas production accounted for 21% of the total consumption, while in 2018 just 6.5% were domestically produced. This is one of the consequences of the increased gas

usage due to the intermittency of solar and wind energy and is as well related to the increased usage of gas for electricity production at night time for the industry, which is not supplied by wind electricity due to the geographical location of the wind power plants.

4. The balance between the German imports and exports of electricity is increasing on an annual basis, with each year the exports exceeding the imports. While this is a positive factor for Germany, it is worth noticing, that the prices for electricity exports are often quite low (or even negative) due to the fact, that on sunny days the PV energy exceeds the demand by far. Overall, we observe the economic benefits from the import/export balance, although the low export prices during favorable weather conditions reflect the problem of intermittency and the absence of storage technology.

5. A diversification of total primary energy supply has not occurred, rather a replacement of energy carriers. Figure 3.7 shows, that in 2002 four energy carriers (gas, hard coal, lignite, nuclear) accounted for 80% of the total installed capacity, while in 2018 87% of the capacity was based on five energy sources – wind, solar, gas, hard coal and lignite. Although it is important to mention, that the installed capacity of solar energy is not accountable for during the nighttime. Therefore, no significant diversification of the total primary energy supply has occurred.

6. The geographic dispersion of renewable energy facilities was previously discussed, and it was shown, that the vast majority of wind power plants as well as solar power plants are geographically bounded to a specific area, which is a consequence of the geotechnical characteristics of RE.

7. The share of both wind and solar electricity has drastically increased in the yearly energy demand, although due to high intermittency the share of solar energy is zero during night times and the wind share is low during summer due to annual wind strength patterns.

8. The overall costs for electricity have drastically increased in Germany due to the renewables surcharge. The transmission and distribution costs have mildly increased, although the German government is planning to 4 energy highways with supporting lines. The total investment for this development was estimated at around 21 – 26 billion euros for 3500 km of new grid connection. Therefore, the grid fees for electricity has not increased drastically due to the increased gas usage for the places, that are currently not reachable for the energy generated by renewables. According to the opinion of Roman Vakulchuk, this is a major problem for Germany and the "supergrid" will not be built in the upcoming 20 years due to the economic unfeasibility.

9. The high gas price volatility especially in 2011 – 2013 reflected on the gas contract structures between Germany and Russia, which will be in-detail discussed in section 4.1.1.

10. The duration of electricity blackouts annually has decreased from 23 minutes to 14 minutes in 2018. This is a significant improvement in this very important aspect of the energy security and could have been reached by among others increasing the share of reliable gas power plants as a back-up energy source.

Having discussed the overall energy sector structure and completed the first 2 steps of the theoretical framework, we have obtained an understanding, which geotechnical characteristics of RE mostly affect the energy security in Germany and how the chosen energy security indicators have changed in the past 20 years. Before moving to the last steps of the framework it is necessary to discuss the situation from the perspective of the Russian energy sector and the past gas relations between the countries, which is done in the following sections.

3.2 Russia

3.2.1 Russian energy sector and policies

The Russian energy sector is a set of enterprises, organizations, production and other complexes that are technologically, organizationally and economically interconnected, covering a system of processes, including field exploration (geological exploration on land and offshore), their operation, processing and storage. Being a resource-rich country, Russia heavily relies on hydrocarbon export. During the period 2000 – 2005 Russia's overall energy export has unprecedently grown by more than 50%, establishing Russia's international position as an energy superpower. Although with the economic crisis in 2008 the energy exports faced a decline and the current oil and gas revenues have significantly dropped compared to 2005 due to the falling prices for hydrocarbons. Even facing a decline, revenue from hydrocarbon export accounted for 25% of the national GDP and 39% of the federal budget (link).

Overall the Russian energy sector is developed in a highly centralized way, which historically stems from the hierarchical Soviet Union system. According to Mitrova and Melnikov (2019), despite the energy market reforms in 1990s, the institutional framework of the Russian energy sector today is still characterized by high corporate concentration and a lack of market mechanisms. For instance, state-owned companies own 70% of the domestic power sector and all of the distribution grids. The majority of Russia's electricity – 63% - is produced by thermal power plants, which are mostly based on outdated technologies (Mitrova and Melnikov, 2019).

Considering hydrocarbon extraction, according to the Ministry of Energy of the Russia Federation, gas industry, along with oil, is the most important sector of the Russian economy. Having the highest gas potential in the world, Russia is one of the largest natural gas exporters, accounting for about 25% of the global gas market. The gas production in Russia is continuously growing, having reached another historical maximum in 2019, which can be seen on table 3.5. Thus, for the past 20 years, Russia has been ranked second in the world after the United States in gas production. Figure 3.8 shows explicitly information on *natural* gas.

Years of production	Billion m^3
2000	584,0
2001	581,0
2002	595,0
2003	620,0
2004	633,0
2005	641,0
2006	656,0
2007	653,0
2008	665,1
2009	583,1
2010	650,7
2011	670,7
2012	654,5
2013	667,8
2014	642,0
2015	635,5
2016	640,2
2017	691,1
2018	725,4
2019	738,0

Table 3.5 Natural gas extraction in Russia.
Source: http://global-finances.ru/dobycha-gaza-v-rossii-po-godam

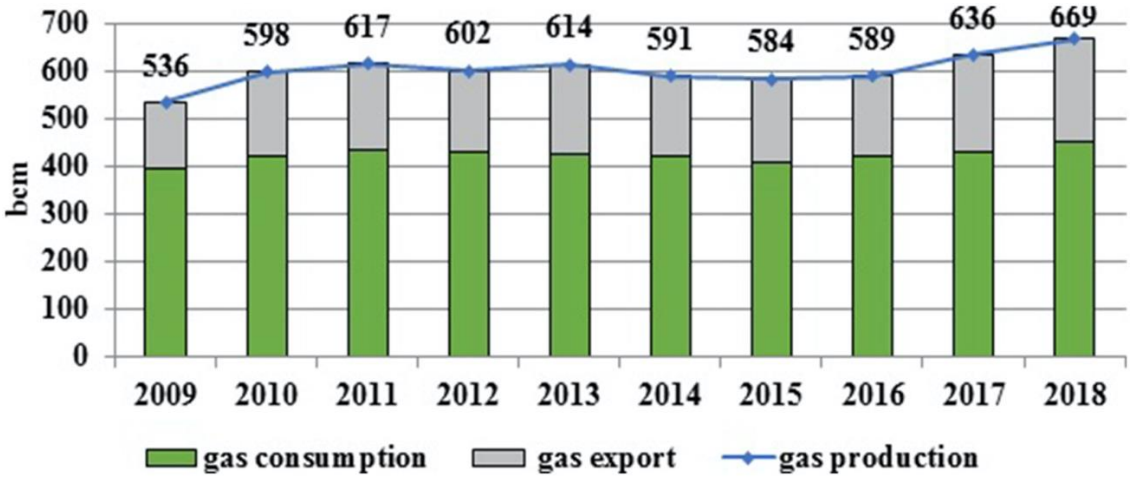

Figure 3.8 Russia's natural gas production, consumption and export.
Source: Kutcherov et al. 2020

Historically Russian natural gas exports are strongly orientated towards Europe, a market on which Russia is therefore highly economically dependent. Most of the Russian natural gas exports occurs to Europe via pipelines. The Russian natural gas export by destination can be observed on Figure 3.9.

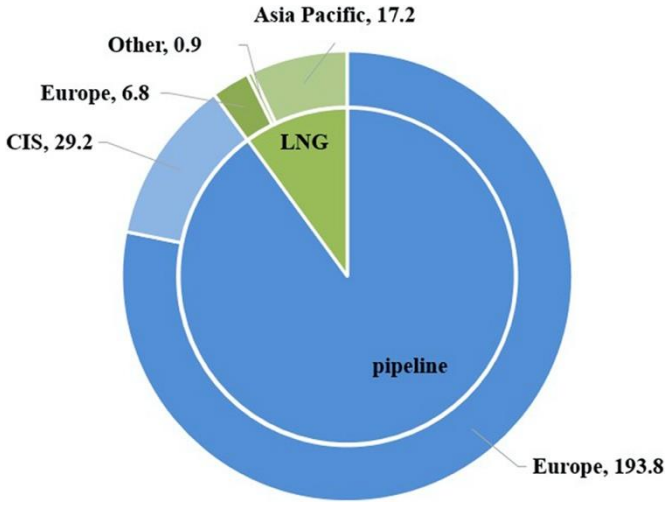

Figure 3.9 Russian natural gas export by destination in 2018.
Source: Kutcherov et. al, 2020

The Russian gas exports is a full monopoly, owned by Gazprom, which was founded in 1988 and transformed into a state-controlled joint stock company in 1992 (Loe, 2019). Gazprom is also dominant on the domestic gas market, although is currently facing strong pressure from its competitors. A gas pricing reform was expected to be introduced in early 2020 in Russia, that would drop the lower limit of regulated prices. Such a step is aimed at decreasing the Gazprom domestic gas monopoly, although as of July 2020, there was no news on the reform to be introduced.

3.2.2. Renewable Energy in Russia

While the development of renewable energy has gained an overwhelming political, economic and societal support in Germany, the situation in Russia drastically differs. Russia has enormous resources for the development of alternative energy. However, despite all the possibilities, the country's energy system still mainly relies on traditional hydrocarbons. Being a country rich in natural resources and in particular fossil fuels in abundance, Russia is still on a conventional energy path. According to multiple studies, Russia has the geographical potential to produce wind, solar and geothermal power in an economically viable way [Tynkkynen 2019, World Energy Council 2007]. Although historically the oil and gas industries have played a pivotal role in Russia's economic, contributing by more than one-third of the GDP [OECD, 2019]. This has made the transition to a low-carbon economy an undesired path for the Russian leaders, which results in the absence of solar and wind energy on a countries scale. A closer analysis reveals, that some steps were taken in the past years aimed at improving the overall countries energy efficiency, reducing GHG emissions and decreasing the installation costs of RE. In 2015 Russia joined the International Renewable Energy Agency (IRENA), which now allows Russia to gain access to information on existing practices related to the use and implementation of renewables, to the latest research results. The energy lobbyist and NGOs hoped that this could if not boost, but at least promote the development of wind and solar energy in Russia, although the numbers did not increase sufficiently according to Figure 3.10. While we do see a gradual increase in the RE share, the numbers are still very low, and no real governmental support is being provided.

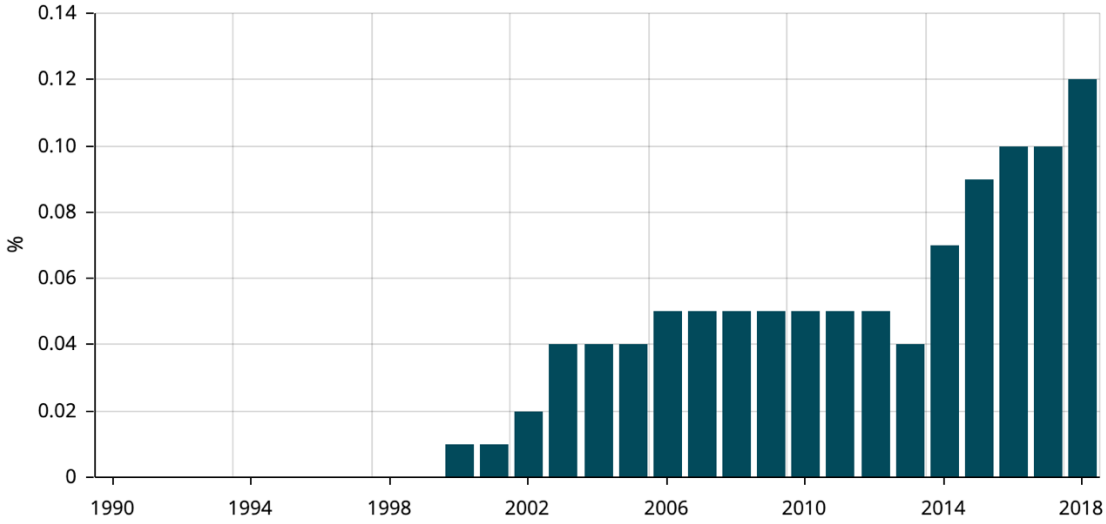

Figure 3.10 Share of wind and solar energy in electricity generation in Russia. Source: Enerdata 2019.

Despite the fact that wind and solar energy are almost absent in the Russian electricity production, a closer look at Figure 3.11 reveals, that in total almost 20% of Russian electricity generated is produced from renewable sources. These high numbers stem from the wide usage of hydro resources for power generation. The overall distribution of electricity generating capacities in Russia can be observed on Figure 3.12. Despite having a significant share of electricity produced from hydro resources, Russia ranks second worldwide in undeveloped hydropower resources. According to the World Energy Council (2007), Russia has much potential for using hydro resources in power production with a theoretical potential of more than 850 TWh being economically feasible. For comparison, the current annual production is roughly 165 TWh, (RusHydro, 2019), which makes Russia ranked 6th worldwide in the share of hydroelectricity. Although Russia has no legislative plans to shift away from conventional fossil fuels usage to hydroelectricity. The reason for it is the fact that overall the topic of climate change is ignored by the Russian government and the country has no clear intention to diversify or modify its energy resources.

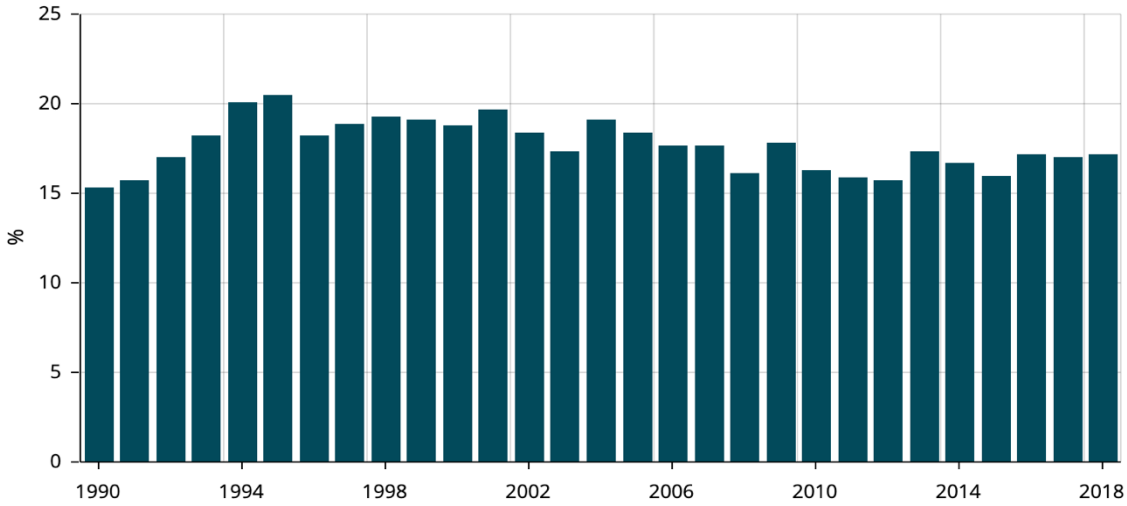

Figure 3.11 Share of renewable energy in electricity generation in Russia.
Source: Enerdata 2019.

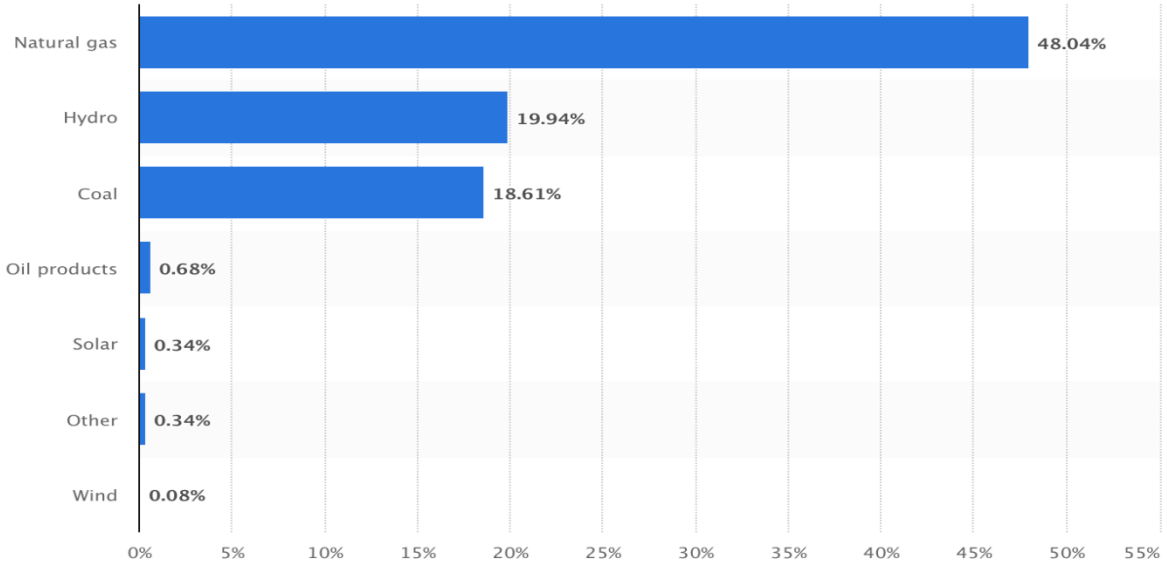

Figure 3.12. Share of installed electricity generating capacity in Russia 2018 by source.
Source: Statista 2020.

Regarding the Russian governmental economic and financial support of renewable energy, already in 2007, a "premium scheme" for wholesale electricity prices was introduced. The intention of that law was basically to create a domestic analogue of the European feed-in tariff. Although these plans remained only on paper and a concrete implementation mechanism was never developed.

In the following years a number of governmental policies aimed at RE development have been signed. In 2009 the Russian government under the direction of president Medvedev made a decision to accelerate the deployment of RE and designed a number of measures. Among others a package of normative legal acts has been signed to support the development of RE in the wholesale market. As a consequence of these acts, in accordance with Federal Law No. 35-FZ, the following rules took place:

1. Grid companies are obliged to buy energy from qualified RE facilities at regulated tariffs.
2. Monetary compensation for qualified RE generation facilities with capacities up to 25 MW for the cost of connection to the grid.

Moreover, Russia's Energy Strategy to 2030, approved by the Government in 2009, set a renewables-based power generation target of 4.5% by 2020 (IRENA 2017). Later on, in 2013 the officials decreased the target for RE, setting a new target of 2.5% by 2020. Further assessment of these targets revealed the absence of economic feasibility and the target date was shifted to the year

2024. Anatoly Chubais, the head of Russia's Association of Renewable Power Development, says that by 2024 the generation of solar and wind energy in Russia is expected to just reach 1%. However, according to the IRENA report (2017), Russia has the potential to increase he projected share of RE up to 11.3% of total final energy consumption by 2030, which would require approximately 15$ billions of annual investments.

In 2011 a governmental policy aimed at promoting renewable energy through the capacity market was added to the Russian Federal Electricity Law. This scheme established regulatory mechanisms for selection of possibly new RE projects for governmental funding. The grant is auctioned during annual tenders and provides an obligation for wholesale market consumers to purchase electricity for 15 years at the cost that is significantly higher than the average wholesale price. Despite the seemingly preferable conditions, the policy was never a success due to the following obstacles for the possible producers. Firstly, this scheme was supposed only for facilities with a power output of at least 5 MW, which eliminates the possibility of developing household rooftop PV panels. Secondly, all regions with fully regulated tariff system and isolated regions (mainly far east Russian regions) are restricted from obtaining governmental financial aid, despite the fact that most of these regions have high geographical potential for wind energy. Finally, only those companies, who would use at least 70% of domestic supplies for manufacturing were allowed to take part in the financial auction. Therefore, despite the initially seemingly high level of governmental stimulation, no actual changed in RE development followed.

Overall, despite all the potential for RE development, Russia continues relying on fossil fuels and almost no governmental or societal attention is being payed to the climate change issue. According to Overland (2019), "There are not many places in the world with fewer incentives to develop renewable energy". Due to this factor and the minor share of wind and solar energy in electricity production, we will further in this research regard Russia as a country with no solar and wind energy and no legalized plans for development of this sector. The following bullet points provide a short sum-up of this subsection:

- Russia has an enormous proven geographical potential of feasible solar and wind energy.
- The share of wind and solar energy in the electricity production has been gradually increasing since 2000, although the numbers are still far from even 1%.
- Renewable energy is present in the Russian energy sector in the form of hydro capacity, which accounts for almost 20% of power generation.
- Russia has signed several Federal Laws promoting RE development on a market level, although no substantial progress has been made since then.
- Russia heavily relies on conventional fossil fuels and no real action in promoting RE development is undertaken.

3.3 Gas-trade relations between Germany and Russia

3.3.1 Historical perspective of the gas trade relations

Russian-German energy cooperation was established almost half a century ago, having been transformed and adapted to today's political and economic realities. The problem of ensuring energy security and finding a reliable supplier of energy resources became acute for European countries that were not rich in hydrocarbons already in the middle of the XX century, when their rapid industrial production required a multiple increase in gas consumption. In the relations of the largest energy partners-Russia and Germany, these trends are most clearly visible.

The first official deal for the supply of Soviet gas between the USSR and Germany was concluded in 1970. However, before that, international politics and the situation either pushed or complicated the possibility of energy cooperation between countries. Subsequently, three more such contracts were signed, when the Soviet gas of Germany was exchanged for pipes. In 1973, the volume of purchased gas and pipes was increased to 120 billion m3 and 2.4 million tons, respectively. The agreement of 1974 provided for additional gas supplies of 60 billion m3 and German pipes of 3.7 million tons. The fourth agreement between the USSR and Germany was signed in 1981, as a result of which the Soviet side undertook to supply an additional 8 billion m3 of gas in exchange

for pipes, as well as compressor stations corresponding to the volume of supplies and the length of the gas pipeline. Thus, natural gas has been supplied to Germany since 1973. The first gas recipients in East and West Germany were Verbundnetz Gas and Ruhrgas. Today, Germany is the largest buyer of Russian gas, and German companies are implementing numerous projects together with the Gazprom Group.

With the beginning of the 2000s and the coming to power of the new President V. Putin in Russia, there was a clear trend to change the course of both domestic and foreign policy. According to the" Energy strategy of Russia until 2020", energy resources and the energy complex of Russia are called "*an instrument for conducting domestic and foreign policy of the state*". Energy is becoming a fundamental element in Russia's diplomacy, which is why energy cooperation with Germany is viewed from a strategic and geopolitical point of view. Changes in the political space of Germany that occurred in the late XX-early XXI centuries also contributed to the transfer of energy to the level of higher politics. In 1998, the German government, headed by G. Schroeder, announced a policy of phasing out nuclear power. Due to the fact that nuclear power played a significant role in the German energy balance and was produced within the country, the refusal to use it provoked the need to increase the import of hydrocarbon resources.

German interest in energy relations with Russia is dictated by objective reasons — Germany is 53rd in terms of natural gas reserves and currently produces just about 12% of gas domestically. Limited natural resources, combined with high energy consumption, force most of the gas needs to be met through imports. Despite the fact that energy cooperation between Russia and Germany has more than forty years of history, it remains associated with the political interaction of countries and the geopolitical situation in the world, which creates enough problems and threats to the relations.

Gas is currently Germanys second most important source of energy. In 2018 Germany consumed slightly less than 90 billion m3 of gas which accounted for 23% of the overall energy consumption in the country. Figure 3.13 shows, that gas is used in all sectors of the German economy and is especially important for the industry sector. Moreover, natural gas accounts for 13% of the German electricity production.

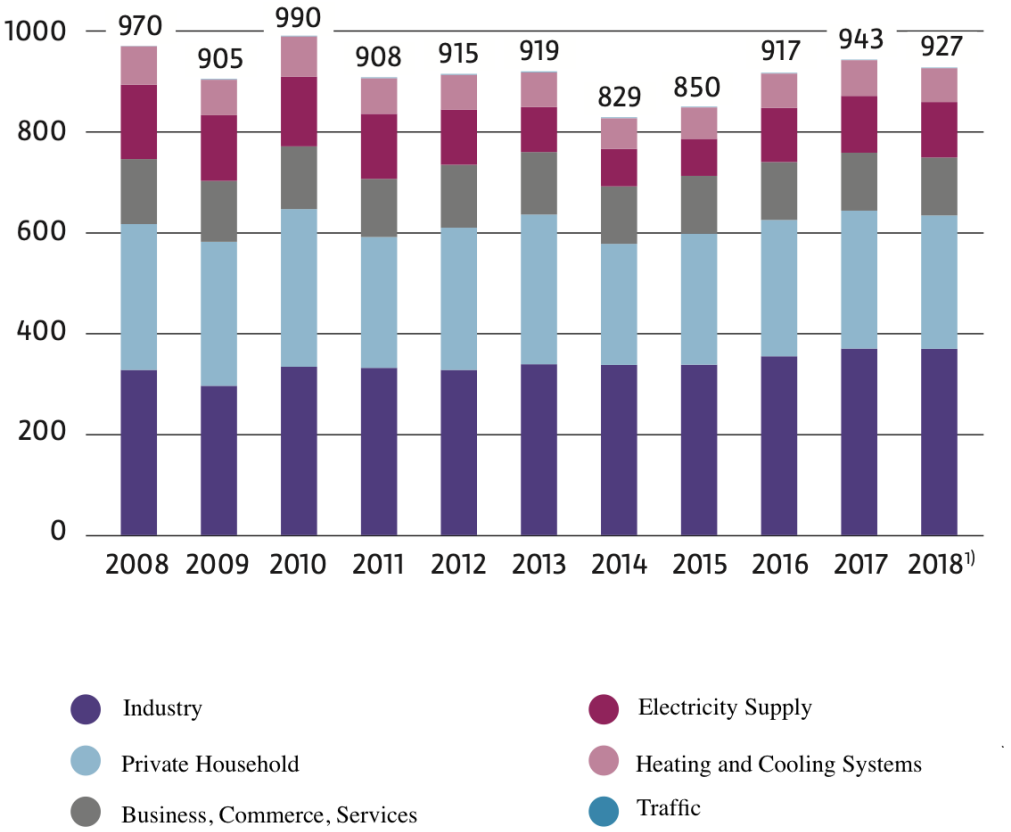

Figure 3.13. Natural gas consumption in Germany by sector
Source: BDEW, 2019

Imports from Russia are a reliable source of cheap gas for Germany. Germany imports 94% of the gas consumed with the main suppliers being Russia, Norway and the Netherlands (LNG from the United States is also entering the German market). Imports from Russia account for about 60% of the gas consumed in Germany and with the launch of Nord stream 2 and the likelihood of dismantling of the Dutch gas extraction in Groningen, Russia's share is likely to increase.

In 2001, Gazprom and E. ON Gastransport (wholly owned subsidiary of Ruhrgas) signed agreements to transport natural gas through Germany to the Netherlands and Belgium. In July 2003, Achimgas JSC, a joint venture between Gazprom and Wintershall, was established to develop the first pilot section of the hard — to-reach Achimov deposits of the Urengoy field. A long-term agreement has been signed between Gazprom and WINGAS to sell natural gas to the UK until 2028. Looking at this project, it is important to emphasize the unconditional political component. On the one hand, as a result of the enlargement of the European Union at the expense of the Baltic States and Poland in 2004, political contradictions between these countries and the Russian Federation complicated the negotiation process. On the other hand, the image of Russia as a reliable supplier of energy resources, the readiness and interest of European countries in cooperation with the Russian side in the field of energy, economy and politics, as well as the important role of Germany as an intermediary between the Russian Federation and the European Union made it possible to implement this project in the end. The success achieved between the countries in the energy field has provoked an improvement in political and economic relations. The clearest proof of Russia's acquisition of the status of Germany's most important partner is the emergence of the concept of "strategic partnership" and the model of "special relations" with Russia (Orttung and Overland, 2011).

On May 18, 2005, Gazprom, RAG and WINGAS signed a contract for the construction of the underground gas storage facility "Haidach" (Austria) — the second largest in Central Europe (active capacity — 2.8 billion cubic meters of gas). In September 2005, Gazprom,

BASF/Wintershall and E. ON signed an agreement on the construction of the Nord stream gas pipeline, a fundamentally new route for gas supplies from Russia to Europe via the Baltic sea. With the coming to power in Germany in 2005, the new Chancellor A. Merkel, who is focused on expanding cooperation with the United States and is concerned about Russia's domestic political development and geopolitical priorities, has seen a noticeable cooling in political relations between the countries. Nevertheless, the principles of pragmatism underlying the new Chancellor's policy have served as a guarantee for the continuation of the Russian-German gas partnership.

In August 2006, the validity of the four main gas supply contracts between Gazprom export and E. on Ruhrgas AG was extended to 2035. According to reports provided by Gazprom, since 2006, Russian gas supplies to Germany have consistently exceeded the 30 billion m3 mark, and in 2014 exceeded 40 billion m^3, which is significantly higher than the imports of all other European Union countries. Russian gas supplies to Germany accounted for about 22 % of the total amount of Russian gas exported to foreign countries, as well as a quarter of the gas transported to EU countries.

In May 2009, a consortium was established for the construction of the Katarina UGS in Germany, which included Gazprom and Verbundnetz Gas. Moreover, in 2010 the first pipeline of the Nord Stream was laid. The shares of Wintershall and E. ON Ruhrgas in the operator company Nord Stream AG were 15.5% each, while the rest (the prevailing majority) is owned by Gazprom. In August 2011, WINGAS completed the construction of the OPAL overland gas pipeline linking Nord stream with Europe's gas transmission networks. In September 2011, construction of the Katarina UGS began in Germany and the first line of the Nord stream gas pipeline was put into operation. On November 8, 2011, commercial gas deliveries began via the first line of the Nord stream gas pipeline. On December 19, 2011, Gazprom and Siemens signed a strategic partnership Agreement in order to ensure further development and strengthening of cooperation between the companies on the Russian and international markets.

On October 8, 2012, the second line of the Nord stream was put into operation, which increased the capacity of the gas pipeline to 55 billion cubic meters per year. The shareholders of Nord Stream AG have decided that the construction of the third and fourth lines of the gas pipeline are both economically and technically feasible. In November 2012, a legally binding agreement was signed between Gazprom and Wintershall on the terms of asset exchange based on sections 4A and 5A of the Achimov deposits of the Urengoy field in exchange for Gazprom's participation in a number of production and marketing assets of the German partner. In January 2013, an agreement on scientific and technical cooperation until 2030 was signed by Gazprom and Verbundnetz Gas. In December 2013, Gazprom and Wintershall signed a major asset exchange agreement. As a result of the transaction, Gazprom increased its stake in the joint gas trading and storage companies in Europe, WINGAS, WIEH and WIEE, to 100%, and also received a 50% stake in WINZ, a company that conducts hydrocarbon exploration and production in the North Sea. Wintershall, in turn, received a 25.01% share of economic participation in the project for the development and development of sections 4A and 5A of the Achimov deposits of the Urengoy oil and gas condensate field. The most important result of the implementation of the Nord stream project was the designation of the project as a priority that meets the interests of the whole of Europe. Thus, Russian gas becomes an indispensable component of energy security not only in Germany, but also in Europe as a whole.

The gradual deterioration of Russia's international image in the eyes of German politicians, associated with Russia's foreign policy in relations with former socialist countries, especially with Ukraine (gas crises and political tensions), with Georgia (recognition of the independence of Abkhazia and South Ossetia), and with the NATO bloc (a new round of confrontation), significantly slowed the development of political relations within Russia — Germany. This changed political situation and relations between the countries, however, did not affect the obligations of the parties under the contracts and within the framework of the Nord stream project. It should be noted that, despite the rather stringent measures and sometimes uncompromising energy policy of Russia concerning transit countries of Russian gas to former Soviet bloc countries (for example, interruption of gas supply), in relation to the German side with all contractual obligations had always been met.

The significant deterioration of Russia's position on the world stage, associated with the political crisis in Ukraine that began in 2013, and the disagreement of European countries with the foreign and domestic policy of the Russian Federation have already had a significant impact on the political interaction between Russia and Germany. The reaction of the German side was immediate, not only in the political context of interaction (sanctions), but also in the energy sector. The current Chancellor of Germany, A. Merkel made a statement about the need to diversify gas supplies, look for new ways of energy supply and new suppliers in order to reduce Germany's energy dependence on Russia. Despite the fact that the political relations between Russia and Germany have undergone significant changes for the worse, the mutual interest of the countries in energy partnership and the experience of long-term mutually beneficial cooperation have played a significant role in the continuation of energy relations between the countries. Moreover, the statement of A. Merkel on the revision of the predominant role of the Russian Federation in providing gas to Germany at the moment remains only a statement: in 2015, the countries signed a new gas agreement that increases gas supplies from Russia to Germany and other European countries within the framework of the Nord stream — 2 project (Energy Strategy of Russia for the period up to 2030).

In 2015, Gazprom, BASF, Uniper, ENGIE, OMV and Shell agreed on building the Nord stream 2 gas pipeline. The new route from Russia to Germany along the bottom of the Baltic sea with a capacity of 55 billion cubic meters will significantly increase the reliability of gas supply to European consumers for decades to come. In May 2017, the Katarina UGS was put into operation in Germany. In September 2018, work began on laying the Nord stream 2 gas pipeline in the Baltic sea. In 2018, Germany set another record for buying Russian gas — 65.7 billion cubic meters. The same year the laying of the Nord stream — 2 gas pipelines began. The new route will also run from Russia to Germany along the bottom of the Baltic sea. Although in 2019 the amount of Russian gas exported to Germany significantly dropped in comparison to 2018. Table 3.6 provides information on the amounts of gas trade between Gazprom and Germany in the past 20 years.

Year	**Gas trade, billion m^3**
2019	55.6
2018	55.3
2017	48.5
2016	46.0
2015	46.2
2014	38.5
2013	39.8
2012	30.0
2011	30.8
2010	34.43
2009	31.5
2008	36.2
2007	35.55
2006	36.54

2005	36.54
2004	37.74
2003	33.21
2002	31.5

Table 3.6. Natural Gas trade between Germany and Gazprom Group.
Source: Gazprom Annual Reports (2002 - 2019)

Considering the price of the natural gas, exact prices of long-term contracts are confidential and unavailable to the public. Although the trend should be somehow similar to the official Germany import border price, that is depicted on Figure 3.14. It is clearly noticeable, that the prices did significantly drop after 2008, after they reached an historical maximum.

Figure 3.14. Germany BAFA Natural Gas import
Source: BAFA, 2019

Thus, over the past 20 years, Russia and Germany have established gas transit through the Yamal — Europe and Nord stream pipelines that meet the interests of both sides. Along with gas, Russia exports oil to Europe and Germany via the Druzhba oil pipeline and the Baltic pipeline system (BTS-1, BTS-2). At present, the discussion about Germany's energy dependence on Russian gas, created by the Russian side, and Russia's desire to preserve this energy dependence at any cost in order to use it for its own political purposes has flared up with a new force in the foreign and Russian press and political circles. Germany, which is bound by long-term contracts and has no alternative ways to meet its natural gas needs, is forced to continue its unprofitable energy relations. Another popular and frequently encountered opinion is the idea of the unreliability of the Russian side as an energy partner, which, in pursuit of its geopolitical goals, can threaten the energy security of the buyer countries.

3.3.2 Major changes in gas trade relations

While the gas trade relations between Russia and Germany can be considered stable, since no major conflict had ever occurred, the relations are constantly changing. The goal of this sub-section is to outline the main changes in gas relations, that are currently occurring, intentionally not including the analyses of these changes. Moreover, some of them (or even all) might not be related to the

development of wind and solar energy in Germany. The analysis of the changes and the discussion of their RE dependency is left for Chapter 4, where the final step of the theoretical framework is performed. Therefore, the following section just briefly outlines the main trends in gas trade relations.

1. Changes in contract structures.

Firstly, according to Mikulska (2020), we are seeing a wave of renegotiations of long-term contracts, which now include greater price flexibility. The majority of contracts between Russia and Germany are long-term with a take-or-pay clause. The previous take-or-pay clauses were usually set at 85%, which in fact means, that the buyer should either accept at least 85% of the total contracted amount or pay for that amount. The current take-or-pay clauses have shifted to roughly 70%, which gives not only a higher flexibility for the buyer, but also encourages a higher market activity during low spot prices (Mikulska, 2020). Moreover, according to Henderson and Sharples (2020), the majority of the newly signed gas contracts have a significantly lower duration. While Gazprom has always been oil-indexing its gas, they are currently moving away from this strategy.

2. Intensification in gas trade relations.

Secondly, we have identified an intensification of gas trade relations, which had been occurring for many years and is still going on. In the past 20 years the German gas imports from Russia have grown by roughly 80% and are expected to continue growing due to a new offshore gas route, that is in the final stage of construction. The Nord Stream 2 has attracted criticism from the USA, Poland, Baltic States and Romania. The opposition of these countries is caused mainly by strategic reasons, such as the loss of their current role of transit countries and the desire of the USA to get a higher market share of LNG in Germany. These political debates have created a pattern of cooperation between Russia and the German government, who are together striving for relieving these tensions.

Chapter 4

Reasoning the changes in the gas trade relations

Introduction

In the previous chapter we have performed the first 2 steps of the theoretical framework by means of looking into the geotechnical characteristics of RE in Germany and analyzing their implications on the energy security indicators. Moreover, we have described the broader picture of the energy system structure both in Germany and Russia as well as detailed the historical development of gas trade relations. Now, having identified the 2 main changes in the gas-trade relations, we will perform the second step of the framework application. This chapter aims at justifying the identified changes and creating a comprehension whether these changes in gas trade relations can be seen as a result of the geotechnical characteristics of RE development in Germany. After having identified the main cause of these changes, we will discuss the patterns of cooperation between Germany and Russia, that are developing due to this.

In order to understand, whether the intensification of gas trade between Germany and Russia and the global changes in the contract structure are caused by the RE development, we will first look into all the possible causes. Such an approach will help to understand, whether these changes are caused by the RE development in Germany or by other contextual variables. Moreover, the analysis of the changes is validated by means of four interviews with experts in the field of renewable energy geopolitics, international relations and international political economy. Therefore, this chapter includes opinions and comments of Jack Sharples, Anna Mikulska, Michael Bradshaw, Roman Vakulchuk and Raúl Bajo.

The structure of this chapter goes as follows. Section 4.1 provides an analysis of the causes in changes of the gas contracts and the gas trade intensification. Section 4.2 continues with an analysis of the patterns of cooperation between Russia and Germany that are based on the development of RE in Germany. Finally, section 4.3 briefly sums up the analysis and provides a conclusion.

4.1 Analyses of the identified changes in gas trade relations

4.1.1 Changes in gas contracts

As discussed in section 3.3.2, the first identified change in the gas trade relations is the wave of renegotiations of long-term contracts, which now include greater price flexibility. The take-or-pay clauses have shifted from 85% to 70%, while the majority of the newly signed gas contracts have a significantly lower duration. Moreover, while Gazprom has always been oil-indexing its gas, they are currently moving away from this strategy.

According to Jack Sharpless, these changes in gas contract structures started occurring approximately in 2010-2012 and have already finished by now. During those years we could observe the prevailing majority of Gazprom's clients renegotiate the contract conditions. Moreover, looking more broadly, this process took place not only with the German gas buyers, but also all other European gas importers. Since one of the changes in the gas contracts deals with the oil linking of the prices, it is necessary to analyze what happened with the oil and gas prices at that time, which is depicted on Figures 4.1 and 4.2 respectively.

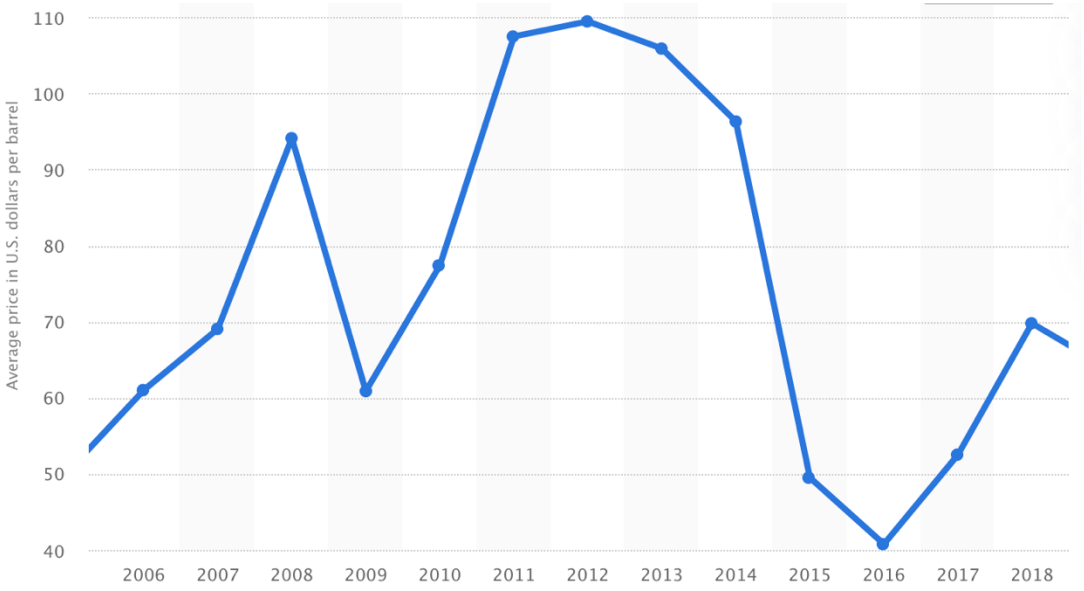

Figure 4.1 Average annual crude oil prices
Source: Statista, 2019.

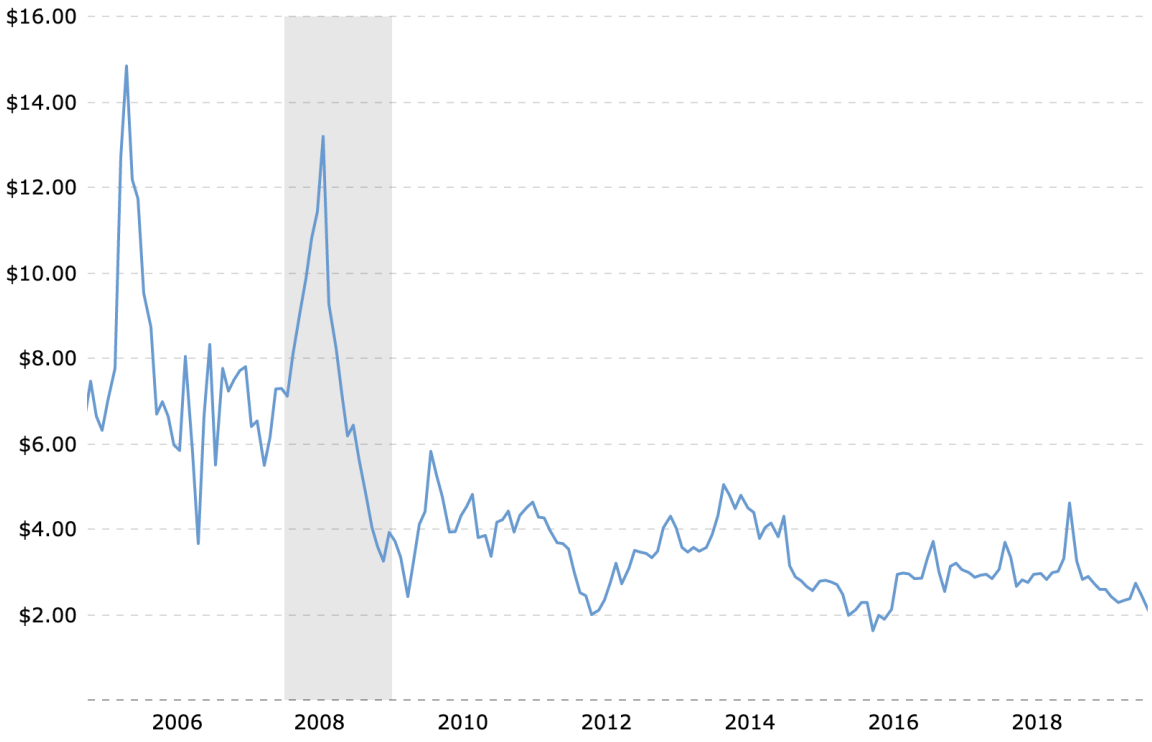

Figure 4.2 Henry Hub natural gas spot prices
Source: Macrotrends.net, 2019.

An analysis of the data reveals, that while the crude oil prices reached its historical maximum in approximately 2012, the hub prices for natural gas stayed on a relatively low level and did not follow the upward trend. Moreover, around this period the natural gas prices stabilized after peaking in 2008. If we now look back at Figure 3.9, we may observe that the natural gas import border price in Germany had an upward trend in the very same period. The change in the price dynamics of oil and gas along with the fully oil-linked gas contracts of Gazprom served as the main reasons for a significant gap formation between the German import prices and the oil indexed contract prices, which did not occur before. The gap can be clearly seen on figure 4.3.

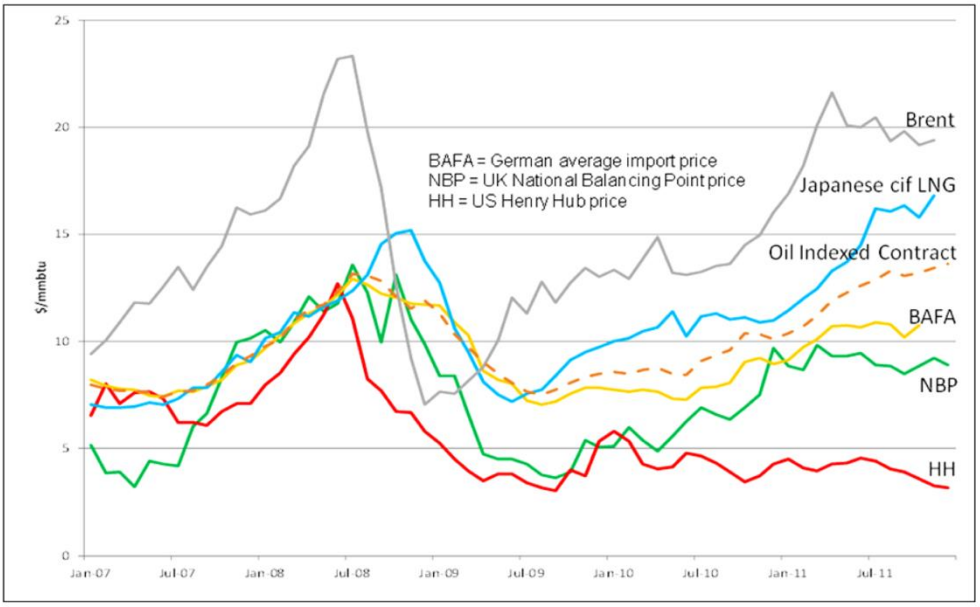

Figure 4.3 Global gas and Brent prices.
Source: Heather, 2012.

Figure 4.3 also shows, that before 2009 the German border prices were pretty much similar to the oil-indexed prices, from which it may be concluded, that the prevailing majority of the gas imported to Germany was oil-linked. Although due to high velocity of the oil-linked prices, the German importers diminished the amounts of imported gas from 100% to 85%, now buying the resting 15% on the hub for a lower price. The reason for 85% were the take-or-pay clauses that were set in the long-term contracts of Gazprom at this level. Overall the German gas import suffered from the factors of high take-or-pay clauses, long-term contracts and oil-indexed gas prices.

This opinion is as well supported by Jack Sharples, a fellow researcher of the Oxford Institute for Energy Studies, who has numerous publications on the topic of EU – Russia gas relations. As he points out in the interview:

The inflexibility of long-term contracts with high take or pay levels were exposed between 2010 and 2012, due to the recovery of oil prices in 2010-11 after their crash in 2008-09. This high oil prices (above $100 a barrel) were sustained from 2011 to 2014, while the supply-demand balance on gas markets could not justify such high prices. For this reason, the prices on the European hubs (based on supply and demand) were significantly lower than the oil-indexed prices in the long-term contracts. This was clearly unprofitable for EU companies that were locked into long-term contracts with Gazprom that had both oil-indexed prices and a high take-or pay-clause, and therefore low levels of flexibility. In the aftermath of that many companies went to Gazprom for renegotiation and this trend has gained a momentum since then. In the last several years, buyers are in a stronger position to renegotiate their contracts due to the high competitiveness of the market. The linking to the hub prices as well as lower take-or-pay clauses and the shorter duration of the contracts are all derivatives of that.

Overall, we can say, that beyond doubt, the changes in the structure of the gas contracts stem from only one factor, which is the recovery of oil prices in 2010. This opinion was supported by the prevailing majority of the interviewees, which points at the fact, that the development of RE in Germany cannot be seen as a cause of this change by any means.

4.1.2 Gas trade intensification

Moving on to the next significant change in gas-trade relations, we have identified in the previous chapter an intensification of gas trade relations, which had been occurring for many years and is still going on. In the past 20 years the German gas imports from Russia have grown by roughly 80% and are expected to continue growing due to a new offshore gas route, that is in the final stage

of construction – the Nord Stream 2. The increasing gas imports to Germany together with the construction of the NS2 are discussed in this section from the perspective of an overall intensification of the gas trade relations. Among the numerous possible factors affecting the intensification if gas trade we will now discuss those, which according to the author and the conducted interviews stand out as the most influencing.

Firstly, based on the analyses conducted in sub-sections 3.1.2 and 3.1.3, we can conclude, that the development of wind and solar energy in Germany causes increased usage of gas, which leads to increased gas imports from Russia. The uneven geographical distribution of the power plants causes an increased gas use for industry during the nighttime and creates the need of grid reinforcement, which is currently one of the main priorities for the German government. Another issue that is related to the necessity of gas is the intermittency of the solar and wind power. The volatility of wind and solar power is a fundamental problem, which leads to the necessity of gas-powered power plants that are used for back-up. The open-cycle gas turbines are an ideal solution to the intermittency due to the low start-up and shut-down costs. The issue of intermittency goes hand-in-hand with the problem of storage, which could possibly solve the intermittency of RE. Although at the moment Germany is not able to deal with it, due to the absence of economical and technically feasible solution. Moreover, the current absence of transportation options of energy in other forms then electricity creates the need to use more gas for electricity generation. These geotechnical issues of wind and solar energy affect the German domestic energy security, which was discussed in section 3.1.3. This leads to the increased use of gas for electricity generation, which is one of the reasons for the increasing gas imports from Russia. Therefore, we can undoubtedly state, that the intensification of gas trade between Germany and Russia stems among other factors from the increasing share of renewable energy. This opinion is supported by the majority of the interviewed experts.

Anna Mikulska: *"We can undoubtedly say, that the increase of gas in the German energy mix stems among others from the geographical and technical characteristics of solar and wind generation. The geographical distribution of wind power plants causes the need for grid reinforcement, which is highly costly and economically unfeasible at the moment. Moreover, the daily intermittency of PV energy together with the annual fluctuation of wind energy cause the need for gas powered power plants as a back-up energy source. Overall, we can conclude, that the increasing share of gas in the Germany's energy mix stems partly from these factors, which in turn leads to higher import volumes of gas from Russia."*

Jack Sharples: *"One reason is the German policy of phasing out nuclear and coal from power generation, which could lead to an increase in the use of gas for baseload power generation, alongside an increased use of renewables. A related second reason can be found in the geographical and technical characteristics of solar and wind energy in Germany, and the attractiveness of gas as a back-up fuel that can balance out the variability of renewable power generation.*"

Roman Vakulchuk: *"The listed geotechnical characteristics undoubtfully limit the use of solar and wind energy and can be considered favorable for gas infrastructure. Moreover, the current technological development does not provide any solution to these issues. The new grid, that is being discussed in Germany is very unlikely to be built both from an economic point of view and societal opposition. The construction of this grid will skyrocket the cost of electricity distribution. Moreover, due to the high-density population on Germany, the society will most likely not allow the government to buy the land for the construction of this grid. Overall the geotechnical issues of solar and wind energy can be considered as one of the drivers for gas trade intensification between Germany and Russia."*

Secondly, the intensification of gas trade relations is strongly affected by the Energiewende. The development of RE is just one of the many factors of the Energiewende, although it is necessary to have a broader look. Speaking broadly, the Energiewende focuses on 2 main goals: cutting the GHG emissions and outphasing nuclear energy. The reduction of GHG emissions is accomplished not only by increasing the share of renewable energy, but also by outphasing coal power plants. Therefore, we can observe a rapid deployment of coal power plants and NPPs, which takes place at a higher velocity than the renewable energy development. This leads to the fact that gas has to balance this difference in production as well as being a back-up power plant due to the

intermittency of renewable energy. German officials have stated multiple times, that gas is currently used as a "bridge" energy carrier on the way to a climate-neutral goal.

Another possible reason for the German high interest of the construction of the NS2 is the shut-down of the Dutch gas field in Groningen, which is the biggest natural gas field in Europe. Germany has been importing a significant share of gas from the Netherlands for decades, although in September 2019 the Dutch government announced the complete decommissioning of the field by 2022 due to due to the increase in induced earthquakes. This will obviously have an impact on the German security of gas import, which will have to be compensated by increased gas imports from Russia.

Another contextual variable reasoning a new gas pipeline between Germany and Russia could be geopolitics. If set to full operation, the NS2 could possibly replace the Druzhba pipeline, that currently runs from Russia to Germany bypassing Ukraine, Belarus, Poland, Hungary and Slovakia and the Czech Republic. The shift from the Druzhba pipeline to the NS2 pipeline could be a big economic and geopolitical asset to both Germany and Russia. Due to the political disputes between Russia and Ukraine and Russia and Poland, Russia could benefit politically and economically from stop paying the transit taxes to these countries. On the other hand, Germany could geopolitically benefit from obtaining all the gas from Russia by sea. According to Anna Mikulska, this could turn Germany into the EU "gas hub" and create a dependency of Poland and the Baltic countries from Germany. It is necessary to mention, that while such a scenario could be possible, this opinion was not supported by other interviewed experts and could be biased by the fact, that Anna Mikulska is a Polish citizen.

The last contextual variable that was identified, is the strong unwillingness of the German government to shift from the Russian gas to the LNG from the US. The American government has multiple times insisted on substituting the Russian gas in Germany by exports of LNG, although Germany has been continuously refusing. This could be explained by unwillingness of long-term investments in order to set up a new infrastructure for LNG as well an unwillingness to become import-dependent from the USA. The debates around the Nord Stream 2 between USA and Germany, which in fact create a pattern of cooperation between Germany and Russia can be explained by this factor.

Overall, we can see, that numerous reasons account for the intensification of gas trade between Germany and Russia. The situation is embedded in a complex environment, where multiple factors play important roles. Although, it was shown, that the development of RE in Germany is one of these factors. Therefore, we proceed with the last step of the framework application, where we analyze the patterns of cooperation between the countries, that are based on this factor.

4.2 Patterns of cooperation

The previous sub-section has shown, that the intensification of gas-trade relations between Germany and Russia is embedded in a complex surrounding with the development of RE being just one of them. It is important to understand that even though the research has proved the influence of the geotechnical characteristics of RE on the gas trade intensification as well as the related patterns of cooperation between Germany and Russia, the situation is embedded in a much broader context. We should keep in mind, that multiple other factors are influencing this process, such as political, economic, societal and other aspects of the Energiewende, which were not accounted for yet in this research. Now, having proved, that the development of RE in Germany is causing the amounts of imported gas from Russia to increase, we can perform the last step of our analysis and discuss the patterns of conflict and cooperation that are a consequence of the gas trade intensification. Following the steps of the created framework, we discuss the 3 dimensions, which are time, intensity and governmental response.

The time indicator provides an insight into the duration of the conflict of cooperation. In the creation of the framework we deliberately did not give a definition to long- and short-term durations. This was done with the purpose of leaving a flexibility for discussion. Therefore, it is now necessary to analyze when the process of gas trade intensification that stems from geotechnical characteristics has begun.

Despite the fact, that Germany has always had good gas-trade relations with Russia, the more rapid intensification of gas imports started around 2013, when the numbers started growing significantly on a yearly basis. The official program of the Energiewende started in 2011. Already by that time renewables have been growing exponentially for a decade, although it was 2011, when Germany pledged to phase out the coal and nuclear power plants. Renewable energy started not complementing, rather outphasing the coal and nuclear, which were mainly used as baseload (nuclear and coal) as well as back-up (coal). Moreover, it was at the same time when the Nord Stream 1 entered its final phase of construction. Since that time the Russian gas has started playing an even more important role in the Germany's energy system, serving mainly as a back-up energy source as well as being transported to the southern and western parts of the country for the use of industry, since the windmills were constructed too far for a feasible electricity transportation. Therefore, we can make an approximation of roughly 10 years. Since the definition of long- and short-term is very vague and also depends on the exact situation, we will compare this time to the overall time of the German-Russian gas cooperation. This has been taking place for approximately 50 years. Therefore, we can define the pattern of cooperation between Germany and Russia which is related to the geotechnical characteristics of RE as medium-term.

Moving on to the intensity of the cooperation, the framework proposes 2 indicators for measuring purposes. Since the intensity indicator provides an overview of the economic impact of the cooperation, it is analyzed with the help of foreign direct investments (FDIs) and direct economic impact. The FDIs can be defined as an investment in the form of a controlling ownership in a business in one country by an entity based in another country and are one of the standard ways of measuring economic involvement. Table 4.1 below provides an overview of the German FDIs in Russia.

Year	Net investment flows
2000	273,210
2005	214,429
2010	1 894,099
2018	3 813,825

Table 4.1

As we can observe, the FDIs have numerously increased. Of course, they may have been affected by many other contextual factors or other types of conflict or cooperation and it is impossible to clearly separate all the possible reasons for the change in the FDIs flows. Although in the past 10 years we have seen numerous German investments into the Russian gas industry, which were in-detail discussed in section 3.1.1. Therefore, despite the fact, that the FDIs have significantly dropped several times due to political instability (war with Georgia, annexation of the Crimea, etc.) we still see a gradual increase over the years. Anna Mikulska and Roman Vakulchuk both mentioned in the interviews, that the intensification in gas trade patterns are among numerous causes for the growing FDIs.

Anna Mikulska: "*The pattern of cooperation between Germany and Russia based on the intensification of gas-trade relations has beyond any doubt strongly affected the German investments flows to Russia. On one hand, numerous investments into the Russian gas infrastructure have been made by the Germans. Although at the same time this affected other sectors of investments, and the overall economic development between the counties has positively reacted to the process of gas intensification.*"

Roman Vakulchuk: "*It is hard to clearly separate the FDIs that stem directly from the gas trade intensification, although we do see a positive trend, and the gas relations can be considered as one of the main causes.*"

Having discussed the positive effect of the gas trade intensification on the FDI flows, we can continue the analyses by discussing the direct economic impact. According to the Russian Federal Customs Service in 2010 Russia gained 58,473.4 million dollars from gas export. Since it is impossible to find the exact numbers, we will make a rough estimation, by accounting for the share

of gas imports to Germany, which were 18.5%. This brings to the number 10,817.6 million dollars of revenue from the gas export to Germany. In 2018 the total gas export revenues were 49,148 million dollars with 25% of the share of export to Germany from the overall gas export, which accounts for 12,287 million dollars of revenue. While we see a significant increase in the numbers, it is also important to note, that a lot of investments have been made by the German companies into the NS2 construction. In total the EU companies have financed half of the project and while the exact numbers are not publicly available, the German companies Uniper and Wintershall have invested not less than a billion dollars.

The last not least variable of the pattern of cooperation is the governmental response to the gas intensification both from German and Russian sides. This indicator has mainly been evolving around the new gas pipelines built between the countries. The current construction of the Nord Stream 2, which plays an important role in the gas intensification, is facing strong opposition from both USA and EU countries, although the governmental response from Germany shows, how important the new pipeline is. The interests of the USA are very obvious – Russia's dominance of gas supply to Germany leaves no market space for the America's LNG. The unfinished pipeline was called a "grave threat to European energy security and American national security" by the US Secretary of State Mike Pompeo. The existing sanctions from the USA target the European vessels laying the pipeline, which caused the project to stop in last December, being completed for 94%. At the same time Ukraine and Poland as well as a number of Baltic countries argue, that the NS2 project will "embolden Russian President Vladimir Putin by giving Moscow more control over crucial energy flows", although do not impose any sanctions. Overall, we see an intense political pressure from numerous countries that for different economical and geopolitical reasons do not want the further gas trade intensification between Germany and Russia. Although the German authorities hold a strong position, trying to prevent the possible intervention of third parties. This position can be mainly seen as a form of German official authorities' response to the aggressive statements of third parties. Below are listed a number of citations of the Germany's official representatives on the topic of the US sanctions for the NS2 construction:

Heiko Maas, the Germany's foreign minister: "*The U.S. administration is disrespecting Europe's right and sovereignty to decide itself where and how we source our energy*".

Heiko Maas: "*European energy policy is decided in Europe, not the US*".

Angela Merkel, Germany's chancellor: "*I see no other option but to talk to the US and make it clear that we do not approve of this practice of extraterritorial sanctions*".

Angela Merkel: "*We do not consider these extraterritorial sanctions, that is those that go beyond the territory of the United States, to be legal*".

Therefore, we can see the governmental response of German authorities, who affirm the determination to complete the NS2 project despite the sanctions from the USA. While the German government is not imposing sanctions on the US, we still do see an open confrontation, which is very illustrative, how much the Russian gas is important to Germany. The overall economic benefit, improvement in FDIs and the political opposition to the US that stem from the gas intensification shows, that the pattern of cooperation between Germany and Russia has significantly intensified.

4.3 Conclusions

This chapter has brought together the knowledge obtained in chapter 3 and structured the information in accordance with the created framework, which is depicted on figure 2.2. The purpose of the chapter was to explain the changes in gas contract structure and the intensification of gas trade relations. This was done by means of applying the theoretical framework created in chapter 2 and the knowledge obtained in chapter 3. Having analyzed the situation step by step from the geotechnical characteristics to the patterns of cooperation the following results have been obtained.

Five geotechnical characteristics of solar and wind energy impact the amounts of gas consumption in Germany. The intermittency and need for storage cause the open-cycle gas turbines to function

as back-up power plants due to the low start-up and shut-down costs. The geographical location of power plants in Germany is limited by the constraints of weather, which has led to the electricity generation very far from the main consumption points. This issue goes hand in hand with the transportation options of energy and the need for grid reinforcements. As Michael Bradshaw mentions, "The German grid was initially designed for other types of flows. A relatively small number of power plants has with time turned into a decentralized system, which is in the wrong place". Therefore, either an extra "super-grid" has to be built, which is currently one of the German priorities, or new technologies using liquid hydrogen have to be introduced.

The 5 geotechnical characteristics that are briefly discussed above have a negative impact on some of the energy security indicators. Therefore, gas is used to balance this negative impact. This has led to increasing gas import rates from Russia. Moreover, the increase in imports has facilitated the patterns of cooperation between Germany and Russia both economic and political. The political cooperation mainly stems from the ongoing NS2 construction and the imposed sanctions from the US. Cooperation on economic level can be deducted from the increase in the FDI flows as well as the numerous investments in gas infrastructure.

Regarding the structural changes in the gas contracts, it was shown, that those stem from completely other factors and are not related to the RE development. The German gas import suffered from the factors of high take-or-pay clauses, long-term contracts and oil-indexed gas prices that were set by Gazprom. The reason for it was mainly the rapid increase in the oil prices in 2012, while the gas prices did not follow the upward trend.

Moreover, despite the fact that a logical connection between the RE development in gas trade intensification was established, the situation is embedded in a complex geopolitical and economic surrounding. Numerous factors have been identified that have a strong impact on the intensification of the gas trade relations and the patterns of cooperation between the countries that is based on that. Firstly, it is necessary to understand, that the global goals of the Energiewende such as outphasing coal and nuclear power have an impact on the gas imports. As Michael Bradshaw pointed out, the outphasing of coal not only impacts the energy production, but also diminishes the storage options of Germany, since the stockpiles of coal served as a way of energy storage. Secondly, the imports from Russia are growing at a high rate due to the shut-down of the gas field in the Netherlands. Moreover, several political reasons were identified, such as the US sanctions on the NS2 and the strong opposition of Poland. These factors lead to an increasing political cooperation between Germany and Russia.

Chapter 5

Discussion

Introduction

This chapter reflects on the created framework, the used methods and the results of the research. Section 5.1 discusses the findings of the research in light of the existing body of knowledge. Section 5.2 reflects on the findings in light of practice. Finally, Section 5.3 critically reviews the created framework as well as the methods that were used.

5.1 Results for theory

This study combines the topics of geopolitics of energy and geopolitics of renewables. Therefore, this section discusses the added value of this research to both of these topics as well as analyses how useful the existing literature was.

This study argues that the global development of renewable energy is affecting the geopolitics and relations between countries. The case of Germany and Russia shows, that solar and wind energy have a visible effect on the patterns of cooperation between these countries. Some literature discusses the possibility of new political interdependencies as renewables displace fossil fuels. Although we should keep in mind, that even though the development of RE is taking place at a high velocity, fossil fuels will still be a dominant energy source for most of the countries in the coming decades. Therefore, the author disagrees with a popular statement, that a completely new distribution of energy power in the world will emerge. The case of Germany has shown, that at this stage of technological development the renewable energy is complementary to fossil fuels due to its geotechnical characteristics. For example, Scholten (2018) mentions, that there is a structural change in geopolitics that stems from the geographical and technical characteristics of renewable energy systems. Based on the knowledge obtained from this research, the author argues with such a definition. No structural change is occurring, since the fossil fuels are not fully outphased. Rather new dependencies and patterns in the geopolitics are emerging, that stem from the development of RE, while the structure of the geopolitics remains unchanged.

The main theoretical result of the conducted research is an established relationship between the development of wind and solar energy in Germany and the cooperation of these countries that is based on the continuous process of gas trade intensification. Numerous scientists have discussed the impact of the Energiewende on the German gas imports, although these findings were mainly published in the form of articles without a clear methodology of application. Moreover, none of the previous researches on this topic have clearly shown which geotechnical characteristics of renewable energy have the most impact on the gas trade relations. Application of the created framework has given scientific evidence, that numerous geotechnical characteristics of wind and solar energy have affected the pattern of cooperation between countries through gas trade. Geographical location of the power plants, stability, need for energy storage, transportation options and grid reinforcements are independent variables of the renewable energy characteristics that played the most significant role in the gas trade intensification. The existing literature has not addressed this topic previously. Therefore, in comparison to other studies on this topic, this research has performed a deeper and more comprehensive analysis.

5.2 Results for practice

The main research question that was formulated in Section 1.3 was: "*How does the development of wind and solar energy in Germany affect the current gas trade relations between Germany and Russia?*" In the light of the performed research it is now possible to answer this question. A number of the geotechnical characteristics that were identified in section 4.1 have an impact on the energy security indicators of Germany as well as security of export for Russia. The implications of these geotechnical characteristics cause an increased gas use by Germany in order to not weaken the

energy security. We have observed that the development of solar and wind energy in Germany together with the overall program of the Energiewende can potentially decrease the energy security of the country. In order to balance this process and not let the RE harm the energy security, Germany chose for an increase in gas consumption, which in turn led to increased gas imports from Russia. Overall it was identified, that 5 geotechnical characteristics of solar and wind energy have led to a pattern of cooperation between Germany and Russia, which is taking place for roughly a decade by now. The pattern of cooperation can be observed both on an economic level, as well as a political level. Below is a list of the main practical findings of this research:

- The 5 identified geotechnical characteristics of solar and wind energy have a significant impact on the domestic energy security of Germany.
- In order to balance the energy security, Germany is increasing the share of gas in energy production.
- The increased use of gas in Germany results in the intensification of gas trade relations between Germany and Russia.
- The increase in dependence from Russia creates a pattern of cooperation between the countries as well as pattern of conflict between Germany and the USA.
- Logical connection between the development of renewable energy in Germany and increased cooperation between Germany and Russia was established.
- Numerous contextual variables are also responsible for the pattern of cooperation that is based on gas trade.

5.3 Reflection on methods and framework

This section includes a critical analysis of the methods that were used to obtain the results as well as of the created theoretical framework. Suggestions for more reliable methods are made and the main weaknesses and strengths of the created framework are discussed.

Methods

While the methods have been clearly and deliberately described in section 1.6, there do exist numerous things, that could have increased the validity and reliability of the research.

Firstly, a higher number of interviews could have been conducted both with the researchers and interested parties (German and Russian governmental employees in the energy sector). While the latter group of respondents were initially included, the escalation of political conflict between Germany and Russia due to the poisoning of Navalny made it impossible. Moreover, the validation of the created framework could have been as well performed by experts in this field, which would make the framework more reliable. Although the author deliberately chose to skip this step for the reason of time constraints.

Another drawback of the used methods is the absence of justification of the chosen energy security indicators. The framework of Sovacool & Mukherjee (2011) was used to assess the energy security due to the fact that it is one of the most widely used approaches to quantifying energy security. Although this framework includes 372 different indicators and just 10 of them were chosen. It is not clear, why the chosen indicators are more important to this study, which has an impact on the reliability of the obtained results. Ideally, a research should have been conducted, which energy security indicators are the most affected by RE development.

Framework

Use of the framework

The framework of Scholten (2018) was initially constructed as an attempt to systematically approach and investigate the topic of RE geopolitics. According to Scholten (2018), the framework designed by him was initially made with global energy relations in mind, not necessarily to be applied to a specific country. Therefore, changes and adaptations were made in chapter 2. The created framework is easy to apply and is indeed an effective way to create a deep comprehension

into the geopolitics of renewable energy. Although after having applied the framework and obtained results, it is necessary to underline, that the framework of Scholten lacks attention to the contextual variables. While they are included as a broader scope, no method is proposed to analyze, to what extent they can be held responsible for the changes. A deeper analysis of the contextual variables might decrease the ease of usage of the framework but is strongly needed.

Another problem that has faced the author during the application of this framework is identifying the changes in energy security, that stem from geotechnical characteristics of RE. The framework of Scholten suggests finding evidence of how the energy security has changed, although this is highly problematic for such a developed country as Germany. The energy security of Germany is very stable and therefore all the weaknesses are immediately targeted. Therefore, it is difficult to identify which exactly aspects of energy security have been affected, since the negative impact of geotechnical characteristics was gradually balanced by the increasing share of gas.

Strengths of the framework

The adapted from Scholten (2018) framework has many advantages. At every step of the framework the concepts are operationalized and analytically examined. Such an approach not only reveals how established bilateral energy relations between Germany and Russia are affected by the geotechnical characteristics of RE, but also creates a clear logical structure with a comprehensive analysis at each stage. The main strength of the framework is the fact, that the framework is structured in a clear logical sequence. The schematic representation helps the user to intuitively understand the sequence they need to follow in order to perform an analysis. The framework allows the user to conduct a research in a relatively new and very important field of science using just a desk research. Moreover, the generalization of the framework creates an opportunity to easily adapt it to different situation, which is a very important feature.

Weakness of the framework

The main weakness of the framework is the absence of clear logical connection between the variables. While on one hand, it is easy to logically link all the steps of the framework, the absence of distinctly marked differences between the steps may create space for misinterpretation. Moreover, the created framework has issues with analyzing the intensity of the conflict or cooperation. The framework used the indicators of FDIs and economic impact, and both of the indicators are highly complex and depend on multiple factors. This creates a necessity to conduct expert interviews, which opinions are used to create a comprehension, to which extent the indicators are linked with renewable energy. Overall the author would suggest using a more economic approach with an in-depth financial research in the analysis of the FDIs for the future studies.

Chapter 6

Conclusion

The conclusion of this research consists of 3 parts and is structured in the following way. Section 6.1 brings forward the main research question and provides an in-depth answer based on the conducted research. Section 6.2 outlines strategic recommendations for Germany and Russia that could be beneficial to them in the long-term. Finally, section 6.3 discusses the limitations of the study and proposes recommendations for further research on the topic of geopolitics of renewable energy.

6.1 Answer to the main research question

The global geopolitics of developed countries in the twentieth century was highly shaped by energy geopolitics, which is outmost dependent on the supply and demand of coal, oil and gas. The development and diffusion of renewable energy technology may reshape the geopolitical power in the world. In the past 30 years there has been established an intense gas trade relation between Germany and Russia, which is constantly changing and evolving. Although it is of high importance, whether the established relations are affected by the rapid increase of solar and wind energy in Germany. Therefore, the main goal of this research was to answer the following research question:

How does the development of wind and solar energy in Germany affect the current gas trade relations between Germany and Russia?

In order to answer this question a theoretical framework of Scholten (2018) was applied with numerous adaptations to this case study. The main variables of the created framework were analyzed. An extensive literature review on the past gas relations and RE development of the countries in the timeframe of approximately 20 years was performed. Two main changes in gas relations were identified: changes in contract structure and intensification of gas trade relations.

In the light of the performed research it is now possible to answer this question. The following geotechnical characteristics of RE affect the German energy security in such a way, that more gas is needed:

- Location – most of the wind power plants are located in the very northern are of Germany, while solar power in harvested predominantly in the south. This creates lack of electricity at night times in the southern areas of Germany, where the industries are located. Since the NPPs and coal-fired power plants are steadily being outphased, gas-fired power plants provide a significant share of the electricity at night times in the southern parts of the country.

- Stability – the electricity harvested from wind and solar is very intermittent, while the grid has to be perfectly balanced at all times. This creates a need for back-up power plants. The open-cycle gas turbines are an ideal solution to the intermittency due to the low start-up and shut-down costs.

- Need for storage – due to the intermittent nature of solar and wind energy, at daytime Germany produces more than needed, which could have been used at night times instead of gas. Although the absence of technologically and economically feasible storage solution drives Germany to export the excess electricity.

- Transportation options – transportation of energy from the northern parts of the country, where the windmills are situated, is currently not done. Energy could be transported in different forms to the southern and western parts, where less RE electricity is produced and therefore more gas is used.

- Grid reinforcement – a massive grid connection from the northern part of the country, where

the windmills are situated to the western and southern regions is needed. According to the IEA (2020) the grid expansion is a stated priority for the German government. Due to the absence of this grid the gas consumption for electricity generation, that is needed for the industry, has not seen a decline. Overall this problem clearly illustrates the issues of the geographical location of the solar and wind energy as well as the need for grid expansion.

The described above implications of geotechnical characteristics on the energy security create an intensification of gas trade relations between Germany and Russia that leads to a pattern of cooperation. It was shown that this cooperation has been taking place for roughly 10 years and has resulted in improvement of FDI flows and mutual economic benefit. Moreover, we also observe political cooperation of Germany and Russia who are together striving to relieve the sanctions of the USA that are imposed on the Nord Stream 2. These conclusions have been validated by 5 experts in the field of energy geopolitics, geopolitics of renewables and international relations.

Another change in the gas-trade relations that was identified, is the change in the contract structure. These changes in gas contract structures started occurring approximately in 2010-2012 and have already finished by now. During those years we could observe the prevailing majority of Gazprom's clients renegotiate the contract conditions. Moreover, looking more broadly, this process took place not only with the German gas buyers, but also all other European gas importers. An analysis in section 4.4.1 has shown, that the inflexibility of long-term contracts with high take or pay levels were exposed between 2010 and 2012, due to the recovery of oil prices in 2010-11 after their crash in 2008-09. Therefore, this change is not related to the development of renewable energy.

Another important conclusion that can be made from this research, is that despite the evidence of the impact of the RE development on gas trade intensification, the whole situation is embedded in a broader context. It was shown, that numerous political, technical and societal factors are also related to the gas trade intensification. The role of these factors should not be underestimated. The situation becomes even more complicated taking into account that the Russian gas and German RE are simultaneously competitive and complementary on the German energy market, as some experts argue, that natural gas can be an intermediate solution if a country is aiming to become carbon-neutral in the long-term.

6.2 Recommendations for Germany and Russia

Based on the conducted analyses strategic implementations are recommended for both countries. The recommendations are made with the purpose of economic benefit for Russia and improvement of energy security of Germany.

Germany:

- Increase R&D in transportation options and energy storage options. The German government has recently adopted the country's coal exit law according to which the coal-fired power generation is outphased in 2038 at the very latest. In case the issues of geographical and technical characteristics are not partly solved by that time, Germany will become even more dependent on Russian gas, which could threaten the energy security.

- Continue the pressure on the US sanctions of the NS2. The new gas pipeline is highly beneficial for the German energy security and billions have already been invested. In case the pipeline is not built, Germany's economy and energy security could suffer.

- Increase financial support of biogas. Currently this energy carrier holds an insignificant share of the energy consumption, although it lacks many geotechnical issues in comparison with solar and wind energy and could partly decrease the Germany's dependency on Russian gas.

Russia:

- Invest in R&D of hydrogen technology. In theory Russia could use the existing pipelines for exporting liquid hydrogen to Germany. This could continue the cooperation between Germany

and Russia and open a new perspective market.

- Research new gas markets. The intensification of gas trade relations that is currently taking place will sooner or later diminish, if Germany sticks to the climate-neutral plan. It is therefore important for Russia to find new markets and develop new gas-based relationship before Germany finds solutions for outphasing gas.

- Increase governmental support for RE development. Section 3.2.2 has shown, that despite all the potential for RE development, Russia continues relying on fossil fuels and almost no governmental or societal attention is being payed to the climate change issue. An improvement in renewable energy could create a new pattern of cooperation between Germany and Russia that would be based on knowledge sharing. This could as well lead to economic cooperation between Germany and Russia and create an increased inflow of FDIs.

Overall, Russian authorities have to clearly understand, that the intensification of gas-trade relations with Germany is a medium-term pattern, that is partly occurring due to the Energiewende program overall as well as geotechnical characteristics of renewables in particular. In the long-term Germany is aiming at becoming climate-neutral, which will strongly decrease the use of gas. The author recommends the Russian authorities to keep that in mind and not overestimate the perspectives of gas exports to Germany in the future. This deduction is supported by opinion of Roman Vakulchuk, who mentioned in the interview, that "*in the upcoming 10-15 years we will see an increase in the Russian gas in Europe overall and Germany in particular, although in the long run 20-30 years perspective we will see a decline. Therefore, while Russia is currently profiting in economic terms from the Energiewende, the country should prepare to lose this market in the long term*".

6.3 Limitations and recommendations for further research

The conducted research has numerous limitations which will be addressed in this section. Firstly, despite the fact, that we have established the impact of the RE development in Germany on the gas trade intensification with Russia, the framework does not allow to measure this impact in comparison to other contextual variables. Hence, having established the logical connection, we are not able to compare this impact with other contextual variables and somehow quantify it. Further research in this area could be based on the results of this study, and analyze, *how much* the development of renewables in Germany is affecting the gas trade intensification.

Secondly, this study is just one of the first attempts of addressing the issue of the geopolitics of renewables, and therefore leaves a lot of space for further research. The future research could target similar cases between other countries or focus on just one country. Both approaches are possible due to the clear structure and high flexibility of the framework. In order to create a better comprehension of the geopolitics of renewables and get a better understanding of the weaknesses and strengths of the framework, it is highly recommended to continue research in this area.

Thirdly, this research has targeted just 10 indicators of renewable energy security. The author would recommend discussing the impact of the RE on all of the 372 indicators of Sovacool. Such a study would be different from the conducted research but would give a deeper comprehension of the underlying processes of the geopolitics of renewables. This approach would require a lot of time and effort, although it is very important to have a complete picture of this subject.

Finally, a study on biogas should be conducted. The current share of biogas in Germany's energy mix is low in comparison with the wind and solar energy. And hence this type of fuel was not included in the research. Although on the first sight it could be a good solution for Germany to decrease the import dependency. Technical and economic prospective of biogas use in Germany should be analyzed and its impact on the energy security of the country should be studied.

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Appendix 1: Interviews

Jack Sharples:

1. *In your opinion, is there a visible change in German-Russian gas relations that stems from the Energiewende implementation?*

- We can see a change, although a more proper word would be intensification. One reason is the German policy of phasing out nuclear and coal from power generation, which could lead to an increase in the use of gas for baseload power generation, alongside an increased use of renewables. A related second reason can be found in the geographical and technical characteristics of solar and wind energy in Germany, and the attractiveness of gas as a back-up fuel that can balance out the variability of renewable power generation. So, gas will continue to become more important for Germany, and Russia is the largest provider of German gas imports. If it is completed, Nord Stream 2 will further increase the capacity for Russian gas deliveries to Germany.

2. *According to some publications, Gazprom is shifting from long-term gas export contracts to more short-term. Is this the result of EU pressure? Could this be related to the future "green" plans of EU?*

- This is mostly due to the European gas market becoming more competitive. The short-term trading of gas is growing in volume, and customers are demanding greater flexibility. So, although Gazprom retains substantial volumes of long-term export contracts, it is also becoming more active in short-term sales. The settlement of the European Commission antimonopoly investigation into Gazprom did not force Gazprom to change the length of its contracts, although it obliges Gazprom to provide price reviews every 2 years, in case the long-term contract prices diverge significantly from the prices on European trading hubs.

3. *The majority of contracts between Russia and Germany are long-term with a take-or-pay clause. The previous take-or-pay clauses were usually set at 85%. The current take-or-pay clauses have shifted to roughly 70%. Could you elaborate on the reasons for this and the expectations?*

- The reduction in the take-or-pay levels occurred over time and unevenly. The inflexibility of long-term contracts with high take or pay levels were exposed between 2010 and 2012, due to the recovery of oil prices in 2010-11 after their crash in 2008-09. This high oil prices (above $100 a barrel) were sustained from 2011 to 2014, while the supply-demand balance on gas markets could not justify such high prices. For this reason, the prices on the European hubs (based on supply and demand) were significantly lower than the oil-indexed prices in the long-term contracts. This was clearly unprofitable for EU companies that were locked into long-term contracts with Gazprom that had both oil-indexed prices and a high take-or pay-clause, and therefore low levels of flexibility. In the aftermath of that many companies went to Gazprom for renegotiation and this trend has gained a momentum since then. In the last several years, buyers are in a stronger position to renegotiate their contracts due to the high competitiveness of the market. The linking to the hub prices as well as lower take-or-pay clauses and the shorter duration of the contracts are all derivatives of that.

4. *Do you see the debates around Nord Stream 2 as a form of cooperation between Germany and Russia?*

- Until recently, yes. Some German companies are financial investors in the NS2 project company. Moreover, the German government has been negotiating with countries such as Poland and Lithuania, which are opposed to NS2. Overall, we could see both commercial and diplomatic support from the German government. The pipeline was (and remains) unwanted by the European Commission, several EU Member States, and the USA, yet the German government kept lobbying for the project. However, the poisoning of Navalny has changed

dynamic and now even previously supportive German politicians are discussing the possibility of stopping the NS2 project.

Anna Mikulska:

1. *Do you believe that the Energiewende has an impact on the gas trade relations between Germany and Russia?*

- The outphasing of the nuclear energy and coal energy together with the intensification of RE calls for ways to balance the intermittency. The gas is perfectly suitable for it due to the low cost of start-up and shut down and the relative cheapness. Overall the gas trade relations between Germany and Russia have a rich history since the 1970s, which created a strong relationship both in terms of diplomatic and utilities. It is necessary to underline, that this positive history creates a mutual trust, which also affects the intensification of the gas trade relations currently.

2. *In case the previous answer is positive, what role, according to you, play the geographical and technical characteristics of renewable energy (intermittency, geographical location and grid reinforcements)?*

- The geographical characteristics of RE systems play an important role. While the biggest problem in Germany stems from the intermittency of solar and wind power and the absence of storage options, the geographical location of the power plants calls for a grid intensification. This would be very expensive and could see a strong opposition from the society. Currently a possible option would be liquified hydrogen, although the technology is not ready yet. Germany should invest more in the R&D of hydrogen, since this would be a good solution to many geotechnical issues of the RE. Although we should not expect the technology on the market any soon.

3. *Do you think that Russia's economic is (or will be) profiting from the German shift to RE in terms of gas export?*

- The pattern of cooperation between Germany and Russia based on the intensification of gas-trade relations has beyond any doubt strongly affected the German investments flows to Russia. On one hand, numerous investments into the Russian gas infrastructure have been made by the Germans. Although at the same time this affected other sectors of investments, and the overall economic development between the counties has positively reacted to the process of gas intensification. A possible important benefit lies in the geopolitical area. If the NS2 is to be finished, Russia can stop transiting the gas through Poland, Ukraine etc. and thereby stop paying the taxes. Moreover, this could be beneficial to Germany, which will turn into the major EU gas hub.

4. *Do you see the construction of the NS2 as a consequence of the Energiewende? If so, could we see the Energiewende as a positive factor for the cooperation between Germany and Russia?*

- The NS2 has many reasons to be built, both economic and political. But the German shift to RE can be considered as one of the main reasons. The construction of the NS2 is definitely a positive factor in the economic and politic cooperation between Germany and Russia, although at the same time it may have negative impact on the Baltic countries, as well as Poland and the USA.

Roman Vakulchuk:

1. *Do you believe that the Energiewende has an impact on the gas trade relations between Germany and Russia?*

- In the past 10 years we have seen a structural change in the way Germany addresses the domestic energy development. Overall, we can say, that the Energiewende has not caused a

structural change in the gas relations with Russia, although the intensification of German gas imports from Russia is one of the main consequences. In the upcoming 10-15 years we will see an increase in the Russian gas in Europe overall and Germany in particular, although in the long run 20-30 years perspective we will see a decline. Therefore, while Russia is currently profiting in economic terms from the Energiewende, the country should prepare to lose this market in the long term.

2. *In case the previous answer is positive, what role, according to you, play the geographical and technical characteristics of renewable energy (intermittency, geographical location and grid reinforcements)?*

- The listed geotechnical characteristics undoubtfully limit the use of solar and wind energy and can be considered favorable for gas infrastructure. Moreover, the current technological development does not provide any solution to these issues. The new grid, that is being discussed in Germany is very unlikely to be built both from an economic point of view and societal opposition. The construction of this grid will skyrocket the cost of electricity distribution. Moreover, due to the high-density population on Germany, the society will most likely not allow the government to buy the land for the construction of this grid. Overall the geotechnical issues of solar and wind energy can be considered as one of the drivers for gas trade intensification between Germany and Russia.

3. *Do you think that Russia's economic is (or will be) profiting from the German shift to RE in terms of gas export?*

- Yes, we can say, that the increase in gas trade volumes has had a positive impact on the Russian economics. Regarding the FDIs, it is hard to clearly separate the FDIs that stem directly from the gas trade intensification, although we do see a positive trend, and the gas relations can be considered as one of the main causes. It is important to note, that we can observe a slight shift in Russia towards sustainability. While Russia is still too far away from the wind and solar development, there exist other options like electric vehicles and liquid hydrogen. The development and implementation of these technologies could be beneficial for political and economic cooperation between the countries.

4. *Do you see the construction of the NS2 as a consequence of the Energiewende? If so, could we see the Energiewende as a positive factor for the cooperation between Germany and Russia?*

- The topic of the NS2 is so politicized, that it is hard to distinguish between different economic and politic advantages for the countries. The NS2 is undoubtfully important for both Russia and Germany, although I would not say, that it is of most importance to the development of gas relations between Germany and Russia. In the long term the project could be unprofitable for Russia, since we can see that the EU regulation of GHG emissions is becoming tighter annually. High carbon taxes could limit the wide use of gas in Germany and the NS2 would become unprofitable in this scenario.

Michael Bradshaw:

1. *Do you believe that the Energiewende has an impact on the gas trade relations between Germany and Russia?*

- The German policymakers failed to think about the need of gas strategy alongside the decisions to phase out coal and nuclear power. I believe that we should discuss not the volumes of traded gas, rather the new role that it is playing in the energy security of the country. The recognition of gas importance in Germany comes just now and we can see an increase in the gas imports. While one could say, that this is the consequence of the Energiewende, the question should be broader than just renewables vs gas.

2. *In case the previous answer is positive, what role, according to you, play the geographical and technical characteristics of renewable energy (intermittency, geographical location and*

grid reinforcements)?

- The increase in necessity for energy storage stems not only from the increase of renewable energy. Coal, that is currently being phased out, used to serve as a way of energy storage in a form of stockpile. Moreover, we should distinguish between long- and short-term storage. Regarding the problem of geographical location and grid reinforcements, the German grid was initially designed for a completely different system then the one we see nowadays. Therefore, I would discuss it as a more general problem. The grid was designed for a relatively small number of centralized power generation systems. Now we have a distributive source of generation often in the wrong place. So, while the cost of RE generation is falling, the overall cost of the RE system is adding significant requirements.

3. *Do you see the construction of the NS2 as a consequence of the Energiewende? If so, could we see the Energiewende as a positive factor for the cooperation between Germany and Russia?*

   It is impossible to answer this question only from the perspective from the renewable energy development. The situation is very complex and depends on multiple actors, among others the US and the Chinese process for LNG. I would recommend study this question in a broader perspective, taking into account multiple variables and actors.