The effectiveness of renewable energy policies in the American and German wind turbine industry: A mixed methods approach

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ABSTRACT

In recent years, global warming has become a primary concern for governments around the world and each country has utilized tools like regulation and funding differently in their shift towards sustainability. The aim of this study is to assess the effectiveness of renewable energy policies (REPs) on increasing installed capacity of wind turbines in the United States and Germany The investigated independent variables include subsidies, tax-incentives, regulation policies, energy consumption, wind share, levelized cost of wind, levelized cost of coal, installation cost, and household energy prices. The dependent variable is installed capacity of wind turbines. A mixed methods sequential explanatory design is used, consisting of a quantitative and qualitative component. This investigation uses quantitative priority, assigning more weight to results from the regression analysis. Data was collected from AWEA, US Energy Information Administration (EIA), EWEA, and German Federal Ministry for Economic Affairs and Energy (BMWi) for the years 1987-2017 to perform an ordinary least squares (OLS) regression analysis. Consequently, a series of semi-structured interviews are conducted with representatives of one German and one American utility supplier to develop a case study for the respective countries. The results indicate that regulation and subsidy have a strong positive relationship between to installed capacity. The impact of tax-incentives was not found to be statistically significant.

Keywords: Renewable energy policy, German wind industry, American wind industry, Regression analysis, Innovation

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TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background

In the past decade, the global economy has experienced significant growth and energy consumption has been increasing accordingly by 2.3% per year according to (IEA, 2019). Considering that the most common sources of energy used around the world are fossil fuels such as coal and oil, carbon dioxide emissions have also risen steeply. As a result, the negative effects of climate change have become a global concern and led to investments in renewable energy. It is also widely recognized that renewable energy sources like wind turbines and solar panels to hold many benefits, among which are carbon emissions reductions, energy security and economic benefits. (Zahnd & Kimber, 2009) concluded that investment in renewable energy technologies will create local jobs, alleviate poverty and offer prosperity to developing regions. (Buonocore, et al., 2016) found that renewable energy will see to a betterment of public health standards, financial savings and provide energy stability.

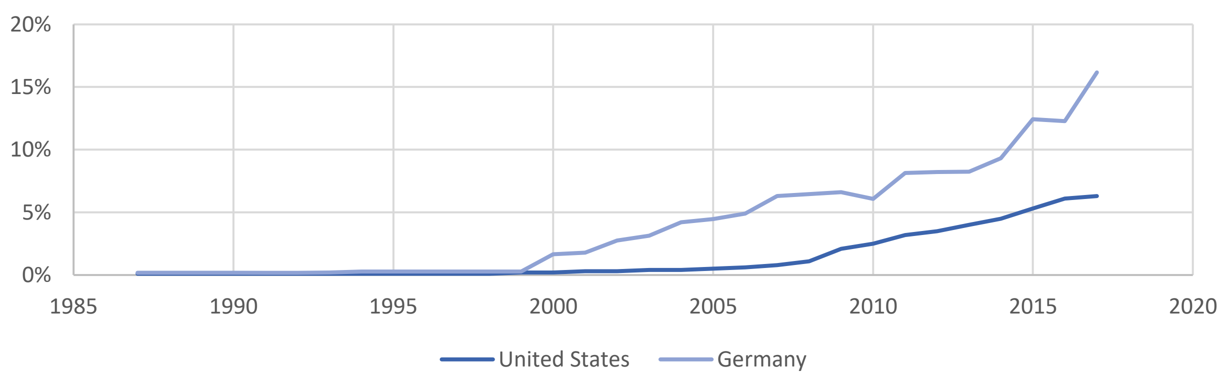
While renewables offer great potential for social and economic benefits, its current presence in the global energy mix is relatively minor. According to (IEA, 2018), 25% of energy generation originates from renewable energy and is expected to increase to 30% by 2022. This is likely the result of the high initial investment associated with wind turbines and solar panels compared to coal and other non-renewables (Beck & Martinot, 2004). One prevalent approach to overcome this downside is to implement instruments called renewable energy policies (REPs), generally involving the use of subsidy, tax incentives, and regulation.

The effectiveness of renewable energy policies (REPs) has thus been the subject of numerous studies and investigations focusing on different countries, policies, and renewable energy technologies. Most studies focus on economic instruments like subsidies (Nicolini & Tavoni, 2017; Kalkuhl et al., 2013; Polzin et al., 2015). Other studies compared the effectiveness of REPs between a collective of countries, mostly comparing continents or using large panel data. (Zhao et al., 2013) conducted a study using panel dataset of 122 countries to determine effectiveness of REPs finding investment incentives and feed-in tariffs to be the only effective instruments. (Kilinc-Ata, 2016) examined policies used across European countries and compared these to US states finding feed-in tariffs and tax cuts to be effective policies. Only a small amount of research accounted for regulation as a variable. (Carley, 2009) conducted an empirical investigation in the United States focusing on state-level policies, creating an index to resemble the extent a state utilizes policy as a REP based on data from 1998-2006. (Delmas & Montes-Sancho, U.S. state policies for renewable energy: Context and effectiveness, 2011) analyzed the effectiveness of Renewable Portfolio Standard (RPS) and Mandatory Green Power Options (MGPO) finding these instruments to have a significant impact on installed renewable capacity.

This study is relevant because renewable energy technologies are considered as a key solution to climate change and an economic opportunity by intergovernmental organizations, businesses, and academics alike. Investing in renewables has historically been a difficult objective due to the high fixed costs associated and incumbent position of the fossil fuel industry. This is especially the case for industrialized countries like the United States and Germany due to the low cost of fossil fuels. (EIA, 2018) reported that the energy mix in the US is heavily dependent on coal, oil and natural gas as 77.6% of electricity is generated from fossil fuels. In the case of Germany, (CEW, 2019) reported that 53.3% of energy came from non-renewable sources. Even though both countries are members of the G-7 as some of the most powerful economies countries around the world, both continue to rely on fossil fuels. This makes both the USA and Germany interesting samples for studying the effectiveness of renewable energy policies.

The significance of the wind turbine industry in the United States and Germany is its fast growth. As a matter of fact, it is the world's fastest-growing energy source, according to (EERE, 2019). This can also be observed in Figure 1 below. Furthermore, wind turbines are known for their large-scale applications, reliability, and efficiency (Boxwell, 2019). Organizations in the wind energy industry thus play a key role in providing employment, reducing emissions, and offering local and national electricity solutions. Due to the urgency of the global warming issue, the American and German governments are today utilizing REPs to further grow installed capacity of wind turbines using subsidy, tax cuts and regulation.

Figure 1. Percentage of Energy Generation from Wind Sources in the United States and Germany during years 1987-2017



1.2 Research objective

The motivation for this research is to provide further empirical evidence on the relationship between renewable energy policy implementation and installed capacity of wind energy in the United States and Germany. Research in this topic is important as it helps politicians and governments with decision-making and allocate their assets efficiently, whether these are time or money.

This paper aims to contribute to literature by making a comparison between Germany and the United States in their use of regulation, subsidy and tax-incentives and its impact on installed base of wind turbines using data from the last 30 years. This analysis adds to previous studies in two ways. First, there is still a scarcity of empirical investigations into the effectiveness of REPs focusing on installed capacity of wind turbines as done by (Dong, 2012). Studies like (Palmer & Burtraw, 2005) focus on electricity prices and patent issuance (Johnstone et al., 2009) instead of impact on the electricity generated. Also, most studies consider renewable energy without distinguishing between different sources (Sun & Nie, 2015; Nicolini & Tayoni, 2017, Shrimali, 2017). Secondly, many studies compare a large sample of countries or aggregate a continent for analyses without regard for their level of economic development (Zhao et al, 2013, Liu, et al, 2019; Giest & Mukherjee, 2018). This study serves to bridge the gap

The purpose of this investigation is to identify the relationship between regulation, tax incentives, subsidy, energy consumption per capita, levelized cost of energy of wind turbines and coal, electricity prices, life-cycle costs and the dependent variable installed capacity of wind turbines. A dataset is created using data from 1987-2017 on the US and Germany considering the variables. All data gathered during this study is obtained from the German Ministry of Economics and Energy (BMWi, 2018; 2019), American and European Wind Energy Associations (AWEA; 2017; EWEA, 2009), Energy Information Administration (EIA 2017; 2018; 2019), and the International Energy Agency (IEA, 2018). Thus, the following research question is formulated:

To what extent does renewable energy policy stimulate the development of wind turbines in the German and American wind energy industry?

This study takes a sequential mixed-methods approach in accordance with (Creswell et al., 2003). This explanatory design has two data collection phases: quantitative followed by qualitative. The quantitative component consists of an ordinary least-squares (OLS) regression model to represent the effect of the regulation, economic, industry-specific and macroeconomic variables have on installed capacity of wind energy. The empirical model is based on the method used in research by (Carley, 2009), analyzing the relationship of variables on installed capacity and total renewable energy share. The qualitative component consists of a case study based on interviews and relevant documents of an organization operating in the wind energy industry of the US and another organization in Germany. This method is identical to the qualitative study by (Musall & Kuik, 2011) doing a case study on local acceptance of renewable energy projects in Germany. The results are compared and triangulated with emphasis on the quantitative results. Thus, if the results from the regression contradict results from the interview, the quantitative outcome will be accepted over the qualitative results. This study will compare data from interviews, data and past studies from peer-reviewed journals, refer to Appendix D for visual model.

In terms of practical relevance, the results of this study are helpful to policymakers and governments when considering implementation of renewable energy policies to stimulate development of renewable energy technology. The presented regression model can be used during decision-making, strategy-setting, and policy reflection enabling efficient allocation of public funds.

This paper is structured as follows; Chapter 2 provides an overview of literature and past studies. Chapter 3 explains the data and methodology used to determine the effect of REPs on installed capacity of wind turbines. Chapter 4 interpretation and discussion of the empirical findings and Chapter 5 presents the conclusions and their relevance to practical applications.

2. LITERATURE REVIEW

2.1 Regulation variable

Today, environmental policy and regulation supporting renewable energy is a conflicting topic in media and politics. Although, past studies have found relatively one-sided results on the effectiveness of regulation. In the case of the wind turbine industry, regulation is regarded to as federal level bills that encourage or require investment in this sector. A modern example of this are portfolio standards, such as Renewable Portfolio Standards in the United States, requiring a certain percentage of renewables in a utility supplier's portfolio. (Casals, 2006) studied government involvement in the European energy market finding current legislation to have serious shortcomings in terms of reducing energy consumption. (Kaya, 2006) conducted a similar investigation focusing on regulation in Turkey supporting renewable energy investments. It was concluded that regulatory policies were effective, noting limitations of financial support models. (Nesta et al., 2014) analyzed REPs in OECD countries finding that policies are crucial in stimulating innovation measured as high-quality patents. Similarly, it was found that absence of regulation creates more competition, which results in a lower quality of innovation. (Reiche & Bechberger, 2004) analyzed the successes in the German renewable energy industry finding it to have been the result of strong regulation, such as the 2000 Erneuerbare-Energien-Gesetz (EEG). (Johnstone et al, 2009) investigated the renewable energy industry based on patent counts in 25 countries and found that regulation is playing a significant role in patent applications. (Delmas & Montes-Sancho, 2011; Carley, 2009) investigated the renewable portfolio standard (RPS) program in the United States which is set out to increase the consumption of renewable energy. It was found that each year RPS was implemented, there was a significant increase in renewable energy generation. In this research, regulation will be considered as the federal-level policies, bills and laws that specifically encourage the development of wind turbines. For example, the renewable portfolio standards (RPS) in the

United States requiring a percentage of utility supplier's portfolios to be from renewable energy.

It can therefore be expected that regulation helps the installed capacity of wind energy for the following reasons: 1) policies like portfolio standards will encourage a shift towards renewables, 2) regulation enables renewables to build up economy of scale and compete with low fossil fuel energy prices, and 3) regulation establishes credibility and trust in the renewable energy market making it more attractive for investment. This prompts to the hypothesis:

H1: A greater number of legislative bills and directives in the energy industry will positively influence the installed capacity of wind turbines.

2.2 Economic variables

Subsidy as a measure to stimulate investment in renewables has received a lot of scrutiny from academics. Subsidy can generally be defined as money receive for meeting certain objectives or investments. The majority of studies showed positive results on the effectiveness of subsidy. An empirical investigation by (González et al., 2005) researched the effect of subsidy on R&D investment for Spanish manufacturing firms finding a positive correlation. A later study using a sample of 2,000 manufacturing firms (González & Pazó, Do public subsidies stimulate private R&D spending?, 2008) reinforced these results finding subsidy to be an effective tool. More specifically to the renewable energy industry, (Yang et al., 2019; Nie, et al., 2016; Nicolini & Tavoni, 2017; Newell et al, 2019, Fell & Linn, 2013) found that subsidies are effective in increasing output of renewable energy in terms of projects and capacity. Therefore, it can be expected that subsidies will positively influence the installed base of wind turbines in the United States and in Germany.

On the other hand, several studies have found subsidy to be ineffective, or even concluded a negative impact. (Toke, 2007) found economic incentives to have a negative influence on local investment in renewables. (Gneezy et al, 2011) studied economic behavior of businesses and individuals finding that extrinsic incentives like cash rewards do not serve as a flawless solution to stimulating behavior. Relative to the renewable energy industry, this would imply that in the short run businesses will participate, but motivations will change over time.

It can be expected that offering subsidies will increase for the following reasons: 1) it will reduce the high fixed costs associated with renewables making it more attractive for investment, 2) encourage larger investments by businesses into wind energy projects, and 3) subsidies enable the development of economy of scale.

H2: A higher level of subsidies on wind energy projects positively influences the development of wind turbines.

Tax incentives are another financial instrument used to stimulate behavior, investment, or business practices. In the wind turbine industry, these are commonly in the form of corporate tax income credit, production tax credits and tax exemptions. An example of this is the American Production Tax Credit awarding money on per kWh basis if produced from domestic wind turbines. Like subsidy, the majority of research found a positive relationship between tax incentives and the intended behavior. (Villca-Pozo & Gonzalez-Bustos, 2019) analyzed tax incentives and policies used in Spain to promote energy efficiency in households. The results indicated that tax benefits alone were not enough as the benefits were not experienced equally among house owners. (Yan, 2018) investigated the impact of tax incentives for electric vehicles in Europe finding that using this policy is effective in shifting demand towards electric driving. Though it may not be the most cost-effective approach, (Yan, 2018) explained that reducing negative externalities is expensive in general. (Matisoff & Johnson, 2017) studied the effect of incentives for investments in solar panels. The results show that tax incentives have contributed significantly to the growth of the solar industry. However, it was found that 2 in 3 cash incentives do not have a statistically significant impact. (Lancaster & Berndt, 1984) also investigated the effect of state income tax credits on solar panel development and found a positive correlation. (Harmelink, Voogt, & Cremer, 2006) studied the policies active in the European Union in 2010 and found that the current policies, among which subsidy and tax-incentives, have a positive influence though falls short of the ambitious goals set.

Based on the outcomes of past research, it can be expected that if a wind turbine project were to receive tax incentives from the government, then a greater level of output will be produced than in a situation where no tax-incentives were to be provided.

H3: A higher level production tax credits and tax exemptions on wind park investments positively influence the development of wind turbines.

2.3 Macroeconomic factors

Increasing levels of energy consumption are one of the reasons why global warming is receiving more attention today than ever before. Organizations like AWEA, EWEA and the IPCC have actively studied the growth of renewable energy use over time in relation to economic development and energy consumption. (BMWi, 2018) released a report including data on German renewable energy statistics. In general, it shows a positive relationship between consumption and renewable energy deployment. In other words, the renewables energy share of consumption has grown significantly in the last 20 years, especially in the wind sector. (IPCC, 2018) published a report on the effects of global warming, reiterating the need for a larger share of renewable energy in the energy mix. Especially considering the continuous growth of consumption and the resulting growth of carbon dioxide emissions. (Lund, 2007) investigated the success of renewable energy in Denmark and whether it is sustainable considering consumption growth. It was found that relying on renewables to satisfy current and future energy demands is cheaper, more efficient and beneficial in terms of emissions reductions. (Sesto & Casale, 1998) found a positive relationship between increasing energy consumption and growth in the wind energy industry. More specifically, it was concluded that wind turbines are the better option for scaling and in terms of social benefits such as providing employment and lowering dependence on imports.

Research by intergovernmental organizations and academics indicate that growing energy consumption will be met with continued growth in the share of energy from wind sources. Therefore, the following hypothesis is formulated:

H4: Increased consumption of energy positively influences the installed capacity of wind turbines.

The wind turbine industry has experienced substantial growth in the last 30 years. Limited studies have been conducted on the relationship between wind industry growth and the impact on local installed capacity. (Lewis & Wiser, 2007) performed a cross-country comparison of the wind energy industry of 12 countries finding a positive relationship between the performance of the global wind power market and domestic installed capacity. (Sahu, 2018) found that the wind energy has grown tremendously worldwide lead by China, USA and Germany. Consequently, China was found to have the largest installed capacity in the last few years.

Based on the conclusions from these papers, it can be expected that a growth in the global wind energy market, then installed capacity of wind turbines will increase as well.

H5: A larger percentage of wind turbines in the national energy mix positively influences the development of wind turbines.

2.4 Electricity trends

Levelized cost of energy (LCOE) is a common indicator for the life-time costs and benefits of energy sources, like fossil fuels, solar panels and wind turbines.

LCOE of wind turbines has been the subject of studies with various objectives. (Blaabjerg & Ma, 2013) researched the development of wind power and found that as the LCOE has been actively reducing over time, installed capacity of wind power has increased significantly. (Lantz et al., 2012) conducted a study under the US Department of Energy and expects future costs of wind turbines to continue to decrease, as well as a continued increase of wind energy presence in the energy mix. (EWEA, 2009) also expects a continued decrease of LCOE from wind turbines and a growth in installed capacity of wind sources.

LCOE of coal has not been a widely researched topic except for organizations like Lazard. (Lazard, 2019) investigated the levelized cost of energy from conventional sources finding coal to cost between $60-$143 per MWh, having been fixed for the last decade or so. Similarly, onshore wind costs between $29-$56, though has experienced a strong reduction in the same period. (Lecuyer & Vogt-Schilb, 2014) researched the energy transition from coal to renewables, finding that the reduction in LCOE of renewable energy technologies poses as a threat to coal power plants. In other words, the cost of renewables has decreased to a point where coal is the more expensive option. Extrapolating from their conclusions, this indicates that coal is a more expensive option and will likely result in an increased share and installed capacity of wind power.

Based on the Law of Demand and the conclusions from past studies, it can be expected that as the costs of wind turbines decrease, demand and thus installed capacity of wind turbines will increase. Similarly, seeing as the LCOE of Coal is relatively constant, if wind energy becomes cheaper than coal, it can be assumed that installed capacity of wind turbines will increase. Therefore, the following hypotheses are formulated:

H6: A lower LCOE Wind will increase the development of wind turbines

H7: A higher relative LCOE of Coal has a positive relationship to the installed capacity of wind turbines.

A primary concern with the increased adoption of renewable energy is an increase in retail electricity price for households. Previous investigations and literature indicate that electricity prices minimize fluctuations, and the projected impact of renewable energy is uncertain. (Iimura & Cross, 2018) found that household prices are path-dependent, suggesting that past decisions impact the current price levels. Furthermore, it was found that share of renewable energy in the energy mix has no significant impact on household electricity prices. (Martinez-Anido et al., 2016) studied the impact of wind power on electricity prices. (Quint & Dahlke, 2019) analyzed wholesale electricity prices in the US finding that adding wind turbines to the portfolio reduces electricity prices in the future of approximately $0.24 per 100MWh. (Carley, 2009) hypothesized that lower price of electricity will offer less incentive to invest in more expensive renewables, while a higher price may stimulate shift to renewable energy.

Based on the studies, it can be expected that a low electricity price results in little incentive to change the energy mix from utility suppliers. However, the potential for future price reduction can incentivize these businesses to invest in wind turbines and other renewable sources. Therefore, the following hypothesis is created:

H8: Higher retail electricity prices will increase the installed capacity of wind turbines.

The fixed costs associated with wind turbines are a commonly discussed topic in literature and media. It has also recently become the focus of studies (Benitez, Benitez & Van Kooten, 2008; Reuter et al., 2012) It is commonly stated that the higher fixed costs associated with wind turbines are the primary downside, as primarily large commercial scale applications are interesting from an investment perspective. (Morthorst, 1999) found the success of wind turbines in Denmark to be associated with greater wind turbine capacities, lowering the relative fixed costs and thus improving profitability. It was concluded that increasing capacity lead to attracting more investment from public and private sources and so shaped the successful wind power market in Denmark. It can therefore be assumed that a lower fixed cost of wind turbines will increase the capacity of wind power projects installed.

H9: Lower installation costs of wind turbines will increase the installed capacity of wind turbines.

3. METHODOLOGY

3.1 Mixed-methods approach

This study follows the mixed-methods sequential explanatory design as described by (Ivankova et al., 2006), consisting of a quantitative component leading into a qualitative component. In terms of priority, greater weight is placed on the quantitative component, or *quantitative priority* as defined by (Creswell, 2017). The reasons for taking a mixed approach are data triangulation, explaining unexpected results, and confirmation of quantitative results, in accordance with the typology by (Bryman, 2006). Following a mixed approach also facilitates a more robust analysis taking advantage of the benefits of both a quantitative and qualitative investigation (Green, Caracelli, & Graham, 1989; Miles & Huberman, 1994)

Appendix D2 shows an illustration of the research procedure followed. The first phase consists of quantitative data collection of numeric data from government, research and intergovernmental organizations. In the second phase, data analyses are performed using SPSS software including descriptive statistics, correlation matrices and ordinary least squares regression. The third phase connects the quantitative with the qualitative component, guiding questions to be asked during interviews. The fourth phase consists of a case study in accordance with (Eisenhardt, 1989) collecting data through semi-structured interviews. This is followed by the coding and analysis of data collected. Lastly, results from both quantitative and qualitative components are integrated and discussed.

3.2 Variables

In accordance with the study on renewable energy policy effectiveness by (Carley, 2009), the following variables have been selected, as shown in Table 1. The primary variables of interest are regulation, subsidy and tax-incentives as these represent renewable energy policies. However, as there is a strong possibility that other factors (i.e. rising consumption levels, cheaper energy alternatives) play a role in the installed capacity of wind turbines, hence variables consumption per capita, wind share of energy generation, LCOE wind turbines, LCOE coal, turbine installation costs and electricity price have been included.

The dependent variable is total amount of installed capacity of wind turbines measured in megawatt-hours. This is coherent with literature and other research in the field (Carley, 2009; Menz and Vachon, 2006; Bird et al., 2005; Munksgaard & Morthorst, 2008; Söderholm & Pettersson, 2011). Data for this variable is collected from IEA Wind Task reports, (IEA, 2017; IEA, 2018; IEA, 2019) and Fraunhofer ISE reports (Fraunhofer ISE, 2018).

Independent variables subsidy and taxes are measured as a weighted index of cash grants, loans and rebates and tax incentives awarded by the government in the US and Germany. As data is limited, it is not possible to include detailed information on cash expenditure and tax rewards in this study. However, using data from the US Database of State Incentives for Renewables & Efficiency (DSIRE), US Department of Energy and the German Federal Ministry for Economic Affairs and Energy (BMWi) an equally weighted index is created assigning values between 0 to 3 representing cash grants, loans and rebate programs. For example, if a country has an absence of any financial incentives awarded by the government, the value ascribed will be 0. Similarly, if a country only awards cash grants and rebate programs, the index value will be 2. Similarly, an equally weighted index is assigned to all types of tax incentives identified as household, corporations, sale of energy and ownership of land and property. This approach of creating indices has been used in past studies (Zhang et al., 2014; Carley, 2009)

Due to the complexity of measurement, regulation is presented as a dichotomous variable, indicating whether a country is actively utilizing policy. This approach will not provide a precise measurement in terms of quality or effectiveness of regulation. However, it does offer basic insight into the relationship between this variable and installed capacity of wind turbines. This will be further discussed in the conclusion under the limitations section. Consequently, a value of one is applied if a government has enacted federal-level policy to benefit renewable energy development. A value of zero is ascribed if no policies are active. Academics (Carley, 2009; Markowitz & Grossman, 2007; Thompson & Scicchitano, 1985) also used regulation as a dichotomous variable in their research in response to data availability and constraints.

The variable consumption is measured per capita basis as average electricity in kilowatt-hours per person. This quantification of consumption is commonly used by academics, databanks, and institutions (EIA, 2017; Hao & Peng, 2017; Statista, 2019) Data on this variable is collected from the EIA, BMWi, and World Bank.

Wind energy share is measured as the total share of wind energy in the national energy production as a percentage. Data on this factor is collected from AWEA and EWEA reports, as well as the Department of Energy.

Levelized cost of energy is a popular measurement of total energy generation costs over a source's lifetime. For wind turbines, this expected lifetime is 30 years according to calculations by (Lazard, 2018). The LCOE of wind power technologies has been the subject of many investigations using this equation. (Aldersey-Williams, Broadbent & Strachan, 2019; Aldersey-Williams & Rupert, 2019, Bruck, Sandborn, & Goudarzi, 2018) Data on this variable has been collected from the US National Renewable Energy Laboratory (NREL) database and Fraunhofer reports. Levelized cost of coal is measured as the sum of costs over the energy produced, with data collected from Lazard, OECD and Fraunhofer.

Installation cost is measured as the cost per megawatt generated from onshore wind turbines. A distinction between off-shore and on-shore projects has been made due to the differing costs of installation and expected production schedules. This measurement is commonly used in academics (Fingersh, Hand & Laxson, 2006; Butterfield et al., 2007, Eriksson, Bernhoff, & Leijon, 2008). Data is collected from reports by the Department of Energy and BMWi.

Electricity price is measured as annual average retail electricity price measured in cents per kilowatt-hour. Data on this variable is collected from the German Federal Association of Energy and Water Industry (BDEW 2019), (EIA, 2019) and (Statista, 2019).

3.3 Quantitative research method

3.3.1 Regression model

The methodology used to determine the impact of independent variables on the dependent variable is ordinary least squares (OLS) regression. This is in accordance with previous studies with a similar objective such as (Carley, 2009; Lin, Omoju & Okonkwo, 2016; Johnstone, Haščič, & Popp, 2009)

(Berry, 1993) outlined four main assumptions that need to be satisfied for a reliable ordinary least squares' regression analysis. First, the assumption of linearity which is satisfied by the model shown in equation 1 below. Secondly, the assumption of perfect collinearity is discussed for the regression models in Chapter 4. The third assumption involves independence of observations. Fourth, the assumption of random sampling. In this study, Germany and the United States are selected purposefully for their developed economies and activeness in the wind power industry. Although, the number of observations is greater than the number of factors to be estimated, thus satisfying this condition.

The OLS method enables the formulation of a regression model to represent the dependent variable *Installed Capacity* for country *i*. In this model, the independent variables subsidy, taxes, regulation, consumption, wind energy share, LCOE wind, LCOE coal, installation costs and electricity price are represented. $\beta 0_i$ resembles the y-intercept and the random error term is indicated as ε_i. Using the variables shown in Table 1, the following equation is formulated:

$$\text{Installed Capacity}_i = \beta 0 + \beta 1\ \textit{Subsidy}_i + \beta 2\ \textit{Taxes}_i + \beta 3\ \textit{Regulation}_i + \beta 4\ \textit{Consumption}_i + \beta 5\ \textit{Wind Share}_i + \beta 6\ \textit{LCOE Wind}_i + \beta 7\ \textit{LCOE Coal}_i + \beta 8\ \textit{Installation Cost}_i + \beta 9\ \textit{Electricity Price}_i + \varepsilon_i \quad (1)$$

3.3.2 Data collection

A database is created using an Excel spreadsheet based on information gathered on regulatory policies, economic policies, macroeconomic factors and electricity trends of the United States and Germany.

The case of the United States is selected for its advanced economic status, per its membership of the G-7. It is also ranked as the second worst polluter in carbon dioxide emissions in the world, according to (Reuters, 2017). As electricity generation from fossil fuels is a major contributor to this statistic, increasing concerns with climate change are pressuring the US government to act. It is therefore interesting to investigate how historically the wind energy industry has benefitted from renewable energy policies, especially in a capitalist market with minimal government involvement like in the United States. Especially considering the instable support practices ranging through presidents and administrations with different values.

Germany is interesting for investigation as it is also a powerful economy and its historically active government in tackling national pollution levels and renewable energy investments. Furthermore, its social market economy favoring fair competition and significant growth in the domestic renewables industry serve as an interesting point of comparison to the US.

Table 1. Description of Variables and Measurements

Dependent Variable	
Installed capacity	Megawatts (MW)
Independent Variables	
Subsidy index	Weighted index of cash grants, loans and rebates
Taxes index	Weighted index of household, corporate and commercial tax options
Regulation index	Country has active federal-level regulatory policies supporting wind energy industry
Consumption	Average kWh electricity used per person
Wind Share	Share of wind energy in energy generation portfolio
LCOE Wind	Sum of costs over lifetime / sum of energy produced (at 30 years)
LCOE Coal	Sum of costs over lifetime / sum of energy produced
Installation costs	Average cost per Megawatt generated of wind turbines
Electricity price	Average annual retail electricity price (cents/kWh)

As public data availability on energy policy and statistics is often limited, a variety of sources are used to develop the database. With data collected from the years 1987-2017, this results in an expected 270 observations. However, as some information overlap is missing, the analysis of Germany has a total of 267 observations and the United States 265.

3.4 Qualitative research method

3.4.1 Thematic content analysis

Content analysis is a popular methodology used for systematically finding and analyzing topics in texts. The purpose of using this method is to "develop object inferences about a subject of interest in any type of communication" (Kondracki, Wellman, & Amundson, 2002, p. 224) The advantages of using content analysis are its unobtrusive approach, direct line of insight into human perspectives and coding applications. The interviews are+ transcribed into a Microsoft Word document and coded manually. As the coding scheme was made prior to the interviews based on established theory from past studies, it follows the deductive coding approach (Pelissier, 2008).

3.4.2 Interview

The qualitative research component of this study consists of two semi-structured interviews with managers of businesses active in the American and German wind turbine industry. (Alsaawi, 2014) stated that the benefit of semi-structured interviews lies in the ability to control the course of the interview while asking open-ended questions allowing for interviewee interpretation and thus enabling a wide array of responses. By performing the quantitative component first, it is possible to cross reference results and ensure reliability and validity of outcomes.

The businesses considered for interviews are limited to electric utility suppliers, as these companies are directly impacted by renewable energy policies. Consequently, two managers with at least 5 years of experience in the wind energy industry were interviewed to ensure reliability of outcomes. Business names, participant names and other personally identifiable information has been anonymized for privacy purposes. Interviews were conducted via telephone, which has in the past received criticism from some literature. However, recent studies like (Cook et al., 2003; Braunsberger, Wybenga, & Gates, 2007) have found that such interviews are a valid method for data collection. The coding guidelines used during this component are shown in Table 2 below.

Table 2. Interview Coding Scheme

Category 1:	**Regulation policy**
CODE:	Regulation
Category 2:	**Economic policy**
CODE:	Subsidy
CODE	Tax-incentives
Category 3:	**Macroeconomic factor**
CODE:	Consumption
CODE:	Wind Share
Category 4:	**Electricity trends**
CODE:	LCOE Wind
CODE:	LCOE Coal
CODE:	Installation Costs
CODE:	Electricity Price

3.4.3 Trustworthiness

Trustworthiness is the degree of confidence in data collection, interpretation and quality, as stated by (Conelly, 2016). (Lincoln & Guba, 1985) set forth four criteria of trustworthiness: credibility, confirmability, dependability and transferability. Credibility can be ensured in the case of interviews by getting to know the participant and his or her background. Since the interviews in this study took place via phone, a small conversation served as a precursor to the interview as an effort to establish a sense of trust and familiarity. In terms of confirmability, this considers whether the same outcomes can be deduced by different interpreters. To ensure accuracy of interpretations, the coding scheme, raw data and interview transcripts are reviewed several times as part of the data analysis section. Dependability refers to the ability of a researcher following the same procedure getting the same results. According to (Morrow, 2005), this criterion can be satisfied by including a research design overview of all steps followed. Lastly, transferability is regarding the application of results to different fields. In this case, the outcomes could be interesting for other sources of renewable energy such as hydro and solar.

4. RESULTS

4.1 Quantitative Data Analysis

4.1.1 Descriptive statistics

In terms of economic policies, based on the minimum values of the subsidy index, it can be observed that Germany has been more stable with providing cash grants in the last three decades as the minimum is 1. In the case of the United States, this value is 0 indicating drought periods of government funding. On average, Germany has also offered more funding to wind turbine projects as the mean value is 1.87, while the mean is slightly lower at 1.67 in the US. Regarding tax-incentives, the opposite pattern emerges as the United States has a minimum value of 1 for tax-incentives, while for the German sample it is 0. The mean value of tax index for Germany is 1.68 and 2.32 indicating a consistency of tax-incentives awarded over time.

Table 3 and Table 4 below shows the patterns in the German and American wind power industry in the last three decades. It is interesting to note the significant growth experienced in terms of installed capacity since 1987. In Germany, this jump went from 100 MW to 56,200 MW and from 350MW to 89,000 MW in the United States. The mean and median values in Germany--16,258MW and 12,000MW--indicate that data is skewed to the right as the mean is greater than the median. This means that more growth has taken place from 2002-2017 than in the period of 1987-2002. Similarly, the median of the US dataset is also below the mean indicating a right skew. However, the difference between mean and median indicating that most of the growth had taken place more recently, after the middle point of 2002.

With regards to regulation, it is evident from the mean value of 0.87 that the government of Germany has taken a more active role in passing regulatory policies to stimulate wind turbine development. However, the standard deviation of .475 points to spread out datapoints indicating instability of regulation policies in German over time. In comparison, the United States is not far off with a mean value of 0.68, though this can be ascribed to the on-and-off relationship of policies due to regular alternation between pro-renewable and anti-renewable presidential administrations.

In both countries, consumption per capita has remained relatively constant over the last 30 years, as can be observed by the low standard deviations in Germany (SD=344.20) and the US (SD=765). The difference in consumption between Germans and Americans is relatively shocking, as the German mean value is at 6,809 kWh per capita and the American mean is at 12,818 kWh—nearly double. Though, this could be the result of higher electricity prices in Europe compared to the USA.

Considering wind energy share, or the percentage of total domestic energy generation coming from wind sources, the German industry has grown noticeably bigger than the US based on maximum and minimum values, from .01 to .16 and from .01 to .06 respectively. On average, the German mean (M=0.04) percent of national energy production is four times larger than its American counterpart (M=0.01)

An interesting observation between levelized cost of energy from wind and coal sources is that on average, wind is the cheaper alternative. In Germany, the mean LCOE of wind being 93.81 and LCOE of coal being 94.58. In the

USA, wind being at 71.52 and coal at 82.35. This indicates that the wind turbine market has achieved a scale at which it has become more affordable than coal sources. However, the standard deviation of LCOE wind in Germany of 9.54 and in the US of 20.55 indicate that this price point has not been stable over the last 30 years.

Installation costs between the United States and Germany seem relatively similar. The mean value of cost per

MW being 2223.83 EUR/MW in Germany and 2035 USD/MW in the United States. Standard deviation for both countries was also identical: 427.11 for Germany and 468 for the US. Median installation cost was slightly different, at 2095.50 and 1950 respectively. This potentially indicates that Germany was incrementally faster at reducing fixed costs associated with wind turbines in the last 30 years.

Electricity price in Germany is significantly higher at a maximum of 29.28 cents per kWh and average of 19.63 cents. In the United States, the maximum retail electricity price was 12.41 and on average costs 8.18 cents per kWh. This is likely the result of increased taxes on retail electricity prices in European countries shifting the financial burden of renewable energy to the user. The benefit of this approach is that it incentivizes more efficient use of electricity while facilitating the shift towards renewables. Furthermore, prices in the US have also been more stable as suggested by the standard deviation of 1.713 compared to Germany with a deviation of 5.22 cent/kWh.

4.1.2 Correlation analysis

Table 5 and Table 6 show the correlation matrices of the covariates analyzed based on data of Germany and the United States. Most correlations found are statistically significant at the 0.05 significance level for both datasets on Germany and the United States. An interesting correlation is that an increase in renewable energy policies positively influences the percentage of renewables in both Germany and the United States. Another significant observation is that subsidy, taxes and regulation are negatively correlated to the levelized costs of energy of wind turbines, indicating the opposite intended effect. This correlation is also statistically significant in both Germany and in the United States. Consequently, REPs do have a positive influence on electricity price, as there is a significant correlation between subsidy, taxes and regulation and the decreasing electricity price. A higher level of installed capacity also seems to attract more government involvement in the form of subsidy, taxes and regulation. The correlation matrices also suggest that implementation of subsidy has a positive influence of tax incentives and regulation. This indicates that once the governments of Germany and the US get involved in the market, a combination of subsidy, tax incentives and regulation are used instead of a single measure. With regards to the dependent variable, it can be observed that implementation of subsidy, taxes and/or regulation have a statistically significant positive correlation to an increase in installed capacity of wind turbines. In Germany, it can also be inferred that a decrease in LCOE of Wind turbines and decrease in installation costs will result in a higher level of installed capacity. Similarly, a higher LCOE of coal results in greater development of wind turbines. However, a lower LCOE of coal in the US seems to result in more wind power capacity installed, which is the opposite relationship as noted in Germany. Another difference between the two datasets is that regulation in Germany is positively correlated to an increase in consumption. However, this is not statistically significant in the American dataset.

4.1.3 Regression analysis

Tables 7 and 8 present the results from the ordinary least squares regression models. Table 7 shows the outcomes of Germany indicating that subsidy and regulation have a statistically significant positive association with installed capacity of wind turbines. Table 8 shows the United States' results, indicating that regulation is the only renewable energy policy to have a statistically significant impact on installed capacity. Both regression models suggest that tax-incentives have an insignificant impact on the development of wind turbines.

An interesting observation is the negative relationship between consumption and LCOE of Coal suggesting that as people use more electricity, coal becomes more expensive. This result can be attributed to the increasing social/environmental cost of fossil fuel consumption, which is increasing the levelized costs of coal sources.

Furthermore, the regression results of the German dataset indicate that variables other than the renewable energy policies had a significant influence. The variable consumption had a small positive association to installed capacity. In other words, an increase in energy consumption per capita has led to more wind turbines being built. Installation costs also had a relatively small positive correlation to installed capacity, however statistically significant as well. The changing price of LCOE Coal and electricity prices seem to have an insignificant negative impact. LCOE Wind also did not have a statistically significant effect on installed base

Contrary to the German regression results, the American dataset does indicate that the variable LCOE Wind has a statistically significant impact on the development of wind turbines. A lower cost of energy thus leads to a higher installed capacity of wind power. An increase in electricity prices also had a positive impact. Similar to the German outcomes, a lower installation cost of wind turbines leads to more capacity installed.

In short, both regression models found that regulation has a statistically significant, positive impact on installed base of wind turbines. Furthermore, lower installation costs have a positive effect on installed capacity as well. The results of both regression models are summarized in Table 9 below.

To investigate if there is any effect of multicollinearity, a collinearity test is conducted presenting tolerance levels and variance inflation factors (VIF) of both models. The results are shown in Table 10 and Table 11. The rule of thumb set forth by (Hair et al, 1995; Hair et al., 2010) claims that a VIF below 10 is acceptable. (Menard, 1995) suggested that a tolerance below 0.20 indicates a multicollinearity problem. For the German sample, two variables fall slightly below this threshold namely consumption and LCOE coal. For the American sample, the tax incentives variable and LCOE of wind fall below the tolerance threshold of 0.20 with values of .171 and .183. This indicates the small potential of a multicollinearity problem.

In order to verify if the conclusions are reliable, a factor analysis procedure is run on SPSS as recommended by the developer (IBM, 2019). Both regression models are rerun using factor component scores to test for a presence of multicollinearity. One downside of this approach is that it presents coefficient estimates as larger, thus indicating more variables as statistically significant. However, in this case this test is used to verify whether the same findings hold negating any impact from multicollinearity.

Table 3. Descriptive Statistics (Germany)

Variable	MAX	MIN	Mean	Median	ST.DEV	25%	75%
Installed capacity (Mega Watts MW)	56200	100	16258	12000	16122	2400	26900
Subsidy index	3	1	1.87	2	.76	1	2
Taxes index	3	0	1.68	1	1.05	1	2
Regulation index	1	0	.87	1	.34	1	1
Consumption (kWh per capita)	7281	6244	6809.36	6796.50	344.20	6485.50	6796.50
Wind Share (Percentage of energy mix)	.16	.01	.04	.03	.04	.01	.07
LCOE Wind ($/MW)	111	70	93.81	97	9.54	88	100
LCOE Coal ($/MW)	130	60	94.58	100	20.23	73	105
Installation cost ($/MW)	3200	1600	2223.83	2095.50	427.11	1950	2362.50
Electricity price ($cents/kWh)	29.28	13.94	19.63	17.11	5.22	15.36	23.69

Table 4. Descriptive Statistics (United States)

Variable	MAX	MIN	Mean	Median	ST.DEV	25%	75%
Installed capacity (Mega Watts MW)	89000	350	20880	3500	28472	1000	40000
Subsidy index	3	0	1.68	2	1.1658	1	3
Taxes index	3	1	2.32	2	1.28	1	4
Regulation index	1	0	.68	1	.475	0	1
Consumption (kWh per capita)	13704	10886	12818	12990	765	12307	13367
Wind Share (Percentage of energy mix)	.06	.01	.01	.01	.02	.01	.02
LCOE Wind (USD$ 2019)	130	45	71.52	70	20.55	55	80
LCOE Coal (USD$ 2019)	112	46	82.35	91	22.72	56	102
Installation cost (USD$ 2019 per MW)	3150	1350	2035	1950	468	1650	2400
Electricity price (cents/kWh)	12.41	6.10	8.18	7.27	1.713	6.81	9.83

Table 5. Correlation Matrix (Germany)

	Installed Capacity	Subsidy	Taxes	Regulation	Consumption	Industry Size	LCOE Wind	LCOE Coal	Install Cost	Electricity Price
Installed Capacity	1	.715**	.753**	.813**	.626**	.752**	-.629**	-.763**	-.897**	.722**
Subsidy		1	.698**	.318*	.742*	.795**	-.539**	-.692**	-.448**	.790**
Taxes			1	.441**	.683**	.877**	-.809**	-.710**	-.621**	.836**
Regulation				1	.143	.343*	-.387*	-.564**	-.853**	.330*
Consumption					1	.838**	-.598**	-.520**	-.331**	.768**
Wind Share						1	-.817**	-.740**	-.566**	.943**
LCOE Wind							1	.710**	.561**	-.787**
LCOE Coal								1	.674**	-.810**
Install Costs									1	-.561**
Electricity price										1

a. *Indicates significance at the 0.10 level. **Indicates significance at 0.05. ***Indicates significance at 0.01.

Table 6. Correlation Matrix (United States)

	Installed Capacity	Subsidy	Taxes	Regulation	Consumption	Wind Share	LCOE Wind	LCOE Coal	Install Cost	Electricity Price
Installed Capacity	1	.912**	.883**	.743**	.654**	.793**	-.562**	.273	-.344*	.954**
Subsidy		1	.924**	.769**	.757**	.654**	-.616**	.042	-.457*	.829**
Taxes			1	.673**	.589**	.681**	-.485**	.182	-.332**	.840**
Regulation				1	.833**	.434**	-.768**	-.313*	-.532**	.599**
Consumption					1	.278	-.889**	-.529**	-.627**	.491**
Wind Share						1	-.399*	.472**	-.210	.822**
LCOE Wind							1	.441**	-.727**	-.414*
LCOE Coal								1	.559**	.413*
Install costs									1	-.247
Electricity Price										1

Table 7. Regression Analysis (Germany)

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Subsidy index	1.842 (5.505)***	.950 (2.318)**	.918 (4.692)***	.506 (2.853)***	.467 (2.500)**	.413 (2.091)**	.362 (1.669)*	.421 *2.658)**	.439 (2.743)**
Taxes index		.934 (3.122)***	.459 (3.038)***	.223 (1.744)**	.136 (.772)	.182 (.987)	.190 (1.014)	.109 (.788)	.101 (.725)
Regulation index			3.422 (9.786)***	3.781 (13.423)***	3.773 (13.262)***	3.799 (13.219)***	3.720 (11.714)***	2.344 (6.273)***	2.203 (5.439)***
Consumption				.002 (4.405)***	.001 (3.226)***	.001 (3.071)***	.001 (3.095)***	.001 (3.416)***	.001 (2.940)***
Wind Share					4.093 (.731)	6.855 (1.063)	6.110 (.920)	4.661 (.791)	10.200 (1.210)
LCOE Wind						.015 (.877)	.019 (1.011)	.019 (1.368)	.018 (1.312)
LCOE Coal							-.005 (-.622)	.000 (-.045)	-.003 (-.371)
Installation cost								-.002 (-4.660)**	-.002 (-4.633)**
Electricity price									-.046 (-.933)
Constant	5.248 (7.779)***	5.352 (9.036)***	3.228 (9.056)***	-7.073 (-3.004)***	-5.766 (-1.939)*	-6.961 (-2.120)**	-7.046 (-2.117)**	-1.947 (-.685)	.102 (.028)
Adj. R^2	.494	.611	.911	.947	.946	.946	.944	.970	.970
Observations	30	60	89	119	148	178	208	238	267

a. Dependent Variable: Installed Capacity

b. The first value represents the unstandardized coefficient. The second value presented in parentheses is the t-statistic. *Indicates significance at the 0.10 level. **Indicates significance at 0.05. ***Indicates significance at 0.01.

Table 8. Regression Analysis (United States)

	1.	2.	3.	4.	5.	6.	7.	8.	9.
Subsidy index	1.475 (11.951) ***	1.066 (3.345) ***	.851 (2.289) **	1.106 (2.630) **	.506 (1.347)	.429 (1.110)	.496 (1.621)	.350 (1.152)	.189 (1.183)
Taxes index		.405 (1.390)	.456 (1.552)	.187 (.580)	.265 (1.018)	.249 (.950)	.110 (.524)	.139 (.689)	.012 (.109)
Regulation index			.523 (1.112)	.993 (1.694) *	.596 (1.231)	.692 (1.394)	1.175 (2.836) ***	1.298 (3.235) ***	.524 (2.228) **
Consumption				.000 (-1.149)	.000 (.347)	.000 (.908)	.001 (1.400)	.001 (1.771) *	.000 (.647)
Wind Share					52.833 (3.676) ***	54.664 (3.754) ***	21.695 (1.486)	21.575 (1.551)	12,429 (1.689) *
LCOE Wind						.013 (.918)	.001 (.088)	.008 (.670)	-.009 (-2.352) **
LCOE Coal							.029 (3.680)*	.036 (4.216) ***	.008 (1.406)
Installation cost								-.001 (-1.736) *	-.001 (-.2.395) **
Electricity price									.713 (7.208) ***
Constant	6.090 (24.280) ***	5.837 (19.008) ***	5.725 (17.797) ***	11.409 (2.356) **	4.534 (1.049)	-.946 (-.128)	-3.560 (-.605)	-5.110 (-.900)	.194 (.064)
Adj. R^2	.825	.831	.832	.808	.875	.875	.921	.929	.981
Observations	29	59	89	118	148	178	205	235	265

a. Dependent Variable: Installed Capacity

b. The first value represents the unstandardized coefficient. The second value presented in parentheses is the t-statistic.

*Indicates significance at the 0.10 level. **Indicates significance at 0.05. ***Indicates significance at 0.01.

Table 9. Summary of regression model results

Variable	Model (GER)	Model (USA)
Subsidy index	S (+)	NS(+)
Taxes index	NS (+)	NS(+)
Regulation index	**S (+)**	**S(+)**
Consumption	S(+)	NS(+)
Wind share	NS(+)	NS(+)
LCOE Wind	NS(+)	S(+)
LCOE Coal	NS(-)	NS(+)
Installation cost	**S(-)**	**S(-)**
Electricity price	NS(-)	S(+)

Table 10. Collinearity statistics of covariates (Germany)

Variable	Tolerance	VIF
Subsidy index	.277	3.607
Taxes index	.218	4.595
Regulation index	.202	4.954
Consumption	.171	5.865
Wind share	.337	2.719
LCOE Wind	.286	3.495
LCOE Coal	.178	4.765
Installation cost	.210	5.623
Electricity price	.363	1.587

Table 11. Collinearity statistics of covariates (USA)

Variable	Tolerance	VIF
Subsidy index	.366	1.522
Taxes index	.182	7.604
Regulation index	.265	6.047
Consumption	.272	1.381
Wind share	.277	3.607
LCOE Wind	.171	8.549
LCOE Coal	.292	8.317
Installation cost	.288	3.470
Electricity price	.393	9.705

4.2 Qualitative Data Analysis

The results are based on the two interviews conducted with business managers operating in the German and American wind power industry. Interviewees were asked about their knowledge and practical experience regarding renewable energy policies and the role of contextual factors. Table 12 below depicts the frequency of sub-codes mentioned in a descending fashion; from most to least frequent. The higher the count, the more important the interviewee perceived the topic to be. Table 13 presents whether the participant indicated a positive or negative relationship between the discussed variable, or topic, and the dependent variable installed capacity of wind turbines. In the following, the investigated topics and their results are discussed.

4.2.1 Regulation

As shown in Table 12, regulation was mentioned a total of 20 times giving it a 32% weight and is therefore considered to be the most important factor. In this study, regulation is defined as the regulatory instruments used by a government to stimulate installed capacity of wind turbines, such as portfolio standards, laws and agencies to oversee performance. Based on the interviewee's statements, it was interpreted that a positive correlation exists between a government's use of supporting regulation and the installed capacity of wind turbines. These results are presented in Table 13 above. Interviewee A stated "*In my perspective, regulation is the best choice when radical change is desired—and it is not perfect, either. Businesses like to make their own decisions."* With this statement, it is indicated that without active involvement from the government, a technology with high associated costs and high social benefits will take a long time to become marketable. A major downside is that companies consider regulations restrictive on profits and an impediment to success. Thus, overdoing regulation can serve to the detriment of the economy as a whole. Interviewee B states "*I think regulation definitely encourages companies to buy green energy. Just like requiring cars to be more efficient. It'll get the job done."* This statement indicates that regulation essentially helps businesses set goals for the future. As the example used, cars in the 1970s were inefficient and highly polluting compared to newer cars. Even today, this is relevant such as the ban on older diesel cars in German cities. Through regulatory policies and standard setting, a similar statement could be made about the global energy mix in the coming years.

Table 12. Frequency of codes per participant

Code	Sub-code	A (N=32)	B (N=31)	Total (N=63)
Regulation	*Regulation*	9	11	20 (32%)
Economic	*Subsidy*	7	5	12 (19%)
Electricity Trends	*LCOE Wind*	5	3	8 (13%)
Electricity Trends	*Electricity Price*	4	2	6 (9%)
Electricity Trends	*Installation Costs*	2	3	5 (8%)
Macro-Economic	*Consumption*	3	1	4 (6%)
Economic	*Tax-incentives*	1	2	3 (5%)
Macro-Economic	*Wind share*	2	1	3 (5%)
Electricity Trends	*LCOE Coal*	1	1	2 (3%)

* A represents the manager from Germany
* B represents the manager from the USA

4.2.2 Economic policies

Subsidy was another important topic discussed during the interviews as it was mentioned 12 times, thus having a weight of 19%. A positive correlation between cash grants and installed capacity of wind turbines was inferred from the interviewee's statements. Interviewee A stated that *"Subsidy's a good method of encouragement for people to buy solar panels. Electric cars. Look at all the people driving a Tesla here today, at least half of them would think twice if they had to pay full-price."* This statement reveals that subsidy has been effective in incentivizing behavior—in this case, individuals purchasing electric vehicles. Applying this to wind turbines, the same could be said for businesses and investors. If there is a natural demand for a product, then a financial incentive of the right amount can push people over the fence and change their behavior. Only if the perceived value exceeds the perceived cost. . Interviewee B shared a similar example, but a different opinion on the matter of subsidy. *"Getting rebates and tax-back on cars like hybrids and that $30,000 Tesla model will definitely get some attention and additional sales. But the fact that the government must step in and help sell a product, to me, means that the product is not market viable."* This interviewee makes the case that if people need extra incentive to purchase a product, then the product on its own is not good enough and should not be forced to succeed. However, for some technologies that may have high costs but also high social benefits, it may be in the best interest of a government to step in and offer subsidy. When asked about subsidies specifically in the wind turbine industry, interviewee B stated that *"It would likely increase sales of wind turbines. If we have a set budget and the government pitches in, there is a good chance we will try to utilize as much of those subsidies as we can. Even if it means spending a little more to get more."* This implies that a company will likely invest more money or larger orders if it experiences a type of discount in the form of government funding.

On the other hand, tax incentives were a less popular topic as it was mentioned just 3 times. Tax incentives are in this study defined as the corporate, household and commercial tax relief programs offered by the government. Interviewee A stated, *"To businesses, tax programs and subsidization fitted to help an industry are almost interchangeable."* This indicates a rather indifference between subsidy and tax-incentives in terms of effectiveness from the perspective of businesses. Interviewee B claimed, *"Tax incentives and subsidy have the same net result."* Based on these statements, a positive relationship between tax incentives and installed capacity was derived. Consequently, as evident from the number of times each topic was mentioned, businesses have a preference to subsidy over tax-incentives.

4.2.3 Macroeconomic factors

In terms of , this topic was mentioned 3 times. This variable focuses on the percentage of energy generated from wind turbine sources in the national portfolio. Interviewee A stated *"Of course, if an industry becomes bigger then you'd expect lower costs over time and larger projects. The only way a business grows is if it's doing something right. Now when costs are reduced, people will buy more—for your wind farms, it could convince a utility company to invest in wind as opposed to another coal plant or solar."* This was in response to the question if the manager believed there to be a relationship between wind share and wind industry growth. The manager suggested that there is rather a confounding variable. Installation costs causes a larger wind power market and a larger installed capacity per year. . Interviewee B made a comment *"Yeah, a larger market leads to larger purchases. Again, with this example, take electric vehicles. The number of electric cars to regular cars has grown tremendously. Compare that to the number of electric cars being sold today. You could say that the market growth results in more orders today."* This manager believes that as a market grows, orders sizes will increase as well. Therefore, a positive correlation between wind share and installed capacity was found.

The topic of energy consumption was mentioned 4 times indicating a lower importance. Interviewee A commenting "*In this day and age, consumption will only continue to increase like population. Only years ago, we all just had a cellphone or mp3 player. Today, we have all kinds of devices running 24/7. I am sure that the wind market is doing well, but that success is not exclusive to renewables."* In short, it can be inferred that Interviewee A believes that the rising levels of consumption are not completely invested in renewables and instead will benefit energy generation from fossil fuels, too. It is then up to the wind power industry to build up a strong position and lower prices to keep attracting investment. Interviewee B stated *"I don't think there is necessarily a relationship there between the two. I just think that one will lead to the other. More consumption leads to more renewables, and vice versa."* Interpreting this point of view, the manager believes that a rising level of energy use will inherently increase installed capacity of wind turbines installed. Thus, a positive relationship between consumption levels and installed capacity was derived.

4.2.4 Electricity trends

Levelized cost of energy from wind turbines was the third most important topic based on frequency as it was mentioned 8 times and a weight of 13%. Levelized cost of energy from coal was found to be least important being mentioned just twice. Interviewee A made the following statement *"As far as I am aware, coal is no longer the cheapest option, but it is still the most popular option. I don't think costs are the reason for this, but rather the issue of energy supply. Wind turbines only generate when there is wind, solar when there is sun. Coal, gas, diesel can produce at any time."* This indicates that the installed capacity is also affected by concerns over stability, not just LCOE. Interviewee B stated that *"It is true, all things considered, larger onshore wind turbines of one megawatt and above are cheaper than energy from coal. But I do not know the exact numbers by heart."* Based on this, it can be assumed that businesses in the interest of cost-minimization and profitability will choose the cheaper alternative. Therefore, a negative relationship between LCOE wind and installed capacity is assumed. Subsequently, a positive relationship between LCOE of coal sources and installed capacity is interpreted, as a lower cost of fossil fuels hinders companies to invest in wind turbines.

The topic of installation costs was mentioned a total of 5 times and both managers had a similar perspective. Interviewee A: *"If the costs are lower, more [wind turbines] will be sold."* Interviewee B *"The initial investment of wind turbines is its biggest bane. While it is profitable as-is, a lower fixed cost opens the proverbial doors to smaller businesses and competition. This will enable market growth, innovation and, simply put, more wind turbines installed."* Both interviewees seem to agree that lower installation costs will lead to a higher installed capacity of wind power. Based on these statements, it is assumed that there is a negative relationship between installation costs and installed capacity.

Electricity prices were mentioned a total of 6 times, being the fourth most important variable according to the interview results. . Interviewee A *"The [German] government has an interesting way of funding renewable energy projects; it includes a portion of taxes in the electricity prices. For the end-user, it's bad because they have to pay more. But for the environment, it is good because people will start using less and pollution will decrease."* When asked regarding the impact of electricity prices on wind turbine development, the interviewee had the following response. *"I think with higher prices; people start expecting higher quality. I think most Germans know where their electricity comes from and how oriented the government is with sustainability. And they appreciate it."* This statement suggests that a higher price results in a higher expectation from consumers, thus can lead to an increase of installed capacity of wind. Interviewee B had a different perspective. *"Electricity prices here are pretty low, about 12 cents per kWh. That's because the infrastructure is heavily dependent on the coal industry which achieved a nice economies of scale. With the current market, a price hike would be difficult to justify because many people from Gen-Z or Gen-X don't see the benefit, or need for, renewable energy. I think once the millennials start buying homes, demand for renewables will increase."*

“I’d have to say that a low price hinders investment.”
These statements by Interviewee B indicate a rather inflexible price point, thus a lower electricity price is expected to negatively impact installed capacity of wind turbines in the current US renewable energy market.

Table 13. Interview results of covariate relationship to dependent variable (installed capacity of wind turbines)

Variable	Relationship	
Subsidy	Positive	2
	Negative	0
Tax-incentives	Positive	2
	Negative	0
Regulation	Positive	2
	Negative	0
Consumption	Positive	2
	Negative	0
Wind Share	Positive	2
	Negative	0
LCOE Wind	Positive	0
	Negative	2
LCOE Coal	Positive	2
	Negative	0
Installation Costs	Positive	0
	Negative	2
Electricity Price	Positive	2
	Negative	0

5. DISCUSSION

5.1 Key findings

This study aimed to investigate the effectiveness of renewable energy policies on the installed capacity of wind turbines. The outcomes confirm the effect renewable energy policies have on the development of wind turbines in Germany and in the USA. This pattern can be broadly observed from the charts shown in Appendix C1, C2 and C3. In C1, a strong growth in installed capacity of wind turbines is visualized. While it is difficult to quantify the optimal balance of renewable energy policies, it is evident that an increase in government intervention is positively correlated to the increase of installed wind turbines since 1987.

Considering regulation, both regression models indicate a statistically significant relationship at the 0.05 significance level. Both participants also indicated a positive relationship between regulation and installed capacity. This topic was also the indicated as most important based on frequency. Therefore, we reject the null hypothesis and accept hypothesis H1. This indicates a positive correlation between regulation and installed capacity of wind turbines. These results correspond with the results of (Carley, 2009; Kaya, 2006; Reiche & Bechberger, 2004).

With regards to subsidy, the German regression model in Table 7 suggests that it has a positive impact on installed capacity. However, this relationship was not found to be significant for the American model in Table 8. From the qualitative analysis, both participants believe that subsidy would positively influence development of wind turbines. Offering subsidy lowers the relative costs for businesses and investors, making it more attractive for investment than a scenario without subsidy. One of two regression analyses found a significant positive correlation and both interviews indicated a similar relationship. Therefore, we reject the null and find there to be enough evidence supporting the claim that subsidies lead to an increased installed capacity of wind turbines. These results agree past studies (Yang et al., 2019; Nie, et al., 2016; Nicolini & Tavoni, 2017)

The impact of tax incentives was found to be insignificant in both the German and American regression analyses. During the interviews, tax-incentives was also given a lower level of importance, while a positive impact was implied. Both regression models do not find a significant relationship, and as this study prioritizes the results from the quantitative component, we fail to reject the null hypothesis. Therefore, tax incentives have no significant effect on the development of wind turbines. These results contradict the conclusions by (Matisoff & Johnson, 2017; Harmelink, Voogt & Cremer, 2006; Lancaster & Berndt, 1984).

Consumption has a small, yet statistically significant positive influence on installed capacity for the German dataset and an insignificant impact for the American data. The topic of energy consumption per capita was mentioned a total of 4 times during the interviews considering it as less important. Based on interviewee responses, a positive relationship to the dependent variable is expected. As one of the regression results indicate a statistically significant positive effect and both interviews indicated a positive relationship, we reject the null hypothesis and accept H4. Thus, as energy consumption levels per capita increase, more wind turbines are being installed. This outcome is in agreement with (Lund, 2007; Sesto & Casale, 2005). The figure in Appendix B3 depicts a slow growth of consumption in the US and a relative stability in German consumption levels. This indicates that the analyzed countries recognize their increasing use of energy and are investing in alternative energy sources to meet future demand.

The variable wind share was found to have a strong positive relationship to development of wind turbines for both datasets, but this correlation is not statistically significant at the 0.05 level. The interview results show that wind share was of less importance to future installed capacity, though a positive relationship was indicated. As the quantitative results take priority, we fail to reject the null hypothesis and find that there is no significant relationship. This means that a growth in the industry does not necessarily result in an increase of wind turbines installed. These results conflict with (Sahu, 2008; Lewis & Wiser, 2007). The percentage of wind sources in the energy production portfolio is shown in Figure 1. This strong growth of installed capacity and the percentage of energy from wind sources indicates that wind turbines are capturing market share. Furthermore, this means that the percentage of energy from wind sources is growing faster than the levels of energy production are increasing.

LCOE Wind was found to have a small, positive impact on installed capacity in the German sample, though statistically insignificant. A small negative impact was found in the American dataset, which was statistically significant. The interviews ranked LCOE of Wind to be the 3rd most important topic and expected a negative relationship regarding its impact on wind turbine installations. As one of the regression analyses reveal a significant negative impact and both interviewees indicated a negative relationship, we reject the null hypothesis and accept H6. Lower lifetime costs of wind turbines result in a greater installed capacity. This conclusion is in line with results from (Lantz et al, 2012; Blaabjerg & Ma, 2013; EWEA, 2009)

LCOE Coal was found to have a small, negative impact on installed capacity in the German sample and a small positive impact for the American sample. Both relationships were not found to be statistically significant. The interviews ranked LCOE of coal to be the least important and interviewees indicated a positive relationship between cost of coal and installed capacity of wind turbines. As both regression analyses show a statistically insignificant relationship, we fail to reject the null and find there is no significant relationship between LCOE of coal and the dependent variable. Therefore, the cost of coal is concluded to not have a direct impact on the installed capacity of wind turbines. However, in Appendix A1 and A2 it can be observed that in both the United States and in Germany, wind has become a cheaper energy source than coal in terms of levelized cost of energy. It can therefore be expected that in the future, the market will shift towards the more economical option—being wind turbines.

Electricity prices were found to have a small negative impact in the German dataset, though this observation is not statistically significant at an alpha of 0.05. For the American sample, a strong positive and statistically significant relationship was found. The interview participants indicated a positive relationship through responses. Based on frequency of codes, this variable was also found to be the fourth most important factor being mentioned 6 times. As one of the regression models was conclusive in agreement with the views of the interviewees, we have evidence to reject the null and accept the alternative hypothesis H8. Therefore, higher electricity prices lead to a search for alternatives and thus more investment in installed capacity of wind turbines. This is in agreement with (Carley, 2009; Iimura & Cross, 2018) In Appendix B2, the average annual retail electricity prices are shown for American and German households. In Germany, prices have nearly doubled in the last 30 years. This could be a primary driver for the search of new and renewable energy sources, as it correlates to a stark growth of installed capacity of wind turbines. The curve of historical electricity prices representing the American market further adds to this premise. As there has been an insignificant growth of electricity prices, there is little reason to look for alternatives. Hence, the limited growth of installed capacity of wind turbines in the same time period.

Lower installation costs associated with wind turbines also were found to have a statistically significant positive relationship to installed capacity for both countries. Based on the interviews, it was determined to be relatively important being mentioned 5 times. The statements by participants indicated a negative relationship between installation costs and installed capacity. Therefore, we reject the null and accept the following hypothesis H9. A recognized downside of wind turbines is the high initial investment required. However, as these installation costs decrease over time, more wind turbine capacity is being installed. These results support outcomes from past research by (Benitez, Benitez & Van Kooten, 2008; Morthorst, 1999; Reuter et al., 2012). Appendix B1 shows the installation costs of wind turbines over the last three decades. It can be observed that there is a steady decrease of installation costs in both the USA and Germany. The lower cost of wind turbines correlates to the installed capacity, providing evidence of the Law of Demand: as prices decline, demand will rise.

5.2 Conclusion

This paper set out to investigate the relationship between renewable energy policies and the installed capacity of wind turbines in Germany and United States in the years 1987-2017. Aside from the policies, the effect of independent variables energy consumption per capita, wind share, levelized cost of energy from wind turbines, levelized cost of energy from coal, installation (fixed) costs, and retail electricity prices were also examined. Data was collected from various sources among which AWEA, EWEA, EIA, BMWi, DoE to create total of 267 observations for the German database and 265 observations for the United States dataset in an Excel spreadsheet. A sequential explanatory mixed-methods approach is used during this study starting with quantitative data collection and analysis followed by a qualitative approach. For both samples, an ordinary least square regression (OLS) model was created to investigate the effect of covariates on installed capacity of wind turbines as the quantitative component. The qualitative component involved a case study informed through use of interviews and examination of archives.

Regarding the research question used as the foundation of this study, the results suggest that there is a statistically significant, positive impact that regulatory renewable energy policies have on the installed capacity of wind energy in both the United States and in Germany. Subsidy was found to have a positive impact on wind turbine development, as it reduces costs and incentivizes investment. Energy consumption per capita was also found to have a positive correlation, as an increase in consumption has led to an increase in installed capacity of wind turbines. This indicates that the majority of growth in terms of consumption is being absorbed by renewables such as wind turbines, as opposed to increasing output from traditional sources. Electricity price also has a positive correlation to installed capacity. Higher prices promote the search for cheaper alternatives, which benefits installed capacity of wind turbines considering their cheaper lifetime costs.

Furthermore, a statistically significant negative relationship was found between installation costs and installed capacity. This suggests that a lower initial investment associated with wind turbine projects will result in more installed capacity. LCOE of Wind also has a negative correlation, indicating that a lower cost of wind turbines over its lifetime will lead to more installed capacity.

Past studies such as (Carley, 2009) used a regression model to examine the relationship between renewable energy policy and installed capacity of renewable energy projects. This investigation followed a similar model with an additional data collection and analysis phase to reinforce the reliability of the conclusions. In terms of academic contribution, the results of this study provide additional empirical evidence and confirmation of previous research on REPs and their effectiveness. In terms of practical application, the following recommendations are intended for business managers, policymakers and other interested parties:

- Offering tax incentives to increase installed capacity of wind turbines is not a successful approach. Instead, regulation and direct subsidy were found to be effective instruments for stimulating a shift towards renewables through wind turbines.
- Lower installation costs of wind turbines are found to significantly increase installed capacity of wind power.
- Wind turbines have a lower LCOE than traditional coal sources indicating that an economy of scale has been achieved. Thus, wind turbines have become a cheaper energy source than traditional coal sources. This relationship can also be seen in Appendix A1 and A2.

5.3 Limitations and Future Research

Potential limitations of this investigation are as follows: First, the data collected did not always have an exact overlap. In some cases, data for certain years was missing and had to be sourced from multiple reports and/or research institutions. Future research can address this by collaborating directly with an organization like AWEA or EWEA for data quality and creditability assurance.

Secondly, the historical effect of REPs was analyzed for the years 1987 through 2017. Therefore, the results can only be used as a guideline at best for future expectations based on what has happened in the past. This limitation can also be addressed by using forecasted values, as commonly done in AWEA and EWEA reports.

Thirdly, the wide timeframe used for this research includes many significant economic events such as the 1979 oil crisis and the 2008 market crash. Future research could benefit from using a smaller and predetermined timeframe during an economically uneventful time could provide more accurate results, as a greater timeframe can be influenced by hard-to-detect third variables.

Fourth, indexes were used instead of exact figures due to data limitations. Reports of government spending is often an aggregate number, lacking the ability to distinguish for example subsidies for wind turbines or solar panels. An index for regulation was also used for lack of a more reliable measurement scale based on available data.

Fifth, the limitations of a mixed methods investigation include a limited qualitative scope. Results are subjective, based on human experiences and their opinions, instead of objective facts. Qualitative studies are also open to interpretation by the researcher and can thus skew results. The small sample size people also leave potential for biased results, as one participant essentially represents an industry (i.e. USA/Germany). Future research can address this issue by preparing a scaled study with a sample size of 10+ participants.

Sixth, the independent variables regulation, subsidy and tax-incentives measurements represent a limitation as an ordinal scale had been used. For regulation, measuring and quantifying posed as a significant challenge—past studies on renewable energy policy have likely neglected this variable as a result. Instead, a dichotomous variable is used to give basic insight whether there is a relationship there or not. As a significant relationship was found for regulation, future research may find interest in further exploring this variable for more accurate quantification of the relationship. Calculating exact values for subsidy and tax-incentives would be a significantly time-consuming project and would still lack accuracy as effects of financial incentives are often experienced in the following years. Therefore, it would be recommended that future investigations focusing on subsidy and/or tax-incentives take a lagged approach for these variables.

To further explore the effectiveness of renewable energy policies, research could be conducted on the impact one country's implementation of REPs has on neighboring countries, such as in the European Union. Furthermore, an investigation into the role of public discourse on the performance of the wind power industry and the renewables sector. This creates a more complete picture of the factors playing a role in the industry with respect to public proponents and opposition. A study focusing on public opinion would be interesting in the current context of climate change and sustainability in comparison to the readiness of companies to invest in renewables. A similarity could be investigated between the renewables industry and the automotive industry, where public demand for electric vehicles sparked a change in organizational strategies for many car manufacturers.

REFERENCES

Aldersey-Williams, J., & Rupert, T. (2019). Levelised cost of energy – A theoretical justification and critical assessment. *Energy Policy*, 169-179.

Aldersey-Williams, J., Broadbent, I., & Strachan, P. (2019). Better estimates of LCOE from audited accounts – A new methodology with examples from United Kingdom offshore wind and CCGT. *Energy Policy*, 25-35.

Alsaawi, A. (2014). A Critical Review of Qualitative Interviews. *European Journal of Business and Social Sciences*.

AWEA. (2017). *US Wind Industry Annual Market Report.* New York: AWEA.

Beck, F., & Martinot, E. (2004). *Renewable Energy Policies and Barriers*. Retrieved from Martinot Web site: http://www.martinot.info/Beck_Martinot_AP.pdf

Benitez, L., Benitez, P., & van Kooten, G. (2008). The economics of wind power with energy storage. *Energy Economics*, 1973-1989.

Berry, W. (1993). *Understanding Regression Assumptions.* Florida, USA: Sage Publications.

Bird, L., Bolinger, M., Gagliano, T., Wiser, R., Brown, M., & Parsons, B. (2005). Policies and market factor driving wind power development in the United States. *Energy Policy*, 1397-1404.

Blaabjerg, F., & Ma, K. (2013). *Future on Power Electronics for Wind Turbine Systems.* IEEE.

BMWi. (2018). *Development of Renewable Energy Sources in Germany 2017.* Germany: Federal Ministry for Economic Affairs and Energy.

BMWi. (2019, July 7). *Energy Data*. Retrieved from German Ministry of Economics and Energy Web Site: https://www.bmwi.de/SiteGlobals/BMWI/Forms/Listen/Energiedaten/energiedaten_Formular.html?&addSearchPathid=304670

Boxwell, M. (2019). *Solar Electricity Handbook 2019 Edition.* Retrieved from Solar Electricity Handbook Web site: http://www.solarelectricityhandbook.com/Solar-Articles/wind-turbines.html

Braunsberger, K., Wybenga, H., & Gates, R. (2007). A comparison of reliability between telephone and web-based surveysB. *Journal of Business Research*, 758-764.

Bruck, M., Sandborn, P., & Goudarzi, N. (2018). A Levelized Cost of Energy (LCOE) model for wind farms that include Power Purchase Agreements (PPAs). *Renewable Energy*, 131-139.

Bryman, A. (2006). Integrating quantitative and qualitative research: how is it done? *Qualitative Research*, 97-113.

Buonocore, J. J., Luckow, P., Norris, G., Spengler, J. D., Biewald, B., Fisher, J., & Levy, J. I. (2016). Health and climate benefits of different energy-efficiency and renewable energy choices. *Nature Climate Change*, 100–105.

Butterfield, S., Musial, W., Jonkman, J., & Sclavounos, P. (2007). *Engineering Challenges for Floating Offshore Wind Turbines.* USA: OSTI.

Carley, S. (2009). State renewable energy electricity policies: An empirical evaluation of effectiveness. *Energy Policy*, 3071-3081.

Casals, X. (2006). Analysis of building energy regulation and certification in Europe: Their role, limitations and differences. *Energy and Buildings*, 381-392.

CEW. (2019, June 26). *Germany's energy consumption and power mix in charts.* Retrieved from Clean Energy Wire Web site: https://www.cleanenergywire.org/factsheets/germanys-energy-consumption-and-power-mix-charts

Conelly, L. (2016). Trustworthiness in Qualitative Research. *Understanding Research*, 435-436.

Cook, L., White, J., Stuart, G., & Magliocco, A. (2003). The reliability of telephone interviews compared with in-person interviews using memory aids. *Annals of Epidemiology*, 495-501.

Creswell, J. (2017). Choosing a Mixed Methods Design. In J. Creswell, & V. Clark, *DESIGNING AND CONDUCTING MIXED METHODS RESEARCH* (pp. 53-107). Ohio, USA: Sage Publishing.

Creswell, J., Clark, V., Gutmann, M., & Hanson, W. (2003). Designs, Advance Mixed methods Research. In A. Tashakkori, & C. Teddlie, *Handbook of mixed methods in social & behavioral research* (pp. 209-240). Sage Publications.

Delmas, M., & Montes-Sancho, M. (2011). U.S. state policies for renewable energy: Context and effectiveness. *Energy Policy*, 2273.

Delmas, M., & Montes-Sancho, M. (2011). U.S. state policies for renewable energy: Context and effectiveness. *Energy Policy*, 2273-2288.

Dong, C. (2012). Feed-in tariff vs. renewable portfolio standard: An empirical test of their relative effectiveness in promoting wind capacity development. *Energy Policy*, 476-485.

EERE. (2019). *Advantages and Disadvantages of Wind Energy* . Retrieved from US Office of Energy Efficiency and Renewable Energy Web site: https://www.energy.gov/eere/wind/advantages-and-challenges-wind-energy

EIA. (2018, May 16). *U.S. Energy Facts.* Retrieved from U.S. Energy Information Administration : https://www.eia.gov/energyexplained/?page=us_energy_home

Eisenhardt, K. (1989). Building Theories from Case Study Research. *The Academy of Management Review*, 535-550.

Erikkson, S., Bernhoff, H., & Leijon, M. (2008). Evaluation of different turbine concepts for wind power. *Renewable and Sustainable Energy Reviews*, 1419-1434.

EWEA. (2009). *The Economics of Wind Energy.* Belgium: EWEA.

Fell, H., & Linn, J. (2013). Renewable electricity policies, heterogeneity, and cost effectiveness. *Journal of Environmental Economics and Management*, 688-707.

Fingersh, L., Hand, M., & Laxson, A. (2006). *Wind turbine design cost and scaling model.* USA: OSTI.

Fraunhofer ISE. (2018). *Levelized Cost of Electricity Renewable Energy Technologies.* Freiburg: Fraunhofer Publications.

Giest, S., & Mukherjee, I. (2018). Behavioral instruments in renewable energy and the role of big data: A policy perspective. *Energy Policy*, 360-366.

Gneezy, U., Meier, S., & Rey-Biel, P. (2011). When and Why Incentives (Don't) Work to Modify Behavior. *Journal of Economic Perspectives*, 191-210.

González, X., & Pazó, C. (2008). Do public subsidies stimulate private R&D spending? *Research Policy*, 371-389.

González, X., Jaumandreu, J., & Pazó, C. (2005). Barriers to innovation and subsidy effectiveness. *Journal of Economics*, 930-950.

Greene, J., Caracelli, V., & Graham, W. (1989). Toward a Conceptual Framework for Mixed-Method Evaluation Designs. *Educational Evaluation and Policy Analysis*, 255-274.

Hair, J., Anderson, F., Tatham, R., & Black, W. (1995). *Multivariate Data Analysis.* New York: Macmillan.

Hair, J., Black, W., Babin, B., & Anderson, R. (2010). *Multivariate Data Analysis.* USA: Pearson Education, Ltd. .

Hao, Y., & Peng, H. (2017). On the convergence in China's provincial per capita energy consumption: New evidence from a spatial econometric analysis. *Energy Economics*, 31-43.

IBM. (2019, July 11). *Running a linear regression on factor component scores*. Retrieved from IBM Web site: https://www.ibm.com/support/knowledgecenter/es/SSLVMB_23.0.0/spss/tutorials/reg_cars_factor_01.html

IEA. (2017). *CO2 emissions from fuel combustion: Highlights.* Paris: International Energy Agency.

IEA. (2018). *Renewables 2018*. Retrieved from International Energy Association Web site: https://www.iea.org/renewables2018/

IEA. (2019, March 28). *News*. Retrieved from International Energy Association Web site: https://www.iea.org/newsroom/news/2019/march/global-energy-demand-rose-by-23-in-2018-its-fastest-pace-in-the-last-decade.html

Iimura, A., & Cross, J. (2018). The impact of renewable energy on household electricity prices in liberalized electricity markets: A cross-national panel data analysis. *Utility Policy*, 96-106.

IPCC. (2018). *Global Warming of 1.5C.* Switzerland: Intergovernmental Panel on Climate Change.

Ivankova, N., Creswell, J., & Stick, S. (2006). Using Mixed-Methods Sequential Explanatory Design: From Theory to Practice. *Field Methods*, 3-20.

Johnstone, N., Haščič, I., & Popp, D. (2009). Renewable Energy Policies and Technological Innovation: Evidence Based on Patent Counts. *Environmental and Resource Economics*, 133-155.

Kalkuhl, M., Edenhofer, O., & Lessman, K. (2013). Renewable energy subsidies: Second-best policy or fatal aberration for mitigation? *Resource and Energy Economics*, 217-234.

Kaya, D. (2006). Renewable energy policies in Turkey. *Renewable and Sustainable Energy Reviews*, 152-163.

Kilinc-Ata, N. (2016). The evaluation of renewable energy policies across EU countries and US states: An econometric approach. *Energy for Sustainable Development*, 83-90.

Kondracki, N., Wellman, N., & Amundson, D. (2002). Content Analysis: Review of Methods and Their Applications in Nutrition Education. *Journal of Nutrition Education and Behavior*, 224-230.

Lantz, E., Hand, M., & Wiser, R. (2012). *Past and Future Cost of Wind Energy: Preprint.* United States: Office of Scientiic and Technical Information.

Lazard. (2018, November 8). *Levelized Cost of Energy and Levelized Cost of Storage 2018.* Retrieved from Lazard Web site: https://www.lazard.com/perspective/levelized-cost-of-energy-and-levelized-cost-of-storage-2018/

Lazard. (2019). *Lazard's Levelized Cost of Energy Analysis Version 12.0.* Lazard.

Lecuyer, O., & Vogt-Schilb, A. (2014). *Optimal transition from coal to gas and renewable power under capacity constraints and adjustment costs.* World Bank Group.

Lewis, J., & Wiser, R. (2007). Fostering a renewable energy technology industry: An international comparison of wind industry policy support mechanisms. *Energy Policy*, 1844-1857 .

Lincoln, Y., & Guba, E. (1985). *Naturalistic inquiry.* Newbury Park, California, USA: Sage Publications.

Liu, W., Zhang, X., & Feng, S. (2019). Does renewable energy policy work? Evidence from a panel data analysis. *Renewable Energy*, 635-642.

Lund, H. (2007). Renewable energy strategies for sustainable development. *Energy*, 912-919.

Markowitz, S., & Grossman, M. (2007). ALCOHOL REGULATION AND DOMESTIC VIOLENCE TOWARDS CHILDREN. *Contemporary Economic Policy*, 309-320.

Martinez-Anido, C., Brinkman, G., & Hodge, B. (2016). The impact of wind power on electricity prices. *Renewable Energy*, 474-487 .

Matisoff, D., & Johnson, E. (2017). The comparative effectiveness of residential solar incentives. *Energy Policy*, 44-54.

Menard, S. (1995). *Applied Logistic Regression Analysis: Sage University Series on Quantitative Aplications in the Social Sciences.* Thousand Oaks, California, United States: Sage Publications.

Menz, F., & Vachon, S. (2006). The role of social, political, and economic interest in promoting state green electricity policies. *Environmental Science and Policy*, 652-662.

Miles, M., & Huberman, A. (1994). *Qualitative data analysis: An expanded sourcebook.* Thousand Oaks, CA, US: Sage Publications.

Morrow, S. (2005). Quality and trustworthiness in qualitative research in counseling psychology. *Journal of Counseling Psychology*, 250-260.

Morthorst, P. (1999). Capacity development and profitability of wind turbines. *Energy Policy*, 779-787.

Munksgaard, J., & Morthorst, P. (2008). Wind power in the Danish liberalised power market—Policy measures, price impact and investor incentives. *Energy Policy*, 3940-3947.

Musall, F., & Kuik, O. (2011). Local acceptance of renewable energy—A case study from southeast Germany. *Energy Policy*, 3252-3260.

Nesta, L., Vona, F., & Nicolli, F. (2014). Environmental policies, competition and innovation in renewable energy. *Journal of Environmental Economics and Management*, 396-411.

Newell, R., Pizer, W., & Raimi, D. (2019). U.S. federal government subsidies for clean energy: Design choices and implications. *Energy Economics*, 831-841.

Nicolini, M., & Tavoni, M. (2017). Are renewable energy subsidies effective? Evidence from Europe. *Renewable and Sustainable Energy Reviews*, 412-423.

Nicolli, F., & Vona, F. (2019). Energy market liberalization and renewable energy policies in OECD countries . *Energy Policy*, 853-867.

Nie, P., Chen, Y., Yang, Y., & Wang, X. (2016). Subsidies in carbon finance for promoting renewable energy development. *Journal of Cleaner Production*, 677-684.

Palmer, K., & Burtraw, D. (2005). Cost-effectiveness of renewable electricity policies. *Energy Economics*, 873-894.

Pelissier, R. (2008). *Business Research Made Easy.* Juta & Co.

Polzin, F., Migendt, M., Täube, F., & van Flotow, P. (2015). Public policy influence on renewable energy investments—A panel data study across OECD countries. *Energy Policy*, 98-111.

Quint, D., & Dahlke, S. (2019). The impact of wind generation on wholesale electricity market prices in the midcontinent independent system operator energy market: An empirical investigation. *Energy*, 456-466 .

Reiche, D., & Bechberger, M. (2004). Policy differences in the promotion of renewable energies in the EU member states. *Energy Policy*, 843-849.

Reuter, W., Fuss, S., Szolgayova, J., & Obersteiner, M. (2012). Investment in wind power and pumped storage in a real options model. *Renewable and Sustainable Energy Reviews*, 2242-2248.

Reuters. (2017, June 2). *Who are the world's biggest polluters?* Retrieved from Reuters Web site: https://www.reuters.com/news/picture/who-are-the-worlds-biggest-polluters-idUSRTXRKSI

Sahu, B. (2018). Wind energy developments and policies in China: A short review. *Renewable and Sustainable Energy Reviews* , 1393-1405.

Sesto, E., & Casale, C. (1998). Exploitation of wind as an energy source to meet the world's electricity demand. *Journal of Wind Engineering and Industrial Aerodynamics* , 375-387.

Shrimali, G., Srinivasan, S., Goel, S., & Nelson, D. (2017). The effectiveness of federal renewable policies in India. *Renewable and Sustainable Energy Reviews*, 538-550.

Söderholm, P., & Pettersson, M. (2011). Offshore wind power policy and planning in Sweden. *Energy Policy*, 518-525.

Statista. (2019). *Energy consumption per capita globally in 2015, by select country (in kilograms of oil equivalent).* Statista.

Statista. (2019, April 12). *U.S. average retail electricity prices 1990-2018*. Retrieved from Statista Web site: https://www.statista.com/statistics/183700/us-average-retail-electricity-price-since-1990/

Sun, P., & Nie, P. (2015). A comparative study of feed-in tariff and renewable portfolio standard policy in renewable energy industry. *Renewable Energy*, 255-262.

Thompson, F., & Scicchitano, M. (1985). State Implementation Effort and Federal Regulatory Policy: The Case of Occupational Safety and Health. *Journal of Politics*, 686-703.

Toke, D. (2007). Renewable financial support systems and cost-effectiveness. *Journal of Cleaner Production*, 280-287.

Villca-Pozo, M., & Gonzalez-Bustos, J. (2019). Tax incentives to modernize the energy efficiency of the housing in Spain. *Energy Policy*, 530-538.

Yan, S. (2018). The economic and environmental impacts of tax incentives for battery electric vehicles in Europe. *Energy Policy*, 53-63 .

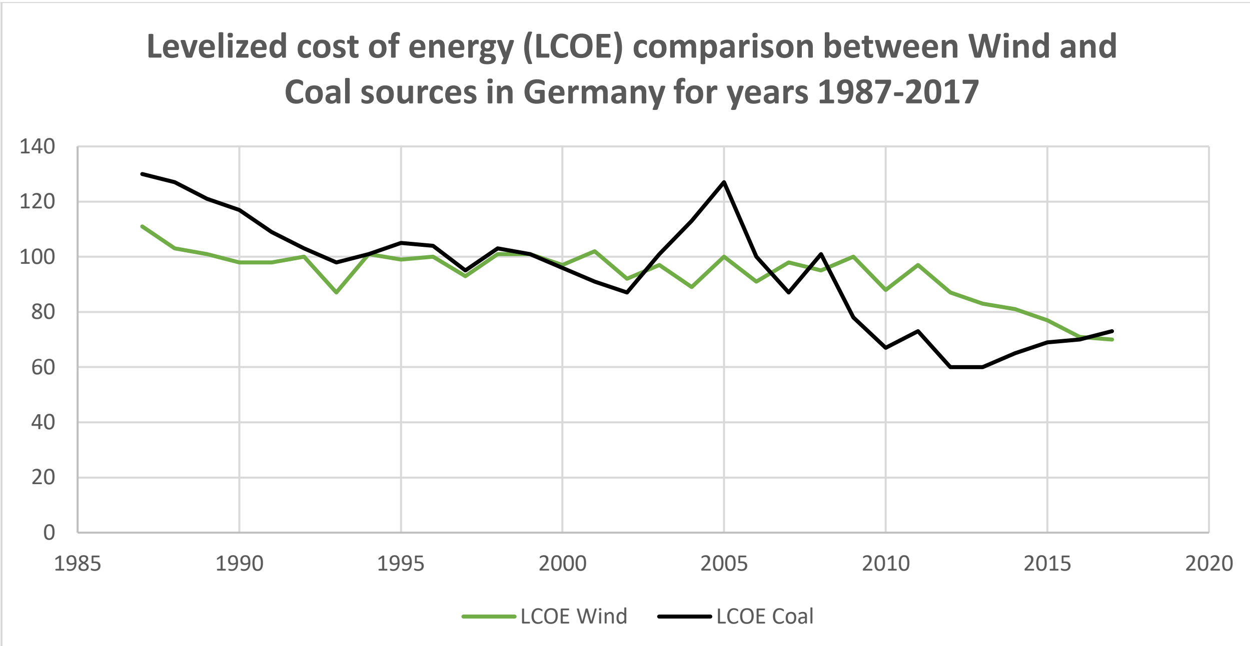
Yang, X., He, L., Xia, Y., & Chen, Y. (2019). Effect of government subsidies on renewable energy investments: The threshold effect. *Energy Policy*, 156-166.

Zahnd, A., & Kimber, H. (2009). Benefits from a renewable energy village electrification system. *Renewable Energy*, 362-368.

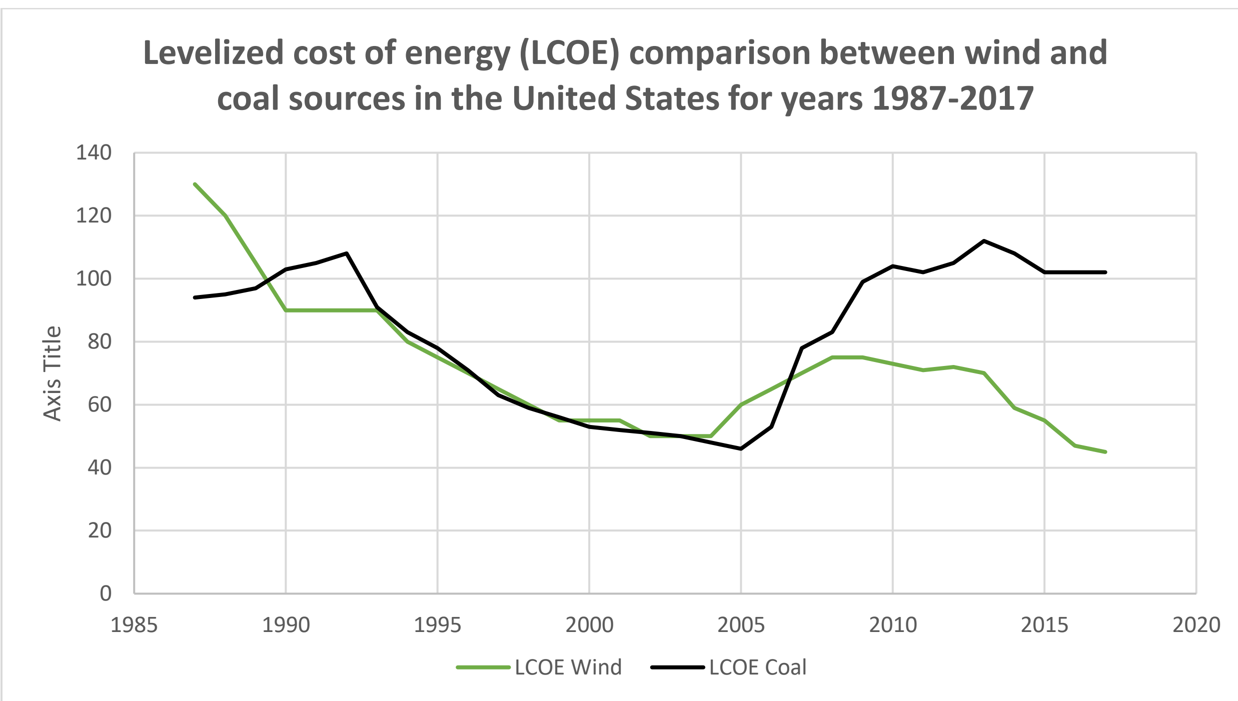
Zhang, H., Li, L., Zhou, D., & Zhou, P. (2014). Political connections, government subsidies and firm financial performance: Evidence from renewable energy manufacturing in China. *Renewable Energy*, 330-336.

Appendix A – Levelized Cost of Energy Figures

Appendix A1 – LCOE Wind and Coal in Germany

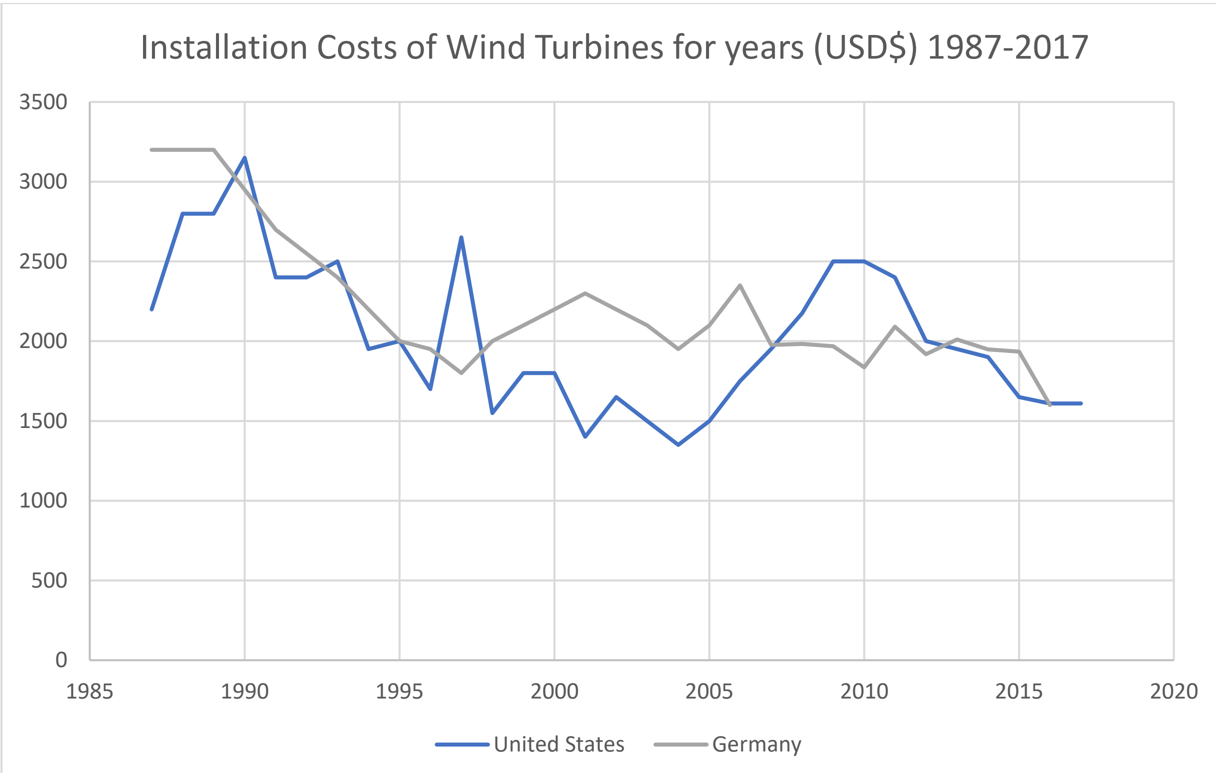


Appendix A2 – LCOE Wind and Coal in the United States

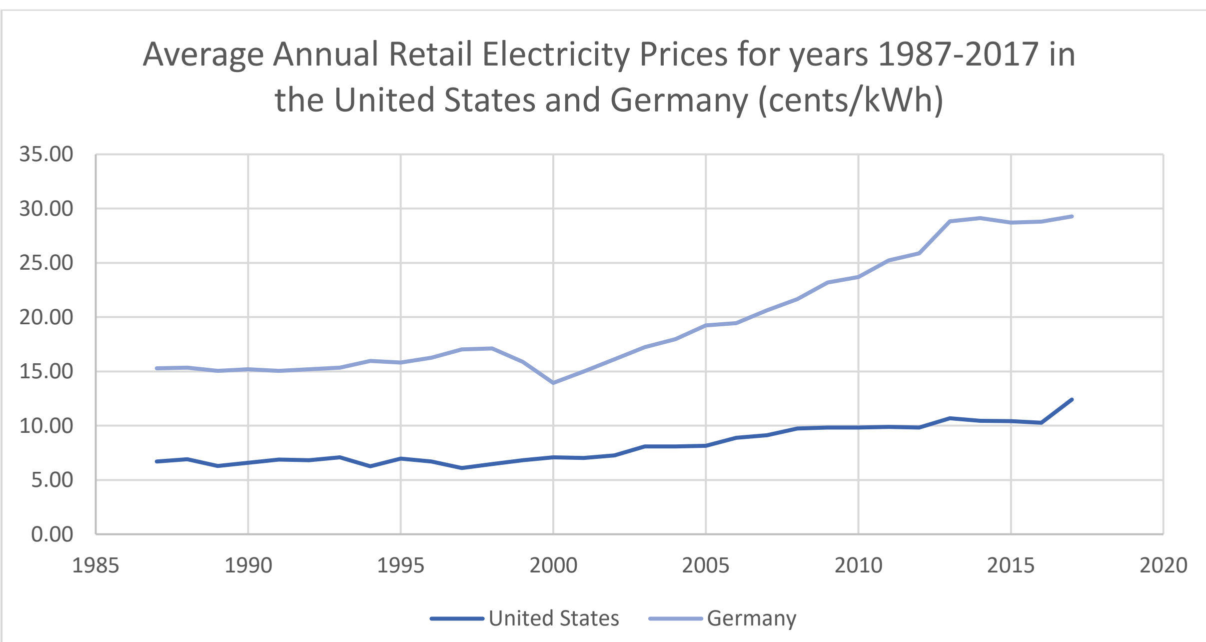


Appendix B – Energy Statistics Figures

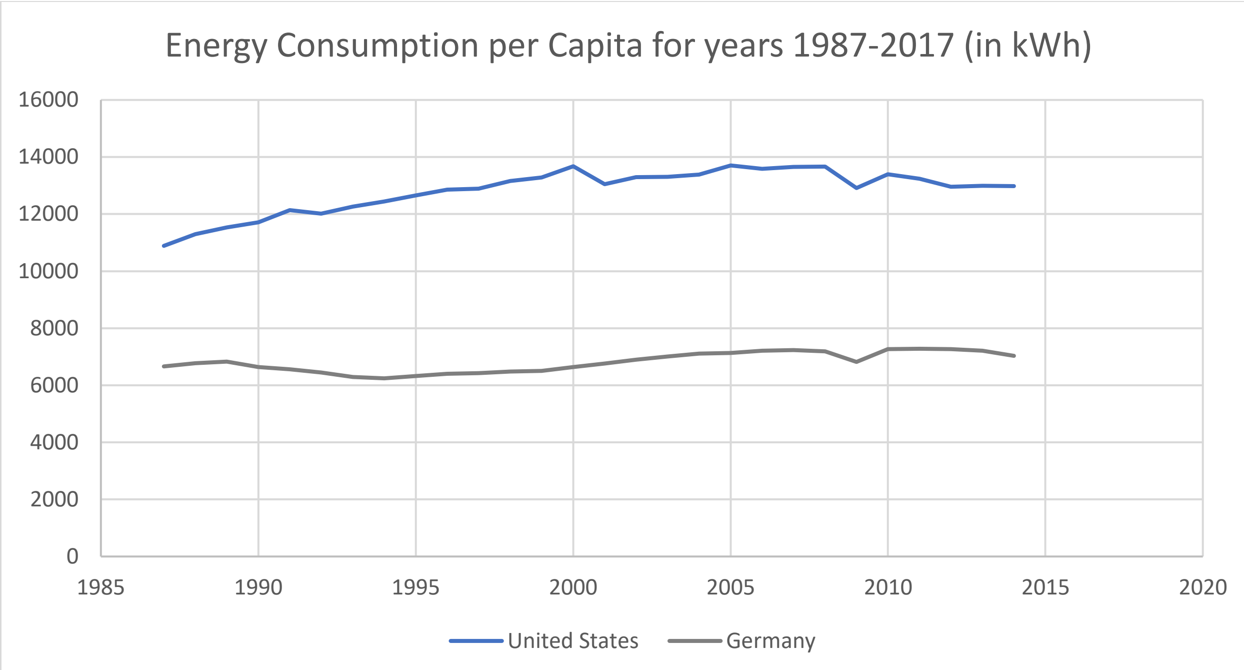
<u>Appendix B1 – Wind Turbine Installation Costs</u>



<u>Appendix B2 – Average Annual Retail Electricity Prices</u>

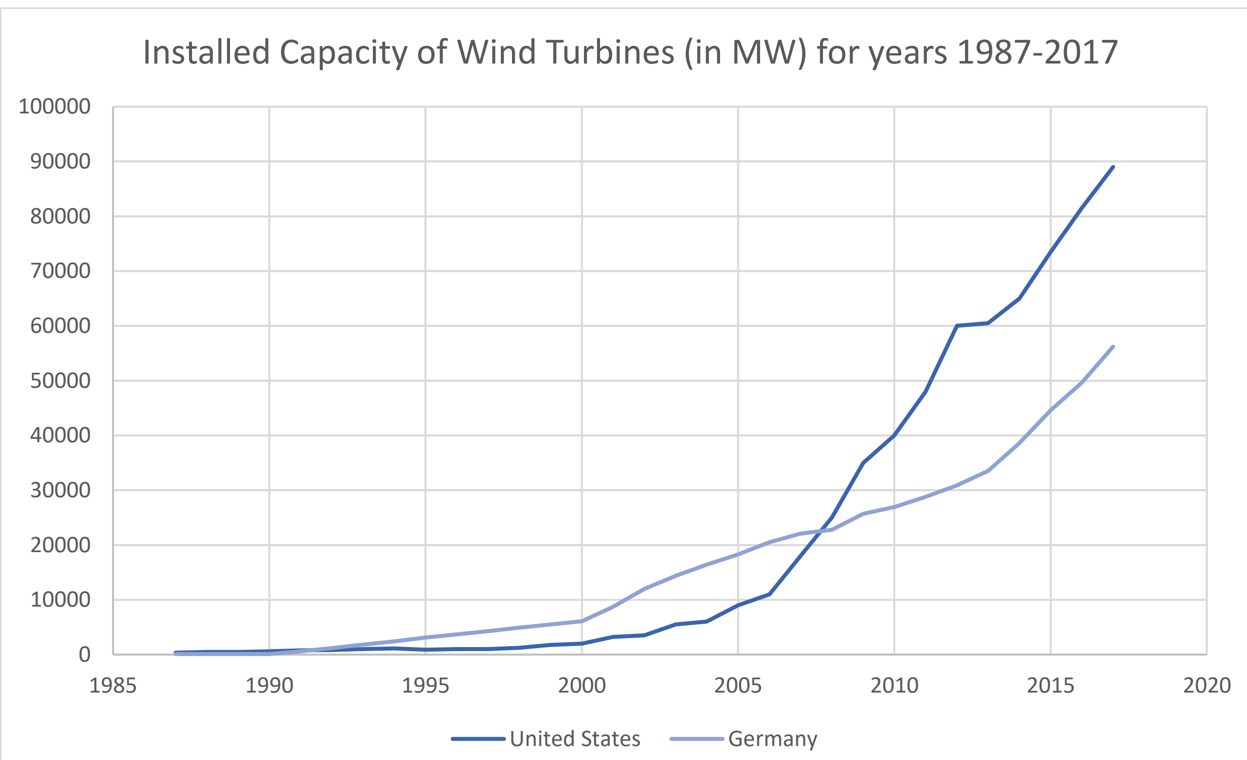


Appendix B3 – Energy Consumption per Capita

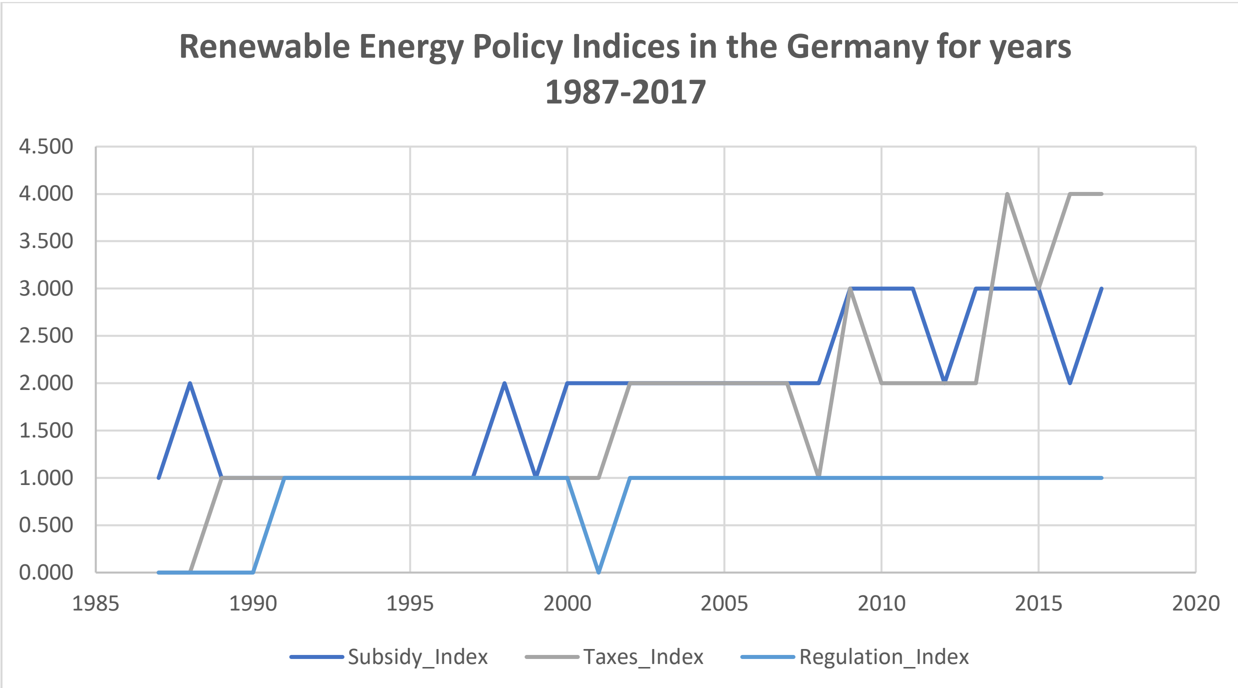


Appendix C – Renewable Energy Policy Figures

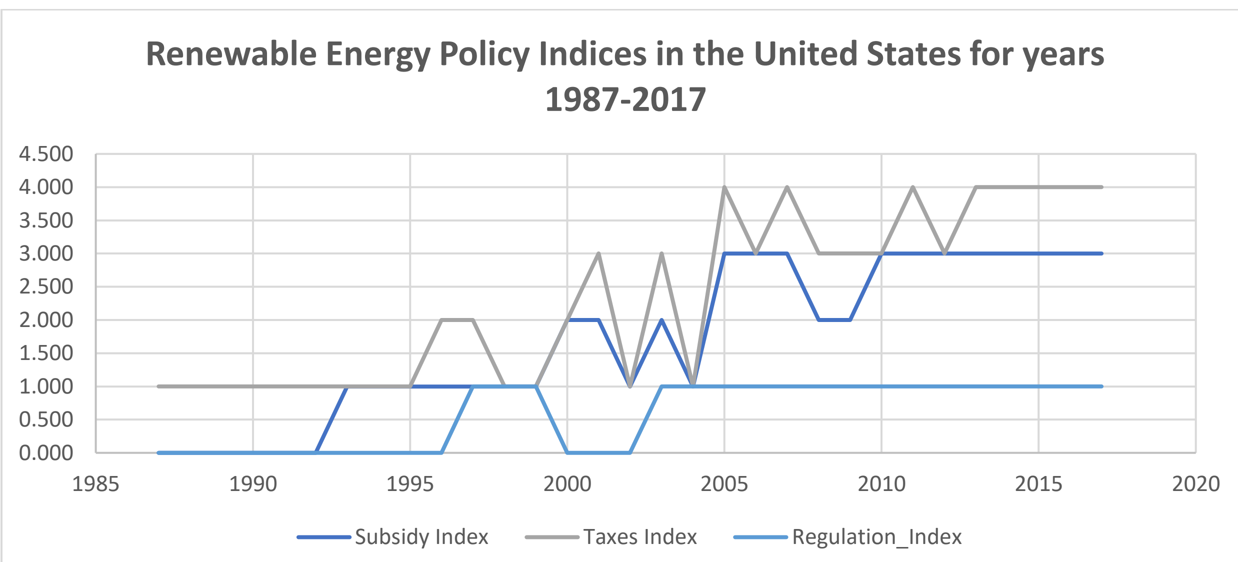
Appendix C1 – Installed Capacity of Wind Turbines



Appendix C2 – Renewable Energy Policy Indices (Germany)

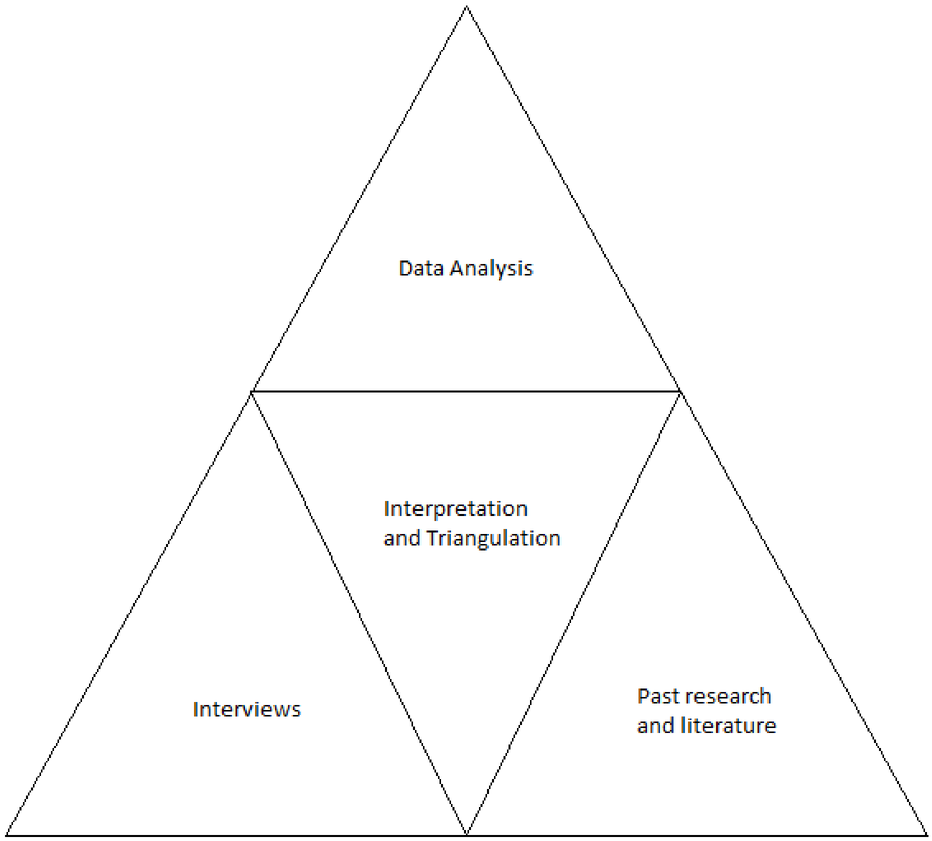


Appendix C3 – Renewable Energy Policy Indices (USA)



Appendix D – Research model figures

Appendix D1 – Mixed methods triangulation model



Appendix D2 – Model of Sequential Explanatory Mixed-Methods Design