



Towards Net Zero: The Russia-Ukraine Conflict as a Catalyst for Green Technologies in the German Energy Sector

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Abstract

The ongoing Russia-Ukraine conflict has had a substantial economic impact on the German energy market. It highlights that rethinking the national energy mix is necessary not only to achieve international and national climate goals but also to achieve a higher degree of independence from imports, especially Russian natural gas imports. Greentech has the potential to play a crucial role in achieving this. However, the pace of innovation depends on various factors, such as investments and the adaptation of policies. This study draws on management theory perspectives to discuss how Greentech innovation can potentially gain momentum considering the geopolitical crisis. Semi-structured expert interviews were performed to identify the possible catalytic effects of the Ukraine war for Greentech. Furthermore, scenario planning was used to identify competitive advantages in the German energy sector for Green Technologies.

The research found that the war has served as an indirect catalyst for Greentech innovation, as movements in external factors are apparent. These external factors, such as policy development and investment trends, are highly influenced by the war, which could give Greentech innovation more traction in the future.

Title: Towards Net Zero: The Russia-Ukraine Conflict as a Catalyst for Green Technologies in the German Energy Sector

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Resumo

O conflito em curso entre a Rússia e a Ucrânia teve um impacto económico substancial no mercado energético alemão. Ele sublinha que repensar o cabaz energético nacional é necessário não só para alcançar os objectivos climáticos internacionais e nacionais, mas também para alcançar um maior grau de independência das importações, especialmente das importações de gás natural russo. A Greentech tem o potencial para desempenhar um papel crucial para alcançar este objectivo. Contudo, o ritmo da inovação depende de vários factores, tais como os investimentos e a adaptação das políticas. Este estudo baseia-se nas perspectivas da teoria de gestão para discutir como a inovação da Greentech pode potencialmente ganhar impulso considerando a crise geopolítica. Foram realizadas entrevistas semi-estruturadas com especialistas para identificar os possíveis efeitos catalíticos da guerra da Ucrânia para a Greentech. Além disso, o planeamento de cenários foi utilizado para identificar vantagens competitivas no sector energético alemão para as Tecnologias Verdes.

A pesquisa descobriu que a guerra serviu como um catalisador indirecto para a inovação Greentech, uma vez que os movimentos de factores externos são aparentes. Estes factores externos, tais como o desenvolvimento de políticas e tendências de investimento, são altamente influenciados pela guerra, o que poderia dar à inovação Greentech mais tracção no futuro.

Título: Rumo ao zero líquido: O conflito Rússia-Ucrânia como catalisador para as tecnologias verdes no sector energético alemão

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Palavras-chave: Transição de Energia, Sustentabilidade, Planeamento de Cenários, Destruição Criativa, Rússia-Ucrânia-Conflito, Sistema de Informação Tecnológica, Vantagem Competitiva

Table of Contents

List of Figures	V
List of Tables.....	V
1. Introduction	1
1.1 Problem statement	1
1.2 Academic and managerial relevance	2
1.3 Research Questions	3
2. Literature Review	4
2.1 Definition of Greentech	4
2.2 The European energy market	4
2.2.3 Powering Germany: An Energy Sector Overview	4
2.2.4 The role of Russia in the European energy market	7
2.2.5 The role of Ukraine in the European energy market	10
2.3 Macroeconomic Disruptors	11
2.3.1 International policies	11
2.3.2 National policies	13
2.4 Future Scenarios	13
2.4.1 Creative destruction – an opportunity for a green energy industry	15
2.4.2 Energy transition through Greentech innovation	16
2.4.3 Technology Information System – A multi-agent solution.....	18
3 Methodology	20
3.1 Research Design and Data Collection	20
4 Findings & Analysis	23
4.1 Summary of interview findings	23
4.2 Porters five forces industry analysis.....	29
4.3 Scenario Planning and External Factors.....	30
5 Discussion	34
5.1 Catalysts	34
5.1.1 Catalysts through investments.....	35
5.1.2 Catalysts through policies	35
5.1.3 Catalysts through collaboration.....	36

5.1.4	Creative destruction.....	36
5.2	Potential catalytic effect of the Russian-Ukraine war	36
6	Conclusion.....	37
6.1	General Conclusion	37
6.2	Limitation	38
6.3	Future Research.....	38
	Bibliography	40
	Appendices	i

List of Figures

Figure 1: Primary energy consumption (PEV) in Germany 2022 (BDEW, 2022)	5
Figure 2: Gas price development Germany 2008-2022 (Forbes, 2022)	6
Figure 3: Gas pipeline linkage between Russia and Europe (Statista, 2022b)	8
Figure 4: Import volume of natural gas from Russia in Germany (Jan 2022 - Oct 2022) (Statista, 2023b)	10
Figure 5 Energy-related EU GHG emissions (MtCO ₂ eq) (Heflich & Saulnier, 2022).....	14
Figure 6: Gas consumption (in exajoules) in EU-28 from 2000 - 2018, including 2050 forecast, by scenario (Statista, 2023a).....	14
Figure 7: Technological innovation system development cycle (Haley, 2018)	19
Figure 8: Answers Question 3	24
Figure 9: Answers Question 4	25
Figure 10: Wordcloud based on Keywords for Question 5	26
Figure 11: Answers Question 9	28
Figure 12: Probability of "yes" Answers for each Uncertainty	33
Figure 13: Probability of "yes" Answer for each Uncertainty including Least Surprise	34

List of Tables

Table 1: Imports of natural gas by partner country (Eurostat, 2023)	9
Table 2: List of Interview Experts	22
Table 3: Interview Guide	22
Table 4: Stakeholders for Scenario Planning	30
Table 5: Trends for Scenario Planning	30
Table 6: Uncertainties for Scenario Planning	31
Table 7: Correlation Matrix of Uncertainties	31
Table 8: Learning Scenarios for Scenario Planning	32
Table 9: Least Surprising Scenario for Scenario Planning	33

1. Introduction

This thesis aims to understand how Greentech innovations can play a role in Germany's current and future energy sector and accelerate the shift to a more sustainable energy mix. Furthermore, insights into the current state of the German energy market will be provided. Challenges, opportunities and the impact of the ongoing Russian war on Ukraine on adopting Greentech innovation will be examined.

Germany needs to reshape its future energy economy, which was and still is dominated by fossil fuels, to meet climate targets. In particular, the country needs to become less dependent on foreign energy imports. The Ukraine war underlines the importance of technological advancements in the energy sector to become less reliant on Russian natural gas. The mainstream trend toward sustainability and pursuing climate goals can create competitive advantages for German companies. Moreover, the concept of creative destruction proposed by Schumpeter enables German companies and new entrants to drive innovation and create new market niches, leading to economic growth (Schumpeter, 1976). This paper aims to help understand how Germany can introduce green technologies to create a more sustainable and resilient energy market that is less dependent on external sources and better prepared to meet future challenges.

1.1 Problem statement

As part of the European Green Deal, the EU has committed to reducing emissions by 80-95% by the year 2050. So far, the clean energy transition has accelerated Europe's sustainable economic development and brought substantial social and environmental advantages for European citizens. (European Commission, 2018). Germany is the largest economy in Europe and will be critical in meeting the goals mentioned above (Heilmann et al., 2020).

Many German businesses and investors are already changing their tactics due to the increased emphasis on environmental, social, and governance (ESG) factors in the private markets and in response to new legislation like the EU's Sustainable Finance Disclosure Regulation (PWC, 2021). However, to meet the Net Zero Emissions by 2050 Scenario, innovation in renewable energy technology must pick up speed. With current technology, the bulk of CO₂ emission reductions can be achieved by 2030; yet, the road to 2050 depends on technologies that have not yet reached a degree of widespread adoption. (IEA, 2022a). The German government has outlined their strategy in the Climate Action Plan 2050 as the nation makes efforts to decrease

emissions across several sectors, including the energy industry. As a result, Germany has successfully maintained a secure and reliable energy supply, which included a balance of oil, natural gas, and electricity in the past (IEA, 2020).

The Russian invasion of Ukraine in early 2022 changed the *status quo* (Ozawa, 2022). Already in 2010, Christophe-Alexandre Paillard highlighted the mutual energy dependency between Europe and Russia concluding with the following question: “Can Europe’s growing dependency on gas stay a purely economic matter, or is it destined to become a source of serious political conflict in the near term?” (Paillard, 2010)

A decade later, the current geopolitical conflict can be considered the biggest humanitarian crisis in Europe since WWII. In 2021, Russia supplied the European Union with 39.3% of its natural gas imports and was the primary oil and gas producer for several European countries (Eurostat, 2022). Energy security concerns have prompted Germany and the rest of the European Union to limit their reliance on natural gas from Russia (European Council, 2023). And it is evident that this radical policy shift will hinder the course towards energy transition. However, in the long run, economics and energy security logic could combine to intensify net-zero transition efforts (McKinsey, 2022). Some of these efforts include diversifying energy supply sources, further improving energy efficiency and accelerating the deployment of renewables, which can be resolved by investing in and driving forward Greentech innovation (European Council, 2023).

1.2 Academic and managerial relevance

This thesis aims to contribute to the academic field of sustainability, environmental studies and innovation strategy by examining the potential relationship between the Russia-Ukraine conflict and the advancement of Greentech technologies within the German energy sector. The research aims to add to the existing body of knowledge on how exogenous factors can impact innovation development following a crisis.

Historically, conflicts have accelerated energy transitions. The transition from coal to oil took place during the First World War, and nuclear energy became a primary energy source during the Second World War. Each of these examples shows how innovations leveraged from crisis and the Russia-Ukraine war again highlights the need for energy innovation, as the effect might be equally transformative (McKinsey, 2022). Many factors come into play, such as integrating new policies, collaboration and ambitious financial efforts to accelerate the adoption of green technology on a commercial scale, yet there is no all-fits-one solution (Engelke et al., 2021).

Furthermore, this study has managerial relevance as it could provide valuable insights for policymakers, investors and other stakeholders involved in Greentech technologies within the European Union. This research aims to identify specific challenges and opportunities for developing and implementing Greentech technologies in regions affected by the Russia-Ukraine conflict within the EU and provide recommendations for addressing challenges and seizing opportunities.

1.3 Research Questions

This thesis will address the following research question (RQ):

RQ: How is the Russia-Ukraine conflict serving as a catalyst for Greentech innovation in Germany?

2. Literature Review

2.1 Definition of Greentech

The term "green tech" refers to a broad category of technology designed with the environment in mind, from its manufacturing process to its usage (Zaid Qamar et al., 2021). The terminology used to describe green technologies is not universally agreed upon, with several terms vying for dominance. "Climate tech," "Cleantech," and "Greentech" are among the most frequently used phrases. Although these terms may have subtle variations in meaning, they are often used interchangeably to refer to environmentally conscious technologies (Engelke et al., 2021).

In the following sections, the term "Greentech" will be used as an umbrella term for technologies in the energy sector that mitigate climate change and decrease reliance on finite resources like fossil fuels.

2.2 The European energy market

Europe is the primary locus in which today's global energy crisis of unparalleled depth and complexity is taking place. Oil, coal, power, food security, and climate change are just a few of the current energy crisis's many facets, but natural gas takes centre stage (IEA, 2022b). The ability of the EU to overcome geopolitical obstacles and cultural pressures in order to safely and inexpensively satisfy future energy demands while undergoing the transition to a low-carbon economy will determine how secure Europe's energy supply will be in the future (Morningstar et al., 2020). Current market tensions are being associated to previous periods of extreme energy disruption, such as the 1970s oil shocks. Energy crises tend to repeat certain patterns.. Both then and now, there were significant geopolitical forces driving price increases, which resulted in high inflation and adverse economic effects. The crises then, as of now, exposed some fundamental linkages and fragilities in the energy system (IEA, 2022b).

2.2.3 Powering Germany: An Energy Sector Overview

Germany is the fourth largest economy in the world, tailing the United States, China, and Japan, and considered the powerhouse of Europe (KPMG, 2023). the term powerhouse does justice to the fact that Germany, with an energy consumption of 12.64 exajoules, is spearheading the 2021 European energy consumption ranking, followed by France and the United Kingdom (Statista, 2023c). To meet this energy consumption, the energy sector produced 220 million metric tons of CO₂ equivalent emissions in 2020. This accounts for approximately 30% of Germany's total emissions, putting the industry under enormous pressure of reshaping it to meet the nations ambitious climate goals (BMWK, 2022b).

Figure 1 displays Germany's primary energy consumption in 2022. A country's primary energy consumption (PEV) is the sum of its energy production, adjusted for import/export and energy storage facility withdrawals. Primary energy is any energy accessible in its unaltered forms, such as coal, wind or nuclear energy. The PEV in Germany decreased by 4.7% in 2022, according to preliminary projections by AG Energiebilanzen, to 11,829 PJ, or 403.6 million tce (BDEW, 2022).

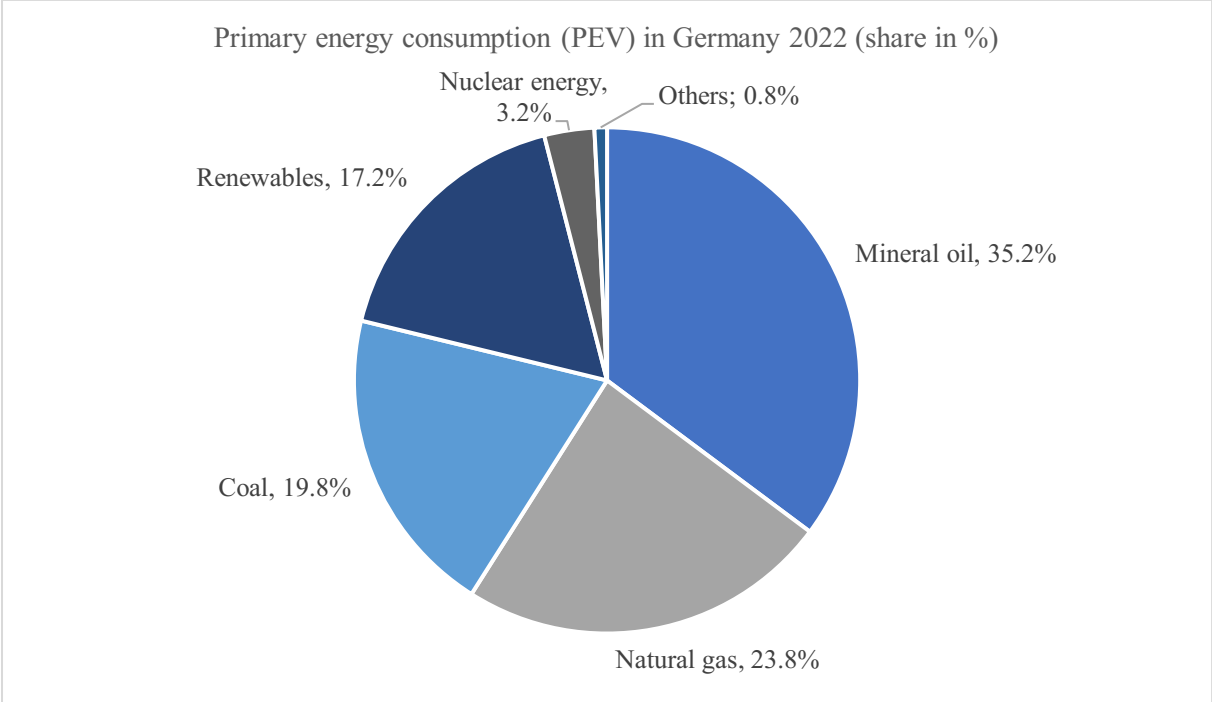


Figure 1: Primary energy consumption (PEV) in Germany 2022 (BDEW, 2022)

To meet the anticipated increase in electricity consumption, a considerable expansion of renewable energy sources is required to replace the coal-fired and nuclear power generation. This is essential for meeting national and international climate change goals in a sustainable way (BDEW, 2022). Logically the energy source mix has changed considerably in the last decades, with a significant increase seen in the utilization of renewable energy sources and natural gas substituting a share of fossil energy productions (Umweltbundesamt, 2022). A key milestone is Germany's Energiewende, a large-scale initiative to transform the country's energy grid with primarily renewable energy sources. By the middle of the century, Germany plans to transition to a low-carbon, nuclear-free energy system thanks to the Energiewende. The three main goals can be used to summarize the energy transition strategy (BMWK, 2022b):

- Cut back on energy use across all industries (by putting efficiency first).
- Use renewable energy sources directly when it is both economical and ecological.

- Use power generated from renewable sources to meet the remaining energy needs.

To achieve these goals, natural gas was seen as a promising source next to renewables within the energy mix in Germany, given its direct advantages for the environment and public health compared to coal and mineral oil (Deyette et al., 2015). Many projections, even those that assume a quick energy transition, predict an ongoing need for gas until 2040 and beyond since gas is typically offered as a likely contender to bring cleaner air and decarbonization (Tsafos, 2020). However, as seen in Figure 2, with the Russian invasion of Ukraine starting in February 2022, the price of gas for homes in multi-family residences increased by 105 per cent as of 2022, from an average of 6.47 cents/kWh the year prior to 13.26 cents/kWh, according to data from the Bundesverbands der Energie- und Wasserwirtschaft (Forbes, 2022).

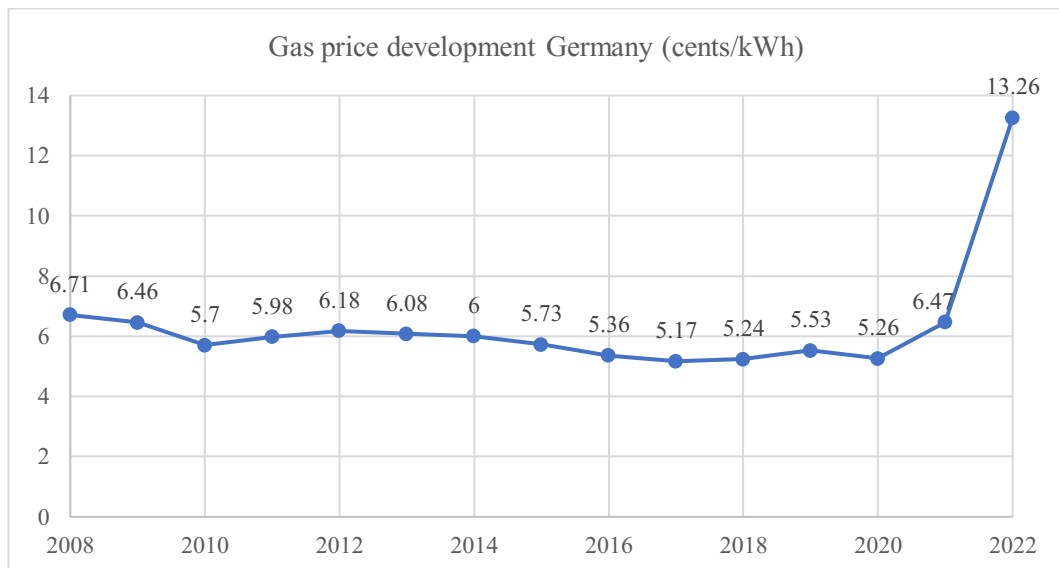


Figure 2: Gas price development Germany 2008-2022 (Forbes, 2022)

The majority of Germany's natural gas demand is imported via an extensive pipeline network, most prominently the Nord Stream pipelines, with Nord Stream 1 (NS1) being operational since 2011 (Kóczy et al., 2022). The Nord Stream 2 (NS2) pipeline was announced in 2015 to satisfy Europe's extensive natural gas demand by doubling the transmission capacity from 55 billion cubic meters (bcm) to 110bcm. Russian energy giant Gazprom received half of the funding for this project from five companies, Uniper and Wintershall (Germany), Engie (France), Shell (United Kingdom) and OMV (Austria). This action resulted in criticism from several other European countries and the United States since these companies are based in countries that clearly benefit from the NS2 project, increasing Europe's dependence on Russian gas and giving Russia greater political leverage (Sziklai et al., 2020). One would assume that a fundamental project of such significance would be fault-proof (Kóczy et al., 2022). This is clearly not the case, with the Danish Energy Agency reporting a leak in September 2022, resulting in a pressure

drop in the NS2 pipeline (Danish Energy Agency, 2022). Since the Russian natural gas supply was put on absolute hold before, neither of the pipelines were operating at that moment, and the leakage resulted in an emission output of approximately 220 Gg tonnes of methane into the atmosphere (Jia et al., 2022). Moreover, the leakage was framed as an act of sabotage and fueled the geopolitical tensions between Russian and the west. With the ongoing investigations, identifying a responsible agent for the alleged pipeline sabotage has not yet been possible. Vladimir Putin is blaming the United States and its allies for blasting the Nord Stream pipelines, while the others, including Germany, are awaiting the results of said investigations (Reuters, 2022). According to Reuters, Russia sees no need to repair and reactivate the pipelines, with tensions not clearing up in the foreseeable future as of March 2023 (Reuters, 2023).

Given these recent developments and gas prices at a record high, the initiative for a 180-degree turnaround to replace gas with coal again arises, thus counteracting the Energiewende and efforts to reduce carbon emissions. This scenario also occurred in the United States in 2013, where increased natural gas costs caused energy providers in several regional markets to ramp up coal facilities instead of natural gas plants (Deyette et al., 2015). This happened with current developments in the North-Rhine-Westphalian village of Lützeath in January 2021. The reason is a political agreement between the federal government of Germany and RWE, which allows the energy company to expand coal mining operations to counteract the energy supply crisis triggered by the Russian war (RWE, 2023).

The German government is taking steps to ensure the shift to renewable energy supplies, including motivating German energy providers to buy regasification facilities at LNG terminals in neighbouring countries and locking in LNG supplies from critical suppliers. The government believes that access to LNG terminals is crucial since it anticipates that LNG will eventually play a significant role in Europe's natural gas supply (Vivoda, 2017). However, it will take Germany until 2026 to construct 56 billion cubic meters of domestic LNG import capacity, almost equivalent to what it imported through pipes from Russia in 2021, according to the Economy Ministries. These capacities are anticipated to reach 76.5 billion cubic meters by 2030, or roughly 80% of the total gas consumed in Germany in 2021 (Bloomberg, 2023).

2.2.4 The role of Russia in the European energy market

It is evident that Russia plays a significant role in the global energy market. According to Godzimirski (2020), Russia was ranked third in energy production in 2018, with a total output of 1484.1 million tonnes of oil equivalent, behind China and the United States. Russia's natural gas production reached a volume of 750 bcm, placing it second behind the United States in the

same year. Around one-third (265 bcm) of Russian natural gas is exported, mainly to Europe. The high import dependency of Europe can be attributed to the fact that in 2019 Russia's natural gas reserves accounted for 38 trillion cubic meters, which accounts for close to 20% of global gas reserves. To put this number in perspective, Russia could maintain their natural gas production for another 55 years with said reserves (Godzimirski J, 2020).

With its geographic influence, Russia has historically set prices and limited supply to regulate using its dominant position, especially in the natural gas market. This is particularly the case when it comes to Ukraine. In general, the price of natural gas sent to all of Europe once functioned as a gauge for the state of bilateral relations; the lower the price, the better the relations. Yet, during the past several years, both Russia and Ukraine have become less dependent on one another in terms of energy. One reason being the Nord Stream pipeline 1, which was became operational in 2011, circumventing the requirement for Ukrainian pipes and giving Russia an alternative route to wealthy European markets (Ozawa, 2022). One-third of consumed gas in Europe comes from Russia. Figure 3 visually demonstrates the main routes and pipeline capacities for natural gas from Russia to Europe. The Yamal pipeline, with a capacity of 33 bcm annually, via Belarus and Poland, and the Nord Stream Pipeline (55 bcm annually), which became operational in 2011, are primarily used routes for German natural gas imports. Additionally, an extra 40 billion cubic meters of natural gas can be transported via Ukraine each year (Statista, 2022b).

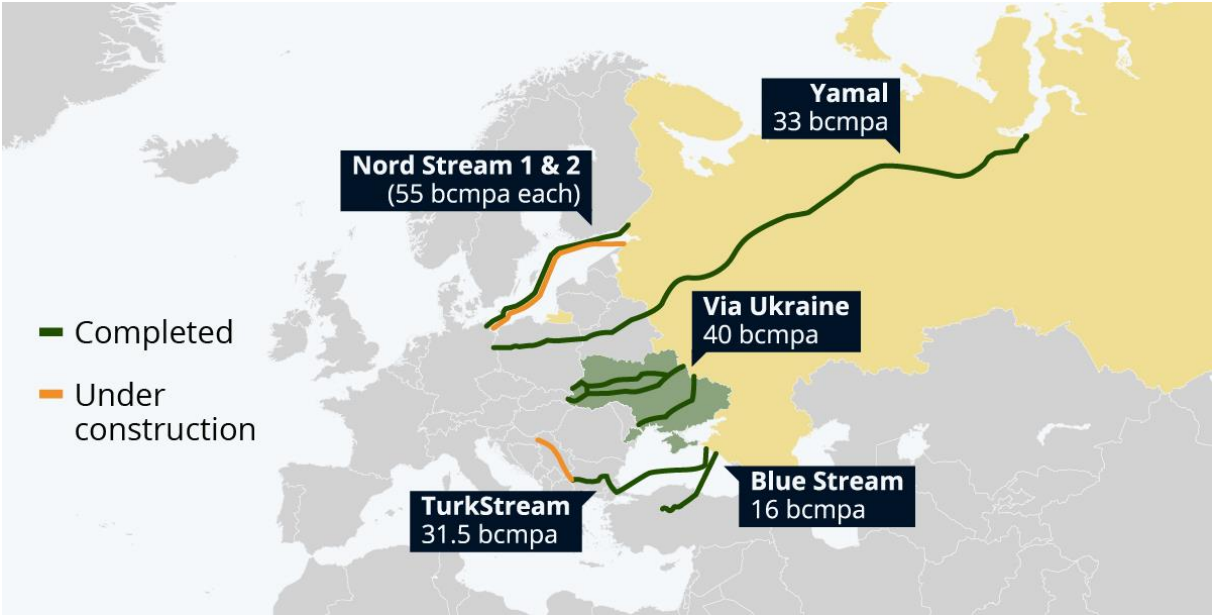


Figure 3: Gas pipeline linkage between Russia and Europe (Statista, 2022b)

As discussed before the Nord Stream 2 project has been put on hold due to Russia's invasion of Ukraine, and the EU's whole energy strategy toward Russia has been hastily revised (Surwillo & Slakaityte, 2022). Additionally, the reduction in gas supplies via Nord Stream 1, which is undergoing repair, put Germany's energy security in perspective during the third quarter of 2022 (Statista, 2022a), considering that Germany imported a majority of natural gas exported by Russia in the past. Around one-third of the Russian gas bought by the EU-27 in that year came from only Germany, which imported more than three times as much as the Netherlands and almost twice as much as Italy, as seen in Table 1 (Eurostat, 2023).

Table 1: Imports of natural gas by partner country (Eurostat, 2023)

Geo Labels	2016	2017	2018	2019	2020	2021
<i>European Union</i>	150.266,505	159.716,902	146.629,528	161.023,499	149.534,167	153.940,635
Germany	58.671,000	62.079,783	43.108,053	46.249,986	52.463,565	55.443,282
<i>Italy</i>	26.830,000	33.107,878	32.846,356	33.449,393	28.716,082	29.170,696
<i>Netherlands</i>	12.612,249	8.450,795	14.663,281	15.831,822	15.165,950	10.730,999
<i>France</i>	8.932,256	8.612,068	9.269,459	10.542,064	7.634,545	9.922,996

With Russia’s war on Ukraine starting in 2022, Germany’s natural gas imports decreased drastically, with close to zero imports in October 2022. For comparison, the natural gas import volume was approximately 953 million cubic meters in August 2022, with the most significant amount imported throughout the observed time being 5 billion cubic meters in May 2022 (Statista, 2023b).

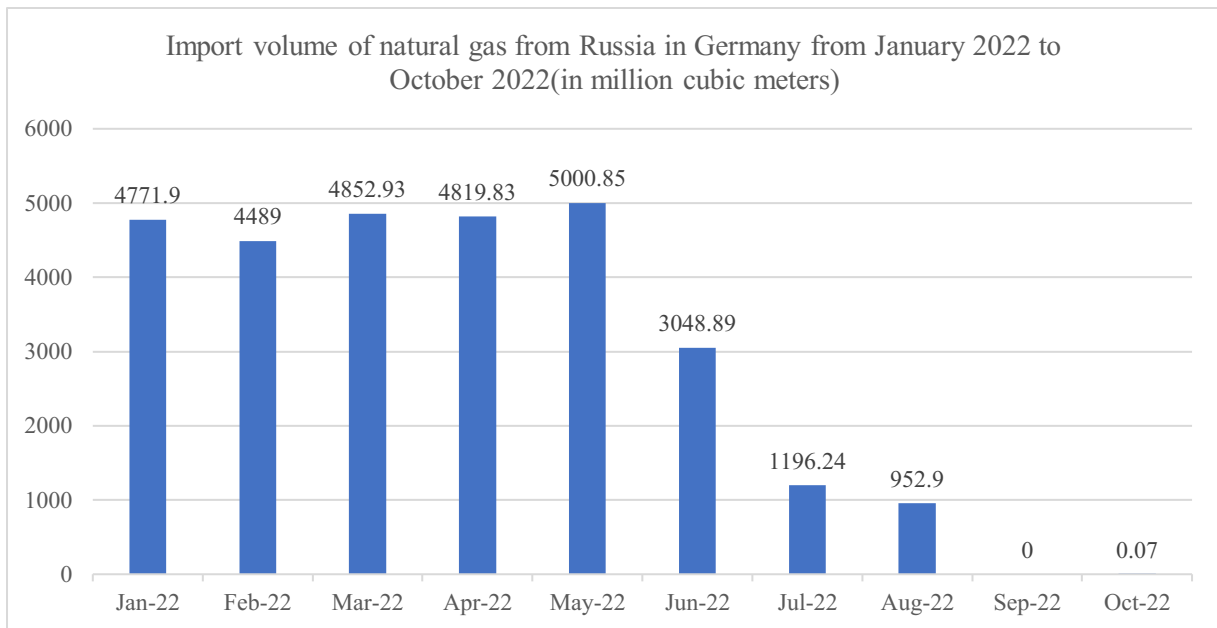


Figure 4: Import volume of natural gas from Russia in Germany (Jan 2022 - Oct 2022) (Statista, 2023b)

Since the summer of 2021, Russia has been destabilizing European natural gas markets by severely decreasing exports and failing to restock Gazprom-owned storage facilities in the EU. By breaking long-term supply agreements treasured by European allies, Russia has leveraged its leftover supplies as a geopolitical tool to split the European front in support of Ukraine, creating a situation of uncertainty for the European energy market (McWilliams et al., 2022).

2.2.5 The role of Ukraine in the European energy market

Europe and the world's energy security depend on Ukraine. The EU has been forced to significantly reassess its prior dependence on Russian energy supplies due to Russia's invasion of Ukraine (IEA, 2023).

The majority of Ukraine's natural gas used to come from Russia. However, after Crimea's annexation, Ukraine stopped importing natural gas directly from Russia and began acquiring it from European countries. Most of this imported gas is still of Russian origin, however, since it is just routed back from countries in Central and Eastern Europe, which use Ukraine's transit pipeline for Russian commodities. Given its favorable geographical position, Ukraine has one of the world's largest natural gas transit infrastructures, and most of Russia's exported gas runs through it. Germany is one of many European countries dependent on that infrastructure, receiving most of their natural gas via Ukraine from Russia (EIA, 2021).

2.3 Macroeconomic Disruptors

2.3.1 International policies

Europe's renewable energy strategy began to take shape with the 1973 oil crisis, which prompted European institutions to look for answers to the upcoming energy challenges (Solorio & Jörgens, 2020). However, one of the crucial milestones emerged in the form of a White Paper on renewable energy in 1997, which was recognized as a significant element of the EU's climate and energy policy. Nearly two decades later, the European Commission pledged to create a unified EU energy market when it submitted an energy market strategy proposal on February 25, 2015. According to the European Commission, the proposal helps create a fully integrated internal energy market where suppliers may freely compete, which is anticipated to improve Europe's potential for renewable energy (Song et al., 2022). In 2020 Morningstar et al. addressed the significance of natural gas when moving away from coal, increasing Europe's energy security, and enhancing efforts to keep on track with the goals committed in the European Green Deal (Section 2.3.1.1) and is aligned with the Paris Agreement (Section 3.1.1) (Morningstar et al., 2020). This illustrates a larger societal shift where participatory, bottom-up measures replace top-down regulated ones (Sending et al., 2020).

2.3.1.1 The Paris Agreement on climate change

The Paris Climate Agreement is a global accord in response to the threat of climate change, which was signed by 195 Nations in December 2015 during COP 21. The main goal is to increase the effectiveness of the global response by keeping the rise in global temperature this century below 2 degrees Celsius above pre-industrial levels. Furthermore, the aim is to maximize efforts in limiting the temperature rise further to 1.5 degrees Celsius (United Nations, 2022). Rules for implementation have been the main topic of discussion since the agreement went into force in November 2016. The Katowice Climate Package, often known as the "Rulebook," was approved at COP 24 in 2018, providing governments with rules for achieving the Paris Agreement aim of keeping global temperature rises to far below 2°C and assisting developing nations with adaptation and readiness (Stimson Center, 2020). The agreement also intends to make financing flows consistent with a low GHG emissions and climate-resilient route and to improve nations' capacity to deal with the effects of climate change. The proper mobilization and availability of financial resources, the implementation of new technological frameworks, and increased capacity-building are required to achieve these lofty objectives. The Agreement also includes a structure for action and assistance that is more transparent (United Nations, 2022).

Finance, technology, and capacity-building support are three of the Agreement's core topics that are particularly pertinent to the green technology industry. While for the first time encouraging voluntary contributions from other Parties, the Paris Agreement emphasizes industrialized nations' duties to assist developing country Participants in constructing clean, climate-resilient futures. Developed nation States agree to give indicative information on future support, including estimated levels of public finance, every two years in addition to reporting on funding previously supplied. The agreement also states that the Green Climate Fund (GCF), among other Financial Mechanisms of the Convention, should serve the Agreement. The Agreement establishes a technical framework, and capacity-building efforts will be expanded through improved support for capacity-building initiatives in developing nation States and suitable institutional structures (United Nations, 2022).

Some signatories have established carbon pricing systems, and many more are developing complementing restrictions aimed at methane and other emissions from coal-fired electrical plants as governments transform their pledges from the Paris Agreement into domestic legislation. However, recent studies reveal significant disconnects between economic, innovation, and climate policies. By coordinating these through market mechanisms primarily geared toward innovation, frameworks for scaling up new businesses that provide climate change solutions can be established (Bak, 2017).

2.3.1.2 The EU Green Deal

The European Green Deal, a comprehensive set of policies designed to make the European Union's economy ecologically sustainable, was presented by the European Commission in December 2019. The objective is to achieve carbon neutrality by 2050 and to use the transition as an opportunity for European industry and the economy. The agreement consists of a wide range of government initiatives and financial incentives designed to reduce pollution while boosting investment and research into environmentally friendly technology (Leonard et al., 2021). Additionally, the European Commission has proposed a series of recommendations that should enable the EU to reduce net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels. To achieve this goal, there is still a long way to go as the 27 EU member states together released 3.9 GtCO₂e in emissions in 2017, including 0.3 GtCO₂e in absorption. For the EU to reach the 2030 and 2050 climate goals, net GHG emissions must be reduced significantly more rapidly (McKinsey, 2020).

Hainsch et al. suggest that in the short term, robust policy enforcement must coexist with technological development and implementation to accelerate the energy transition (Hainsch et

al., 2022). To achieve the policies goal the European Commission committed to an investment of 1 trillion euros for sustainable causes, including driving green tech innovation, until 2030 to meet their goals (European Commission, 2020). However, depending on the policy scenario, an extra 4.1 to 4.7 trillion euros will be needed, increasing the total to about 6 trillion in order to achieve a full reduction by 2050 (Lee-Makiyama, 2021).

2.3.2 National policies

2.3.2.1 German “Energiewende”

Germany is moving along a pathway that will fundamentally transform the present energy supply system from the current fairly centralised to decentralized, with the phase-out of nuclear power by the year 2022. Renewable energy sources have to be significantly increased, and current transmission infrastructures must be upgraded (Kühne & Weber, 2018). In the energy transition, smaller, new sorts of businesses driven by consumers, the government, or small private investors coexist with a technologically advanced decentralized dynamic. Since the Renewable Energy Sources Act (EEG) was first passed in 2000, the number of energy cooperatives has increased (Becker et al., 2016).

The German government adopted the most significant change to its energy strategy, presenting its new policies to accelerate the “Energiewende” on July 8, 2022, to achieve net zero targets. In order to encourage the growth and spread of renewable energy sources, the German government has announced substantial modifications to its energy regulations (BMWK, 2022a).

New strategies and actions to boost renewable capacity have been added to the **Renewable Energy Act**. To hasten the deployment of offshore wind, the **Offshore Wind Act** has been updated. The new Wind Energy Area Requirements Act, which imposes a need to make 2% of Germany's land area suitable for wind power, is included in the **Onshore Wind Act**. Additionally, the **Energy Industry Act** includes provisions that will accelerate system development and improve the integration of renewable energy across the country. These modifications signify a substantial shift in Germany's use of renewable energy (BMWK, 2022a).

2.4 Future Scenarios

The 2022 Global risk report published in early 2023 classifies “Failure to mitigate climate change” and “Failure of climate-change adaption” as the leading long-term challenges for today's society (World Economic Forum, 2023). The European Parliament presented a

successful pathway model where a net-zero scenario is achievable with a united approach. This united approach is necessary more than ever to substitute the cut-off natural gas demand by Russia (Figure 5) (Heflich & Saulnier, 2022).

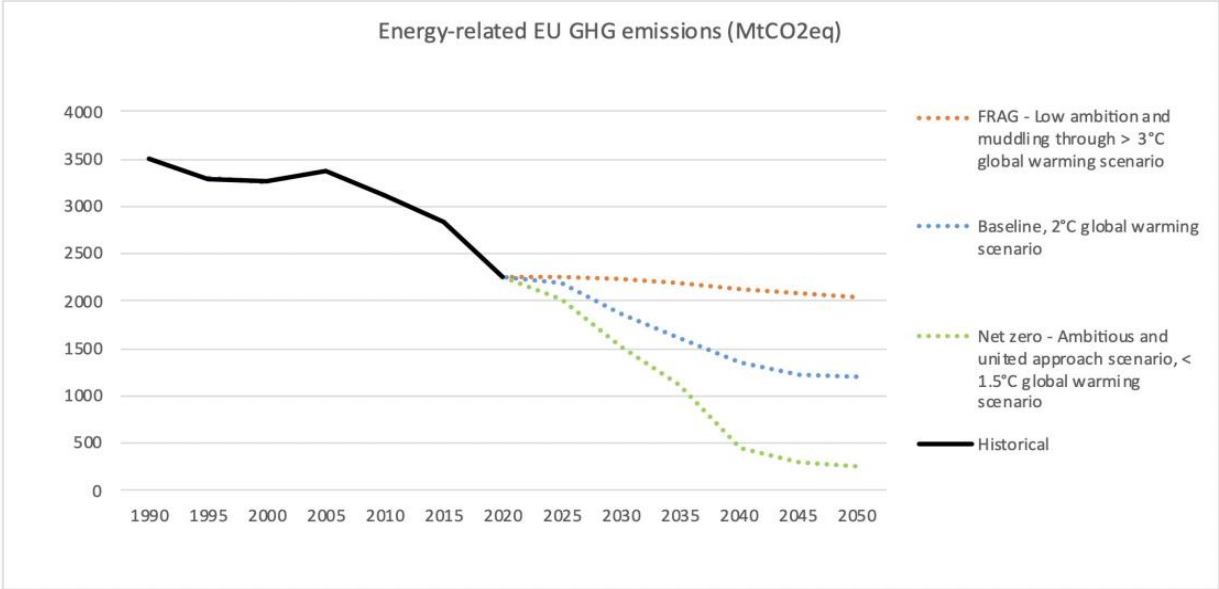


Figure 5 Energy-related EU GHG emissions (MtCO2eq) (Heflich & Saulnier, 2022)

With the drastic increase in the price of gas, especially in Germany, the decoupling of natural gas is also imperative. Industry, heating costs and the price of electricity have become increasingly dependent on this type of supply in recent years (Agora Energiewende, 2022). The current geopolitical underlines how important it is not only for the environment but also for the socio-political spectrum to realize the net zero scenarios for natural gas (Ozawa, 2022).

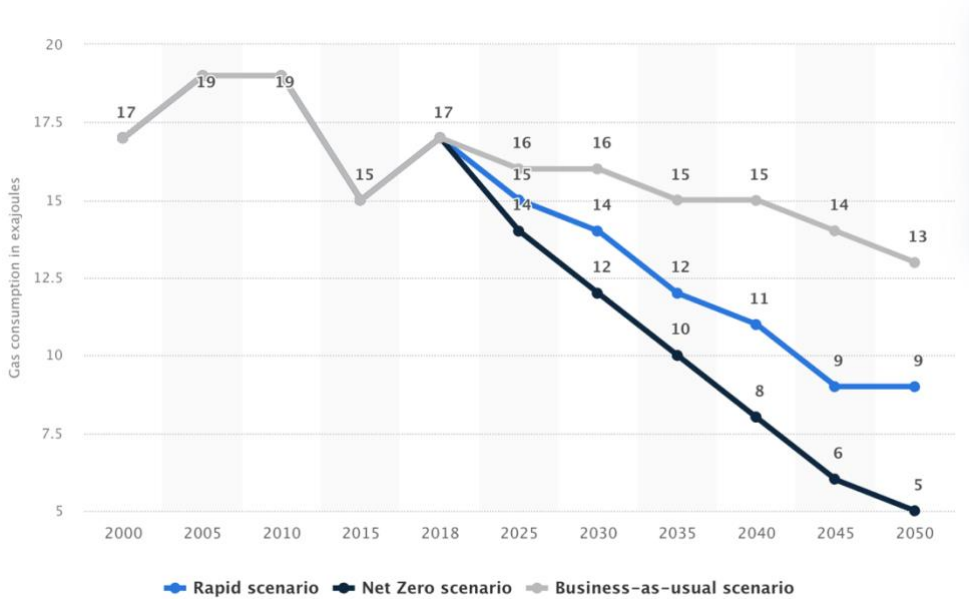


Figure 6: Gas consumption (in exajoules) in EU-28 from 2000 - 2018, including 2050 forecast, by scenario (Statista, 2023a)

Policies and their included targets have undoubtedly accelerated the adoption of green technologies in the energy sector over the last few years (Renné, 2022). Three key strategies—increasing energy efficiency, decarbonizing electricity, and moving from fuel combustion to electricity—are critical factors in the base scenario to make the transition from a high-carbon to a low-carbon possible (Sachs et al., 2020). According to Knutti et al., Greentech innovation, such as carbon capture and carbon storage technologies, will be pivotal to achieving net zero or negative emissions scenarios (Knutti et al., 2016). Sachs et al. similarly highlight the importance of mainstreaming these technologies into net-zero governmental strategies and policies (Sachs et al., 2020).

2.4.1 Creative destruction – an opportunity for a green energy industry

In *Capitalism, Socialism, and Democracy*, Schumpeter introduces the term “creative destruction”, where he argues that new innovation substitutes existing ones as they become outdated over time (Schumpeter, 1976). Schumpeterian thinking is typically simplified to the two tenets of economic growth and development: innovation is the key to competitiveness, and the entrepreneur is the destroyer of economic equilibrium. He believes the entrepreneur generates opportunities through new innovations, processes and marketing strategies (Tülüce & Yurtkur, 2015). Schumpeter saw creative destruction as a positive force that drives this economic growth and development. He argued that it leads to the creation of new jobs and industries and helps to raise living standards over time (Schumpeter, 1976). According to the Austrian economist, these sector developments are driven by entrepreneurial innovation. The Schumpeterian theory of economic development contrasts the static neoclassical competition model with a dynamic competition where rivalry via innovations affects the foundations and existence of economic actors (Ülgen, 2015).

Globalization has forced organizations to perform cross-cultural commerce and use multidimensional production and marketing methods to be competitive. Businesses have become increasingly complicated and harder to manage, resulting in performance gaps, vague accountability, and complex decision-making processes that cast doubt on their long-term survival (Rajagopal, 2014). In the context of this thesis, competitive advantage refers to the ability of green technology innovations to gain an edge over currently still embodied environmentally harmful sources of energy production by offering superior products or services, achieving lower costs, or developing new business models that are better adapted to changing market conditions. Firms that are able to adapt quickly to changes in the market and

capitalize on new opportunities are more likely to maintain their competitive advantage over time (Schumpeter, 1976).

2.4.2 Energy transition through Greentech innovation

“The net-zero transformation is already causing huge industrial, economic and geopolitical shifts – by far the quickest and the most pronounced in our lifetime ... The road to net zero means developing and using a whole range of new clean technologies across our economy: in transport, buildings, manufacturing, energy. The next decades will see the greatest industrial transformation of our times – maybe of any times. And those who develop and manufacture the technology that will be the foundation of tomorrow's economy will have the greatest competitive edge.”

- Ursula von der Leyen, January 17th 2023

With over half the world's population living in cities, public transportation, renewable energy, new industries, and ICTs are becoming increasingly relevant. Technological innovation is essential to solving economic and environmental issues, including energy efficiency (United Nations, 2023). According to the Energy Transition Commission, enough natural resources are available to achieve a zero-carbon economy.

Some economists believe that economies of scope and scale benefit large corporations to create and profit from novel goods more quickly than small companies. Large enterprises were thought to boost economic growth and reduce the small firms' share in markets (Rajagopal, 2014). According to Pakura, however, two-thirds of the most significant sustainable developments have been ascribed to startups, which have been named as the industry's primary motivator (Pakura, 2020).

As the majority of green-tech companies are innovative start-ups or small and medium-sized organizations (SMEs), their main challenge is to pinpoint their research and development (R&D) and innovation pathways (Marra et al., 2017). Investments in early-stage green technology are essential to accelerate the sustainability cause and increase variety in the financial markets. Doing so carries a high risk, making it difficult for many businesses to receive funding (Jonsdottir et al., 2023). Meijer et al. also identified the main barriers to sustainable energy innovation for startups and SMEs in an actor-based analysis resulting in limited financial resources, risk averseness and technological complexity being dominant (Meijer et al., 2019). Likewise, regarding the energy transition, the Energy Transition Commission underlines the importance of investment needs to move faster to accelerate the desired outcomes (Energy Transition Commission, 2020).

Recent studies have shown that there is a positive leverage effect between financial efforts on energy security through technological innovation and that renewable energy investments reduce

CO2 emissions by energy intensity (Lee & Wang, 2022; Yang et al., 2022). Looking at Figure 7 renewable energy investments have generally been declining in Germany as well in recent years. According to the Federal Ministry for Economics and Climate Action Germany (BMWK) investments in the installation of renewable energy plants peaked in 2010 at nearly €28 billion and dropped down to €10.6 billion in 2019. The reason for the considerable drop in financial efforts is due to the fact that the cost of development significantly declined after 2010 while new installations continued to be built. Investments in 2021 amounted to about €14.2 billion, with most investments fulfilled in the solar and wind sector (BMWK, 2022c).

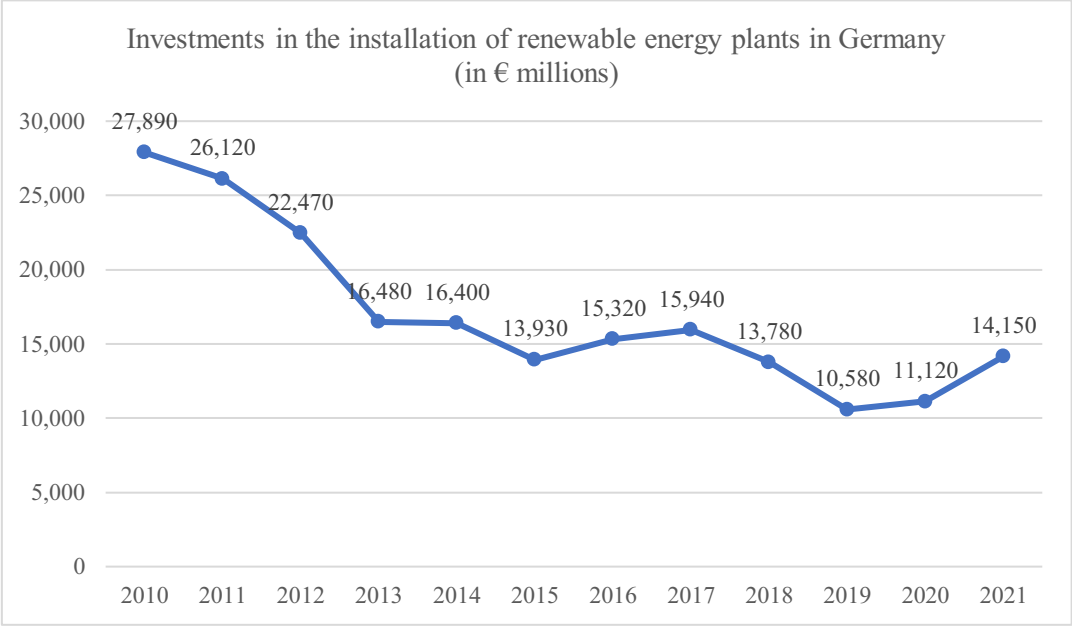


Figure 7: Investments in the installation of renewable energy plants in Germany 2010-2021 (BMWK, 2022c)

When looking at the Greentech ecosystem, financial efforts increased in 2022 despite being a rough year for venture capital funding. According to Net Zero Insights’ analysis, Greentech investments in Europe saw an uprise of 33%, to a total of \$35.6 billion, compared to 2021. As a driving force, the energy sector accounted for \$18.6 billion of allocated investments growing 81% year over year. Greentech investments in Germany received \$5.1 billion, placing it at the forefront of European countries (Net Zero Insights, 2023). Additionally, international financial efforts are set in place. In July 2022, the European Commission released a statement about using their Innovation Fund to promote 17 large-scale innovative Greentech projects with an investment of €1.8 Billion (European Commission, 2022).

Next to investments, energy technology advancements are often the product R&D efforts of a single organization. Radical ideas, however, come more frequently from teamwork (Greco et al., 2017). Start-ups rely on internal and external innovation. The key to addressing these

barriers is an open innovation approach. Creating network partners, such as academic institutions and support platforms/other start-ups, which are necessary for commercial adoption and accessibility next to providing funding for breakthrough innovations (Pakura, 2020).

Popp indicates that an increase in energy prices substantially benefits innovation (Popp, 2002). With energy prices at a record high due to the current geopolitical conflict, the allocation of funds for renewable energy in nations of the European Union has grown. Ultimately, this will help to meet the European Green Deals 2030 goal (Saktiawan et al., 2022).

In reaction to Russia's invasion of Ukraine, energy markets, investment plans and policy have altered, and those changes will last for decades. The economic rationale for cheap, clean technology with competitive pricing today carries more weight than the environmental case for clean energy, which does not need to be emphasized (IEA, 2022b).

2.4.3 Technology Information System – A multi-agent solution

The technological innovation systems framework, referred to as TIS, is a model that is frequently applied in research that investigates the development and creation of new technological fields and industries (Markard et al., 2015). Phirouzabadi & Chen demonstrate that the TIS framework is currently involved in technological innovations, socio-technical transitions, system innovations, and sustainable technologies like energy. They also demonstrate how the TIS framework has the potential to be widely used in radical innovations and processes of socio-technical configurations (Mirzadeh Phirouzabadi & Chen, 2016).

The TIS framework (Figure 8) is often described as a combination of factors that actively support the growth of a particular technology sector. These factors may include individuals, networks, institutions, and technologies (Bergek et al., 2015). Interactions between technology-specific policy mix, innovation function and the technology system structure constantly interact with each other and cause structural transformation. The structure of an innovation system will be built up by strengthened by solid functions (Haley, 2018).

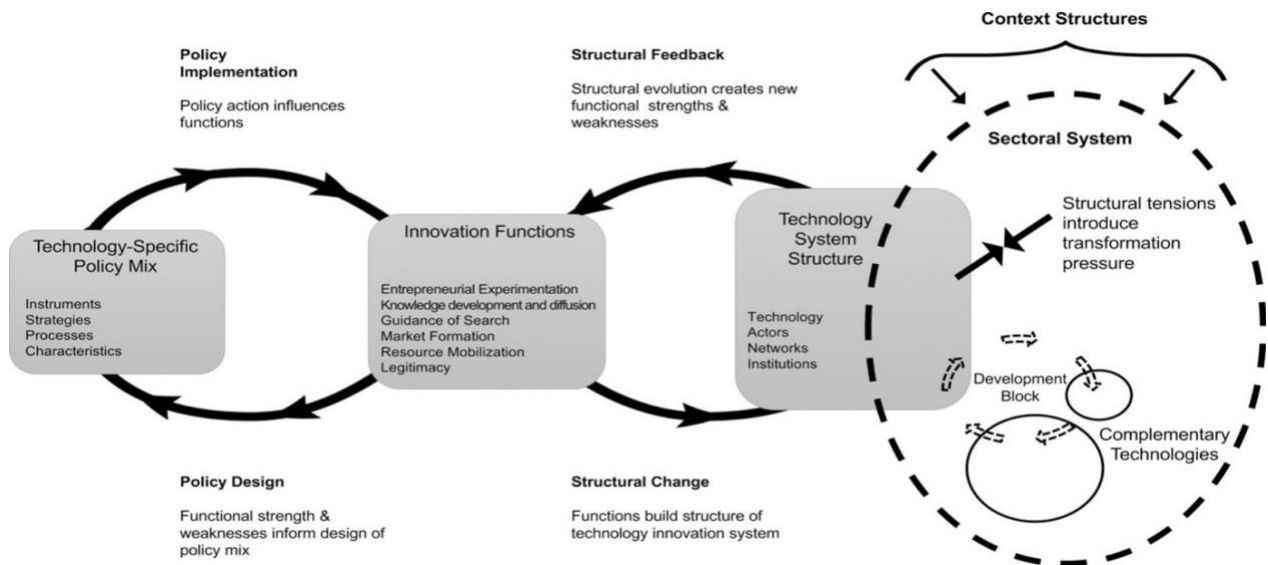


Figure 7: Technological innovation system development cycle (Haley, 2018)

As was previously indicated, various players, including policymakers, entrepreneurs (but occasionally also incumbents) and energy companies, work to encourage innovation within the green tech sphere. However, these same individuals can also accidentally create barriers. Decision-makers should be aware of the reasons and goals for why incumbents desire to enter the green tech policy arena (Negro et al., 2012).

According to Planko et al., entrepreneurs are crucial actors in the Technology Innovation System structure since they harness the hidden potential of fresh ideas and turn them into success stories. Social learning starts with testing new technologies, while information can be found on how the technology performs under various situations and how customers, competitors, the government, and suppliers react (Planko et al., 2017). Nevzorova & Karakaya identified being proactive with respect to challenges as one of the main drivers accelerating the knowledge transfer within TSIs. Challenges can be understood as complicated, difficult circumstances that need systematic solutions. They raise hope and the conviction that introducing new technology would help solve these problems (Nevzorova & Karakaya, 2020). The conflict between Russia and Ukraine presents a window of opportunity to accelerate the energy transition. Policymakers must provide opportunities for actors within the TSI to accelerate innovation to ensure an efficient and affordable energy supply to consumers (Matsushita, 2022).

3 Methodology

This dissertation draws both primary and secondary data, whereas the secondary data is implemented in the chapter Literature review to underline the body of knowledge gathered from the literature. The secondary data includes official information and forecasts from government agencies, corporate reports and public documents related to net zero scenarios and the energy industry. A qualitative research approach was used to assure the internal validity of the findings, according to the standards for data triangulation, to confirm the results across various data sources (Yin, 2003). In line with Clark & Creswell (2007), a mix of these research methods that triangulates techniques is useful when neither the qualitative nor the quantitative approach is sufficient to answer a given research topic (Clark & Creswell, 2007). Additionally, Porter's Five Forces Framework (Porter, 1980) provides an overall understanding of the German energy sphere and the opportunity gap for Greentech innovations.

The findings from the literature review, Porter's Five Forces Framework and the interviews will be used for planning different scenarios to help answer the **research question** (*How is the Russia-Ukraine conflict serving as a catalyst for Greentech innovation in Germany?*). In line with the Schoemaker (1995) approach to scenarios, the impact of various external factors is considered to create possible future scenarios. Schoemaker argues that traditional forecasting methods are often inadequate in the face of rapid change and uncertainty and that scenario planning offers a more flexible and dynamic way of thinking about the future. To effectively use scenario planning, it is essential to identify relevant stakeholders, trends, and uncertainties that will shape Germany's future energy landscape, considering the current geopolitical conflict (Schoemaker, 1995). To effectively use Schoemakers approach, three learning scenarios are built to further identify a least surprising scenario based on external factors.

3.1 Research Design and Data Collection

A semi-structured interview approach was carried out in line with Burgess (Burgess, 2002), using a pre-determined interview guide that included a list of open-ended questions and topics that need to be covered during the conversation. Open-ended questions gave interviewees the opportunity to make sense of topics without predetermining standpoints. Silverman (Silverman, 2006) emphasises in *Interpreting Qualitative Data: Methods for Analyzing Talk, Text and Interaction*, that choosing experts from different backgrounds can lead to a more comprehensive understandings of a research topic, mitigate biases and assumptions, and increase the validity and reliability of research findings. Therefore, a range of interview partners

acting within the German energy sector were interviewed (Table 2). The selection process focused primarily on representatives from major energy companies and founders of green tech start-ups trying to disrupt the current energy landscape. All of the interview participants have relevant sector experience and are in management positions or similar. A total of 10 interviews were conducted, with the interviews carried out online. All the interviewees agreed to allow their insights to be disclosed. Interviewees all preferred to be anonymized, with the interviews summarized in the appendix.

It is worth noting that the experts who were interviewed for this thesis had no prior knowledge of the specific research questions or the goal of the thesis, which was to investigate the potential competitive advantage of green technology in the German energy industry in the current macroeconomic environment. This approach ensured that the interviewees provided unbiased and objective insights without being influenced by the research objectives or assumptions. Therefore, the semi-structured approach, in which an interview guide was developed and used to guide the conversation, allowed for flexibility and exploration of relevant topics (Table 3). The interview guide consists of 10 questions, including open-ended questions, yes and no questions and ranking questions. This method sought to answer qualitative questions of “what”, “how”, and “why” instead of quantitative inputs focusing on amount and frequency (Yilmaz, 2013).

Based on the literature review, one of the main drivers for a green transformation in the current energy landscape can be associated with climate goals set by international and national policies. The path of achieving these goals got significantly disrupted by the Russian war on Ukraine. The western, especially Germanies, dependency on Russian natural gas provides an opportunity to transform the energy landscape in the long run. This transformation requires not only substantial investments but also innovative green tech solutions. A high degree of collaboration between agents is necessary to enable these innovations to have a long-term positive social and environmental impact. Hence, the interview questions were designed to explore a range of topics, including the current state of the industry and the challenges and opportunities presented by the ongoing war.

Table 2: List of Interview Experts

ID	ROLE	TYPE
EXPERT 1	Founder of German Greentech Startup	Startup
EXPERT 2	Previous founder of German Greentech Startup	Startup
EXPERT 3	Head of Expansion at German Greentech Startup	Startup
EXPERT 4	Startup Partnerships Manager at German energy company	Energy company
EXPERT 5	Sustainability Manager at German energy company	Energy company
EXPERT 6	Principal investor at German venture capital Firm with sub focus on Greentech	Venture Capitalist
EXPERT 7	Founder of German Greentech Startup	Startup
EXPERT 8	VP Innovation at German energy company	Energy company
EXPERT 9	Manger at innovation platform and venture capital firm focused on sustainability	Venture Capitalist
EXPERT 10	Country Manager at German Greentech Startup	Startup

Table 3: Interview Guide

ID	Question	Type
1	Are you aware of international (EU Green Deal) and national policies/initiatives and their goals to reduce carbon emissions?	yes/no
2	How important are government policies and regulations in promoting the adoption of green technologies in the energy sector?	open
3	On a scale from 1 – 5 how confident are you that the net zero scenario according to the European Green Deal will be achieved by 2050? (ranking, where 1= not confident at all, 5= extremely confident)	ranking
4	Do you think the war will lead to changes in how Germany sources its energy, such as an increased emphasis on domestic renewable energy sources or a move away from fossil fuels? (ranking, where 1= unlikely, 5= certain)	ranking
5	What are some of the most promising Greentech innovations in the energy sector that you believe will have the greatest impact when it comes to achieving carbon neutrality in the next decade?	open
6	What barriers do you see to the widespread adoption of green technologies in the energy sector and if so, how can they be overcome?	open

7	In your opinion, how does the Russia-Ukraine conflict affect investments in green technologies?	open
8	How will the increased adoption of green technologies in the energy sector impact energy prices and the cost of living for consumers?	open
9	How important do you think collaboration between different actors (entrepreneurs, policy makers, energy companies) will be in driving the adoption of green technologies in response to the Russia-Ukraine conflict? (ranking where 1= not important at all, 5= extremely important)	ranking
10	Is your company part of an (open) innovation network or knowledge transfer ecosystem?	Yes/no

4 Findings & Analysis

4.1 Summary of interview findings

The first question (Q1) on the interview guide inquired whether the experts were aware of international and national policies/initiatives and their goals to reduce carbon emissions. The experts all stated that they were cognizant of such policies. Hence it can be assumed that there is a high degree of awareness regarding international and national policies and activities targeted at decreasing carbon emissions in the industry's ecosystem. This also shows that climate goals are at the core of the energy industry. It is clear that international and national policies and initiatives will play a critical role in shaping the industry's approach to energy production and consumption as the sector seeks to reduce its carbon footprint and move towards a net-zero future.

When questioned about the importance of government policies and regulations in promoting the adoption of green technology in the energy industry (Q2), the experts unanimously agreed that these factors are both necessary and highly beneficial. The relevance of governmental policies in establishing a legal framework that can increase the accessibility of green technology is emphasized by Experts 1, 4, 5, and 7. Expert 1 emphasized that without political incentives, many green technologies would not be viable. It was also highlighted by Expert 7 that policies provide the necessary incentives for economic growth and startups to make a more substantial impact and that the conflict has already resulted in a leverage effect. Expert 2 stressed that politicians are responsible for shifting subsidies towards green solutions to become competitive and marketable: “the market works in such a way that they go the cheapest way. You buy the electricity that is cheapest, you drive the car that is cheapest”. Expert 3 believed that market forces and consumer demand will be the key in adopting green technologies but acknowledges

that policies and regulations are still necessary. Based on the answers given, it can be assumed the energy industry is an area where policies can work effectively, particularly in mitigating CO2 emissions and reducing the financial barriers to adoption.

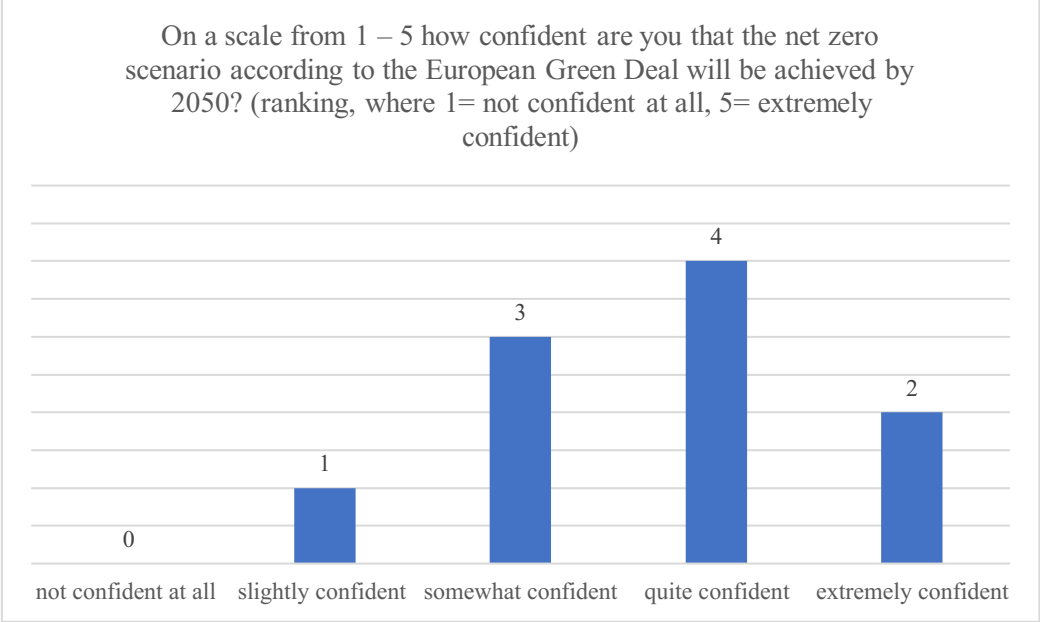


Figure 8: Answers Question 3

Based on the responses for Q3, the experts have varying levels of confidence in achieving the net-zero scenario according to the European Green Deal by 2050. Two Experts (expert 2 & Expert 7), both founders of Greentech startups, were highly confident that the climate goals will be achieved, with Expert 2 additionally stating that these goals are feasible in the 2050 scenario but not in the 2030/2035 scenario planning. Only one interviewee (Expert 1) was on the lower spectrum of the confidence scale. All other experts had a moderate level of confidence, with a rankings of 2, 3 and 4.

It's possible that individuals who were more optimistic about reaching the net-zero scenario by 2050 were more receptive to present and future policies, as well as the development of green technology. They might also think that these goals are being pursued with strong political intentions. The less confident experts, on the other hand, could be more concerned about technological, economic and social challenges that need to be overcome in order to achieve a net zero situation by 2050.

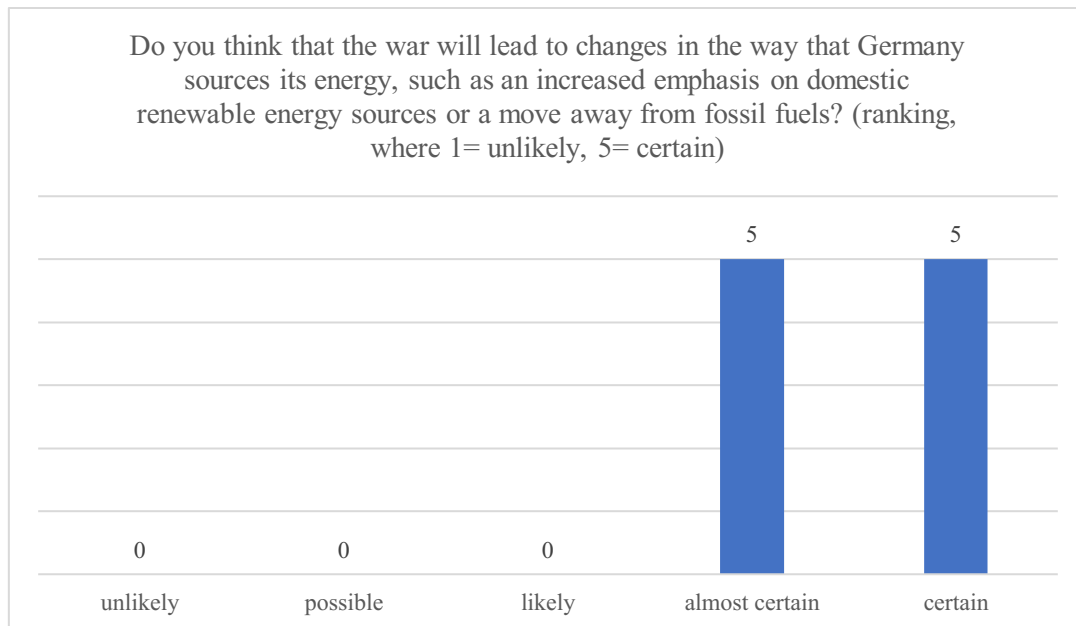


Figure 9: Answers Question 4

The experts were optimistic about the possibility of the war leading to changes in how Germany sources its energy. Results of Q4 (Do you think the war will lead to changes in how Germany sources its energy, such as an increased emphasis on domestic renewable energy sources or a move away from fossil fuels?) show that all of the interview participants rated their confidence level at 4 or 5 (very likely or certain).

The reason for this could be Germany's increasing switch to sustainable energy grids in recent years. The country has committed to meeting climate targets and has continuously invested in renewables, such as wind and solar, as well as the Greentech sector. The current situation in Ukraine may also have influenced the responses, as it favors a shift to renewable over natural gas imports from Russia. Additionally, the experts may be confident in the potential for increased emphasis on domestic renewable energy sources because Germany already has a strong domestic renewable energy sector.

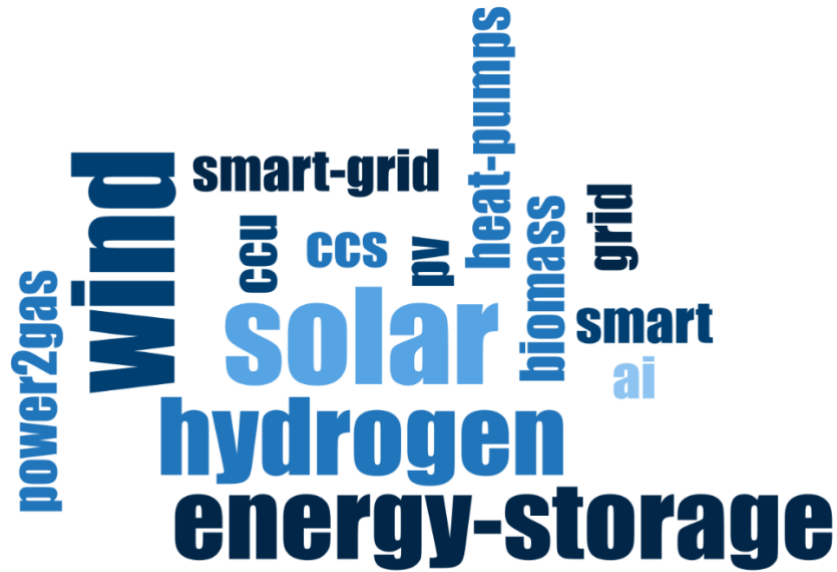


Figure 10: Wordcloud based on Keywords for Question 5

The respondents identified various promising green technologies in the energy sector that could have a significant impact on achieving carbon neutrality in the next decade (Q5). Looking at the word cloud above, the most mentioned technologies include solar, wind, energy storage solutions and hydrogen. According to Experts 1, 2, 3, 5, 7 and 9 solar and wind energy will stay critical components in the future energy mix and in achieving carbon neutrality, especially if their efficiency increases.

Hydrogen is another promising technology that multiple experts mentioned. Experts 2, 5, 6 and 9 are excited about the potential of green hydrogen to cover energy demands. Expert 5 mentions that the widespread adoption of green hydrogen could play a significant role in achieving carbon neutrality.

When looking at specific solutions, energy storage is mentioned by Experts 3 and 4, as they can help integrate intermittent energy into the energy mix. CCU and CCS is mentioned as well in utilizing CO₂ and reducing the carbon footprint. Expert 8 sees power-to-gas as a technology that could find increased adoption in the future to move away from conventional natural gas and reduce import dependencies.

Question 6 tried to identify barriers to the widespread adoption of green technologies and how they could be overcome. Start-up founders, as well as managers within energy companies (Experts 1,2,3,6,7,8, 9), believe that the cost of implementation or adoption will be one of the main challenges, which can be attributed to a lack of funding or governmental incentives. Expert 8 believes that this challenge can be overcome through governmental tax breaks and

subsidies. Furthermore, Expert 1 believed that instruments such as the US Inflation Reduction Act should be implemented into Germany's tax system. Experts 3 and 5 stated that the amount of R&D for some deep green technologies needed is also seen as a challenge, with Expert 6 adding that the lack of technological know-how could hinder widespread adoption. When it comes to participants within energy companies, the lack of scalability is mentioned, with Expert 10 mentioning that the general infrastructure is there yet. However, solutions mentioned to overcome challenges include collaboration between actors and exploring new business models such as energy-as-a-service. Furthermore, customer demand for renewables is increasing, and consumers are becoming more conscious of their electricity consumption, which can create opportunities for green technologies to become more accessible and widespread.

With the literature review and Q6 indicating cost as possibly the main barrier, the experts were asked in Q7 how the Russia-Ukraine conflict will affect investments in green technologies. Overall, the respondents were relatively confident that the war has the potential to drive investments into green tech, to enable a sustainable and stable energy supply in the future. Expert 5 described the current situation as a double-edged sword because the current focus lies on short-term energy security. Responses were very likely influenced by the current market trend towards sustainable energy sources, with Expert 5 mentioning that where the market trend goes, investments will follow. Similarly, Expert 1 believed that the main focus is on dependency and that investments are just a side effect. Expert 6, a principal from a leading German VC, expresses that even though it seems that investments are done more carefully now, in general, the amount of VCs interested in green technologies is getting bigger. One of the start-up founders (Expert 2) doubles down on this, mentioning that the individuals behind investments are emotionally driven, resulting in more impact investments. Expert 10 also mentioned that there were efforts to push capital flows towards the Greentech before the war.

Question 8 was an open question: How will the increased adoption of green technologies in the energy sector impact energy prices and the cost of living for consumers? It is evident that we are currently facing an enormous disruption through the Russian war on Ukraine and the cut-off of natural gas. After analyzing the answers of the experts, some of them believe that in the long run, prices will decrease again or at least level off and go down to the pre-war scenario (Experts 2, 5 and 10). However, in the view of Experts 1 and 6, energy prices will not drop in the near future. The reason could be that Germany was highly dependent on imports in the past. Expert 2 stated that France, which relies a lot on nuclear energies and the United States have far fewer fluctuations due to the fact that they are independent. +

Experts 1,6, and 7 believe that consumer behavior will play a crucial role when it comes to energy consumption and that energy needs to be used more efficiently. Expert who expresses green technologies have the chance to involve consumers really actively. High inflation over the last year has already shown consumer adoption of higher energy prices. In the literature review, it became evident that there is no moving back to Russian natural gas in the foreseeable future. Expert 8 had a similar view but believes that renewables have the possibility to be a cost-efficient substitute. Expert 5 stated that it would come down to the availability and efficiency of such technologies. The majority of the experts believed that, over time, the increased use of green technology in the energy industry would decrease energy prices and have a positive effect on consumers.

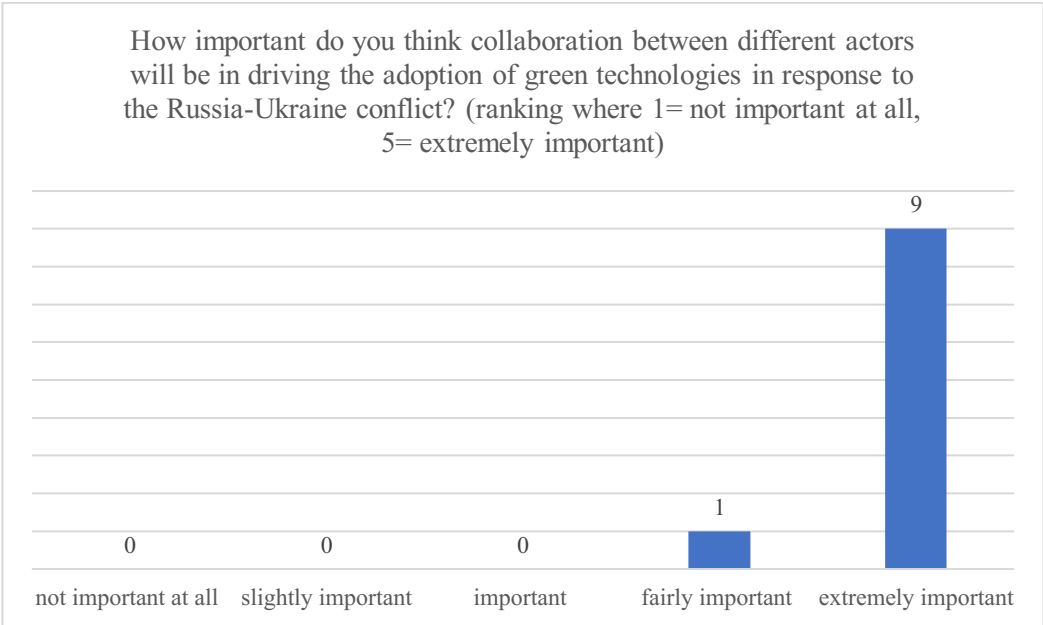


Figure 11: Answers Question 9

The literature review demonstrated that collaboration is essential in overcoming barriers and accelerating innovation. Therefore, the respondents were asked about the importance of collaboration for adopting green technologies in response to the Russia-Ukraine war (Q9). All the experts gave this the highest rankings of 4 and 5. This indicated that, similarly to the research done before, all believed that collaboration among different actors is crucial for effectively addressing the challenges faced by the energy sector and accelerating transition towards sustainable and green technologies. It can be assumed that the experts recognized that the transition towards green technologies requires coordinated efforts and collaboration to address various challenges. as it can facilitate the exchange of knowledge, resources, and expertise to overcome these barriers and achieve common goals.

This was also reflected in question 10, as all companies, except one, are part of an innovation network or knowledge transfer ecosystem.

4.2 Porters five forces industry analysis

The German energy industry is currently experiencing a significant shift towards green tech and renewable energy sources, driven by government regulations and consumer demand for more sustainable options. This shift creates opportunities for disruption and competitive advantage for companies that can effectively navigate the changing landscape. In this context, Porter's Five Forces framework (Porter, 1980) can be a valuable tool for analyzing the competitive dynamics of the German energy industry.

1. Threat of new entrants: **MODERATE** - The German energy sector is extensively regulated and has significant barriers to entry due to the need for large capital investments in infrastructure and technology. There may be opportunities for new entrants as green tech innovations are still developing.
2. Bargaining power of suppliers: **HIGH** - The German energy sector is heavily reliant on the import of natural gas and oil from other countries. Green technologies may diminish the negotiating strength of incumbent energy suppliers when new renewable energy suppliers enter the market.
3. Bargaining power of suppliers: **MODERATE** - Due to a lack of alternative energy sources and inadequate price control, German energy purchasers have little bargaining power. Cost-efficient green technology and new suppliers may give buyers greater alternatives and bargaining power.
4. Threat of substitutes: **HIGH** - Green technologies pose a significant challenge to the German energy industry. As the costs of green technology continue to decline and environmental regulations become more stringent, the threat of substitutes is a present threat for the main actors in the energy landscape.
5. Competitive competition: **HIGH** - The conventional energy business in Germany has an intense competitive rivalry. The increasing focus on renewable energy has led to significant changes in the market, with traditional energy companies investing heavily in renewable energy sources to remain competitive.

Overall, the German energy industry faces significant challenges and opportunities with the emergence of green technologies. While traditional energy sources face increased competition from renewable energy sources, new entrants and suppliers have the chance to disrupt the industry and improve competition. Businesses that can use green technology and renewable

energy sources to differentiate themselves from competitors and fulfil changing customer needs, in particular, are well positioned to acquire a competitive edge.

4.3 Scenario Planning and External Factors

The following stakeholders (Table 4) have been identified to play a crucial role in the Greentech ecosystem.

Table 4: Stakeholders for Scenario Planning

<i>No.</i>	<i>Stakeholder</i>
ST1	Governmental Regulators
ST2	Entrepreneurs/Innovators
ST3	Investors (private/public)
ST4	German energy suppliers
ST5	Russia
ST6	Ukraine
ST7	Consumers

Tables 5 and 6 illustrate the trends and uncertainties Greentech in the energy industry faces identified through the literature review, Porter's five forces framework and the interview findings.

Table 5: Trends for Scenario Planning

<i>No.</i>	<i>Trend</i>	<i>Outcome (if yes)</i>
TR1	Increasing demand for renewable energy sources due to climate change concerns and the commitment to meet international and national climate targets	positive (+)
TR2	Increasing demand renewables as substitutes for domestic energy imports (e.g. natural gas)	positive (+)
TR3	Slow adoption of renewable energy infrastructure	negative (-)
TR4	Increased investment in renewable energy and innovative green technology.	positive (+)
TR5	Inflation, partly based on rising energy prices for end consumers	negative (-)

Table 6: Uncertainties for Scenario Planning

No.	Uncertainty	Outcome (if yes)
UN1	Will Russian-Ukraine war increase the pace of innovation and adoption of green technologies in the energy sector?	positive (+)
UN2	Will Germany be able to substitute Russian natural gas imports and keep transport via NS1 and NS2 on hold?	positive (+)
UN3	Will the Russian-Ukraine war increase public and private investment in green energy infrastructure?	positive (+)
UN4	Will the Russian-Ukraine war accelerate renewable energy sources to become cheaper than traditional fossil fuels?	positive (+)
UN5	Will the Russia-Ukraine conflict impact consumer behavior and demand for affordable green energy?	positive (+)
UN6	Will the Russian-Ukraine war be able to enforce more effective green energy policies and regulations?	positive (+)

The correlation matrix in Table 7 shows that almost all uncertainties, except UN2, either correlate positively or neutrally. Therefore, we can assume that current trends favor innovative Greentech in Germanies energy market.

Table 7: Correlation Matrix of Uncertainties

	UN1	UN2	UN3	UN4	UN5	UN6
UN1	<i>X</i>	0	+	+	+	+
UN2	<i>X</i>	<i>X</i>	0	0	0	-
UN3	<i>X</i>	<i>X</i>	<i>X</i>	+	+	+
UN4	<i>X</i>	<i>X</i>	<i>X</i>	<i>X</i>	+	+
UN5	<i>X</i>	<i>X</i>	<i>X</i>	<i>X</i>	<i>X</i>	+

With the correlation between uncertainties and trends being constant for all scenarios, three learning scenarios have been developed in Table 3 based on the outcome of uncertainties.

Table 8: Learning Scenarios for Scenario Planning

<i>Scenario Type</i>	<i>Scenario Name</i>	<i>Scenario</i>
Optimistic	<i>Greentech Revolution</i>	The Russian-Ukraine conflict continues, and Germany has to substitute the energy demand of Russian imports (UN2). Therefore, the pace of innovation and adoption of green technologies in the German energy sector has increased rapidly (UN1). Public and private investments into Greentech increase with the implementation of green energy policies and regulations, which further accelerate the energy transition (UN3 & UN6). Energy costs decrease due to sufficient energy security provided through the implementation of innovative technology. Moreover, consumers develop more responsible and sustainable behavior (UN5). The Russia-Ukraine war has accelerated a fundamental shift in the energy sector, and international and national climate targets are being met.
Business-as-usual	<i>Incremental Progression</i>	The Russian-Ukraine conflict continues, and Germany has to substitute the energy demand of Russian imports (UN2). A continuation of the current trends can be seen, with some incremental progress towards renewable energy sources. The Greentech sector continues to attract investments, but it is not sufficient to drive a significant change (UN3). Technological innovations continue, but the implementation and widespread adoption is too slow (UN1). Green energy is not price competitive in the short run but may be long-term (UN4). The energy sector struggles to meet consumers' demand for energy, as the Russian natural gas dependency cannot be covered (UN5). Fossil fuels continue to dominate the energy sector, as government policies are not radically adapted to the market situation (UN6). In this scenario, the Russia-Ukraine war shows that changes are necessary, but the actions of the agents in the energy sector are possibly too slow and insufficient.
Adverse	<i>Slow and Fragmented Transition</i>	The Russian-Ukraine war ends in the near future, and the natural gas supply from Russia via NS1 and NS2 will be reinstated (UN2). Hence, the accelerated momentum for innovative technology to disrupt the energy sector is put on hold (UN1). The Greentech sector gets less attractive to invest in as the baseline scenario on the way to net zero continues (UN3). Governmental regulations and policies are neglected as energy security through fossil fuels are met (UN6). Renewables and Greentech can are not cost-effective enough to compete with fossil-sourced energy (UN4 & UN5). The Russia-Ukraine conflict does not have an immediate effect on Greentech innovation, and climate goals are unlikely to be met as the baseline scenario for net-zero will likely uphold.

According to the weight assigned to a "yes" response for each uncertainty, Figure 12 profiles each situation. Each scenario depends on the trends, which are consistent across all of them.

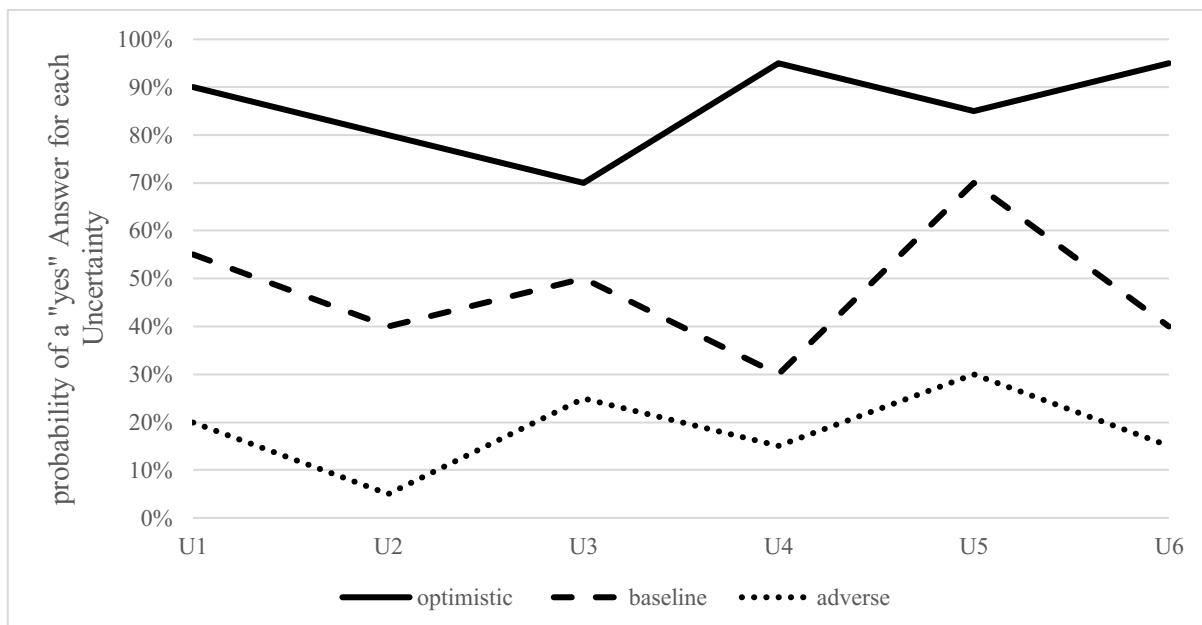


Figure 12: Probability of "yes" Answers for each Uncertainty

The all-positive and all-negative situations were internally consistent, as Table 7's correlation matrix only showed one negative correlation between UN2 and UN6. Based on these learning scenarios, a least-surprising scenario has now been built that incorporates all trends and improbabilities in view of the Russia-Ukraine conflict.

Table 9: Least Surprising Scenario for Scenario Planning

Least-Surprising Scenario
<p>It is still uncertain when and how the Russian war on Ukraine will end. Germany focuses on substituting natural gas and other fossil fuels as the independence from Russian imports continues with the phase-out of NS1 and NS2 (UN2). Demand for renewable energy sources is rising as awareness of climate change grows as The Russian-Ukraine conflict has acted as a catalyst for change, accelerating the pace of innovation and adoption of green technologies in the energy sector (UN1). Yet, a significant obstacle to meeting this demand has been the delayed adoption of renewable energy infrastructure (TR3). This triggers an increasing amount of investment in green technologies and renewables (TR4). It has become apparent in light of the conflict between Russia and Ukraine that continuing to rely on fossil resources, and in particular natural gas, is unsustainable (TR3). As a result, there is a renewed commitment to meeting international and national climate targets (TR1). The Russia-Ukraine conflict has also had a positive impact on green energy policies and regulations. Governments have realized the importance of investing in green technologies, and the primary focus lies in implementing policies to support this (UN6). This has encouraged more public and private investment in green energy infrastructure innovation (UN3). However, the benefits of fundamental changes on the way to the national "Energiewende" will be only visible in the long term. Moreover, it is not possible to reduce energy prices in the short term (TR5), as achieving a sustainable change in the energy mix takes time. Effectively consumers have to become more sustainable in their behavior (UN5), as</p>

renewable energy sources still need to become more cost-effective to compete with fossil fuels (UN4), as it is unlikely to achieve a green revolution in the near future.

Based on the scenario planning, Greentech innovations are in a favorable position in the German energy sector in relation to the factors relating to the Russia-Ukraine war.

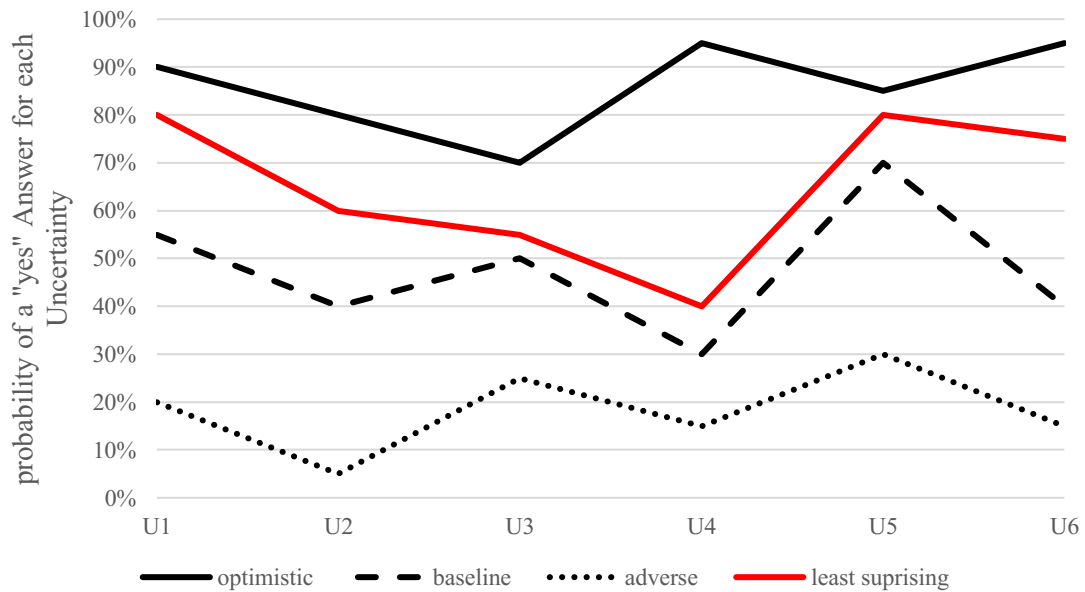


Figure 13: Probability of "yes" Answer for each Uncertainty including Least Surprise

5 Discussion

5.1 Catalysts

The results gathered from the literature and the interviews implicate a favorable market position for Greentech in Germany's energy sector at this point in time. The war between Russia and Ukraine makes it evident that the German government needs to restructure its current energy mix. Chapter 2.2.3 identified that in 2022, 82% of Germany's primary energy consumption was attributed to fossil energy sources and nuclear energy (BDEW, 2022). The interviews indicated that experts are convinced that the war has focused increased attention on sustainable energy sources away from fossil fuels. Green technologies will be preminent in achieving this, assuming certain factors exist. Three main drivers, namely investment, policy measures and cooperation between actors in the energy sector, were identified in the literature review and confirmed by the expert interviews.

5.1.1 Catalysts through investments

The literature review suggests that investments in renewable energy have been decreasing in Germany since 2010, which is primarily due to the cost of development decreasing. The cost factor of Greentech was also seen as one of the main barriers by the experts interviewed. According to the literature review, however, investments in the Greentech ecosystem have increased pace in the energy sector. This indicates a positive leverage effect between financial efforts meeting the European Green Deals goals through technological innovation. Furthermore, an increase in energy prices due to the conflict can accelerate the allocation of funds for renewable energy in nations of the European Union.

The interview findings further support the literature's stance on the positive impact of the Russia-Ukraine conflict on green technology investments. Respondents expressed confidence that the war can potentially drive investments into green tech, enabling a sustainable energy transition in the future. Even though experts are concerned that the current focus is on short-term energy security, it is likely that investment in the energy sector will be influenced by the trend towards renewables, which can give green technology a competitive advantage.

5.1.2 Catalysts through policies

According to the experts, government policies and regulations are considered essential in promoting the adoption of green technology in the energy industry. By coordinating economic, innovation, and climate policies through market mechanisms primarily geared toward innovation, frameworks for scaling up new businesses that provide climate change solutions can be established. Through Porter's Five Forces Framework, one barrier for new entrants can be linked to the high regulation in the sector. Therefore, the energy industry is an area where policies can work effectively in reducing the financial barriers to adoption. Green technologies can also improve Europe's potential for renewable energy and enhance efforts to keep on track with the goals of the European Green Deal and the Paris Agreement. Policies provide the necessary incentives for economic growth and for new market entrants to make a more substantial impact. They offer the required incentives for economic growth and for new market entrants to have a more significant overall impact. Therefore, agents can gain a competitive advantage through policies that support Greentech's development and adoption in the transition to a sustainable and net-zero future.

5.1.3 Catalysts through collaboration

To address the barriers to green technology, the literature points to the importance of an open innovation approach, including creating network partners, such as academic institutions and support platforms/other start-ups, to facilitate breakthrough innovations. Experts believe that collaboration will be crucial in the widespread adoption of Greentech in light of the war in Ukraine. A Technology Information System (TIS) presented in the literature review has the potential to be widely used in radical innovations. Active collaboration between agents, with the entrepreneur as a central figure, and the right policy mix can significantly encourage innovation. In line with Nevzorova & Karakaya, challenges can be primary drivers when it comes to TIS (Nevzorova & Karakaya, 2020). The Russia-Ukraine conflict is one of the biggest challenges the energy sector has faced in decades, a competitive advantage for Greentech innovation can be achieved through working together to not rely on foreign imports.

5.1.4 Creative destruction

Schumpeter's concept of "creative destruction" is applicable to the current situation in the German energy sector, where traditional sources of energy production are becoming outdated and unsustainable. The findings emphasize that the transition towards net-zero emissions requires the adoption of green technology innovations in the energy sector. Through Greentech innovation, greenhouse gas emissions can be reduced which can also lead to economic growth. In line with Schumpeter's theory, Greentech innovations that offer cost-effective solutions and those better adapted to changing market conditions may gain an edge over current environmentally harmful sources of energy production. The experts believe that this will be the case in the long term. Some innovations may not be at the point where they are scalable for widespread adoption. However, firms that can adapt quickly to market changes and capitalize on new opportunities are more likely to maintain their competitive advantage over time.

5.2 Potential catalytic effect of the Russian-Ukraine war

The literature review and qualitative findings suggest that the ongoing war can potentially disrupt the above factors severely. Beyond the political and economic spheres, it is apparent that Russia's war on Ukraine has had far-reaching consequences. Regarding the energy sector, the conflict has highlighted the risks of Germany's energy dependence on Russian gas imports. Supply disruptions and rising energy costs are effects that have already been observed since the war began, prompting German policymakers to accelerate the transition to renewable energy sources such as wind and solar. The disruptions observed in the energy sphere are highly favorable for technological innovations within the sector, giving new market entrants the

possibility to help reduce Germany's dependence on a single energy source. This transition is not without its challenges, requiring significant investment, infrastructure changes, and new policy frameworks. As no direct catalyst effect of the war was identified, movements in external factors are apparent. These external factors, such as policy development and investment trends, are highly influenced by the war, which on the other hand, have a direct leverage effect on Greentech innovation. Germany already implemented new strategies and actions to boost renewable capacity earlier this year, with the Renewable Energy Act, the Onshore Wind Act, the Offshore Wind Act, and the Energy Industry Act, in response to the war. Furthermore, investments into the Greentech ecosystem are picking up pace. The Scenario Planning identified that the current external factors create a significant opportunity for Greentech if specific barriers, such as the lack of energy infrastructure, can be overcome.

6 Conclusion

6.1 General Conclusion

The energy sector is one of Germany's key drivers of economic growth and development, but it is also a major contributor to global greenhouse gas emissions.

The goal of this thesis was to describe the current energy market and the effects of the Russia-Ukraine conflict on it, while identifying factors that give green technologies a competitive edge against fossil fuels. The Russia-Ukraine conflict has had a significant impact on the German energy sector, particularly in terms of market volatility and supply chain disruptions.

Through a multi-method approach, this study has shown that green technologies are not only environmentally beneficial but also have a greater resilience against market shocks and uncertainties. This finding underscores the importance of investing in sustainable energy and creating policy frameworks as a means of achieving both environmental and economic sustainability. The results further indicate that the Russian war on Ukraine has an indirect catalyst effect, through external factors, for Greentech in the German energy sector as these are vital not only for achieving climate goals but also for ensuring energy security and independence.

Furthermore, this thesis contributes to the ongoing discourse on climate change and creative disruption by highlighting novel developments in the German energy sector. The study demonstrates the potential for creative disruption in the energy sector and underscores the importance of finding sustainable solutions in the face of geopolitical uncertainties.

In conclusion, this thesis serves as a call to action for policymakers, businesses, and individuals to prioritize the adoption of green technologies and work towards a net-zero future. It is essential that we continue to explore and implement sustainable energy solutions as we navigate the challenges of the 21st century. Through innovation, cooperation, and determination, we can achieve a sustainable and prosperous future for all.

6.2 Limitation

The results of the thesis must be viewed with caution, as several limitations can be observed. The Russia-Ukraine conflict involves a high degree of uncertainty, as it is unclear when and how the war will end. The future outcome of the war may affect the validity and generalizability of the results.

Furthermore, the results are based on a limited number of interviewees. The interview sample of 10 is relatively low, with the participants all active in the German energy sector and having links to Greentech or having founded companies in this field themselves. This can lead to a bias in assessing factors and limits the generalizable nature results. The scope of the paper was kept broad regarding Greentech, and the various technologies were not dealt with in detail. Likewise, policies and regulations are a very complex topic, which would have exceeded the scope of this thesis.

Despite these limitations, this study provides valuable insights into the important trends in promoting the adoption of green technologies in the German energy sector, influenced by the Russian war on Ukraine.

6.3 Future Research

Further research can be conducted to expand on the findings of this thesis and address its limitations. The long-term effects of the Russia-Ukraine conflict on the German energy sector will only be assessable in coming years, determining further drivers and barriers in substituting the high import volume of Russian natural gas and oil.

Eventually, a bigger sample size might be considered for the qualitative interviews, including experts from various backgrounds and countries, to acquire more insight. Additionally, more in-depth study may be performed on the unique challenges and opportunities for the German energy industry to reach net-zero emissions and the role of individual technologies in this process. This might involve a review of the prospective influence of future government policies and regulations, as well as the efficacy of present incentives. Performing a quantitative analysis

of future consumer behavior can add further insights into the industry transformation and how climate goals can be achieved.

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Appendices

ID	ROLE	TYPE
EXPERT 1	Founder of German Greentech Startup	Startup
EXPERT 2	Previous founder of German Greentech Startup	Startup
EXPERT 3	Head of Expansion at German Greentech Startup	Startup
EXPERT 4	Startup Partnerships Manager at German energy company	Energy company
EXPERT 5	Sustainability Manager at German energy company	Energy company
EXPERT 6	Principal investor at German venture capital Firm with sub focus on Greentech	Venture Capitalist
EXPERT 7	Founder of German Greentech Startup	Startup
EXPERT 8	VP Innovation at German energy company	Energy company
EXPERT 9	Manger at innovation platform and venture capital firm focused on sustainability	Venture Capitalist
EXPERT 10	Country Manager at German Greentech Startup	Startup

ID	Question	Type
1	Are you aware of international (EU Green Deal) and national policies/initiatives and their goals to reduce carbon emissions?	yes/no
2	How important are government policies and regulations in promoting the adoption of green technologies in the energy sector?	open
3	On a scale from 1 – 5 how confident are you that the net zero scenario according to the European Green Deal will be achieved by 2050? (ranking, where 1= not confident at all, 5= extremely confident)	ranking
4	Do you think the war will lead to changes in how Germany sources its energy, such as an increased emphasis on domestic renewable energy sources or a move away from fossil fuels? (ranking, where 1= unlikely, 5= certain)	ranking
5	What are some of the most promising Greentech innovations in the energy sector that you believe will have the greatest impact when it comes to achieving carbon neutrality in the next decade?	open
6	What barriers do you see to the widespread adoption of green technologies in the energy sector and if so, how can they be overcome?	open
7	In your opinion, how does the Russia-Ukraine conflict affect investments in green technologies?	open
8	How will the increased adoption of green technologies in the energy sector impact energy prices and the cost of living for consumers?	open
9	How important do you think collaboration between different actors (entrepreneurs, policy makers, energy companies) will be in driving the adoption of green technologies in response to the Russia-Ukraine conflict? (ranking where 1= not important at all, 5= extremely important)	ranking
10	Is your company part of an (open) innovation network or knowledge transfer ecosystem?	Yes/no

Expert 1		
Question	Type	Answer
Are you aware of international (EU Green Deal) and national policies/initiatives and their goals to reduce carbon emissions?	yes/no	yes
How important are government policies and regulations in promoting the adoption of green technologies in the energy sector?	open	they are crucial, without a political incentive structure a lot of green technologies will not fly
On a scale from 1 – 5 how confident are you that the net zero scenario according to the European Green Deal will be achieved by 2050? (ranking, where 1= not confident at all, 5= extremely confident)	ranking	2
Do you think the war will lead to changes in how Germany sources its energy, such as an increased emphasis on domestic renewable energy sources or a move away from fossil fuels? (ranking, where 1= unlikely, 5= certain)	ranking	5
What are some of the most promising Greentech innovations in the energy sector that you believe will have the greatest impact when it comes to achieving carbon neutrality in the next decade?	open	Triple the amount of solar in Germany are planned, at the end it all comes down to green energy. Also I'm a big fan of heat pumps and like the German government for pushing this in the housing sector
What barriers do you see to the widespread adoption of green technologies in the energy sector and if so, how can they be overcome?	open	Green premium is still too high and tax incentives need to be in place, similar to the US Inflation Reduction Act
In your opinion, how does the Russia-Ukraine conflict affect investments in green technologies?	open	I think it's now more about independence and not so much about green electricity, this is more a side effect.
How will the increased adoption of green technologies in the energy sector impact energy prices and the cost of living for consumers?	open	Prices will increase in the short run, but in the long run it might affect consumer behaviour, meaning consuming energy on different times of the day based on the price, e.g. washing the cloths when the sun is shining.
How important do you think collaboration between different actors (entrepreneurs, policy makers, energy companies) will be in driving the adoption of green technologies in response to the Russia-Ukraine conflict? (ranking where 1= not important at all, 5= extremely important)	ranking	5
Is your company part of an (open) innovation network or knowledge transfer ecosystem?	Yes/no	Yes

Expert 2		
Question	Type	Answer
Are you aware of international (EU Green Deal) and national policies/initiatives and their goals to reduce carbon emissions?	yes/no	yes
How important are government policies and regulations in promoting the adoption of green technologies in the energy sector?	open	Very, very strongly... because the market works in such a way that they go the cheapest way. You buy the electricity that is cheapest, you drive the car that is cheapest ... politicians are responsible for shifting the subsidies towards green solutions, so that they become competitive according to normal, simple business cases, and then the whole thing will be pushed. Then it will develop.
On a scale from 1 – 5 how confident are you that the net zero scenario according to the European Green Deal will be achieved by 2050? (ranking, where 1= not confident at all, 5= extremely confident)	ranking	5 (annotation: we won't make the 2030, 35 targets, but I think we will make the 2050)
Do you think the war will lead to changes in how Germany sources its energy, such as an increased emphasis on domestic renewable energy sources or a move away from fossil fuels? (ranking, where 1= unlikely, 5= certain)	ranking	4
What are some of the most promising Greentech innovations in the energy sector that you believe will have the greatest impact when it comes to achieving carbon neutrality in the next decade?	open	all the wind energy, that's a green technology. Solar, if they can now achieve increased efficiencies. Hydrogen as a means of transporting energy and as a storage medium.
What barriers do you see to the widespread adoption of green technologies in the energy sector and if so, how can they be overcome?	open	Rising purchase prices ... The whole world is asking for this now, and in addition, it's hard to get. The frequent problems in the production of the technologies because they need rare materials ... and there is not enough government funding.
In your opinion, how does the Russia-Ukraine conflict affect investments in green technologies?	open	Yes, definitely. Especially on the investor side ... when I look at the individual level there are more and more investors making impact investments. Because these are individuals who are emotionally driven ...these individuals invest as angels, but of course also as LPs for VCs, and that's how it works.
How will the increased adoption of green technologies in the energy sector impact energy prices and the cost of living for consumers?	open	I don't think it will have a very high impact because it will level off. With all the green energies, we can reduce our dependence on other countries and that makes it much more controllable for us. You can see that with countries like France, which rely a lot on nuclear power, that they have much better energy prices or also the Americans, that they have much better energy, lower energy price fluctuations. And that's what we're going to achieve .. due to scaling effects in the production costs of green energy i also believe that they will not skyrocket
How important do you think collaboration between different actors (entrepreneurs, policy makers, energy companies) will be in driving the adoption of green technologies in response to the Russia-Ukraine conflict? (ranking where 1= not important at all, 5= extremely important)	ranking	5

Is your company part of an (open) innovation network or knowledge transfer ecosystem?	Yes/no	yes
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Expert 3		
Question	Type	Answer
Are you aware of international (EU Green Deal) and national policies/initiatives and their goals to reduce carbon emissions?	yes/no	yes
How important are government policies and regulations in promoting the adoption of green technologies in the energy sector?	open	Yes policies and regulations are highly needed (annotation: innovation) ... energy sector is highly regulated ... they are just a small part in the whole system ... I believe market forces and consumer demand will be the key in adoption of green technologies. The more people want it the more government have to act
On a scale from 1 – 5 how confident are you that the net zero scenario according to the European Green Deal will be achieved by 2050? (ranking, where 1= not confident at all, 5= extremely confident)	ranking	3
Do you think the war will lead to changes in how Germany sources its energy, such as an increased emphasis on domestic renewable energy sources or a move away from fossil fuels? (ranking, where 1= unlikely, 5= certain)	ranking	4
What are some of the most promising Greentech innovations in the energy sector that you believe will have the greatest impact when it comes to achieving carbon neutrality in the next decade?	open	energy storage solutions, smart grid technologies ...of course renewable energy sources such as solar and wind
What barriers do you see to the widespread adoption of green technologies in the energy sector and if so, how can they be overcome?	open	Green technologies in the energy sector cost a lot most of the time. A lot of R&D is necessary for some technologies ... Energy infrastructure and regulatory frameworks is not yet optimal for a lot of deep tech integration. That will be the main challenge to integrate them
In your opinion, how does the Russia-Ukraine conflict affect investments in green technologies?	open	I do believe that the war pushes investment in green tech. Even though we saw the tech bubble bursting last year I still see strong investments in our branche ... the energy sector has a lot of room of improvement
How will the increased adoption of green technologies in the energy sector impact energy prices and the cost of living for consumers?	open	... as stated before the cost of integration is high ... we have seen the actual cost of renewables has decrease over time. I believe compared to now cost will decrease over time ... Thats one of the main issues i see. It is essential for consumer to afford clean energy.
How important do you think collaboration between different actors (entrepreneurs, policy makers, energy companies) will be in driving the adoption of green technologies in response to the Russia-Ukraine conflict? (ranking where 1= not important at all, 5= extremely important)	ranking	5 (annotation: we actively seek out partnerships with other businesses, researchers to drive innovation in the sector)

Is your company part of an (open) innovation network or knowledge transfer ecosystem?	Yes/no	yes
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Expert 4		
Question	Type	Answer
Are you aware of international (EU Green Deal) and national policies/initiatives and their goals to reduce carbon emissions?	yes/no	yes
How important are government policies and regulations in promoting the adoption of green technologies in the energy sector?	open	Absolutely essential ... unlikely that these technologies would be able to compete with fossil fuels on a level playing field. Policies need to provide regulatory frameworks these technologies ... one important step to make energy more affordable for consumers and businesses
On a scale from 1 – 5 how confident are you that the net zero scenario according to the European Green Deal will be achieved by 2050? (ranking, where 1= not confident at all, 5= extremely confident)	ranking	4
Do you think the war will lead to changes in how Germany sources its energy, such as an increased emphasis on domestic renewable energy sources or a move away from fossil fuels? (ranking, where 1= unlikely, 5= certain)	ranking	5
What are some of the most promising Greentech innovations in the energy sector that you believe will have the greatest impact when it comes to achieving carbon neutrality in the next decade?	open	Several promising green technologies that we see promising... energy storage solutions and smart grid technologies help us to integrate intermittent renewable energy sources into energy supply chain ... CCU and CCS technologies help us to reduce the CO2 intensity of our fossil fuel sources ... looking at last Q3 and Q4 from last year to increase energy storage will be crucial
What barriers do you see to the widespread adoption of green technologies in the energy sector and if so, how can they be overcome?	open	Customer demand for renewables is too high to keep up with. We are exploring new business models, such as energy-as-a-service, to make green technologies more accessible .. collaborate with stakeholders to access new innovation ... especially startups ... there is so much going on right in the startup scene
In your opinion, how does the Russia-Ukraine conflict affect investments in green technologies?	open	Definitely will continue to attract investments ... Challenging year energy suppliers but we see that way of thinking must be changed and to adapt investments are necessary ... we have our own inhouse investment team looking for attractive opportunities
How will the increased adoption of green technologies in the energy sector impact energy prices and the cost of living for consumers?	open	Green tech will make a positive impact in the future when it comes to costs for consumers. Right now it is uncertain how for example energy prices will be for upcoming heating period

How important do you think collaboration between different actors (entrepreneurs, policy makers, energy companies) will be in driving the adoption of green technologies in response to the Russia-Ukraine conflict? (ranking where 1= not important at all, 5= extremely important)	ranking	5
Is your company part of an (open) innovation network or knowledge transfer ecosystem?	Yes/no	Yes

Expert 5		
Question	Type	Answer
Are you aware of international (EU Green Deal) and national policies/initiatives and their goals to reduce carbon emissions?	yes/no	yes
How important are government policies and regulations in promoting the adoption of green technologies in the energy sector?	open	... crucial role in promoting the adoption of green technologies ... without the government's support, it is difficult for these technologies to gain a foothold in the market .. financial barriers are too high at the moment
On a scale from 1 – 5 how confident are you that the net zero scenario according to the European Green Deal will be achieved by 2050? (ranking, where 1= not confident at all, 5= extremely confident)	ranking	3
Do you think the war will lead to changes in how Germany sources its energy, such as an increased emphasis on domestic renewable energy sources or a move away from fossil fuels? (ranking, where 1= unlikely, 5= certain)	ranking	4
What are some of the most promising Greentech innovations in the energy sector that you believe will have the greatest impact when it comes to achieving carbon neutrality in the next decade?	open	There is a lot of movement in hydrogen for years now ... green hydrogen can play a significant role in reducing CO2 and cover energy demands .. excited in how the wide spread adoption will move along ... also of course pv, wind and biomass.
What barriers do you see to the widespread adoption of green technologies in the energy sector and if so, how can they be overcome?	open	Lack of scalability .. We see many interesting technologies on the market, that just aren't as usable as we would like yet A lot of R&D is necessary for widespread adoption and performance for new technologies ... solar is in the market for years and there are still improvements of solar panels every year
In your opinion, how does the Russia-Ukraine conflict affect investments in green technologies?	open	Double edged sword ...at the moment I believe short-term energy security is or was prioritized, but the whole market trend is towards sustainability ... where the market trend goes, investments are made. Rather confident though that investments in technologies will continue and the war will not change this
How will the increased adoption of green technologies in the energy sector impact energy prices and the cost of living for consumers?	open	Energy prices and the cost of living for consumers will depend on a variety of factors. For example the availability and efficiency of the technologies. In my opinion the potential for lower prices is there but we will see how sector is adopting ... all in all it would be important to just get prices back to the same as before of war and dont have much of fluctuations

How important do you think collaboration between different actors (entrepreneurs, policy makers, energy companies) will be in driving the adoption of green technologies in response to the Russia-Ukraine conflict? (ranking where 1= not important at all, 5= extremely important)	ranking	5
Is your company part of an (open) innovation network or knowledge transfer ecosystem?	Yes/no	yes

Expert 6		
Question	Type	Answer
Are you aware of international (EU Green Deal) and national policies/initiatives and their goals to reduce carbon emissions?	yes/no	yes
How important are government policies and regulations in promoting the adoption of green technologies in the energy sector?	open	We have reached a point where politics is already creating good incentives for renewable energy sources. I think Germany is already on the strong side of promoting innovation. a good example of mitigating co2 emissions is carbon pricing. Germany is strong when it comes to creating incentives to reduce co2 emissions. The energy industry is a sector where this works quite well because there are already many new technologies.
On a scale from 1 – 5 how confident are you that the net zero scenario according to the European Green Deal will be achieved by 2050? (ranking, where 1= not confident at all, 5= extremely confident)	ranking	3
Do you think the war will lead to changes in how Germany sources its energy, such as an increased emphasis on domestic renewable energy sources or a move away from fossil fuels? (ranking, where 1= unlikely, 5= certain)	ranking	5
What are some of the most promising Greentech innovations in the energy sector that you believe will have the greatest impact when it comes to achieving carbon neutrality in the next decade?	open	... promising amount of technologies on the market ... taking into account the Russia situation renewables will play the main part when it comes to covering. ... how we can cover in periods of lets say where there is not enough solar or wind available ...energy storage and hydrogen will be a intersting to follow
What barriers do you see to the widespread adoption of green technologies in the energy sector and if so, how can they be overcome?	open	.. cost of implementation and wide spread adoption .. Technological know-how. Seems many new companies just jump on the greenwashing train and try to ride it out without proper expertise and feel for what the market needs
In your opinion, how does the Russia-Ukraine conflict affect investments in green technologies?	open	From my industry perspective VCs are more reserved when it comes to investments over the last year ... it seems like the pool of VCs interested in clean tech is getting bigger and the sector is picking up speed ... investments need to keep picking up speed for a successfull energy transitions
How will the increased adoption of green technologies in the energy sector impact energy prices and the cost of living for consumers?	open	in the short run not. I dont think that as long as inflation and living costs rise enregy prices will go down. In the long term possibly yes as there is a more diversified energy mix and government will do something drastic about the prices. Consumer behavior might change though .. can see responsible

		consuming already in households ... maybe mostly because of high prices but with the right incentives and technologies hopefully from a more sustainable motive
How important do you think collaboration between different actors (entrepreneurs, policy makers, energy companies) will be in driving the adoption of green technologies in response to the Russia-Ukraine conflict? (ranking where 1= not important at all, 5= extremely important)	ranking	5
Is your company part of an (open) innovation network or knowledge transfer ecosystem?	Yes/no	yes

Expert 7		
Question	Type	Answer
Are you aware of international (EU Green Deal) and national policies/initiatives and their goals to reduce carbon emissions?	yes/no	yes
How important are government policies and regulations in promoting the adoption of green technologies in the energy sector?	open	Super important. one of the most important things about policies is that they promote economic growth ... without the incentive, hardly anything would change. even if we look at climate targets and so on ... important that countries commit to co2 targets and policies provide this incentive and, in the best case, help us startups in particular to make a stronger impact. We already see that the war resultet in a leverage effect
On a scale from 1 – 5 how confident are you that the net zero scenario according to the European Green Deal will be achieved by 2050? (ranking, where 1= not confident at all, 5= extremely confident)	ranking	5
Do you think the war will lead to changes in how Germany sources its energy, such as an increased emphasis on domestic renewable energy sources or a move away from fossil fuels? (ranking, where 1= unlikely, 5= certain)	ranking	5
What are some of the most promising Greentech innovations in the energy sector that you believe will have the greatest impact when it comes to achieving carbon neutrality in the next decade?	open	There are the classics like solar and wind that will be the main component of sustainable energy ... there are so many deeptech technologies that will be interesting for the future. We are seeing that consumers are becoming more and more cautious about their electricity consumption. I think it will be important for consumers to track where their energy is coming from, how much they are using and what it is costing them. AI solutions can become very important for this so its all about predicting actual needs
What barriers do you see to the widespread adoption of green technologies in the energy sector and if so, how can they be overcome?	open	High costs. The attention for green energy is there. but the resources for implementation are still not here ... we are in a bit of a weird phase right now ... cutbacks from russian imports have to be compensated somehow that means fast action is

		important ... let's see if in the next few years the infrastructure can keep up with demand
In your opinion, how does the Russia-Ukraine conflict affect investments in green technologies?	open	Yes i am pretty confident about that. I think the russia ukraine war has focused the attention of the population on the importance of stable energy supply. Also for the government and investors it means that the demand is there and that this is a hot topic right now.
How will the increased adoption of green technologies in the energy sector impact energy prices and the cost of living for consumers?	open	I don't think we'll see any big changes here. Again, it's mainly about how to reduce demand ... this applies to households and businesses alike ... we need to use energy more efficiently - that's the be-all and end-all.
How important do you think collaboration between different actors (entrepreneurs, policy makers, energy companies) will be in driving the adoption of green technologies in response to the Russia-Ukraine conflict? (ranking where 1= not important at all, 5= extremely important)	ranking	5
Is your company part of an (open) innovation network or knowledge transfer ecosystem?	Yes/no	yes

Expert 8		
Question	Type	Answer
Are you aware of international (EU Green Deal) and national policies/initiatives and their goals to reduce carbon emissions?	yes/no	yes
How important are government policies and regulations in promoting the adoption of green technologies in the energy sector?	open	There is definitely a need for these ... we need more incentives to move away from fossil based energy sources. Best case scenario to achieve net zero in the future. Policies are an instrument that can force this change
On a scale from 1 – 5 how confident are you that the net zero scenario according to the European Green Deal will be achieved by 2050? (ranking, where 1= not confident at all, 5= extremely confident)	ranking	4
Do you think the war will lead to changes in how Germany sources its energy, such as an increased emphasis on domestic renewable energy sources or a move away from fossil fuels? (ranking, where 1= unlikely, 5= certain)	ranking	5
What are some of the most promising Greentech innovations in the energy sector that you believe will have the greatest impact when it comes to achieving carbon neutrality in the next decade?	open	Power to gas is a promising technologie. Scaling up power-to-gas technology, we can reduce the need for imported natural gas from Russia ... can be stored for energy shoratge as well
What barriers do you see to the widespread adoption of green technologies in the energy sector and if so, how can they be overcome?	open	High cost for us to implement some of these technologies into business. Governmental tax breaks and subsidies can be an incentive. Scalability can also be an issue ... promising new innovations we look at are often early stage and need to be tested heavily to become POC (annotation: Proof of concept)

In your opinion, how does the Russia-Ukraine conflict affect investments in green technologies?	open	... Sustainability is at core of the future energy sector. I expect heavy investment in especially energy infrastructure from public hand and new technologies from private hand
How will the increased adoption of green technologies in the energy sector impact energy prices and the cost of living for consumers?	open	Highly depends on how the Russia Ukraine situation is playing out. I don't see moving back to Russian natural gas as a near possibility ... renewables have the potential to be more cost efficient in the future
How important do you think collaboration between different actors (entrepreneurs, policy makers, energy companies) will be in driving the adoption of green technologies in response to the Russia-Ukraine conflict? (ranking where 1= not important at all, 5= extremely important)	ranking	5
Is your company part of an (open) innovation network or knowledge transfer ecosystem?	Yes/no	yes

Expert 9		
Question	Type	Answer
Are you aware of international (EU Green Deal) and national policies/initiatives and their goals to reduce carbon emissions?	yes/no	yes
How important are government policies and regulations in promoting the adoption of green technologies in the energy sector?	open	I would say that they do play a major role, in that they are ultimately the decisive factor in determining the targets of energy companies ... I just believe that in a widespread context, this can only be pushed forward by policies, because the market cannot drive it on its own.
On a scale from 1 – 5 how confident are you that the net zero scenario according to the European Green Deal will be achieved by 2050? (ranking, where 1= not confident at all, 5= extremely confident)	ranking	4
Do you think the war will lead to changes in how Germany sources its energy, such as an increased emphasis on domestic renewable energy sources or a move away from fossil fuels? (ranking, where 1= unlikely, 5= certain)	ranking	4
What are some of the most promising Greentech innovations in the energy sector that you believe will have the greatest impact when it comes to achieving carbon neutrality in the next decade?	open	... the hot thing right now is in fact hydrogen ... it will be partly the transition in technology and first of all the bluer one. But of course the goal should be to push green hydrogen ... a relatively strong change in dependence on Russian oil was brought about, which was of course also clearly due to the LNG terminals and also of course due to the import of gas from other countries ... for me, and that was also the strongest in the medium term, was of course the expansion of wind energy, which also gave a major push
What barriers do you see to the widespread adoption of green technologies in the energy sector and if so, how can they be overcome?	open	... depends on the area in which the energy companies are positioned. If you are now in the uniper and have built up a large part of your business on Russian gas, there are strong barriers to changing everything ... companies like RWE, which are

		strongly driving their wind energy expansion, regulatory restrictions always are a strong factor that slows down ... it's important to streamline or simplify the processes before the war, it was always the investment amount was still a bottleneck ... is it really worth taking so much money in hand to build up a new wind farm? ... I would still say that for me the obstacles at the government level
In your opinion, how does the Russia-Ukraine conflict affect investments in green technologies?	open	in the medium term will definitely be strongly favoured, because we simply want to ensure that we will never again be so dependent on any country ... we have to find long-term models and that is only possible if we invest in green technologies. short-term level it was difficult at first, because the collapse of profits in the energy sector ... led to investment stops ... the Russia-Ukraine conflict has definitely led to more investments in green tech technology and will continue to do so.
How will the increased adoption of green technologies in the energy sector impact energy prices and the cost of living for consumers?	open	would say that we have the regulatory and also through our potential future market power that we have in Germany and in Dach, in terms of green technologies, that we will definitely see lower prices in the end and of course the technologies will improve and not so much energy will have to be used to convert the hydrogen or other sources in the networks ... the technologies will also improve.
How important do you think collaboration between different actors (entrepreneurs, policy makers, energy companies) will be in driving the adoption of green technologies in response to the Russia-Ukraine conflict? (ranking where 1= not important at all, 5= extremely important)	ranking	5
Is your company part of an (open) innovation network or knowledge transfer ecosystem?	Yes/no	yes

Expert 10		
Question	Type	Answer
Are you aware of international (EU Green Deal) and national policies/initiatives and their goals to reduce carbon emissions?	yes/no	yes
How important are government policies and regulations in promoting the adoption of green technologies in the energy sector?	open	crucial one.. political instruments at both EU and national level are very strongly related to the digitalisation of energy.. this basic task of creating infrastructure, the digitalisation of infrastructure, has led to the fact that innovation can arise in the first place and, for example, consumers can also use green technologies
On a scale from 1 – 5 how confident are you that the net zero scenario according to the European Green Deal will be achieved by 2050? (ranking, where 1= not confident at all, 5= extremely confident)	ranking	4

Do you think the war will lead to changes in how Germany sources its energy, such as an increased emphasis on domestic renewable energy sources or a move away from fossil fuels? (ranking, where 1= unlikely, 5= certain)	ranking	4
What are some of the most promising Greentech innovations in the energy sector that you believe will have the greatest impact when it comes to achieving carbon neutrality in the next decade?	open	Renewables are a catalyst for many other things, such as our product ... I think the end is really the combination of everything ... the issue of raw materials ... that's not a technology, but I think that only with a raw materials strategy at the European level can we have any independence at all ... if the next dependency is not gas, it's cobalt or nickel or whatever they mine a lot of ... above all smart energy management will be key
What barriers do you see to the widespread adoption of green technologies in the energy sector and if so, how can they be overcome?	open	The basic problem is always there where the infrastructure does not work ... where it is old, where data is unreliable, where processes are not digitalised, it is simply difficult for Greentech. So it's hard for green tech to gain a foothold the ... so as Barrier, I would say, lack of infrastructure, especially of digital infrastructure.
In your opinion, how does the Russia-Ukraine conflict affect investments in green technologies?	open	For me, it is primarily a political and social development that goes hand in hand with this ... feeling that even before that there were efforts to push capital flows towards the Greentech in the direction of generally more sustainable investments ... in this respect, I find it difficult to attribute this to the war, because I think that in principle there was already a movement that has been there for a long time.
How will the increased adoption of green technologies in the energy sector impact energy prices and the cost of living for consumers?	open	...huge opportunity ... no one really understands electricity. no one understands how and what is written on their electricity bill, no one understands how this price comes about ... something that, in case of doubt, most Germans don't even bother with ... green technologies have the chance to involve consumers really actively ... the word democratisation is a bit hackneyed, but it's the democratisation of the energy transition and that's not just a bit of well-being, but it's quite clear, to understand what I'm actually doing ... huge opportunity for real cost reductions and optimization
How important do you think collaboration between different actors (entrepreneurs, policy makers, energy companies) will be in driving the adoption of green technologies in response to the Russia-Ukraine conflict? (ranking where 1= not important at all, 5= extremely important)	ranking	4
Is your company part of an (open) innovation network or knowledge transfer ecosystem?	Yes/no	no (annotation: not yet)