Analysis of usage behavior and investigation of factors influencing the use of electricity from renewable energy sources in Germany

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Kurzfassung

Diese Studie untersucht, was die Absicht der Menschen beeinflusst, erneuerbare Energien zu nutzen und erforscht die Lücke zwischen Einstellungen und tatsächlicher Nutzung sowie Zahlungsbereitschaft. Eine Online-Umfrage wurde mit Teilnehmern aus verschiedenen Hintergründen durchgeführt. Die Analyse zeigt, dass Einstellung, Engagement und Politik die Hauptbeeinflusser sind, während Umgebung und subjektive Normen keinen Einfluss haben. Die Studie findet auch eine Diskrepanz zwischen positiven Einstellungen gegenüber erneuerbaren Energien und deren tatsächlicher Nutzung, und dass die Menschen nur bereit sind, einen Preis zu zahlen, der den aktuellen Strompreisen ähnelt. Der finanzielle Aspekt benötigt aufgrund von Umfragebeschränkungen weitere Forschung.

Abstract

This study investigates what influences people's intent to use renewable energy and explores the gap between attitudes towards and actual use of it, as well as willingness to pay. An online survey was conducted with participants from diverse backgrounds. The analysis reveals that Attitude, Commitment, and Politics are the main influencers, while Surroundings and Subjective Norms have a very low impact. The study also finds a discrepancy between positive attitudes towards renewable energy and its actual use, and that people are only willing to pay a price similar to current electricity rates. The financial aspect needs further research due to survey limitations.

1 Introduction

Germany's energy transition represents one of the most significant challenges in its history, marking the first time a society has consciously decided to completely transform its entire energy system [1]. This transformation, driven by the expansion of renewable energies, has led to a noticeable reduction in the use of fossil fuels and a 27% decrease in greenhouse gas emissions between 1990 and 2015 [2].
The expansion of renewable energies, including water, wind, geothermal energy, and biogas, is a key element of this transformation. Other contributing factors include increased energy efficiency, market, and system integration of renewable energies into the German power and heat grid, and the expansion of the grid and storage [1].
The success of this transformation depends on the cooperation of politics, business, science, and civil society, as well as the acceptance of the costs associated with the conversion and changes in consumption behavior [1]. The conventional German energy system, based predominantly on centralized large oil, gas, coal, and nuclear power plants, differs significantly from the demand-independent and distributed production of renewable energies [3][4].
The cooperation of all parties affected by the infrastructure changes, including citizens, municipalities, investors, citizens' initiatives, operators, and environmental protection associations, is crucial for the expansion [3][4].
The clean energy transition requires the involvement and cooperation of citizens and users of energy, including changes in their own households, sharing the costs of investments in renewable energies, changes in mobility behavior, and participation in planning procedures [3][4].
In recent years, the consequences of climate change, such as the rapid melting of glaciers or long periods of drought, have become increasingly evident [5]. Climate change is a global problem acknowledged by most people [6]. Many people are aware of the ecological benefits of renewable energies and want to contribute to mitigating climate change [7]. This paper uses a representative survey to explore how sustainable people in Germany consider themselves to be and how positive knowledge about electricity from renewable energies influences their choice of electricity supplier [7].

2 Background

2.1 The energy industry in Germany

The energy sector in Germany is a vital industry, employing over 496,000 people in more than 1,000 companies as of 2018 [8]. This sector has seen a dynamic shift towards renewable energy sources in recent years, largely due to the influence of the Renewable Energy Sources Act (EEG) [9]. This shift has brought about new demands on the sector, particularly the need for more flexibility from conventional power generating plants [8].
The value chain in energy production is a complex process that begins with the procurement of primary energy sources, such as coal, oil, gas, and biomass. These sources are then converted into useful energy like electricity and district heating in power or heating plants. This energy is then transported, traded, and sold (distributed), with the

costs for each stage forming the basis for the energy price paid by end consumers [8].
In Germany, the energy market is dominated by four major electricity producers: RWE, E.ON, Vattenfall, and EnBW. These companies play a significant role in the generation of electricity [8]. However, there is also a large number of medium-sized producers, especially local or regional municipal utilities, which often also take on the role of the basic supplier. As a result of the clean energy transition, operators of biomass, wind power, or photovoltaic plants have emerged as a new type of producer in recent years [8].
Electricity suppliers are crucial players in the energy industry, acting as intermediaries between the customer, the electricity producer, and the electricity grid. They ensure the supply of electricity to households or businesses and handle all the coordination so that the electricity reaches the point of consumption and can be billed [8].
Grid operators, on the other hand, are responsible for the infrastructure and transport routes of the electrical power. They ensure stability and that the generated electricity reaches the consumers. In Germany, there are four transmission system operators: 50Hertz Transmission, Amprion, TransnetBW, and Tennet TSO [8].
The state plays a significant role in the energy industry as a regulating instance. The power grid, which is necessary for the distribution and transport of electricity, represents a natural monopoly due to high market entry costs. As such, the state regulates the transport and distribution of electricity [11]. State-regulated transmission and distribution network charges account for around a quarter of electricity prices. In addition, the state levies other charges, taxes, and surcharges [8].
The expansion and conversion of the grid infrastructure and reliable electricity meters are crucial for a successful energy transition. More than 90% of the installed capacity from renewable energies is connected to the regional distribution grid, necessitating significant expansion [10]]. The state has also contributed to significant changes in the energy market through legislation such as the EEG [8].

2.2 Government support for the energy transition

In 1974, the federal government launched a program for energy research, which included research into renewable energies. However, at that time, energy research was primarily focused on nuclear energy. In 1979, about 65% of energy research expenditures in Germany went to nuclear fission or fusion, while renewable energies received only 4.4% of research funds [29][12].
The Electricity Feed Act, introduced in 1990, was a significant step for the energy turnaround in Germany. It obligated energy supply companies to purchase and pay for electricity from renewable sources. This law formed the basis for the expansion of renewable energies in Germany and promoted the decentralization of the energy supply [29].
From the late 1980s, climate protection became a more significant factor in energy policy [13]. However, attempts to achieve a basic consensus on energy policy in Germany were unsuccessful, marking the beginning of the nuclear phase-out in Germany [14][15][16].
The clean energy transition gained momentum from 1998 onward with the federal government of the SPD and Bündnis90/Die Grünen under Gerhard Schröder (SPD) as chancellor. The Renewable Energies Act (EEG) passed in March 2000 was the most decisive law in this respect. The EEG aimed to enable the sustainable development of energy supply in the interest of climate and environmental protection and to significantly increase the contribution of renewable energies to the power supply [17][18][9].
The latest EEG 2023 came into effect on January 1, 2023, setting the target of increasing the share of renewable energies in gross electricity consumption to at least 80% by 2030 [20].
The EEG obliges the grid operator to connect renewable energy plants to their grid on a priority basis and to purchase the electricity generated on a mandatory basis. The duration of the subsidy is generally 20 years. For plants with an output of up to 100 kilowatts, subsidies are provided in the form of a fixed feed-in tariff, differentiated according to renewable energy source, plant output and various other parameters [19].
Exceptions to the EEG subsidies are wind energy and photovoltaic plants above a certain capacity. For these plants, the level of remuneration is not uniformly specified, but is determined in tenders. Tenders to determine the level of support were first included in the EEG in 2014 and initially only applied to ground-mounted photovoltaic systems for testing purposes [19].
The subsidies are financed by the end consumers, to whom the costs are passed on. Since 2021, the EEG surcharge has been partially covered by payments from the federal budget and the EEG surcharge has been reduced. In order to quickly relieve electricity customers of the steep rise in energy costs, the Bundestag passed a resolution on April 28, 2022 to completely eliminate the EEG surcharge. From July 1, 2022, electricity customers will no longer have to pay the EEG surcharge [19][21].

2.3 Environmental and climate debate in Germany

The environmental and climate debate in Germany has a rich history, closely tied to global warming and the energy transition. The burning of fossil fuels for energy and the resulting CO2 emissions are key contributors to climate change, with the energy sector accounting for a large proportion of climate-harming greenhouse gases. The environmental and anti-nuclear power movement of the 1970s marked the start of the energy transition in Germany [22][23].
The modern European environmental movement is considered to have begun with the European Year of Nature Conservation in 1970, which saw the first Europe-wide environmental campaign with over 200,000 actions. In Germany, an environmental movement emerged in the 1970s, spurred by a shift in thinking about the environment and a desire to protect natural resources and combat pollution [24].

The anti-nuclear movement gained momentum following the Chernobyl nuclear power plant disaster in 1986, and the so-called ‚Waldsterben' (forest dieback) became a focal point for the environmental movement in the Federal Republic [24]. The environmental movement expanded to federal level by the end of the 1980s, influencing political discourse on issues such as waste disposal, animal fattening, the growing hole in the ozone layer, and forest dieback in South America [25].
The reunification of Germany in 1990 marked a new era for environmental movements. Public debate about environmental protection grew louder in the territory of the former GDR, leading to the formation of Bündnis 90, a coalition of citizens' movements and opposition groups in the GDR, in February 1990. This party later merged with the Green Party, and both ran as one party in the 1994 Bundestag elections under the name Bündnis 90/Die Grünen, winning 7.3% of the vote and 49 seats in the Bundestag [26].
The creation of the European Union in 2000 had a significant impact on environmental policy in Germany, introducing numerous environmental laws and directives that required greater regulation of industry and cooperation between member states [27]. The Kyoto Protocol set a binding limit for greenhouse gas emissions under international law, and Germany ratified the Protocol on May 31, 2002, committing to reducing greenhouse gas emissions by 21% in the period 2008 to 2012 compared to 1990 levels [28].
The environmental movement experienced a surge of globalization in the 1990s, with established environmental organizations such as WWF, Greenpeace, and BUND beginning to operate at international level and forming global coalitions. This led to the German environmental movement becoming more diverse, recognized, and international, both in its issues and in its forms of action [29].
In recent years, climate protection has become a central pillar of the environmental movement. Movements like Fridays for Future and Letzte Generation have become voices for the fight against the climate crisis and have helped making climate action a central issue in the political debate [30].
Despite increased awareness and acceptance of climate protection and the energy transition, there is a discrepancy between people's general attitude toward renewable energy and their attitude when they are directly affected by measures to obtain it. While there is a high approval rate for the expansion of renewable energy plants, approval decreases when it comes to the construction of new plants in the vicinity of their own residence [31]. This discrepancy highlights one of the basic problems standing in the way of the energy transition [32]. Despite the high approval of renewable energies, the expansion is characterized by local acceptance problems [32]. This shows that a generally positive attitude towards renewable energies is not yet sufficient to drive the energy transition [32].

3 The experiment design

3.1 Statement of the problem

Energy is crucial for economic and social development, and the decision, made by politicians, for the energy transition and the expansion of renewable energies is supported by the majority of the population [33]. Despite the impact of the Corona pandemic in 2020 and the resulting change in the focus of the topics discussed in public, environmental and climate protection remained important topics for many people. The moral dimension of these debates has become increasingly important, with ethical obligations towards the environment, future generations, and other living beings being emphasized [33]. Most people desire to be perceived as moral, leading to many striving to present themselves as sustainable and environmentally conscious, particularly on social media [34]. However, this presentation often involves little sacrifice and personal commitment and may not align with a person's behavior in real life [34]. An example of this is the consumption of organic food. While surveys indicate an increase in the number of people claiming to buy organic food frequently, this increase is not reflected in total food sales in Germany [35][36][37].
The expansion of renewable energy facilities has been supported by subsidy programs such as the EEG subsidy system. However, despite high approval levels, the expansion of renewable energies is stagnating, partly due to a lack of approval for expansion projects and the high societal cost of renewable energy [37].
This paper investigates the discrepancy between general approval and actual willingness to use renewable energies and the factors that drive this behavior. The next chapter will describe the general procedure and the collection of data in more detail.

3.2 General description and survey

This paper aims to compare the general attitude towards electricity from renewable energy sources with actual usage. A representative group of users were surveyed about their general attitude towards renewable energy, and the discrepancy between the general approval and actual use of such electricity is examined. The influence of the participants' social environment, education level, income, and willingness to use electricity from renewable energy sources is also investigated.

The specific research questions to be answered are:

I) What are the factors that influence people to use renewable energy?
II) What is the relation between attitude and use of renewable energy?
III) What are people willing to pay for electricity from renewable energy sources?

The survey involved 1090 participants, 76% of whom completed it. Each participant was at least 18 years old. Participants were reached through personal contact, social media, and multiple email distribution lists. After

participating, they were asked to share the survey within their networks.
The survey is divided into three chapters. The first chapter collects general information about the participant. The second chapter asks about the participant's personal attitude towards the use of electricity from renewable energy sources. The third and final chapter asks about the participant's personal attitude and opinion on the use of electricity from renewable energy sources.

4 Results and analysis

4.1 Results of the survey

This chapter provides a comprehensive summary of a survey conducted with 1090 participants, focusing on their attitudes and perceptions towards renewable energy sources. The survey is divided into three sections, and the analysis excludes participants who did not agree to the terms or did not complete the survey.
In the first section, general demographic information about the participants was collected. The gender distribution was 57.2% male, 40.8% female, and 1.2% diverse.

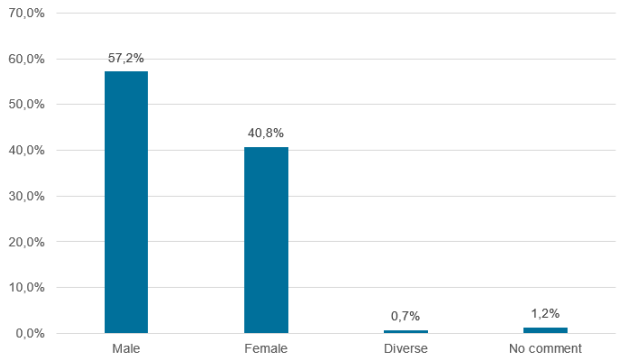

***Figure 1**: Result of Q2: Gender distribution of participants*

The majority of participants were between 30 and 44 years old. In terms of education, over two-thirds, or 67.6%, of the participants held an academic degree.

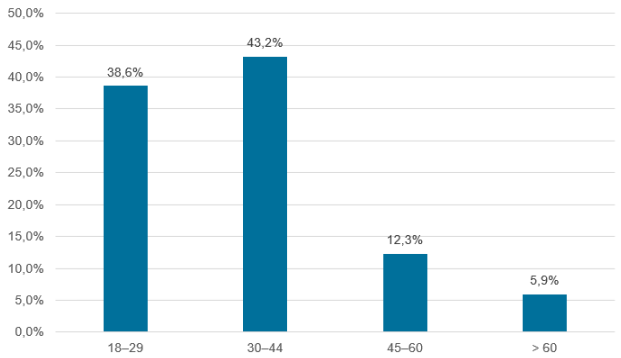

***Figure 2**: Result of Q3: Age of the participants*

When it came to income, a quarter of the participants earned less than 19,999 € annually, while 6.6% earned 100,000 € or more. Most participants, 55.4%, lived in large cities with over 100,000 inhabitants, and 47.9% lived in rented apartments.

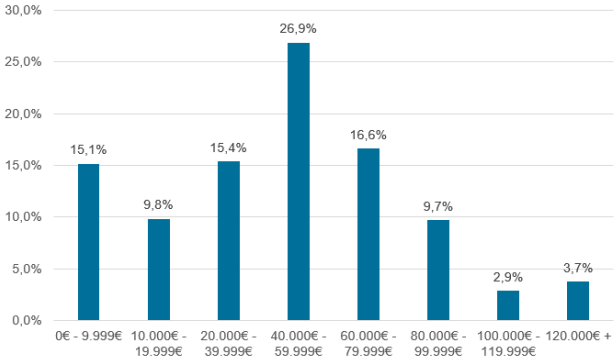

***Figure 3**: Result of Q5: Annual income of the participants*

The second section of the survey focused on the participants' attitudes towards renewable energy sources. Most participants agreed with the idea of using electricity from renewable sources, with 61.4% strongly agreeing that using electricity from renewable energy sources to power their household is a good idea. Furthermore, 75.6% of participants agreed or strongly agreed that they were generally willing to pay more for environmentally friendly products. The participants also expressed a high level of concern about environmental issues, with 85.6% agreeing that they were concerned about environmental problems such as global warming.
The third section delved deeper into the participants' attitudes towards electricity from renewable energy sources. Almost half of the participants, 48.9%, saw a high to very high positive influence of electricity customers on the development and expansion of renewable energy sources. Over 60% considered it likely that they would purchase their own renewable energy system to generate electricity. If given the choice, 77.6% of participants stated that they would prefer to use self-generated electricity from a renewable energy source.
However, there were also barriers to the adoption of renewable energy. The main barrier was the high price, with 64.5% of participants stating that too high prices would be the main reason for them not to switch to renewable energy sources. The second most common reason, cited by 27.1% of participants, was the belief that the transition to renewable energy is the responsibility of the government, not individuals.
The results of this survey provide valuable insights into the public's attitudes towards renewable energy. Understanding these attitudes can help inform strategies for promoting the adoption of renewable energy, addressing barriers to its use, and highlighting the benefits of renewable energy sources.

4.2 Analysis of different groups

This chapter outlines the methodology used for analyzing the survey results based on different participant groups. The participants were grouped according to age, residential area, highest level of education, and annual income. This allowed for more targeted insights into different groups' attitudes towards electricity from renewable energy sources.

For the age and residential area groups, participants directly selected their respective subgroup in the survey. For the average annual income group, various response options were summarized.

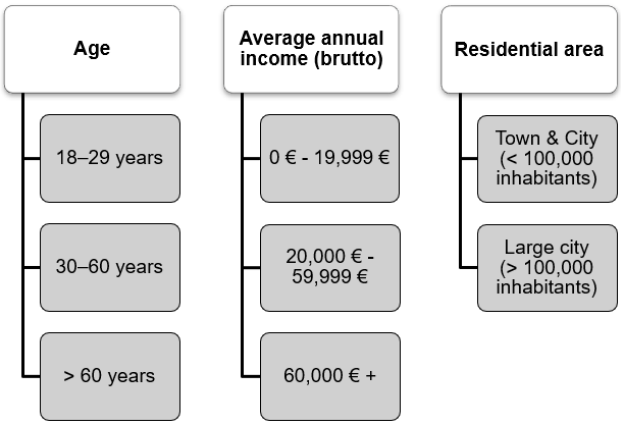

***Figure 4**: Differentiating characteristics Age, Average annual income (brutto) and Residential area with subgroups*

This resulted in three subgroups for age and average annual income, and two subgroups for residential area, creating a total of 18 peer groups.
However, some of these groups had fewer than 20 participants, which limited the reliability of the analysis. As a result, these groups were excluded from the analysis. This affected groups with unusual combinations of differentiating factors, such as people under 30 earning more than 60,000 €, or people between 30 and 60 earning less than 20,000 €.
Additionally, the 60+ years age group was not well represented, so this group was analyzed as a whole without further differentiation by income or residential area.

Peer group: Age (years): Average annual income (€): Residential area:	**PG1** 18–29 1–19,999 Town&City	**PG2** 18–29 1–19,999 Large city	**PG3** 18–29 20,000–59,999 Town&City
Peer group: Age (years): Average annual income (€): Residential area:	**PG4** 18–29 20,000–59,999 Large city	**PG6** 18–29 60,000+ Large city	**PG7** 30–60 1–19,999 Town&City
Peer group: Age (years): Average annual income (€): Residential area:	**PG9** 30–60 20,000-59,999 Town&City	**PG10** 30–60 20,000-59,999 Large city	**PG11** 30–60 60,000+ Town&City
Peer group: Age (years): Average annual income (€): Residential area:	**PG12** 30–60 60,000+ Large city	**PG 19** 60+	

***Figure 5**: Peer groups with enough participants to be evaluated in the analysis*

After these adjustments, the remaining groups were analyzed according to the three research questions.

4.3 Analysis of the experimental results

4.3.1 Research question I – What are the factors that influence people to use renewable energy?

The research uses Structural Equation Modeling (SEM), a multivariate analysis method, to examine complex relationships between variables. SEM is particularly useful for examining associations between measurable and latent variables, allowing for the estimation of direct and indirect effects between variables. This method is also used in psychology and marketing research to test theories and evaluate how well they fit the data.
The analysis is performed using RStudio software. The data set consists of 26 variables, including age, average annual income, residential area, and responses to 23 questions from Chapter 2 of the survey. After eliminating missing values, the data set was reduced from 811 to 794 observations.
Factor analysis was then performed to identify common factors and reduce variables in the data set. This process assumes that the variables are distributed normally, which was verified using the Multivariate Normality Test. The results of the test showed that the internal consistency values of the variables are very high, as indicated by the alpha reliability coefficient of 0.9345. This suggests a high reliability of the data and that the variables truly belong together and are not the result of random measurement errors.
The six factors identified through factor analysis explained 61.3% of the total variance in the data set. The chi-square test showed a significant deviation from the null hypothesis, which states that the data are randomly distributed. This indicates that the assumption of six factors is the best explanation for the data.
The factors were named as follows: Intention, Commitment, Subjective Norms, Attitude, Surroundings, and Politics.

Factor 1 – Intention	Intention to use electricity from renewable energies for the supply of the own household in the (near) future
Factor 2 – Commitment	Willingness to make personal sacrifices, such as higher electricity costs, in order to use electricity from renewable energy sources
Factor 3 – Subjective norms	Believe that the use of electricity from renewable sources is something good and has a positive effect
Factor 4 – Attitude	General attitude towards electricity from renewable energies
Factor 5 – Surroundings	People in the personal environment who influence the opinion
Factor 6 – Politics	Political decisions

Figure 6: Assignment of the factors based on the assigned variables (questions) with explanation of the factors

These factors form latent variables, which are not directly measurable variables, but are estimated on the basis of several observable indicators, such as the questions at hand. They are used to explain correlations between variables in a model.
The SEM was constructed based on these factors, and the model was tested for fit. The test results showed that the

model has a good fit to the data, with a chi-square test statistic value of 816.931 on 215 degrees of freedom and a very low p-value of 0.000. The baseline model test statistic value is 11816.679 on 253 degrees of freedom, with a p-value significance of 0.000, indicating that the user model has a much better fit to the data compared to the baseline model.

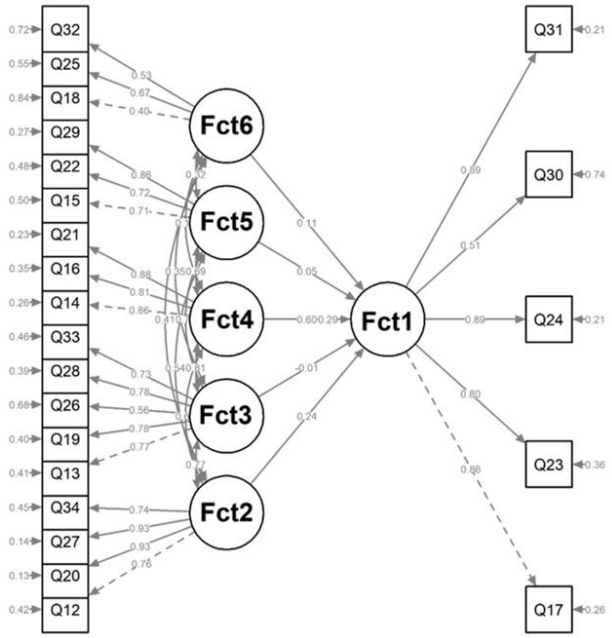

***Figure 7**: Result graph of SEM with correlation among factors and variables on each other, a higher value indicates a greater influence on the factor*

Regression analysis was performed on the complete data set and then on comparison groups. The results showed that the Attitude factor had the largest standardized coefficient, followed by Commitment and Politics. The Surroundings and Subjective Norms factors had very small and negative standardized coefficients, indicating very little influence.
The analysis showed that the factors Attitude and Commitment had the greatest influence across all comparison groups. The Commitment factor influenced the Intention factor for 8 of the 11 comparison groups, while the Attitude factor influenced the Intention factor in 9 of the 11 comparison groups. In 8 of the 11 comparison groups, Attitude was the factor with the highest influence on Intention. This suggests that people's attitudes towards renewable energy and their commitment to personal sacrifices for renewable energy use are the most significant factors influencing their intention to use renewable energy in the future.

4.3.2 Research question II – What is the relation between attitude and use of renewable energy?

The second research question investigates the extent to which attitudes toward renewable energies influence their actual use. The analysis uses the two factors, Attitude and Intention, from the factor analysis of the first research question. The Wilcoxon test, a non-parametric hypothesis test, is used for the analysis. This test investigates whether two samples are significantly different from each other and allows the null hypothesis that the means of the two samples are the same to be tested against the alternative that they are different.
The data set cleaned in the previous chapter is used for the analysis. The mean is taken from questions Q17, Q23, Q24, Q30, and Q31 belonging to factor 1 - Intention, and from questions Q14, Q16, and Q21 belonging to factor 4 - Attitude. The Wilcoxon test is then performed using the RStudio software.

PG	Age (years)	Average annual income (€)	Residential area	p-Wert
	Complete cleaned data set			< 2.2e-16
1	18–29	0–19,000	Town & City	1.522e-08
2	18–29	0–19,000	Large city	< 2.2e-16
3	18–29	20,000–59,000	Town & City	4.079e-06
4	18–29	20,000–59,000	Large city	3.623e-07
6	18–29	60,000 +	Large city	0.001455
7	30–60	0–19,000	Town & City	0.0001289
9	30–60	20,000–59,000	Town & City	9.001e-09
10	30–60	20,000–59,000	Large city	1.753e-05
11	30–60	60,000 +	Town & City	0.002076
12	30–60	60,000 +	Large city	3.432e-07
19	60+	–	–	0.002649

***Figure 8**: Results of the Wilcoxon test of the entire data set or the peer group with the p-value for evaluating the null hypothesis*

The results of the analysis show that for both the comparison groups and the entire data set, the Wilcoxon test p-value is < 0.05, and the null hypothesis can therefore be rejected. This means that there is significant evidence that the mean values of the two factors, Attitude and Intention, are significantly different from each other. In other words, there is a difference in response behavior for both factors, indicating that attitudes toward renewable energies do have an influence on their actual use.

4.3.3 Research question III – What are people willing to pay for electricity from renewable energy sources?

The third research question investigates the participants' actual willingness to pay for electricity from renewable energy sources. In part 3 of the survey, questions 38 and 39 ask participants to indicate what price they consider reasonable, or would be willing to pay, for one kilowatt hour of electricity from renewable energy sources.
The results of question 38 show that 29.3% of the participants consider a price of 26–35 cents per kilowatt hour to be appropriate. To get a more detailed view, the weighted average price is calculated by taking the middle of each price category, multiplying it by the percentage, and then summing up these values. This results in a weighted average price from question 38 of 23.9 cents per kilowatt hour.

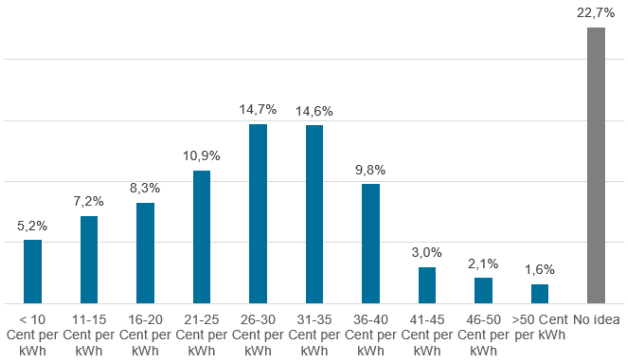

***Figure 9**: Results of Q38: What would be an acceptable price for electricity from renewable energy sources that you would be willing to pay?*

In question 39, participants were able to use a slider to set the price they would be willing to pay for a kilowatt hour of electricity from renewable energies. The average electricity price chosen by all participants was 29.65 cents per kilowatt hour.
The results of these analyses provide valuable insights into the actual willingness of participants to pay for electricity from renewable energy sources. The next chapter will evaluate and analyze the results of the three research questions.

5 Discussion and Conclusion

This chapter provides an exhaustive discussion on the findings derived from an analysis conducted on the factors influencing the use of renewable energy. The analysis was based on several research questions that were formulated with the primary aim of identifying ways to influence the usage behavior of renewable energies. This is a topic of great importance, considering the significant role renewable energies play in reducing environmental pollution and mitigating the effects of climate change.
The first research question was addressed using a structural equation model. This model was employed to determine which factors have the greatest impact on the use of renewable energy. The results of the analysis suggest that the most influential factor is the attitude towards renewable energy. This finding aligns with the general understanding that a person's attitude often underlies and determines his or her actions and decisions. Therefore, a generally positive attitude towards renewable energy means that it is more likely that a person will use it. Other factors that can influence a person's attitude include their perception of the benefits of renewable energy or their rejection of fossil fuels. Additionally, the willingness of people to use renewable energy (Commitment) has an influence on the Intention to use electricity from renewable energy, although not as big an influence as the attitude. This means that people who are willing to invest time and energy in switching to renewable energy are more likely to use it.

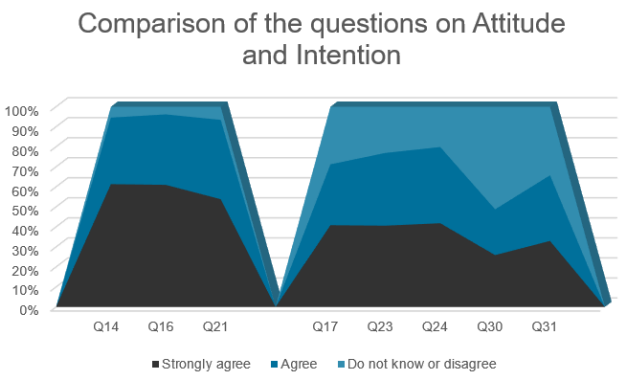

***Figure 10:** Comparison of the approval for the use of electricity from renewable energies in the questions on the factors Attitude and Intention*

The second research question builds on the first by examining in more detail people's attitudes and intentions to use renewable energy. For this analysis, the Wilcoxon test was conducted. This test was used to examine whether there is a difference in central tendency between renewable energy attitudes and intention to use. The results of this test for all groups rejected the null hypothesis and confirmed the alternative hypothesis. According to the alternative hypothesis, there is a difference with respect to the central tendency of the answers to the questions of both factors. This suggests that positive attitudes toward renewable energy alone are not sufficient to completely influence intention to use. It appears that other factors such as availability, price, and individual circumstances not considered in the analysis play a significant role.

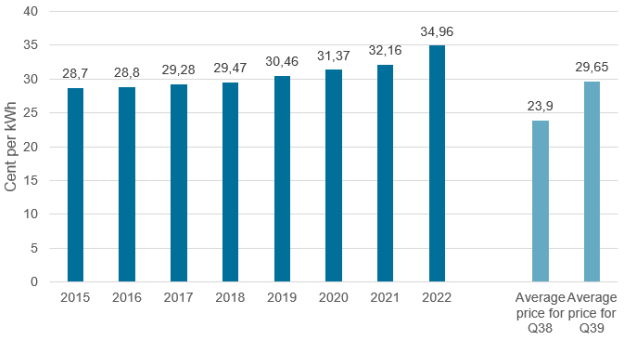

***Figure 11**: Comparison of the electricity price from 2015-22 and the indicated average price for a kilowatt hour in Q38 and Q39*

The third research question explores what price for electricity from renewable energies the participants consider to be reasonable. The results of this analysis show a discrepancy between the price participants are willing to pay for renewable energy and the current electricity price. Despite expressing a willingness to pay more for renewable energy, when asked about specific prices, participants were not willing to pay more than the current electricity price. This suggests that the price of electricity is a significant factor in the intention to use renewable energy.

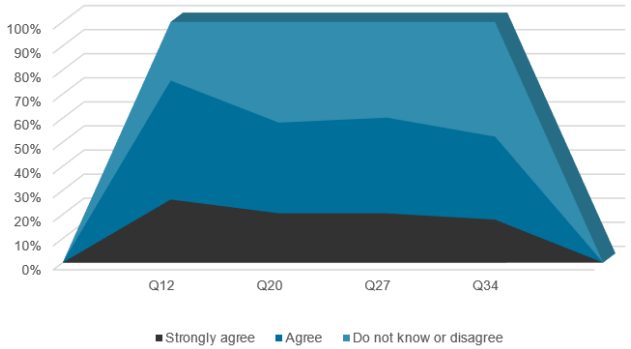

***Figure 12**: Illustration of agreement to the questions of Factor 2 - Commitment*

In conclusion, while a positive attitude towards renewable energy is an important factor, it does not guarantee its use. The price of electricity is also a significant factor in the intention to use renewable energy. Therefore, it is crucial to make renewable energy prices affordable for consumers and to raise awareness about the environmental impact of electricity consumption. Future research in this area is needed to explore other factors that may influence the intention to use renewable energy. This could include factors such as the availability of renewable energy sources, the perceived benefits and drawbacks of using renewable energy, and the influence of government policies and incentives on renewable energy use. Furthermore, it is essential that people are and become fully informed about the environmental impact of electricity generation and consumption to fully appreciate the value of their contribution through the price of electricity and of renewable energy sources. This will help in encouraging more people to switch to renewable energy sources, thereby contributing to the global efforts to combat climate change.

Moreover, the study also found that the factor Politics also has an influence on the Intention to use electricity from renewable energies, although by far not as strong as the influence of Attitude and Commitment. This implies that policies such as laws, incentives, and subsidies positively influence the intention to use renewable energy, although people's personal beliefs and attitudes have more influence on intention. However, it is conceivable here that political measures positively influence people's attitudes with political speeches, incentives, or campaigns.

In addition, the analysis also revealed that the Surroundings and Subjective Norms, on the other hand, have only a very small influence on the Intention to use renewable energy. This means that the Surroundings, such as the opinion of friends or family, have little to no influence on the intention to use electricity from renewable sources. The same is true for Subjective Norms, which is the belief in the positive effect of renewable energy, which like the Surroundings has almost no influence on the intention to use renewable energy.

The study also highlighted the importance of peer groups in influencing the intention to use renewable energy. The factor with the most decisive influence on Intention is in Peer group 1. The participants in peer group 1 are 18–29 years old, have an annual income of 1–19,999 € and live in a town or city with less than 100,000 inhabitants. Here it can be assumed that this combination fits to many students in the peer group, who can be assumed to have a certain affinity to sustainability.

Overall, the findings of this study provide valuable insights into the factors influencing the use of renewable energy and highlight the need for further research in this area. The results also underscore the importance of making renewable energy more affordable and accessible to consumers, and of raising public awareness about the benefits of renewable energy and the environmental impact of electricity consumption.

6 Critical Review and Outlook

The analysis presented in the previous chapter, while providing valuable insights, has several limitations that need to be critically examined. The conclusions drawn from this analysis should be viewed with reservation, as they require further research for validation and expansion.

The first limitation pertains to the representativeness of the data set used for the analysis. The participants in the data set only correspond to the structure of German society to a limited extent, particularly in terms of academic qualifications and age distribution. For instance, the proportion of academics in the data set is not comparable with the population in Germany, and the age distribution in the data set does not align with the actual demographics in Germany. This discrepancy has led to limitations in the statistical analyses, particularly in certain comparison groups such as age, residential area, and average annual income. Future research should aim to gather a more representative sample that better reflects the structure of German society. This would involve more balanced and targeted comparison groups, with a particular focus on underrepresented groups such as people over 60.

The second limitation is related to the structure of the survey itself. The survey was limited in its ability to capture the full range of participants' opinions due to its structure and potential lack of clarity in question wording. The questions were limited to definite answers and only a few options were given for free responses. This could have led to a restriction in the diversity of responses and potential inaccuracies. Future research should address these issues by including additional questions with open-ended response options and ensuring greater clarity and precision in question wording. This would allow for a more comprehensive understanding of participants' opinions and perspectives.

The third limitation involves the choice of the structural equation model for analysis. An important limitation of factor analysis is that it is based on several assumptions, including the normal distribution of variables and the linear relationship between variables. If these assumptions are not met, factor analysis may yield inaccurate or biased results. Even though internal consistency was demonstrated for all factors using the reliability analysis, the possibility of bias in the results remains. Future research should confirm the analysis with another statistical model and validate the assumptions made in this study.

In the regression analysis, the covariance among the factors was not included due to the scope of the work. This could mean that the influence of two factors individually did not appear significant, but in combination with another factor, they might have had a major influence. Therefore, in further research, the factors and their correlation to each other should be examined more precisely. This would provide a more comprehensive understanding of the interplay between different factors and their collective influence on the intention to use renewable energy.

The final limitation is related to the use of the Wilcoxon test for the comparison of the Intention and Attitude factors. While it can be applied to non-normally distributed data, the test has lower ability and is less sensitive, so significant differences between groups can also be overlooked. Future research should verify the results with further statistical analysis. This would provide a more robust validation of the differences between the two factors and offer a clearer understanding of their relationship.

Despite these limitations, the paper has made some progress in investigating the intention to use renewable energy and identifying factors that may influence this intention. However, further research is needed to elaborate on these factors and confirm the results of this work.

The paper suggests that financial factors, such as the price of electricity, may influence the intention to use renewable energy. It also proposes sector coupling as a measure to reduce costs for private households. This involves connecting different sectors like electricity, heating, and transport to balance energy demand and supply. Other options for lowering the price of electricity for private households include promoting solar systems for electricity generation, introducing smart grids to optimize electricity consumption, and legislating for energy-efficient household appliances.

The study provides evidence that the price of electricity influences consumers' intention to use electricity from renewable sources, alongside the statistically significant factor of Attitude. However, further research is needed to fully understand these influences and to identify other potential factors. This is crucial in order to achieve the climate targets of the Renewable Energy Sources Act.

In conclusion, while this paper has taken important steps towards understanding the intention to use renewable energy and the factors that influence it, there is still much work to be done. Further research is needed to validate and expand upon these findings, and to explore other potential influencing factors. This will be crucial in informing strategies to promote the use of renewable energy and achieve climate targets. [38][39][40][41][42]

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