**EVALUATING ENERGIEWENDE: A SUCCESSFUL OR FAILED ENERGY TRANSITION ATTEMPT?**

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# EVALUATING ENERGIEWENDE: A SUCCESSFUL OR FAILED ENERGY TRANSITION ATTEMPT?

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I certify that thesis satisfies all the requirements as a thesis for degree of Master of Arts in Sustainable Energy.

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Arts in Sustainable Energy.

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# ABSTRACT

## EVALUATING ENERGIEWENDE: A SUCCESSFUL OR FAILED ENERGY TRANSITION ATTEMPT?

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Paris Agreement highlighted the emergency of climate change. Climate change concerns brings along the utmost importance of transition to cleaner energy sources. Germany's energy transition also known as Energiewende became the most popular energy transition with its challenging climate targets. Besides, Energiewende not only contains transition to renewables, but also refers to a nuclear phase-out. Germany's nuclear phase-out became popular mostly after Fukushima disaster in 2011. However, Germany already had a nuclear phase-out program before Fukushima disaster, but it was more sustainable and long-term phase-out. Germany's immediate nuclear phase-out decision put Energiewende into more challenging situation because Germany started to lose its sustainable and clean energy sources while transforming into renewables. This circumstance leaves fossil fuels as the only alternative along with renewable energy. Importance of fossil fuels in Germany's primary energy consumption caused to question

Energiewende's climate targets. The main objective of this study is to find the driving goals of Energiewende and measure the success of it in line with the energy transition theory.

Keywords: Energy Transition, Energiewende, Germany, Low Carbon energy transition.

# ÖZET

## ENERGIEWENDE'NİN DEĞERLENDİRİLMESİ: BAŞARILI MI YOKSA BAŞARISIZ BİR ENERJİ DÖNÜŞÜMÜ GİRİŞİMİ Mİ?

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Paris Antlaşması iklim değişikliğine resmiyet kazandırdı. Böylece iklim değişikliği temiz enerji kaynaklarına geçişin önemini arttırdı. Almanya'nın enerji dönüşüm program Energiewende iddialı iklim hedefleri sayesinde en popular enerji dönüşüm programı haline geldi. Energiewende sadece yenilenebilir enerjiye dönüşümü içermiyor, aynı zamanda nükleer enerjiden vazgeçilmesini de içeriyor. Almanya'nın nükleer santrallerini kapatma kararı Fukushima felaketinden sonra gündemde yer edinmeye başladı. Aslında Almanya'nın Fukushima felaketinden önce de nükleer enerjiden vazgeçme kararı vardı. Ama bu karar daha sürdürülebilir uzun vadeli bir nükleer enerjiden vazgeçiş sürecini kapsıyordu. Almanya'nın Fukushima felaketinden sonra aldığı nükleer santrallerin bir kısmını hemen kapatma kararı, Energiewende'yi daha zor bir konuma soktu. Çünkü Almanya sürdürülebilir ve temiz bir enerji kaynağını kaybetme sürecine girdi. Bu durum fosil kaynakları yenilenebilir enerjinin yanında tek alternatif olarak bıraktı. Fosil yakıtların Almanya'nın birincil enerji tüketimi içerisindeki önemi de

Energiewende'nin iklim hedeflerinin sorgulanmasına yol açtı. Bu çalışmanın temel amacı, Energiewende'nin hedeflerini tespit etme ve başarısını enerji dönüşümü teorisne göre ölçmek üzerine kurulmuştur.

Anahtar Kelimeler: Enerji Dönüşümü, Energiewende, Almanya, Düşük Karbonlu Enerji Dönüşümü.

TO MY LATE GRANDMOTHER
MAY SHE REST IN PEACE

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# CHAPTER 1

## Introduction

Germany is the fourth largest and the most populated country of the EU with 82 million population which equals to 16% population of the EU and the biggest economy in the EU (GTAI, 2018). Germany's GDP is equal to 21% of the EU's GDP and Germany has the $4^{th}$ biggest GDP in the world (World Bank, 2017). Even with the high population, Germany is still in top 20 with its GDP per capita according to World Bank (2017) data. Germany is also the biggest market of the EU. It is a high-tech industry country and exporting volume of Germany proves this fact. Automotive, machines, chemical goods, IT hardware, electronics, optical goods and pharmaceuticals are the main export goods of Germany and automotive and machines constitutes one third of the exports (GTAI, 2018).

Considering Germany's capacity of economy and industry, it would not be surprising to find the biggest share of final energy consumption in the EU belongs to this country. Germany's final energy consumption share is 20% in the EU (Eurostat, 2017) and industrial countries like Germany highly dependent on energy generation. Energy usage of industrial sectors has the highest share in the world in which the industrial sector uses 54% of the worlds energy (Romero et al., 2019). Industry of Germany surely requires all types of energies but there should also be a balance between energy demand and energy sources because Germany has specific climate related aims and a part of Kyoto Protocol and Paris Agreement (COP 21). Besides, Germany's own climate targets are more challenging compared to the UN's and the EU's climate targets (BMU, 2019).

In today's conjuncture, climate change is a fact that requires a global action and this fact accepted by large scale economies as seen in Kyoto Protocol and COP 21. Reducing Green House Gas (GHG) emissions may be the answer for reducing the devastating effects of climate change. GHGs consist of carbon dioxide, methane, nitrous oxide and water vapor and many sources such as agriculture, forestry and burning fossil fuels produce GHG. For example, livestock farming produces methane gas because of animal's digestion systems. Deforestation reduces the number of trees, but trees absorb carbon dioxide from the atmosphere. As a result, when trees are cut down, they release their stored carbon dioxide into the atmosphere (CFR, 2009). Agriculture and forestry also have negative effects whereas biggest source of GHG emission is burning fossil fuels (EPA, 2016). Reducing usage of fossil fuels, increasing energy efficiency and promoting renewable usage are some of the elements that may reduce GHG emission.

Germany has an energy transition process for meeting climate targets, providing energy sustainability and stability, and also for decreasing energy dependency and energy consumption which is called Energiewende. It has also great support from citizens for following climate friendly policies (Amelang, Wehrmann & Wettengel, 2019). Whereas, Germany has another challenge for building a climate friendly energy profile instead of decreasing fossil fuel energy sources and it also has a nuclear phase-out program. In other words, Germany is already phasing out a climate friendly energy source (Figure 2). Energiewende is becoming more and more challenging due to loss of nuclear power. This loss brings a question mark on fossil fuels as well because renewable energy sources are not enough for meeting the energy need of Germany alone for the time being. It must be supported by another energy sources, and nuclear phase-out leaves only fossil fuels behind.

Finding the driving goals of the Energiewende would help to understand Germany's energy transition program. For understanding and analyzing the driving force behind it, the Joas et al (2016) made a survey among more than 50 policy experts in 2016. According to the study, climate protection has been determined as the most important goal of the Energiewende. The second most agreed fact is that, if climate change does not happen, Energiewende would still be a logical project. This study will also question if it is really true that Energiewende makes sense without the climate change targets of its own.

For reaching a complete view about Energiewende, following research questions will be answered in Analysis and Findings Chapters.

i) What are the driving goals of Energiewende?
ii) What are the challenges of Energiewende?
iii) What is the reaction of public regarding Energiewende?
iv) Is Energiewende a successful or failed attempt?

Therefore, the main aims of this study are to evaluate the Energiewende, to conduct a content analysis and policy analysis methodologies in order understand if it is a successful or failed energy transition attempt for Germany.

Accordingly, this study consists of 7 chapters. **Chapter 1** is the Introduction section which gives general information about Germany's economy, industry and energy needs. It also mentions about climate change and Energiewende's general characteristics.

**Chapter 2** is Methodological Framework and Literature Review where content analysis and policy analysis are explained, and literature review has been done, and main methodology of the study has been created.

**Chapter 3** demonstrates and states German energy mix, starting with fossil fuels coal, oil & natural gas and continues with renewable energies such as wind solar and biomass. In this chapter energy sources are analyzed according to consumption, capacities of production and dependency on imported energy.

**Chapter** 4 is about Policy Making of Germany. In this chapter Germany's energy policy is analyzed in line with the EU's energy policy for understanding main framework of Energiewende. Also, nuclear phase-out policy is explained in detailed.

**Chapter 5** gives information about Historical Background of Energiewende including, history of nuclear energy, anti-nuclear movements in Germany and local disputes related to Energiewende.

**Chapter 6** is the section for Analysis and Findings. This chapter applies methodological framework to evaluate the success of Energiewende around the research questions.

**Chapter 7** is Conclusion section which contains a brief conclusion about Energiewende's situation according to analysis and findings of this study. This chapter also evaluates and forecasts the future of Energiewende.

# CHAPTER 2

## Methodological Framework and Literature Review

Content analysis and policy analysis are the main pillars of the methodology in this study. Content analysis is defined by several scholars with its different aspects. There are couple of different approaches for content analysis much as common point could be basically defined as: content analysis is an analyzing tool for obtaining the information especially in a textual material (Holsti, 1969; Krippendorf, 2004; Cavanagh, 1997; Hsieh & Shannon, 2005; Duriau, Reger & Pfarrer, 2007). Holsti (1969) handles content analysis by using five characteristics. For Holsti, content analysis should have *objective and systematic* producers, should be *quantitative,* should have *generality* and should concentrate to *manifest content*. Krippendorf (2004) describes content analysis as an *empirically grounded method* which includes exploratory process and prognostic purposes. To be more specific, content analysis examines data to get to the information and understand how that information could be used for *enabling* or *preventing* the situations according to Krippendorf (2004). Furthermore, *quantitative* or *qualitative* data, as well as *deductive* or *inductive* approaches are elements which may be used in content analysis method (Manimozhi & Srinivasan, 2018). Content analysis is also used for reaching an empirical basis to see the changes in public opinion (Stemler, 2001). This utility of content analysis will be indispensable for this research because in the next stages, importance of public opinion on Energiewende is going to be discussed. For the purpose and content of this study, content analysis method has been chosen as main pillar of methodology and it has supported with policy analysis which is vital for understanding the policy implications of energy transition. More specifically, first, a literature review is conducted for understanding the impacts of the energy transition concepts. In literature review part, history of energy transition and how energy transition has been accepted by scholars is analyzed.

For the international organizations including both intergovernmental and non-governmental, energy transition is a prominent key element. The main reason seems to be the climate change mitigation. It is obvious that climate change mitigation is one of the most important driving factors for several scholars (Pearson & Foxon, 2012; Fouquet & Pearson, 2012; Laird, 2013; Sovacool, 2016). However, it is not the only driving factor of the energy transition and according to International Energy Agency (IEA), climate change mitigation is not the only target. Reducing air pollution and delivering electricity to all over the world, especially to people who still don't have access to electricity, are main targets of The Clean Energy Transition Programme (CETP, 2017). When look at the European Union's side, it is clear, climate change mitigation is one of the most important driving factors of the modern energy transition programs (ECCP, 2004). Also, energy transition has been popular among scholars too. Therefore, there are couple of approaches on energy transition from many scholars.

Araújo (2014) claims that, there is not a globally accepted energy transition definition. The author gives examples of various definitions from the energy transition literature to prove her statement. For the author, definition of energy transition has changed during different eras. After the literature review, the author presents that transitions can happen in different characteristics of energy systems such as; *efficiency, density, sustainability, reliability and portability.* According to definition of Araújo (2014), there are couple of approaches for energy transition and it is difficult to find a common acceptance. Some scholars such as Grubler (2012); Gismondy (2018); Smil (2004) and Fouquet (2010) approach it from historical background for demonstrate a roadmap for the next energy transitions from the lessons of previous energy transitions; on the other hand, some scholars like Sovacool (2016); Laird (2013), Miller et al., (2013) and Fouquet & Pearson (2012) approach it from analyzing change in energy or economic systems. The reason why there is not a globally accepted energy transition definition may be found energy transition itself because when a transition completed another transition to other energy source or system starts and all transitions have their own dynamics.

Grubler (2012) approaches to energy transition with historical background of the energy transition. Because the author claims that current energy systems are not sustainable and there is a need for an energy transition to provide sustainability. According to the author, for providing a decent energy transition, studying energy transition history would be vital because there are lots of deficient energy transition implementations lies down in the past and it is very important to take lesson from the mistakes of the past to develop successful projects for the future. To clarify how energy transitions works, the author points out to the energy transition in United Kingdom (UK). Because the UK's energy transition history is very important sample because it is a trailblazer of the Industrial Revolution. According to Grubler (2012), *"technological and associated institutional transformations in energy end-use are the fundamental drivers of historical energy transition."* For example, steam power in transportation created demand for coal and internal combustion engines lead do development of oil industry. Also, according to the author, new technological developments enabled improvement of traditional technologies and they become more efficient and cheaper. Beside these facts, authors' another finding is development of pioneers are slow in energy transition. Whereas late adopters will have faster energy transition beside the pioneers because they would have advantages of pioneers' experience. Price of the new technologies will decrease in time, also (Grubler, 2012).

Gismondi (2018) also gives importance to historical theory of energy transition. Author divides energy types into two for pointing out the effect of technological developments on transformation of energy types which can be listed as: less efficient *water, wood, peat, coal* and more efficient *mobile oil, gas* and lately *nuclear and renewable* sources. Like Grubler (2012), the author also mentions about effects of industrial growth on energy consumption. For the author, energy consumption increased in each decennium of industrial growth. It would not be wrong to say that there is a positive correlation between industrial growth and energy consumption under the light of this information. Industrial growth aside, author also draws attention on another important fact in energy transition history, which is military and corporate interests. After World War II, The European Recovery Plan and Marshall Plan targeted to rebuild energy infrastructure as oil based in Europe. According to the author, reason behind these plans is to weaken coal mining and transportation in Germany and United Kingdom and to provide rising of petrolization controlled by United States in Europe. In a nutshell, global authority of United States military secured dissemination of oil but it came with costs of corroding democratic power of citizens according to the author. The other interesting finding of the author about globalization is *consumer capitalism* and *the energy intensification.* That means corporations move their mass production to developing countries because of reasons such as cheaper labors and tax compensations. This leads to transportation of goods from developing countries to developed countries by using trucks and ships. And consequently, that transportation process creates an energy use and increases CO2 emissions (Gismondi, 2018).

Smil (2004) categorized history of the energy transition into three eras. According to the author, domestication of animals and controlling fire for manufacturing metals established the first energy transition. The second energy transition started couple of thousand years later by replacing muscle power with windmills and waterwheels. The use of renewable energy increased efficiency and power capability. The third energy transition came with engines and fossil fuels. For the author, it had started with couple of European countries, and then achieved by all industrialized countries in $20^{th}$ century; though, this transition has not achieved globally, yet. The third energy transition is still in progress in the low-income economies especially in Africa as the author clarifies. The author also included nuclear and renewable energy in third energy transition too. The author also criticizes Industrial Revolution whereas, it is divided from other views on Industrial Revolution. Unlike the main thought which points out importance of steam engines are main driving factor of Industrial Revolution, the author argues that, textile industry is the key element of transformation of production and this industry is energized by water power instead of the coal. For the author, coal only provided the expansion of iron producing process. As for the $21^{st}$ century, the author demonstrates global dependency on fossil fuels to show difference between usage of fossil fuels in 1950 and 2000. In 1950, fossil fuels share is 35% in energy supply. It risen to 60% by 2000 while share of coal stayed nearly at 25%. Besides, 90% of commercial energy usage is provided by fossil fuels. The author also shows that worlds %10 richest population used 40% of commercial energy in 2000. He also argues that higher usage of energy does not mean higher life quality. United States use double the amount of energy when compared to European Unions' richest countries and Japan while life quality is higher in the European Union and Japan (Smil, 2004).

Energy democracy is a very important part of energy transition (Thombs, 2019; Paul, 2018; Morton & Müller, 2016). Thombs (2019) defines climate change as a *socio-ecological crisis* and says, this crisis leads to *a sustainable future*. The cases of Paul (2018) and Morton & Müller (2016) clearly show that lack of energy democracy plays very important role in the fails of energy transition attempts. It is clear that energy democracy and energy transition have a strong contiguity with each other. Burke & Stephens (2017) criticizes importance of energy democracy in a very detailed manner. According to the authors, shifting in 100% renewable energy for decreasing the dominant fossil fuel dependency is a goal of energy democracy. That is why energy democracy plays a very important role in modern energy transition projects. Other goals provide public and social control in the energy sector, rebuild energy sector for improved democratic process and provide environmental sustainability and social justice (Burke & Stephens, 2017). According to the authors, energy is acknowledged as a public good mainly instead of commodity and related to this fact, energy democracy includes new economic system that includes distribution of financial energy sources with communities and citizens. In other words, social ownership of the energy is one of the key elements of energy democracy in renewable energy transition. Furthermore, the authors argue very specifically about 22 policy instruments about energy democracy. In conclusion, authors demonstrate an opportunity: Transition from fossil fuel-based energy to renewable based energy requires shifting the technology. Other than the technology, it is very important to shift social and political measures with energy democracy to achieve a complete energy transition process (Burke & Stephens, 2017).

Sovacool (2016) defines energy transition as "a change in energy system such as change of a fuel source, technology or prime mover." As Sovacool (2016) says, according to mainstream view, energy transition takes time to actualize. He analyses energy history of United States portfolio to demonstrate mainstream view in numbers. Crude oils journey from exploratory stages to 10% of national market share took 50 years. It took 103 years to reach 5% of total energy consumption for coal while natural gas needed 70 years to reach 20% from 1% of total energy consumption. Also 25% of nuclear share took 38 years. Like Grubler (2012), the author also mentions that learning from previous energy transitions could help to accelerate future energy transitions. The author also describes not all transitions are slow like mentioned in mainstream view even in prime movers. To clarify the speedy transitions, the author has reviewed five transitions project in five countries. The common points of these transitions are successful cooperation between people and government, and especially dedicated government programs promote the transition. Sovacool explains this change of speed to indicate that world learned a lot from past transitions and future transition would be accelerated. The author also compares past and future transitions motivations. According to the author, past transitions were price and available resource orientated. The future transitions could be motivated with social and political orientated. Because author demonstrates that climate concerns and insufficient resources could clarify the future transitions.

Laird (2013) says, energy transition can be described as major changes into energy systems according to energy analysts. The author also states that the source of worries about energy shortage determines by rising and falling prices of oil and those concerns about oil prices regulate political agendas in Untied States. Even the low prices of oil could not affect the energy transition concept because of climate change concerns and future statue of oil as Laird (2013) says. For the author, fuel types consisted energy systems according to policy elites. Therefore, fuel and fuel-based technologies are core elements for policymakers and public. However, for the author energy system means much more than fuel types. For example, when energy transition happens, some business lines reduce and others rise, and this will change social life. Therefore, changing energy systems shape social, political, economic and cultural aspects (Laird, 2013).

Miller et al., (2013) also define energy transition as a change in fuel sources according to mainstream view of energy transition as Sovacool (2016) pointed out. Besides that, the authors also discuss energy transitions social, economic and political aspects like Laird (2013) argued. Authors' another common point with Sovacool (2016) is: "energy transitions take time". For the authors, especially social and economic aspects of energy systems take time. Furthermore, the authors say that fuel concept is not main fact as mainstream view pointed out. Arrangement between social, economic and political forms with new energy technologies are key point of the energy transition for the authors. Especially the most important part of the energy transition is *"organizing a new energy system around the fuel."* Same as Laird (2003), Miller et al. (2013) mention about energy transitions social effect like changing generation causes to changing business sectors, thus workers should adopt to the new jobs. Additionally, authors explain why late developers have faster energy transition as Grubler (2012) mentioned. For the authors, infrastructure is the key element to expedite energy transition. Finally, authors draw attention to importance of energy justice in energy transition. For the authors, *"energy is essential to human life"* and political systems do not give enough importance to this right. For the authors, energy justice also defines what types of energy should be chosen, where would be correct place to build and help to analyze advantages, risks and costs. Lastly Miller et al. (2013) see energy transition as a socio-technological transformation.

Fouquet (2010) is another author who approaches energy transition from historical background. Fouquet focuses United Kingdom's energy transition like Grubler because United Kingdom made the first transition to fossil fuels in history and it is the "only clear case" as a first mover in an extensive energy transition as the author clarifies. The author categorizes main drivers of United Kingdom's fossil fuel transition under four main titles, which follows as: *heating, power, transport* and *lighting.* Beside the main drivers, the economic drivers of energy transition are cheaper prices and better services as the author says. The author also describes that *energy source, the supply network* and *the services* are transformed as a result of energy transition. Fouquet also joins main view of energy transition which is: “energy transition takes time”. For the author, from innovation to diffusion process, transition requires minimum 50 years in average according to history of energy transition from 700's to 2000's. Additionally, Fouquet makes a connection between the past and the new energy transitions for centralizes willing to pay higher prices concept. Author says in the past, for energy transitions, some parties were willing to pay higher prices for *easier, cleaner* and *more flexible* services. Current energy transition motivation is decreasing the carbon emission and shifting the cleaner energy sources could increase the electricity prices. At this point, the author clarifies not only all parties would be willing to pay higher prices but also governments should involve providing a niche market. Because in the end, the key to the energy transition is *better and cheaper services* (Fouquet, 2010).

Fouquet & Pearson (2012) describe energy transition as a switching to an economic system which is dependent to one or more technologies and energy sources. The authors also emphasize on analyzing past energy transitions to demonstrate options for energy policy to next energy transitions. Furthermore, the authors say, if the price of the new energy is cheaper and more efficient than the current ones, energy transition may be considered as successful according to past transition concept. Whereas nowadays, services which are provided by new energy sources are more expensive than current energy sources as authors says. In this case, consumers paying extra money for cleaner energy do not seem sustainable and because of that the authors suggest building a developed niche market for adequacy of the cleaner energy sources. The authors also point out that reaching to niche market through technological innovation requires minimum 40 years, so it is not wrong to say that energy transition to cleaner sources is still in progress. Besides, the authors also describe another historical view of energy transition which is: energy transitions have led to major increase in energy consumption. This fact causes the authors to come up with a possibility of low carbon energy sources, however; it does not guarantee the reducing of fossil fuel consumption in future. The authors also summarize difference between past energy transitions and low carbon energy transition as past energy transitions had profits for both consumers and producers. In low carbon energy transition, the key factor is climate change, in other words it contains public good and that is why the authors point out the importance of *greater government encouragement.*

Pearson & Foxon (2012) come with a strong possibility, which is a low carbon energy transition that could transform to "low carbon industrial revolution." To analyze this possibility, the authors focus on past economic and technological elements of energy transitions to create a roadmap for low carbon energy transition. First, the authors clarify the difference of low carbon energy transition as Fouquet (2010) and Fouquet & Pearson (2012) agreed before, which is "palliating climate change is a social good." The second common view of the authors is low carbon transition requires "systemic policy for promote low carbon transitions." The authors also refer the arguably weak situation of low carbon technologies against incumbent ones. The authors advert requirement support for niche markets from policy actors until low carbon technologies reach cost reduction levels. The authors also bring possible challenges against to low carbon transition. In this case the authors bring attention to *sailing ship effects* which is explained as even if low carbon technologies reached the competitive level against to incumbent high carbon technologies, those incumbent technologies can fight back against low carbon technologies with lower market and fuel costs. At this point, carbon taxes and 2050 low carbon targets are shown as the driving factors of low carbon transitions as the authors argue.

Wilson & Grubler (2011) say main element of change is technology according to technological determinism. The authors also argue that social elements shape the technology according to social constructivism. The authors approach to energy transition under the light of these two opposite views. Beside these two perspectives, technological change is the key factor in past energy transitions, and it will be also the key factor in future energy transitions as authors describe. Like Grubler (2012), Gismondi (2018) and Smil (2004), the authors also put emphasis on industrial revolutions for understand the history of energy transition and agree that energy transitions take time and late adopters have faster progress in transition as previous scholars agreed. For the authors, global energy systems were shaped from two main transitions; First one was coal powered steam power and the second one was displacement of steam power by “electricity and petroleum-based technologies”. When the authors analyze the driving factors behind these transitions, they found out that demanding on energy is the key factor such as *lighting, heating, mobility and power* which are demanded by consumers. The authors also describe why electricity and petroleum-based technologies had substituted the steam powered technologies. The main reasons were not economic concerns or energy scarcity which were identified as important driving factors of energy transition by several scholars. Moreover, they weren’t the key factors in these two transitions for the authors. The other description of the authors enlightens how new technologies compete with incumbent ones with higher prices: the answer is “performance.” For the authors, performance overcomes economy with ability of provide an *improved* or *new energy service* as a driving factor of technological change. The other important factor of the new technology is *formative phase* according to the authors and they describe formative phase as a period between the innovation of technology and widespread commercial usage. During formative phase, technologies are tested and boosted, also prices are reduced. In other words, technology shapes every aspect according to market demands as authors states. Beside technical sides of transition, the authors diverse future low carbon transitions from historical energy transitions with policy factor. They say that historical transitions had poor directions in regulations, prices and policies and with *driving role of policy*, future transitions will have globally integrated markets and stronger information and communication share. Thanks to these integrations, the authors predict that future energy transitions will have potential for faster progress while criticizing low carbon technologies with patrol-based technologies are still competitive against to low carbon technologies and had similar results as patrol-based technologies like Pearson & Foxon (2012) argued. The authors found out low carbon technologies have not performance advantage over patrol-based technologies yet and as Pearson & Foxon (2012) underlined, the authors also agree that policies should support niche markets for boosting the performances of new technologies.

Ediger (2019) says combination of low carbon fossil fuel like natural gas and promoting renewable energy is the key of low carbon energy transition. Child et al.

(2018) puts forward that low carbon energy transitions requires technological developments for providing a sustainable transition with political, economic, socio cultural and institutional changes. Chen et al. (2018) also underline the importance of technology and requirement of integration between of management, economics and environmental sciences. Meadowcroft (2009) describes energy transition as changing of *technologies and social practices.* Author also underline the importance of environmental policy integration to transition and adding energy transitions take 20 to 50 years to happen.

As Araújo (2014) said, there is not a globally accepted common energy transition definition. After the literature review phase of this study, it is impossible to deny Araújo (2014). In the literature review of this study, it can clearly be seen that some scholars pointed out same or similar points. For using their common definitions and findings, the methodology of this study has been built. Some common points of the scholars are about the definition of energy transition, but there are common findings which are about how modern low carbon energy transitions should be. The definitions or findings which have been supported at least by two scholars are included in the Table 1. 20 articles were evaluated (Grubler, 2012; Gismondi, 2018; Smil, 2004; Paul, 2018; Morton & Müller, 2016; Burke & Stephens, 2017; Sovacool, 2016; Laird, 2013; Miller et al., 2013; Fouquet, 2010; Fouquet & Pearson, 2012; Pearson & Foxon, 2012; Wilson & Grubler, 2011; Child et al., 2018; Chen et al., 2018; Meadowcroft, 2009; Araújo, 2014; York & Bell 2019; Thombs, 2019; Ediger, 2019) to reach minimum two common definitions or findings of energy transition and 11 articles out of 20 met this requirement. Other articles have been excluded from Table 1. The definitions are indicated with light green and findings are indicated with light brown in Table 1.

**Table 1: Energy Transition Definitions and Findings by Scholars**

| | Wilson & Grubler | Smil | Burke & Stephens | Sovacool | Laird | Miller et al | Fouquet | Fouquet & Pearson | Child et al. | Chen et al. | Meadowcroft |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Decrease in usage regarding older energy sources | + | + | + | + | | + | + | | | | |
| Major changes for energy systems | + | | | + | + | + | + | + | + | + | + |
| Cheaper Prices | | | | | | | + | + | | | |
| Reducing Carbon emissions (Climate change concerns) | | | | + | + | | + | + | + | + | |
| Switching to an Economic System | | | + | | | + | | + | + | + | |
| Cooperation between public and government (Energy democracy) | | | + | + | | + | | + | + | + | + |
| Energy Transition takes time | + | | | + | | + | + | + | | | + |
| Late adopters have faster transitions | + | | | + | | + | | | | | |

According to Table 1, “decrease in usage in regarding energy sources”, “major changes for energy systems” and “Reducing Carbon emissions (Climate change concerns)” are the most common definitions of energy transition. “Energy transition takes time” and the importance of “cooperation between people and government” are the most common findings of the scholars. In this case, same similar findings of scholars are merged into one definition like “cooperation between public and government”. Some scholars like Morton & Müller (2016), Paul (2018) and Burke & Stephens (2017) analyze this notion under energy democracy. Whereas Sovacool (2016) Miller et al. (2013) and Fouquet & Pearson (2012) mention about cooperation between public and government. “Switching to an economic system” is the second common definition of energy transition. Reducing carbon emission is attached with modern low carbon energy transitions. It does not have a valid definition for previous energy transitions. Also, the least common definition which is “cheaper prices” belong to previous energy transitions but in low carbon energy transitions “cheaper prices” are not the main concern as Fouquet (2010) defines, all parties are willing to pay higher prices for decreasing carbon emissions.

To measure Energiewende’s success or failure, energy transition of Germany will be analyzed according to above-stated definitions and findings of Table 1. Besides, Germany’s current energy data is going to be analyzed according to the EU’s and Germany’s energy targets. This approach will prove or disprove how successful Energiewende is. Following methodological framework and literature review, next chapter will analyze energy profile of Germany.

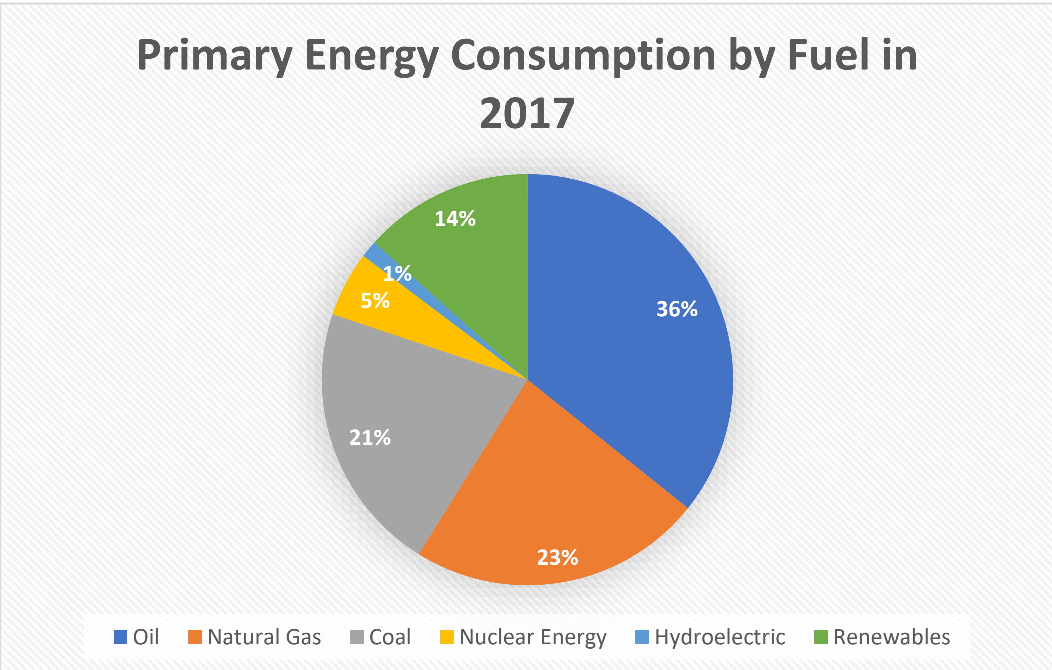
# CHAPTER 3

## Energy Profile of Germany

### 3.1. Germany's Energy Mix by Resources

As a high-tech industry country, Germany has a place in top 10 in world including many rankings of energy statistics. For instance, Germany is the 7th in the world and number 1 in the Europe in primary energy consumption (BP, 2018). Germany also share top 3 spot with United States and China in wind energy capacity. Germany also be in a very important position in energy importing. Germany is the number 1 natural gas importer in the world (EIA, 2017). In production side, Germany is the 25th biggest energy producer country in the world. Being 7th in energy consumption, and 25th in energy production should draw a picture about Germany's production and consumption ratio. It is clear from the statistics that Germany is an energy dependent country.

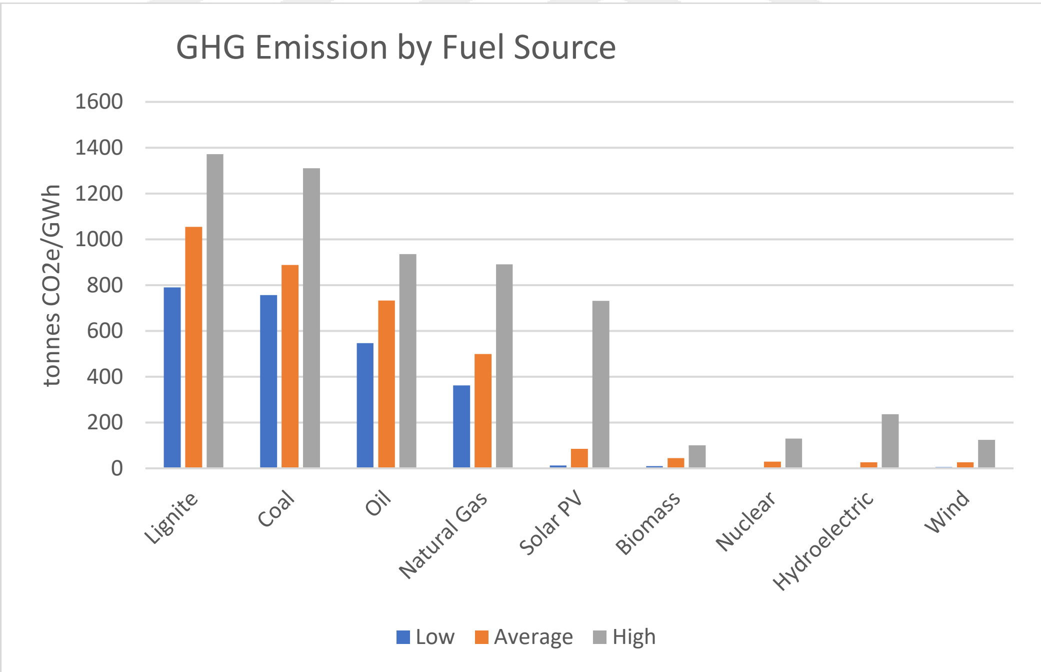
**Figure 1: Primary Energy Consumption by Fuel (Source: BP Stats, 2018)**



Before analyzing important fuel types in Germany's energy mix individually, examining primary energy consumption of Germany by fuel type will be helpful to understand the importance of fuels in Germany's energy Mix. According to Figure 1, conventional energy sources consist of oil, coal, hydroelectric including nuclear energy dominate energy mix of Germany with combining 86% of share in primary energy consumption. Yet, not all these conventional energy sources pollute the environment. 6% of conventional energy sources consist of nuclear and hydroelectric which have very little carbon footprints compared to other conventional energy sources (Figure 2). In the light of this information, 80% of fuel in Germany's primary energy consumption consist of polluting sources (coal, oil and natural gas). Whereas, polluting fuel sources are not polluting equally. In this case natural gas should be highlighted. Natural gas is the most innocent emitting energy source between coal and oil. According to EIA (2018), coal is the most polluting energy source. Oil, follows coal and the least polluting fossil fuel is natural gas. Oil have the biggest share with 36% in primary energy consumption with 119.8 Mtoe. Natural Gas follows with 23% share with 77.5 Mtoe. Coal has the third biggest share and very close to natural gas with 21% equals to 71.3 Mtoe. Renewables follow coal with 14% share equals to 44.8 Mtoe. Nuclear energy has only 5% share with 17.2 Mtoe and hydroelectric has 1% share in primary energy consumption with 4.5 Mtoe. In other words, these share in primary energy consumption by fuels tell that, conventional energy sources are still dominating German energy mix even rising capacity of renewable energy.

Emission rates of primary energy sources provides important data for Germany. Because Germany has competitive targets for reducing GHG emissions. According to Figure 2 there is no zero emitting energy source including nuclear and renewable energy sources. Whereas nuclear and renewable sources such as solar, biomass, wind and conventional hydroelectric have very little impact beside fossil fuel sources as seen in Figure 2. In Figure 2, all energy sources have individually high average and low emitting data. In this figure low bar shows lowest emitting data and high bar shows the highest emitting data. Though the reference point should be the average emission data. Because average data do not include just mean of highest and lowest scores. It shows the general average emitting rate. The most polluter top three sources are the top consuming energy sources of energy according to Figure 1. Whereas in Figure 2, natural gas has advantage over coal and oil considering average GHG emission. According to WNA (2011) data used in Figure 1, lignite emits 1054 tonnes CO2 per GWh. Coal follows with 888 tonnes CO2 per GWh. Oil emits 733 tonnes CO2 per GWh and Natural gas emits 499 CO2 per GWh. This data demonstrates that, natural gas emission is nearly half of coal and lignite combined and this explains why natural gas accepted as the most cleaner fossil fuel. The other sources emission impacts are negligible. Nevertheless, nuclear position in Figure 1 is noticeable. According to Figure 2, nuclear emission is lower than solar and biomass. The differences are negligibly small, but it shows that nuclear is clean alternative as renewable sources in GHG emission perspective. In the light of data in Figure 1, finding how lignite is common in Germany's energy mix is important because it is the most polluting energy source.

**Figure 2: GHG Emission by Fuel Source (Source: WNA, 2011)**

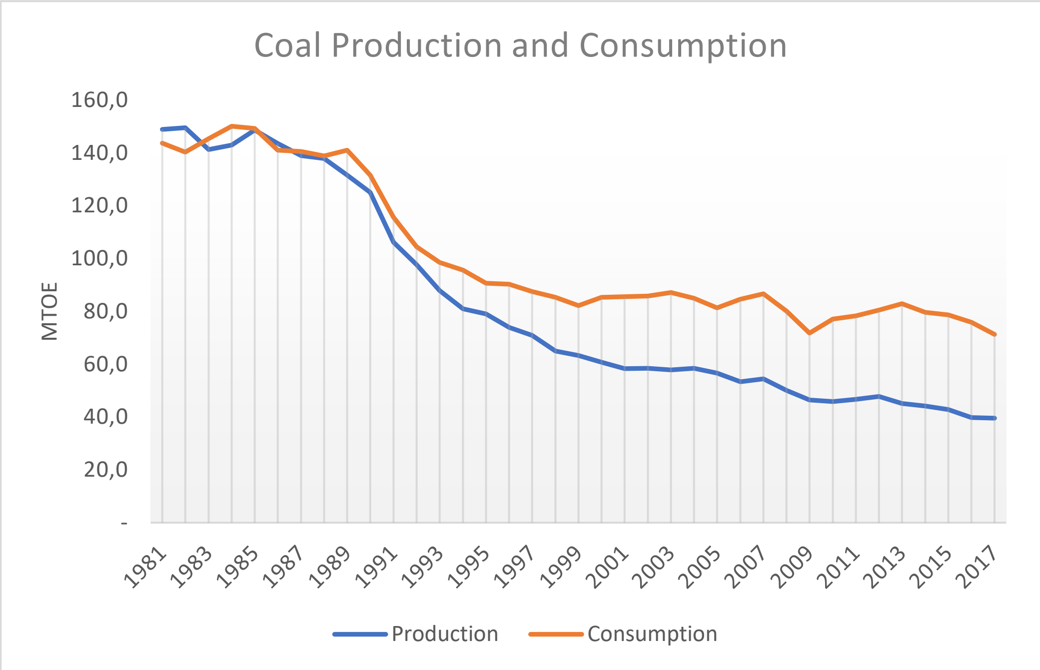


## 3.2. Coal

Coal has always been a very important energy source for Germany for decades because coal mining was the key element for industrial development in Germany at the end of the $19^{th}$ century (Müller, 2019). Additionally, coal played very important role with steel for creating fundamentals of European Union in 1950’s. European Coal and Steel Community has been established mainly to prevent any further conflicts between European countries essentially between Germany and France because of coal and steel (Rittberger, 2012). Also, coal and lignite were the key element of economic development of both Federal Republic of Germany and German Democratic Republic after World War II (Leipprand & Flachsland, 2018).

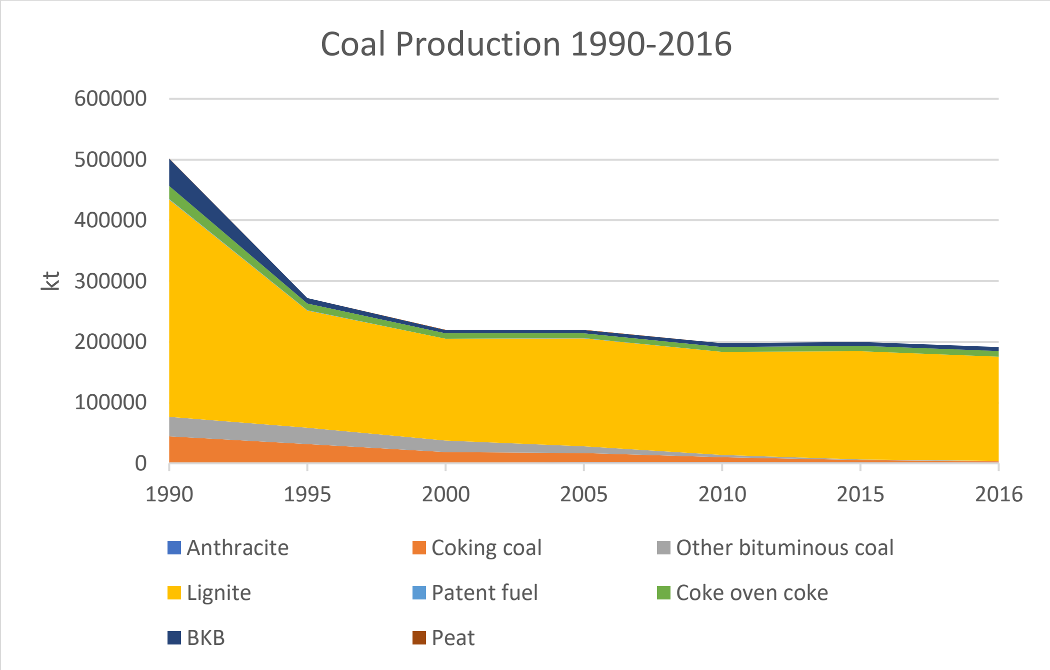
Coal is also a very important energy source in primary energy consumption of Germany despite of low carbon policies. On the other hand, in mining part, there are some complications. For example, hard coal mining phased out due to extraction of hard coal became uneconomic in Germany in 2018 (Leipprand & Flachsland, 2018). However, hard coal still exists in Germany’s energy generation and that means, Germany continues to use hard coal-based power plants with imported hard coal. According to Germany’s long-term goals such as Climate Protection Plan 2050, coal seems like it won’t be a permanent solution for Germany’s energy portfolio; however, considering nuclear phase-out policy of Germany, coal will continue to be in Germany’s energy portfolio until renewable sources grow enough to meet Germany’s energy needs. This makes coal an important energy source for Germany even with enthusiastic GHG emission reduction targets. Additionally, according to EUROCOAL (2019) Germany report, EEG subsidies for promoting renewable energy caused to decrease of coal carbon certificate prices including wholesale electricity prices. This also led to a decrease in operation profits throughout coal-fired power plants. According to the same report, some coal-fired power plants which have 12.2 GW total capacity combined applied to grid agency for closure whereas, they have rejected due to security of supply concerns. This case should underline coal as an important energy source for Germany’s energy portfolio once and for all.

**Figure 3: Coal Production and Consumption in Germany (Source: BP Stats, 2018)**




Beside hard coal phase-out, Germany is still the world leader in lignite producing. According to IEA Coal Information (2018), Germany produced 171.3 million tons Lignite in 2017. Russian Federation followed with 75.6 million tons and Turkey followed with 74.1 million tons. Germany is the world's greater lignite producer however, in Figure 3, it is clear, this great lignite production does not fulfill Germany's coal demand. Germany was the net exporter between 1981 and 1982. Also, between 1985 and 1987 Germany can full filled its own coal consumption with production whereas after 1987 to 2017, Germany's production has not fulfilled domestic consumption need. Starting in 1990, the gap between production and consumption has raised. In 2017, the gap between consumption and production hit 31.7Mtoe.

**Figure 4: Coal Production in Germany (Source: IEA Coal Information, 2018)**




Lignite deserves a special attention when analyzing coal production of Germany. As shown in Figure 4, anthracite, coking coal, bituminous coal, patent fuel, coke oven coke, BKB (brown coal briquettes), peat and lignite constitute Germany's coal production. Figure 4 shows that 90% coal production of Germany consists of lignite with 171,547kt in 2016. According BP Stats (2018), Germany had 36,100 million tonnes sub-bituminous and lignite reserve in 2017. According to Figure 4, there are no big differences between lignite production between years since 2000. This information leads us to this conclusion: If Germany continues to produce similar levels like 2015-2016 of average 174,806kt, Germany's lignite reserves would be enough for the next 206 years. Also, Germany will have shut-downed all coal-fired power plants until 2038. However, this medium-term coal phase-out policy will not change shot-term energy needs of Germany; even promising lignite reserves, Germany is a coal importer country. Germany imported total 47.9 million tonnes coal in 2017 (EUROCOAL Market Report, 2018).

**Figure 5: Germany's Coal Imports vs Exports (Source: IEA World Energy Balances, 2018)**

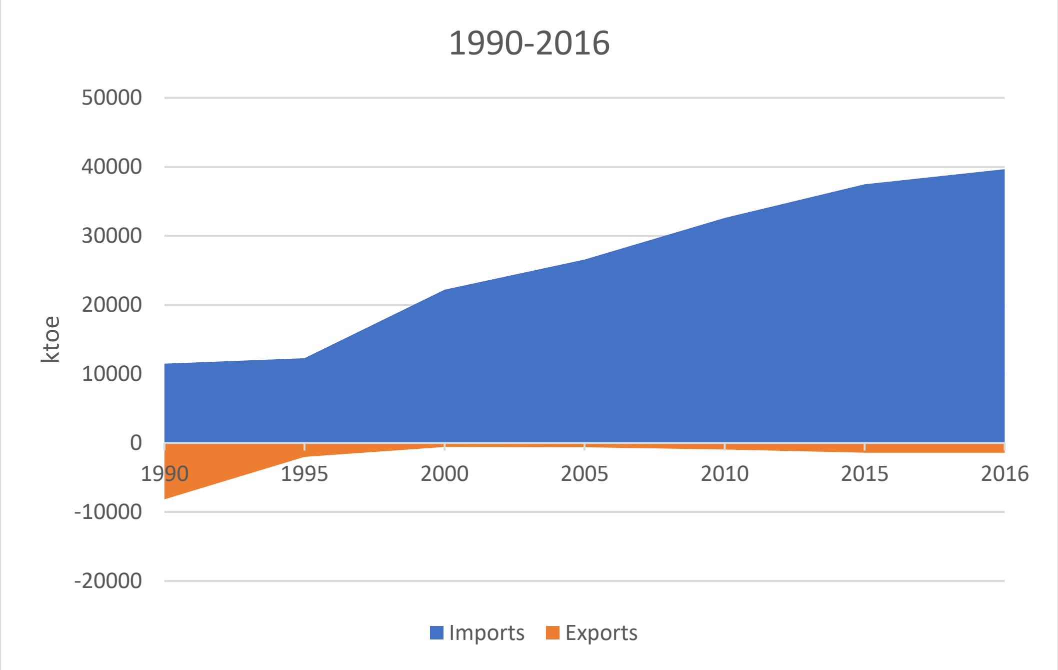


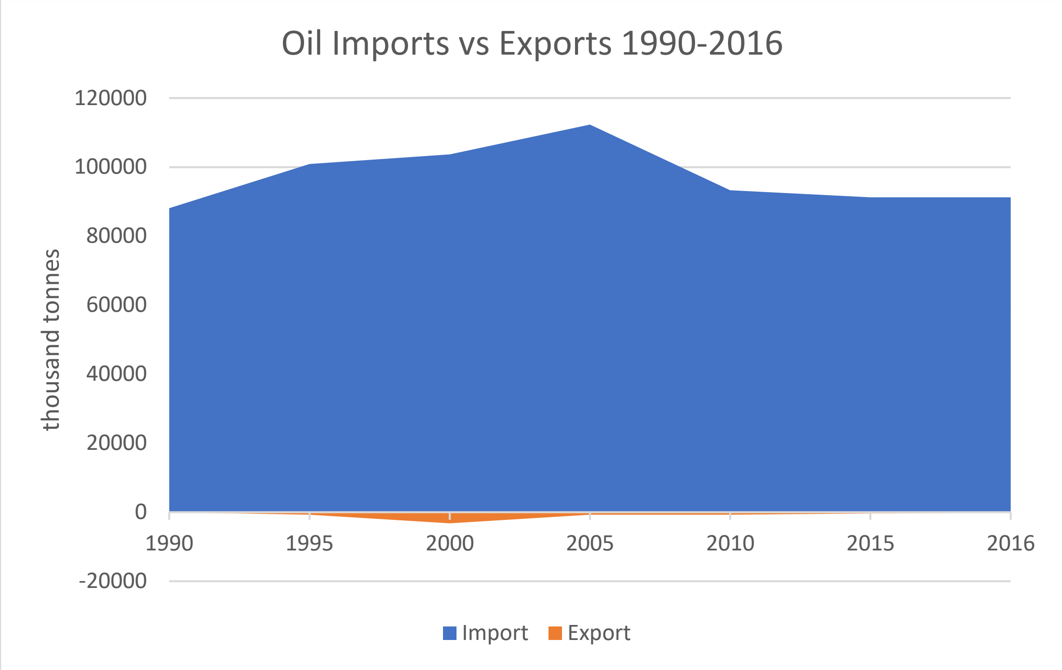

Figure 5 demonstrates Germany's coal dependency clearly. According to Figure 5, Germany's import rate is increasing year by year since 1995. In export side, there is some increase from 2010 to 2016 whereas, it is not a significant change in comparison with increasing import rate. This figure clarifies that Germany is highly dependent on imported coal for its coal-fired energy generation.

## 3.3. Oil

Oil has the highest share in Germany's primary energy consumption (Figure 1)**;** however, Germany has not significant oil reserves for fulfill its domestic needs. Germany produced 2.4 million tonnes of oil. However, imported oil amount hit to 91 million tonnes in 2016 (BMWI, 2019a). Like coal, Germany is a net importer of oil, too. The biggest oil supplier of Germany is Russia and Russia has almost 40% share in imported crude oil of Germany. This high dependency on imported oil, led Germany to take some precautions for eliminate possible interruptions in security of supply. Because Germany has already experienced a great interruption in security of supply. In the past, Germany is one of the most effected countries from 1973 oil crisis. Considering continuing dependency on oil today, Germany has a working mechanism for providing stable oil supply. The Federal Ministry for Economic Affairs and Energy is directly responsible for protecting Germany’s supply security to protect the country from possible energy crises. One of Germany’s solution for eliminating effects of the possible interruptions on supply security is implementing strategic petroleum reserves since 1998. Those reserves are equal to 90 days of oil imports and spread to all around the country for responding quickly when they needed (BMWI, 2019a). In other words, if Germany’s oil supply would cut down, Germany can resist 90 days without any need of further import. Stockpiling Association is responsible for oil reserves of Germany which is liable to Federal Ministry for Economic Affairs and Energy and this institute holds 24.5 million tonnes of crude oil and finished petroleum products combined according to BMWI Conventional Energy Sources (2019).

High usage of oil in Germany also can be attributed to Germany’s advanced industry. Beside the fuel usage, oil is also the main element of lubricant oils. Those oils are used in the industry and became waste oils. Those waste oils are very harmful to nature. According to European Union Waste Oils directive, Germany re-refined 76% of waste oil in 2015 and 5% of waste oil used in energy recovery in 2015 (Zimmerman & Jepsen 2018). European Union’s 2020 recycling goal is 60% and 2025 goal is 85%. According to EU’s recycling of collectable waste oil goals, Germany is in a good situation because Germany already achieved 2020 goal in 2015. High usage of oil products is criticized by several sources because of Germany’s ambitious goals about clean energy, however in this case it is not wrong to say Germany’s institutions do whatever they can to reduce negative implementations of oil-based production in this case.

**Figure 6: Germany's Oil Imports vs Exports (Source: IEA, 2018)**

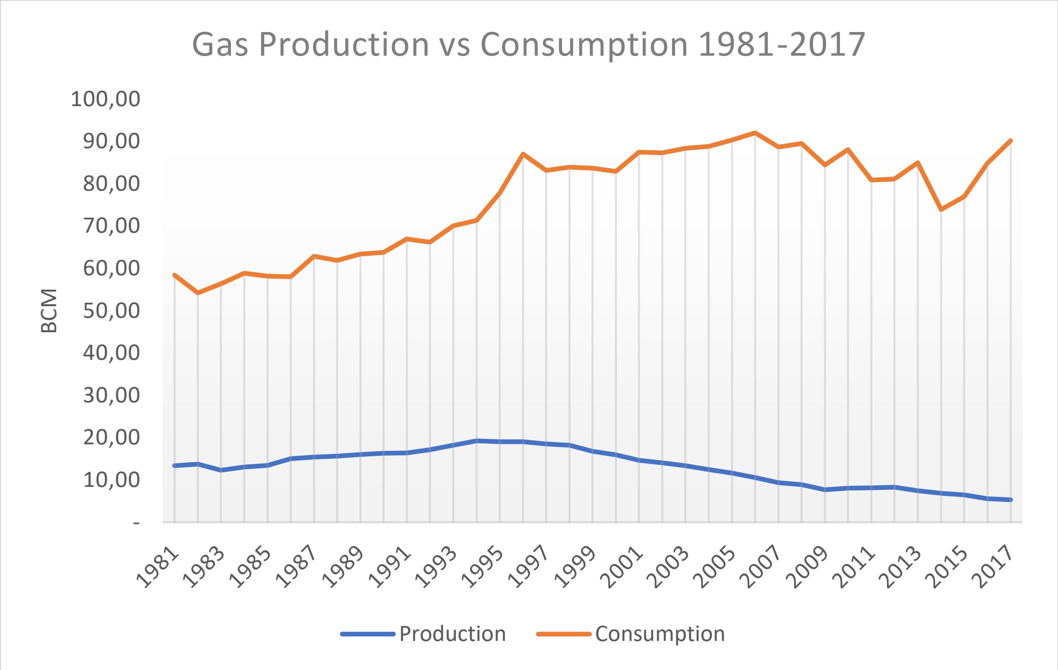



## 3.4. Natural Gas

Natural gas has the second biggest share in Germany's primary energy consumption, but its importance is not about just the big share in primary energy consumption. Natural gas also the lesser GHG emitter fossil alternative for Germany's energy mix for balancing GHG emission to reach Germany's climate coals. This may also explain why natural gas usage in Germany is so much popular.

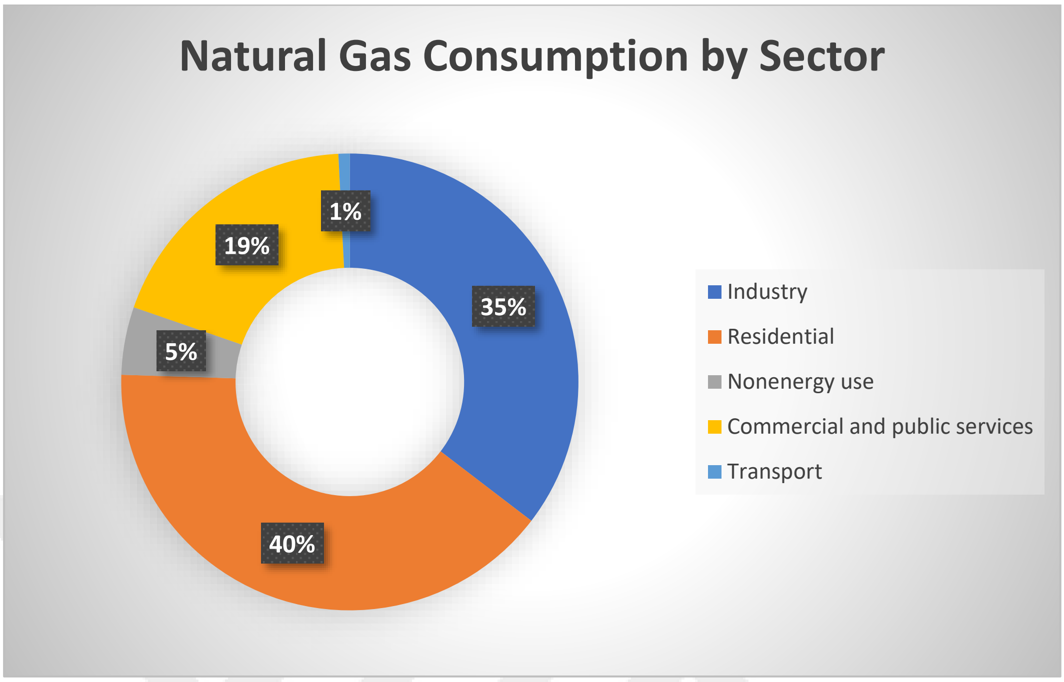
High emitting fossil fuels aside, share of natural gas in global primary consumption has been expected to rise nearly 50% by 2040 (BP, 2019). This case puts natural gas in an important role as a supporting energy source alongside with renewables in future. With considering Germany's coal phase-out plan for 2035, it will not be wrong to expect natural gas protect its importance and keep a respectful share in primary energy consumption in future of Germany. Figure 7 demonstrates the demand for natural gas in Germany and according to Figure 7, there is a big gap between production and consumption rate of natural gas in Germany since previous years to nowadays. Additionally, this gap increases yearly due to high levels of consumption and decreasing production levels of gas production in Germany. However, starting from 2014, there is a sharp increase observed in the consumption. This fact can be interpreted as increasing demand for gas consumption. In production side, decrease is not as sharp as in consumption. Consequently, it is not wrong to say that, the gap between consumption and production could continue to widen in following years. In other words, Germany's dependence on natural gas doesn't look like it will be going down.

**Figure 7: Gas Production vs Consumption in Germany (Source: BP Stats, 2018)**




For underlining the importance of natural gas for Germany, Figure 8 demonstrates the natural gas consumption by sector. According to Figure 8, residential and industry usage consist the main consumption, then commercial and public services usage follows. It is especially important to understand that residential usage has the highest share with 40%. In other words, possible shortages with natural gas could directly affect public life, hence this would create a difficult situation to handle.

**Figure 8: Germany's Natural Gas Consumption by Sector (Source: IEA Gas, 2018)**




Lower GHG emission rates strengthen natural gas importance for sure but it is not the only reason. Another powerful side of natural gas is *high flexibility of gas tribunes* which supports the stability of electric generation (Hauser et al., 2018). In other words, when you need a less electric energy, you can throttle down the gas tribunes or if you need more generation, you can increase the generation capacity without any consequences. This ability of natural gas-fired power plants makes them a great energy generation source for energy mix, because other technologies like coal-fired power plants or renewable based power plants are not flexible like natural gas-fired power plants. This makes natural gas as a great supporting energy generation alternative when you are promoting renewable energy capacity. The downsides of renewable technologies will be analyzed in detailed over renewable energy part of the study.

Lower GHG emission rates and flexibility of natural gas can make it look like a great alternative energy source for Germany, whereas gas resource capacity of Germany is limited as seen in Figure 6 and this makes Germany supply dependent mainly on Russia, Norway and Netherlands. However foreign gas dependency is not only Germany's problem but also the problem of the most of European countries. Because of this European Commission approved European Energy Security Strategy in May 2014 for improving security of energy supply. One of the main reasons of this act of the European Commission was possible interruption of Russian gas due to political instability in Ukraine during that years. To prepare for possible interruptions, European Union prepared stress test for analyzing affects of possible interruptions in natural gas supply (European Commission, 2014).

Germany's position on natural gas is also important for European countries, because Nord Stream pipeline which carries Russian natural gas reach other European countries from Germany. Nord Stream pipeline is important natural gas resource because it is alternative way to reach natural gas instead of Brotherhood pipeline which passing through Ukraine for reach to Europe. Norway provide gas to Europe and Germany via Europe and Europe II pipelines, which are directly reach to European continents and they are safe for security of supply. With considering Germany's hub position especially over Nord Stream, and in future Nord Stream II, Germany has total length of 511,000 km gas grid. Nord Stream II will not be only alternative for Germany because including Nord Stream II there will be other new pipelines that will carry Germany natural gas. Turkish Stream, TAP, TANAP will supply natural gas to Germany when they will be operational between 2025 to 2035 (Hauser et al., 2018). In the light of all this information, it will not be wrong to conclude that Germany's dependency on natural gas will continue to rise, and also BP (2019) predicts the same. Whereas, the new pipelines would help to diversify Germany's natural gas source pool and they could be decreasing the threat for security of supply. Germany's possible success in renewable energy could also help to decrease to dependency on imported energy in future. This topic will be clarified in Renewable Energy part of the study.

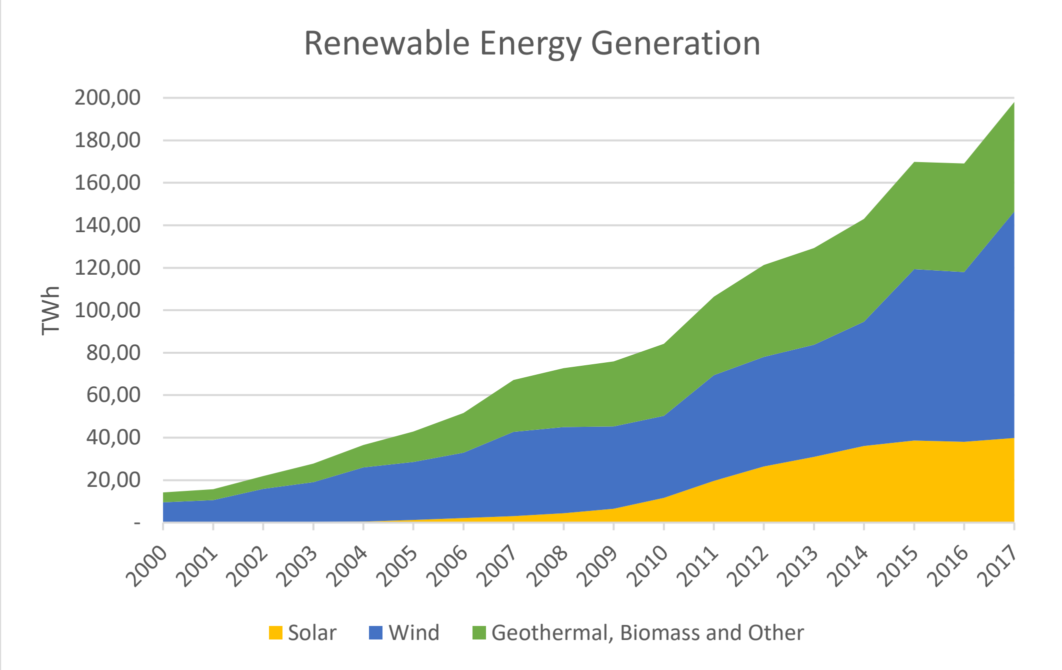
## 3.5. Renewable Energy

Renewable energy has been the most important energy source and it will continue to be in the following years regarding Germany, because Germany searches all the answers in renewable energy and build its energy future around renewable energy. Renewable energy is the core of the Energiewende and the reasons are obvious; First, reducing imported energy dependency and GHG emissions are two of the Germany's energy objectives (BMU, 2019). As mentioned in previous chapters, coal, oil and natural gas consist 80% of Germany's primary energy consumption as seen in Figure 1 and Germany is dependent on import for all these types of energy sources. 80% is a huge number, and a country which is highly dependent on imported energy, also has an advanced industry that wants to decrease this dependency. Germany is trying to do this exactly, and renewable energy provides a lot of answer for Germany's need in the theory. Renewable energy-based power plants do not require imported energy for working. As the name implies, renewable sources are being in nature and generally you do not need drilling or refining them for use. Wind and solar energy are great examples. In renewable energy, feasibility has an important role for finding the most effective windy areas or the ideal solar irradiation but at the and all countries can achieve these sources without an imported source but the technology.

Renewable energy is a respectful alternative for reducing dependence on imported energy and the most suitable way to reduce GHG emissions. Renewable energy sources emit very less amount of GHG as demonstrated in Figure 2. Beside fossil fuels, those emission rates are totally low enough to be ignored. These two sides of renewable energy which are climate friendly and does not requires imported fuel make renewable energy is a great answer for Germany's situation. However, like all other energy sources, renewable energy has downsides, too. The most important downside is that renewable energy sources are not flexible like natural gas. As a result of lack of storage, the most renewable energy sources generate electricity while they have access to the energy sources. For example, you cannot produce energy from solar power plants at nights, or you cannot get electricity from wind power plants when wheatear is calm. Nowadays, energy storage technologies from renewable energy are not sufficient enough because of high costs. As Grubler (2012) mentioned, technology always provide cheaper and efficient solutions. Battery technologies are under development and they will be more efficient and cheaper in the following years. This means, improvement on batteries could help reducing downside of renewables and help renewable energy to become more flexible. Today, there is a need for alternative energy sources to obtain the sustainability of energy generation.

Considering Germany's mid-term and long-term energy targets, renewable energy is expected to fill the gap of nuclear and fossil fuels. Beside the transition from fossil fuels to renewable sources, renewable energy is also creating its own economy. It is a new economy around renewable energy and aims to become a lead technology exporter. Success of renewable energy will answer lots of problems of Germany in theory. It is a green energy sources well as having lesser impact on climate because of lower GHG emissions. Because of that, renewable energy has already great support from people in Germany along with environmentalists and green movements. Also, it creates new job opportunities, and renewable energy sector reached 371,400 employees in 2013 and 18.8 billion Euros invested in energy plants (REA, 2014).

**Figure 9: Germany's Renewable Energy Generation by Source (Source: BP Stats, 2018)**




As Figure 9 demonstrates, Germany has a great increase in renewable energy generation since between the first EEG in 2000 and the last EEG published in 2017. Renewable energy generation increased approximately ten times since 2000. Germany has increasing generation trend in all renewable energy source year by year.

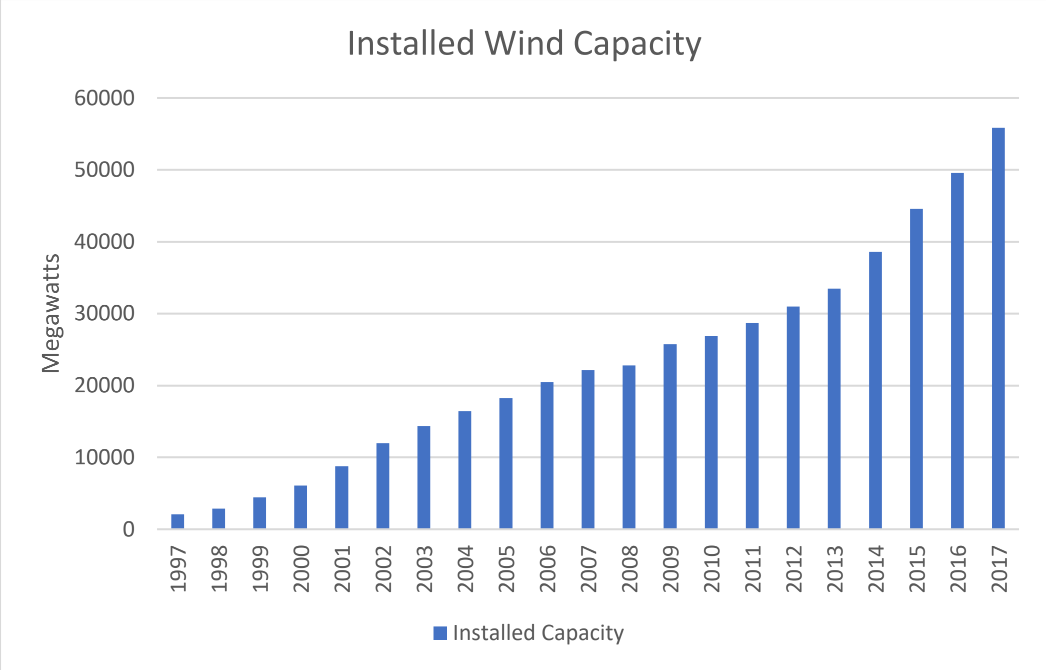
Germany also considers to cooperate with European countries for providing stability while making smooth transition to renewables. Also, the EU's fully integrated internal energy markets have the similar targets as Germany which can be summarized as "energy should flow freely across the EU" (EC, 2019). With integrated energy markets, Germany could import clean energy from other European countries including Norway, which is not a member of the EU, but has cooperation with the Union. According to this vision, Germany is considering using Norway's hydropower to provide a stability in German electricity demand (Gullberg, Ohlhorst & Schreurs, 2014).

## 3.6. Wind

Wind power is the largest renewable energy source of Germany. Since the end of 1980's, wind energy has grown and became the main pillar of renewable energy. Beside the onshore expand, Germany also aims to grow offshore capacity, too. In 2017, Germany reached 5407 MW of offshore capacity. The aim is reaching to 15,000 MW by 2030 (BMWI, 2018). Germany has highly assertive wind energy as figure 10 demonstrates. Germany has an increasing momentum in installed capacity. This increase does not seem to be slowed in following years. Germany's installed wind capacity increased 13% from 2016 to 2017.

Technological development continues in wind energy. In 1980's wind tribune capacities were between 55 kW to 80 kW but in 1990's, they reached 1.5 MW capacity. Nowadays wind tribune capacities reached 3 MW to 6 MW and due to their size and height, they became more efficient, silent and cheaper. Also, electric generation from wind power is getting cheaper. Nowadays prices change between 5 to 9 cent per kWh. By 2020, it is expected to fall below 5 cents per kWh (Amelang & Wehrman, 2019). Other than importing energy, European Energy Market also can solve Germany's wind energy surplus until grid expansion completed, which will be mentioned in the next chapter.

**Figure 10: Germany's Installed Wind Capacity (Source: BP Stats, 2018)**

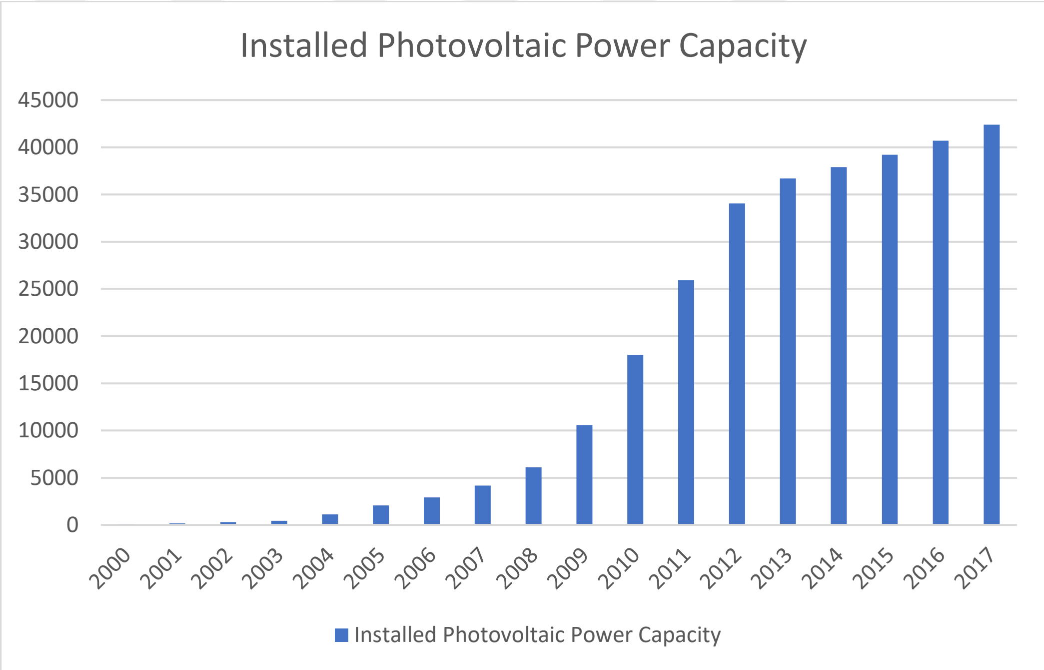



Germany has the greatest wind potential in northern territories of the Germany and this potential is decreasing into southward (Jung & Schindler, 2018). Because of this, most of the wind power plants are planted in the northern part of Germany. Whereas, the most of industry is in the south part of Germany. This creates a dilemma in German power production because of lesser demand in North and higher production. More than two third on shore wind power plants are installed in the Northern cities. German grid faces with surplus due to high production of northern wind power plants (Appunn, 2018). To deal with this issue, Germany has been building new grid lines from the North to the South for transmitting the generated energy from northern power plants to the southern part of the country (Bundesnetzagentur, 2014).

### 3.7. Solar

Germany is trying to reach and promote all kinds of renewable energy sources. Solar energy could be seems not fitting enough for Germany in first taught because of Germany's irradiation levels, whereas Germany reached 42,000 MW installed capacity in 2017 as Figure 11 shows and generated 40 TWh electric from photovoltaic power. On the contrary, wind power, Germany has the best irradiation potential in southern and it decreases into northward (Solargis, 2019). In other words, Germany has the best irradiation potential in the same location where Germany's the most part of industry stands.

**Figure 11: Germany's Installed Photovoltaic Power Capacity (Source: BP Stats, 2018)**




Solar power is relatively newer technology compared with wind energy for Germany. As Figure 11 demonstrates German solar energy has started to its momentum in 2010's. Also, solar power is more flexible than wind because beside the bigger photovoltaic farms, there is also an option for installing smaller photovoltaic systems for buildings. Those smaller photovoltaic systems below 750 kW have subsidies as *production tax credits*, *net metering* and feed-in tariffs (Ruf, 2018). Germany reached 1.5 million installed photovoltaic systems in 2016 and

96% of these systems are small scaled (Ruf, 2018). In other words, 96% of 41,700 MW installed capacity is belonged to smaller photovoltaic systems (BP Stats, 2018).

Germany's 2030 solar target is to reach to 66 GW installed photovoltaic capacity and Germany hit 42 GW in 2017 as seen in Figure 11. According to current data 2030 target seems reachable whereas, as seen in Figure 11, Germany's installed photovoltaic capacity has smaller momentum in last years. Rodrigues et al. (2016) attribute this slowing in growth to reductions in feed-in tariffs. However, cost of photovoltaic panels is decreasing, too (EIA Solar, 2018) and the price reduction could fill the gap of driving power of feed-in tariffs.

## 3.8. Biomass

Biomass has a different place among other renewable energy sources because it is the most flexible renewable energy sources and as a result, it can be used as solid fuel, liquid fuel or biogas. Also, biomass is the only carbon-based renewable energy source (Strzalka, Schneider & Eicker, 2017). Thanks to flexibility of biomass, it is practical to replace fossil fuels with biomass.

Biomass is also important for the EU's target for 2020 of 10% fuel supply from renewable energy source. Biomass fulfilled 4% of the electricity consumption, 6% of heat, 7.3 % of total fuel consumption and 4.9% of primary energy consumption in 2017 (BMEL, 2019). Biomass is a promising energy source for Germany. Following energy profile of Germany, next chapter will analyze German energy policy making.

# CHAPTER 4

## Understanding German Energy Policy Making

### 4.1. Germany Energy Policy

Energy policies were considered as a part of economic policies until 1950's in Germany (known as West Germany). The first independent energy policy was established under Christian Democratic Party's government between 1949 and 1963 for building an energy infrastructure to prevent energy shortages (Hake et al., 2015). Since then, German energy policy has grown and nowadays it runs one of the most ambitious energy transitions. Germany's energy vision contains long term goals. In 2010, Germany adopted a new Energy Concept which set targets for transition into renewable energy. The aim of the Energy Concept 2010 was to implement long term strategy for building an environment friendly system, affordable and reliable energy supply by 2050.

Analyzing German energy policy with using only a domestic perspective could not give accurate answers. Because Germany wants to promote renewable energy and energy efficiency globally using the basis of Energiewende with assuming a leadership role in the world (Steinbacher & Röhrkasten, 2019). With keeping in mind Germany's global vision about energy transitions, it is important to analyze Germany's domestic goals beforehand to draw a clear picture in the end. Countries' domestic energy sources have direct impacts on determining energy policies. This assertion can be proven by looking the positions of countries which are wealthy in particular type of energy source such as United States, Saudi Arabia and Russian Federation which are oil rich countries (BP Stats, 2018). Oil policies are important in those countries for promoting their oil industry. Whereas, countries poor in raw materials must imply different energy policies for dealing with dependency on imported energy and providing supply security. Germany is a nation that poor with raw materials for producing energy whereas technologically rich (Winter, 2012). Technologically rich countries like Germany could crate alternatives for decreasing dependency in primary energy sources. In Germany's situation, these alternatives are improving energy efficiency and switching to renewable technologies like Steinbacher & Röhrkasten, 2019 mentioned. Energy efficiency is considered as a hidden fuel (IEA, 2013) and that is why technologically rich countries like Germany have targeted to improve energy efficiency. Energy efficiency is a very important tool for all countries, and it should not be underestimated by any means.

For criticize and analyze German energy policy, it is important to understand European Unions' energy policy, too. There will be missing parts to analyze Germany's energy policy without understanding European Union's energy policy. Matlary (1997) says, *Economic* and *political integration* constitute the core of European Union's energy policy (as cited in Renn & Marshall, 2016). According to Renn & Marshall (2016), *deregulation and liberalization of European energy markets, climate change and energy security* are the three primary energy policy developments of European Union. The member states of the European Union's energy policies are expected to be compatible with the EU's energy policy.

**Table 2: Climate Action Programmes of the EU and Germany (Source: BMU, 2019)**

| Climate Action Programme | 2020 | 2030 | 2050 |
|---|---|---|---|
| EU's Climate Action Targets | 20% cut in GHG compare to 1990 levels. | 40% cut in GHG compare to 1990 levels. | 80% to 95% cut in GHG compare to 1990 levels. |
| Germany's Climate Action Targets | 40% cut in GHG compare to 1990 levels. | 55% cut in GHG compare to 1990 levels. | 80% to 95% cut in GHG compare to 1990 levels. |

European Union is very ambitious about climate goals and it has separated goals for each year starting with 2020. As Table 2 demonstrates, Germany and the EU's climate action targets are harmonious with each other. Whereas, Germany's targets are more challenging than the EU's, especially in regards to short and mid-term targets. The EU's 2020 GHG emission reducing target compared to 1990 levels is 20%; however, Germany's target is double of it which equals to 40%. This challenging target shows how Germany is ambitious about decreasing GHG emission. Also, Germany's superiority on target levels continues to 2030, too. The EU's target is 40% cut in GHG emission compare to 1990 levels which equals to Germany's 2020 target. Germany's 2030 target is reducing 55% of GHG emission compared to 1990 levels. Both the EU and Germany meet in the same target range for 2050 expectations which are between 80% to 95% cut in GHG emission compared to 1990 levels.

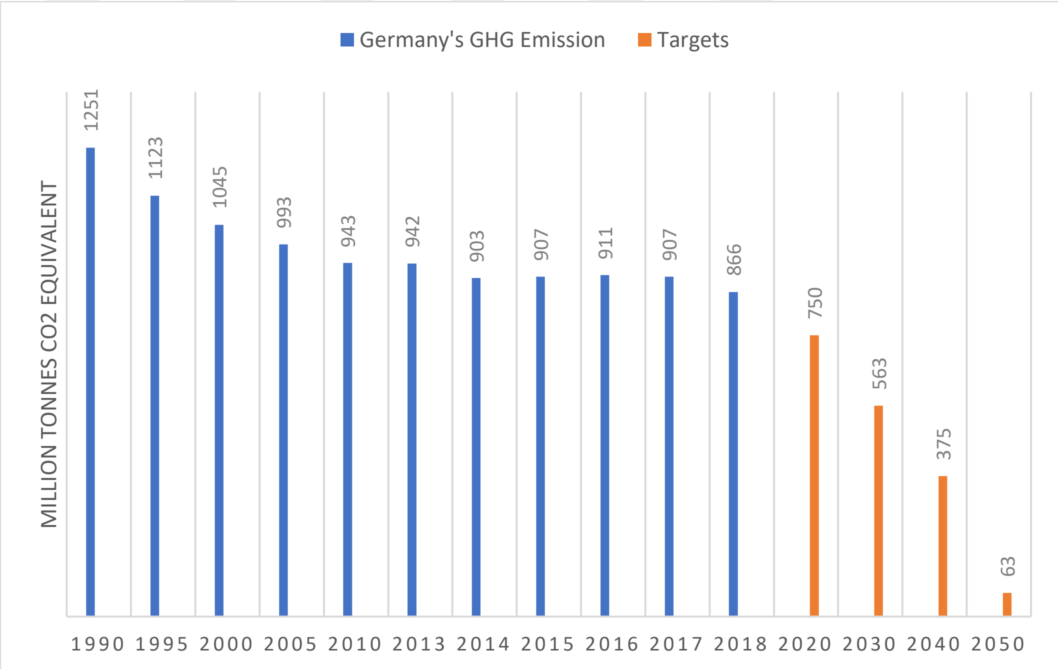
For energy efficiency, the EU's targets reduce primary energy 20% by 2020 and 30% downsize targets by 2030 according to business as usual scenario (NEEAP, 2018). Germany's primary energy reducing target is 20% by 2020 and 50% by 2050 according to 2008 levels (IEA, 2019).

It seems Germany is very ambitious about GHG goals and Germany's promoting renewable energy supporting those ambitious targets, too. However, Germany still have big amount of fossil fuel share in final energy consumption. Huge dependency on fossil fuels looks like it will be a challenge for Germany's GHG emission targets. Because Germany already runs nuclear phase-out program. Germany started to lose GHG friendly energy source which has other risks than GHG emission whereas nuclear' GHG levels are clean as renewable energy sources according to Figure 2.

Both the EU and Germany have not only GHG reducing targets, but also their clean energy policies include renewable energy share targets in total energy consumption and energy efficiency. Germany set 2020 GHG emission target in 2007 and in 1990 Germany's GHG emission was around 1250 million tones. Germany's 2020 target is reducing this emission to 750 million tones. Whereas in the latest years, Germany's GHG emission rates are far from reaching 2020 targets. According to recent GHG emission numbers Germany is going to miss the first climate target in

2020. According to BMU (2014), Reducing GHG emission by around 33% to 34% in 2020 expected. In April 2019, Environment Ministry updated their expectation to 32% for 2020. In other words, Germany is going to miss 2020 targets by 8%. This will be a success according to the EU's target though, it will be a failure for Germany's own climate target. Figure 12 demonstrates why Germany is going to miss the first climate target. Germany has not a continuously decreasing trend in GHG emission rates. For example, there is a little difference between 2005 and 2010. Also, there is not a significant downward trend between 2014 to 2017. Germany should have had a continuity in decreasing levels year by year to reach 2020 target.

**Figure 12: Germany's GHG Emissions by Year (Source: UBA, 2019a)**




The Climate Action Programme 2020 of Germany consists of nine components. All these components have impacts on reducing GHG emission. National Energy Efficiency Action Plan (NAPE) is the one of these components and it targets increasing energy efficiency especially for individual energy usage like providing energy efficiency in buildings and regulate business for providing energy savings. NAPE targets reducing 25 million tonnes GHG emission with energy efficiency. Energy efficiency is a vital part of Energiewende. Germany set the goal as 20%

reduction in primary energy consumption for 2020 and 50% reduction for 2050 compared to 2008 levels (IEA, 2013). *Strategy on climate friendly building and housing* is second component of The Climate Action Programme. The second component focuses on NEPA's building side. Climate friendly buildings are the target of the second component and building a climate neutral building by 2050 is the most ambitious goal of this component. Germany wants to decrease fossil dependency for residential heating including consumption of 80% less primary energy and providing remaining energy demand from renewable sources until 2050 (Bauermann, 2016). This component also targets to keep housing affordable for people who has low income to keep this project applicable. The third component's target is transport sector. Third component 2020 target is to save 10% of final energy consumption by 2020 and 40% by 2050 compared to 2005 levels in transport and it also includes electric vehicles (EVs) goals which have increasing market share of EVs to 1 million by 2020 and 6 million by 2030. The fourth component is for reducing climate impacts of wastes and agriculture. The fifth component is in accordance with the EU's climate policy which is *reforming emissions trading.* This long-term goal is to do 40% reduction by the EU until 2030 compared with 1990 levels with help of emission trading. The sixth component has modernization of fossil fuel-based power plants and continue to expand renewable energy sources for making Germany nearly carbon free by 2050. The seventh component contains articles for regulating state in line with climate friendly policies. The eighth component is *research and development* which comprises *energy research* and *transformation research* for promoting energy efficiency and renewable energy. The final component is to raise awareness for industry, consumers and local authorities. Because Germany believes wide participation and awareness are required for achieving the goals of Energiewende.

Germany runs its climate and renewable energy goals with using Renewable Energy Source Act (EEG). Germany already published seven EEGs firstly in 2000 and the last ones in 2017. EEG is the legislative part of Energiewende and it regulates feed-in tariffs, payments, auctions, transparency, legal consequences and penalties. In other words, it forms the basis of the transition. Regulations of EEG reduces risk of installation of power plants for private operators and investors.

Also, EEG guarantees fixed tariffs for 20 years with release of EEG in 2000. Thanks to EEG, private operators can build a business plan for their investment with lower risk because Germany is an early feed-in tariff implementer (Leiren & Reimer, 2018; Hitaj & Löschel, 2019). Germany has feed in tariff law since 1991. Electricity Feed-in Act is released in 1991 for promoting wind energy; however, there were need a more complex regulation for boosting renewable energy. Therefore, first Renewable Energy Act was released in 2000 to prepare a foundation for a more advantage policy for renewable energy. Feed-in tariffs have a positive impact on development of renewable energy in Germany. Feed-in tariff is the driving factor of wind power since 1991 (Hitaj & Löschel, 2019) and it is not the only driving factor of wind energy. Sahu (2015) demonstrates that, top ten world leading solar power producing countries have feed-in tariff system and incentive policies supported by the governments.

Germany supported renewable energy development mainly with feed-in tariffs until 2014. Auctions model for solar energy was introduced in 2014 and two years later, Germany switched to auctions. The latest released EEG in 2017 regulates the auctions for renewable energy. This decision provides a competition between professional parties whereas small installations still gets feed-in tariffs (Leiren & Remimer, 2018).

## 4.2. German Nuclear Phase-out Policy

Nuclear phase-out is one of the important and challenging part of the energy transition process of Germany. It became more popular with Chancellor Angela Merkel's support after Fukushima disaster whereas, Germany had already had a nuclear phase-out plan before Merkel's government. In 2002, former German government already had made a nuclear phase-out policy which was more optimizing policy for considering getting maximum benefit from existing nuclear power plants. Therefore, according to The Atomic Energy Act, which was modified in 2002, the average life of operational lifespan of nuclear power plants were determined by 32 years (IAEA, 2018). With including average operational life span, they decided to shut down all the nuclear power plants by 2023. There by, all nuclear power plants were going to shut down after they were provided their maximum benefits during their average operational life span. In 2010, things changed, and Merkel's government decided to extend nuclear power plants' operational life span until 2038 for obtaining a more stable transition from conventional energy sources to renewable energy sources.

Germany's rushing nuclear phase out is also a popular topic around scholars. Rehner & McCauley (2016) criticize the nuclear phase-out from the perspective of balance between energy security and environmental justice. More comprehensively, energy security is defined by four pillars, which are *availability, accessibility, affordability* and *acceptability* (Kruyt et al., 2019). According to the authors, Germany's nuclear phase out policy is mainly environmental justice orientated. This makes Energiewende weak in perspective of energy security because Germany has lost its electricity capacity due to nuclear phase out in 2011 through Fukushima disaster effect. Environmental justice was dominant in that decision instead of energy security concerns. That energy capacity loss lead to Germany to involved conventional power sources to fill emptiness of nuclear capacity (Bruninx et al, 2013).

In this part, this study focuses on nuclear phase-out after 2011. Because this phase-out was not planned like previous nuclear phase-out policies. Fukushima disaster was the main driving force, because it showed that to world, nuclear disaster can happen even in high tech country like Japan. With considering anti-nuclear consensus in Germany, government implemented a phase-out plan immediately. According to this new phase-out plan, extended nuclear lifetimes in 2010 had been removed. Also, this new phase-out policy had included immediate shutdown of eight older nuclear power plants in 2011. The youngest of these power plants commercial started in 1980 and the oldest ones' commercial started in 1975. Also, instead of 2038, remaining power plants will be shut down until 2022. From the period of 2010 to 2011, Germany's nuclear policy had changed dramatically due to Fukushima disaster.

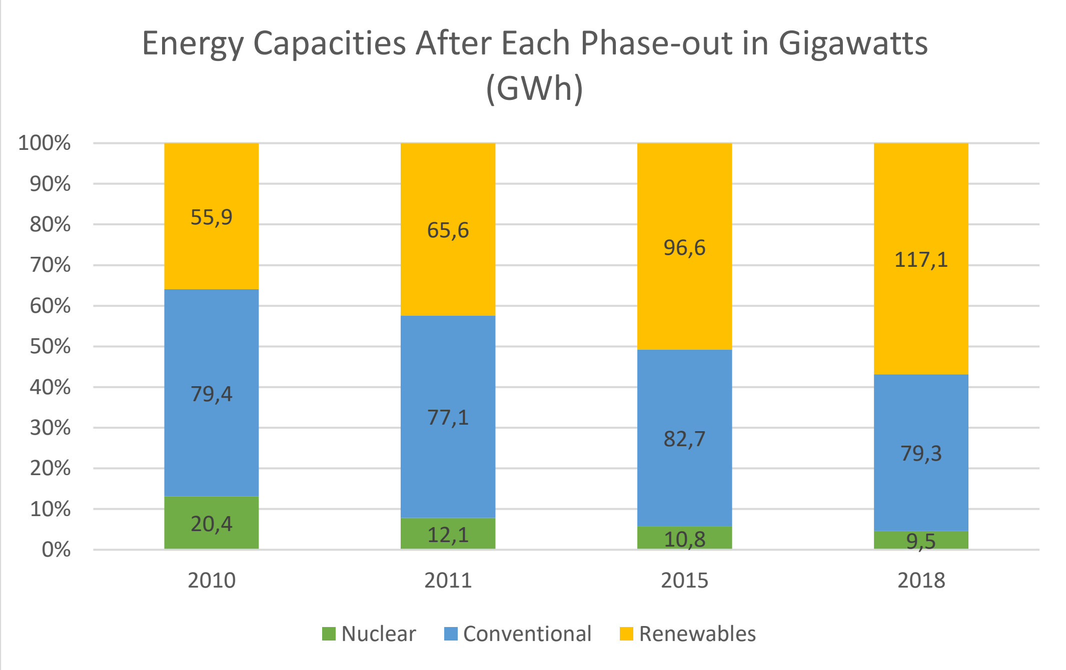
**Table 3: Operational and Closed Nuclear Power Plans After 2011 Phase-out Decision (Source: IAEA, 2018; IEA, 2013)**

| **Reactor** | **Capacity MW (e)** | **Gross Power Generation GWh 2010** | **Status** | **Commercial Date** | **Shutdown Date** |
|---|---|---|---|---|---|
| Brokdorf | 1410 | 11945 | Operational | 22.12.1986 | 2021 |
| Emsland | 1335 | 11560 | Operational | 20.06.1988 | 2022 |
| Grohnde | 1360 | 11417 | Operational | 01.02.1985 | 2021 |
| Gundermmingen-C | 1288 | 10936 | Operational | 18.11.1985 | 2021 |
| Isar 2 | 1410 | 12007 | Operational | 09.04.1982 | 2022 |
| Neckarwestheim 2 | 1310 | 10874 | Operational | 15.04.1988 | 2022 |
| Philippsburg 2 | 1402 | 11797 | Operational | 18.04.1984 | 2019 |
| Gundermmingen-B | 1284 | 9954 | Shutdown | 01.02.1984 | 31.12.2017 |
| Grafenrheinfeld | 1275 | 7938 | Shutdown | 17.06.1982 | 27.06.2015 |
| Biblis A | 1167 | 5042 | Shutdown | 26.02.1975 | 06.08.2011 |
| Biblis B | 1240 | 10306 | Shutdown | 31.01.1977 | 06.08.2011 |
| Brunsbuettel | 771 | .. | Shutdown | 09.02.1977 | 06.08.2011 |
| Isar 1 | 878 | 6543 | Shutdown | 21.03.1979 | 06.08.2011 |
| Krümmel | 1346 | .. | Shutdown | 28.03.1984 | 06.08.2011 |
| Neckarwestheim 1 | 785 | 2208 | Shutdown | 01.12.1976 | 06.08.2011 |
| Philippsburg 1 | 890 | 6791 | Shutdown | 26.03.1980 | 06.08.2011 |
| Unterweser | 1345 | 11239 | Shutdown | 06.09.1979 | 06.08.2011 |
| **Operational TOTAL** | **9515** | 80536 | | | |
| **Shutdown After 2011 TOTAL** | **2559** | 17892 | | | |
| **Shutdown in 2011** | **8422** | | | | |
| **Grand TOTAL** | **20496** | | | | |

In a short time period like this, implementing a phase-out policy could be a challenging task. Before analyzing the effects of the last nuclear phase-out policy, let's analyze how it changed the energy capacity of Germany. According to Table 3, Germany's total nuclear capacity was 20.4 GWh in 2010. Whereas, after immediate shutdown decision in 2011, Germany lost 8.4 GWh of capacity suddenly. In other words, Germany had lost 41% of its nuclear capacity at once. In the following years, Germany had closed two of their nuclear power plants in 2015 and 2017. They had 2.5 GWh capacity combined and as a consequence, only 9.5 GWh of nuclear capacity left for Germany's nuclear portion.

Germany entered to nuclear era a little bit late compared to United States and Europe, but it has had a lot of nuclear power plants. From 1968 to today, Germany has shut downed 29 nuclear power plants (IAEA, 2018). Before nuclear phase-out policy had been accepted in 2011, nuclear capacity of Germany's portion was 13% in total energy capacity with 20.4 GWh (Figure 13). In the same year, conventional energy production capacity consisted nearly 50% of total energy capacity with 79.4 GWh and Renewable energy capacity share in total energy capacity was nearly 36% with 55.9 GWh. After nuclear phase-out policy was accepted in 2011, nuclear energy capacity of Germany decreased to 7% from 13% in one year due to shut downed 8 nuclear power plants with 12.1 GWh capacity. In the same year power generation from conventional energy sources had protected 50% share of capacity and renewable energy capacity raised to 42% with 65.6 GWh of total capacity. After shutdown of Grafenrheinfeld power plant, nuclear capacity share in total energy capacity increased to 5% in 2015 with 10.8 GWh. In the same year, conventional share in total energy capacity decreased to 43% in total energy capacity, whereas that does not mean, total capacity of conventional energy sources has reduced. Capacity of conventional energy sources raised to 82.7 GWh from 77.1 GWh in 2015. The share of conventional energy capacity reduced because renewable energy capacity raised to %51 from 42% in four years. After the shutdown of Grafenrheinfeld power plant in 2018, nuclear capacity share decreased to 4% with 9.5 GWh in total energy capacity. Decreasing of conventional energy capacity trend also continued in the same year with %39, whereas it did not lose too much capacity with 79.3 GWh in comparison with last years. The main reason of decreasing conventional energy share in total capacity was to increase the trend of renewable energy by 57% with 117.1 GWh of capacity.

**Figure 13: Energy Capacities After Each Phase-out (Source: Fraunhofer ISE, 2018)**




According to Figure 13, following the shutdown of nuclear power plants, Germany tried to protect the equilibrium of the energy capacity with raising the share of renewable sources and keep the energy capacity of conventional sources. When Figure 13 analyzed, it seems that Germany succeed to fill the gap of nuclear capacity, whereas there is are two problems regarding this figure. First one is that renewable energy source capacities are not reliable as nuclear energy capacity. Renewable energy-based power plants generate electricity while they have reached to energy source. However, in nuclear side, you can generate electricity 24 hours a day, nuclear is a flexible energy source and it will be beneficial with high shares of renewable energy (Jenkinst et al., 2018). The second problem is that according to Germany's energy policy, it is trying to decrease GHG emissions but there is no significant decrease in conventional energy capacity which are one of the main sources of GHG emissions (Figure 2). In the following part of this study, it will try to find the answer to the said two possible problems. Following German energy policy making, next chapter will analyze historical development of Energiewende.

# CHAPTER 5

# Historical Development of Energiewende

## 5.1. History of Nuclear Energy in Germany

The term of Energiewende represents German energy transition. It is usual that nowadays, Energiewende could build an image on minds about Germany's modern renewable energy transition process. It is not a wrong perception; however, it has missing parts with its current state of understanding. The truth is that the term of Energiewende contains more than a renewable energy transition process. Energiewende contains wider background including Germany's current energy transition phase. There is a philosophy lies beneath the history of Energiewende and to understand that philosophy, it is necessary to look at the roots of Energiewende which goes back 1970's. Whereas, before analyzing the roots of the movement about Energiewende, it is vital to understand Germany's nuclear energy program briefly between 1950's and 1970's to explain Energiewende's roots.

Germany's nuclear energy adventure started in 1955 with establishment of German Atomic Commission and Federal Nuclear Affairs. Few years later, Germany's first nuclear program was launched with contribution of joining EUROTOM (European Atomic Energy Community) in 1957. Starting nuclear adventure of Germany could be connected to West Germany's integration to Europe because according to Hake et al. (2015), Germany had to establish a nuclear program as a requirement for joining NATO and integration to Europe after Paris Agreement in 1955. Under the light of this information, the starting of Germany's nuclear program can be attributed to external political suppression whereas, continuity of German nuclear program had been supported from inner politicians due to security of supply after the coal crisis in 1958 (Hake et al. 2015).

It is obvious that, supply crisis had helped nuclear energy to consolidate its condition back in 1950's. Also 1958 coal crisis was not the last crisis which nuclear supporters benefited. The 1974 oil crisis could be counted as the biggest crisis which brings the importance of security of energy supply and using domestic energy sources for western countries. The 1974 oil crisis had lots of impacts on energy history because when APEC (Arab Petroleum Exporting Countries) used energy as a political weapon and put an embargo on western countries (Europe and USA mostly) it was unexpected by western countries due to their support on Israel during Yom Kippur War. This embargo caused oil prices to quadrupled (Kettel, 2019) and consequently, several scholars have analyzed its effects, whereas, in Germany's nuclear situation, the most important impact of 1974 oil crisis was to underline the importance of using domestic sources which helped nuclear supporters to consolidate its condition of nuclear energy for the second time. This situation will be clearer in following part with anti-nuclear movements.

## 5.2. Anti-Nuclear Movements

Anti-nuclear movements in 1970's was considered as the foundation of Energiewende by several sources (Morris, 2014; Hockenos, 2015; Hake et al. 2015; Evans, 2016). The first anti-nuclear movement in Germany started against a nuclear construction site in a village called Wyhl (Morris & Pehnt, 2012; Hockenos, 2015). At first, university students started an anti-nuclear campaign against the construction site, then lots of people from different backgrounds like wine villagers and citizens started to join the campaign (Hockenos, 2015). Thus, it transformed to an anti-nuclear movement sided by citizens from a protest started by a small sized group of activists. Consequently, they pushed government to step back and the nuclear power plant project in Wyhl was cancelled. Anti-nuclear movement has a connection with fight against an authoritarian government who was trying to promote large number of nuclear power plants without paying attention to public opinion. Public wanted to participate in decision making process in that case instead of safety concerns about the nuclear power (Paul, 2018).

The success of the protests, wide participation and support led this movement in the next stage in following years which is forming a political party. In 1979, the Political Union of the Greens was established and in 1980, they sent Joschka Fischer as an elected representative to the parliament. In the same year, they became an official federal party and as an official federal party, they entered the parliament with 5.6% of the vote in 1983 (Conradt, 2006). Thus, the anti-nuclear protesters of 1970's claimed right to speak in state level in 1980's. This success of Greens in political era was just the beginning for their political adventure. After Chernobyl disaster, Greens strengthened their hands and they rose their votes. Whereas before continuing to their success in political arena, Greens were excluded from parliament after reunification of East and West Germany because they did not support to reunification and they stayed under the election threshold of 5% of the votes and excluded from the parliament. After that defeat, in 1993 they decided to be united with East Germany based Alliance '90. In 1998, they built a coalition with Social Democrats; hence, Greens had ruling power thanks to this coalition and Joschka Fischer became a foreign minister. Greens and Social Democrats had ruled until 2005 elections and this election led Greens as opposition party again.

After Fukushima disaster in 2011, Greens rejoined the government under coalition with liberal conservative party CDU (Christian Democratic Union of Germany) thanks to nuclear concerns of German voters. However, Greens' success shouldn't have been measured with their attendance in government. Their most important success is creating a country with wide awareness about anti-nuclear standpoint and renewable supportive perspective. Nowadays, green policies have been supported in all kind of political parties in Germany. Under the light of this fact, it would not be misguided to say that Greens already achieved their goal about anti-nuclear stance. To prove this statement, looking at Chancellor Angela Merkel's stance after Fukushima disaster would be logical to point the importance of green policies in Germany's political environment.

## 5.3. Historical Background of Nuclear Phase-Out

Fukushima disaster has played a very important role in Germany's nuclear phase-out. Chancellor Angela Merkel's statements may support this fact (Reuters, 2015) because Germany's main procedure of nuclear phase-out did not contain immediate shut down of nuclear power plants (WNA, 2019). Whereas, after Fukushima disaster, German government has decided immediate shut down of eight of the nuclear power plants in Germany. The rest of the nuclear power plants will be shut downed by 2022. Chancellor Angela Merkel's anti-nuclear statements, followed by governments immediate shut down decision are noticeable progress because Chancellor Angela Merkel was in supporting side of the nuclear energy (Spiegel, 2011). Before Fukushima disaster German government decided to extend some nuclear reactors lifespan for 14 years. Whereas, after Fukushima disaster, nuclear phase-out stated to be associated with Merkel's name. The most important part could be the shocking effects of Fukushima disaster and German citizens attitude against nuclear energy whereas, it does not change the fact that Green's anti-nuclear movement has been claimed by conservative chancellor. After Fukushima disaster, it is obvious that nuclear phase out process have had support with wide range of people including opposite sides of political parties.

Before passing to next stage it is important to understand the reason why Chancellor Angela Merkel had support for nuclear energy before Fukushima disaster. The reason is that with or without nuclear phase-out shifting to renewable energy has been in Germany's energy policy (IEA, 2014). In accordance with standout and vision of Germany about Kyoto Protocol and Paris Agreement, including 2020, 2030 and 2050 goals, promoting renewable energy has always been the part of the plans. It is also important to not forget the fact that, Germany is an energy dependent country (Figure 5; Figure 6; Figure 7). With including all these parameters, Chancellor Angela Merkel viewed nuclear energy as a supporting source for Germany's energy needs while shifting to renewables is in the progress. While shifting from conventional energy sources to renewable sources, nuclear energy had supposed to be a fulcrum for not increasing the energy dependency.

After Fukushima disaster that policy has been abandoned.

While trying to understand Germany’s nuclear phase-out, it is clear that renewable energy has always been an issue. When Greens have acted against nuclear energy, they have come with an alternative which was renewable energy. Ever since the starting point of anti-nuclear movements in Germany, renewable energy has always been in the agenda of Greens. Therefore, it will be wrong to analyze anti-nuclear movement or nuclear phase-out without renewable energy in Germany. In addition, there is no sort of alternatives for Germany because when we look at other alternatives, there are two kinds of energy sources which are coal and natural gas. As for natural gas, Germany is the biggest importer of Russian gas (Gazprom, 2017). Natural gas is cleaner alternative of coal whereas it is increasing energy dependency. Coal is another alternative whereas it is one of the main sources of GHG emission. So, on the one hand there is a natural gas which is increase your energy dependency, on the other hand there is more polluting fossil source which endangers your climate policies. These facts also help us to understand why Germany insist on shifting to renewables.

## 5.4 Public Conflicts Related Energiewende

Public movements and publics reactions are crucial in Germany as seen in anti-nuclear movements in the past. There are still some protests and reactions whereas nuclear is not the subject this time. German people react to coal and even renewable sources due to some reasons. Local conflicts may be ignored by authorities sometimes and this could create a big problem in the future. The study of Reusswig et al., (2016) demonstrates how local energy conflicts of Germany has slow down Energiewende's wind power and power grid development.

Engelsbrand is a municipality known as a very active in energy programs and climate protections since 2009. Even this municipality won European Energy Award in 2012. No one could foresee the transformation of Engelsbrand as a center of an anti-wind energy movement. Wind park project in Engeslbrand caused a “Not in My Back Yard" (NIMBY) movement. Because citizens worried energy park would be too close to their houses. This movement grew day by day and opposites found a fraction called "Liveable Engesbrand" and they participated to local council elections as consequence they entered to local council with almost 30% of the votes and they became the strongest fraction in the municipal council. Finally, decision makers have had to cancel the wind farm project of Engelsbrand. When the project got canceled, the firm had already started to invest, and the investors incurred losses. Engelsbrand case may be seen as an extreme example whereas according to study of Reusswig et al., (2016) one out of ten wind farm project faces with similar cases.

The Energiewende promotes coal power for filling the absence of nuclear power. This attitude creates another problem because coal is a highly GHG emitting energy source and it creates paradox in the climate protection orientated project. It also affects local populations of Germany. Morton & Müller (2016) criticize The Energiewende in the view of local energy conflict due to *coal conundrum*. The governments project consists expansion of the current existing brown coal (lignite) mines and opening new mines in Lusatia. According to this project five new coal mines were planned to open in three villages, and this means demolition of that villages. This fact created a reaction against expansion of coal mines. Also, it provides a perception about climate contribution was destroyed by the coal industry with support of the state governments. Furthermore, according to Morton & Müller (2016) the image of the Energiewende in public mind is "exiting from nuclear power and increase the renewable energy share." However, coal power fills the gap of the nuclear power with renewable energy. Also, the defenders of the coal mention the reliability of the coal power. Because renewable energy sources have storage deficit and dependent on seasonal movements, but coal is a national resource of Germany. These two different sides of the Energiewende creates the paradox of the climate concerns of the Energiewende. In the end, both sides agree that the Energiewende requires more energy democracy for the affected parties of the situation (Morton & Müller, 2016).

Extension of coal mines is not a new problem of Germany. In 1994, Brandernbutg government decided to extend the brown coal mines in Janschwalde. This preference of the government caused to protests and lots of lawsuits were filed regarding this issue. According to the authors' analysis, great number of socio-environmental disagreements are mainly related to low carbon economy. Naturally, fossil fuels are the main topic of those conflicts. Whereas, beside the protest against to expansion of coal mines, citizens also not happy about renewable energy-based production, such as high voltage energy power lines. Energiewende needs those high-tech power lines because, Southern part of Germany uses more energy beside the Northern part due to industry. Because South is more industrialized than North. However, Northern Germany has rich with rural wind areas and produced energy in North must transmit to South. Because of this fact, Germany invests in high voltage power lines and this attitude creates another problem for citizens. Because citizens and environmental NGO's argues that, high voltage power line projects cause to electromagnetic fields and it is harmful for people health and nature (Weber & Cabras, 2017).

Coal centered disputes also continued in 2007. The expansion of Jänschwalde mine contains demolition of three villages which are Atterwasch, Kerkwitz and Grabko. After people learn that their homes going to be destroyed, they started to organize large scaled protests and afterwards they collected 20,000 signatures against mine expansion. Also, with 80,000 signatures, citizens can demand a referendum; however, they could not reach that number. There were only 900 residents living in all three village. The other signatures came from other parts of Germany as a support for the villagers. Also, some NGO's had been involved and environmentalist anti-coal oriented NGO Lausitzcamp enlarged the local protest and brought media support with it. Beside the protests, Swedish owner of the mine decided to sell the shares of it to the Czech energy company. The government was planning on approving the mine expansion plan by 2014. First, they postponed this plan to 2015 but they did not declare an exact date. Finally, in 2017 new owner of the mines decided to cancel the expansion of Janschwalde mine. According to the author, there are four important actors such as government, stakeholders, local citizens and NGO's. The attitude of negligible actors beside the government and stakeholders are not practical in mine business in Germany (Müller, 2018).

The challenges of the Energiewende are not only coal oriented. Also, energy transitions cost burden on household is another downside of the Energiewende. According to Frondel, Sommer & Vance (2015) the electricity costs for German house holders were doubled through feed in tariff introduced with Renewable Energy Sources (RES) in 2000. For the authors, this increase in electricity costs won't decrease in future, yet electricity costs will continue to increase due to phase out process of the remaining nuclear power plants. In line with the Energiewende, all remaining power plants will shut down until 2022. So, there is no hope for possible reduction in electricity costs for households in Germany (Frondel, Sommer & Vance, 2015).

In Germany, it is important to approach energy struggles by including public opinion. Like success of NIMBY movement in Engeslbrand, in nuclear phase-out progress, public opinion played a very important role. All those disputes should not be underestimated because roots of Nuclear phase-out belong to public movements as told in previous part of the study. Also, NIMBY movement became successful, and representatives of NIMBY have chairs in the municipal council because both NIMBY and nuclear phase-out movements started in 1970's and have similarities. If movements like NIMBY spread widely to Germany, it would be a nightmare for Energiewende. Following historical development of Energiewende, next chapter will discuss analysis and findings.

# CHAPTER 6

## Analysis and Findings

The EU and Germany attach much importance to mitigation of climate changes as seen in their climate targets for 2020, 2030 and 2050. Germany has even more challenging targets beside the EU. Decreasing fossil fuel usage and promoting renewable energy are main topics for both the EU and Germany for reaching the climate targets. For analyzing Germany's energy transition, this study has four main research questions as described in the Introduction part.

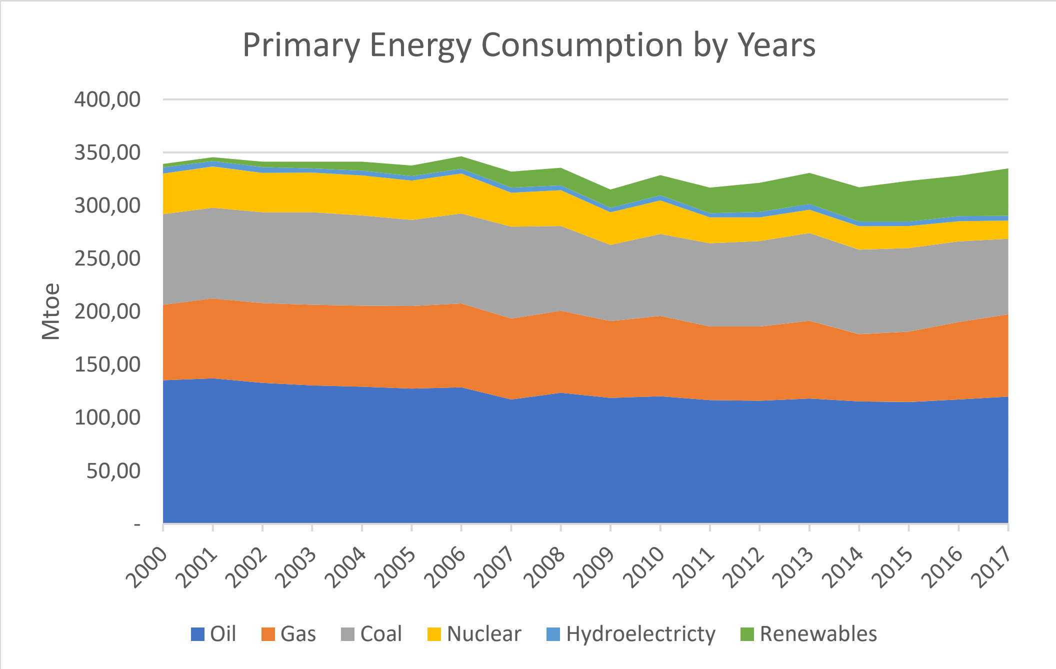
The *first research question* is about *driving goals of Energiewende*. As demonstrated in previous chapters Energiewende's driving goals are *(1) reaching the climate targets which are reducing GHG emissions, increasing renewables in primary energy, increasing energy efficiency and decreasing imported energy dependency.* Germany has progression in reducing GHG emissions. According to Figure 12, Germany has already reached the EU's 20% cut in GHG emissions according to 1990 levels whereas, Germany is going to missing its own target which is 40% cut in GHG emissions according to 1990 levels. Germany Ministry of Environment expecting 32% cut in GHG emissions according to 1990 levels for 2020. Whereas Germany is close to reaching to 18% share of renewable energy in final energy consumption by 2020. Germany's renewable energy share in final energy consumption has reached 16.6% according to UBA (2019b). As far as efficiency concerned, Germany is far away from its goal. Its 2020 energy efficiency goal is 20% reduction in primary energy consumption according to 2008. Germany reduced 7.6% of primary energy consumption in 2015 (BMWI, 2019b). For decreasing imported energy goal, Germany still highly dependent on imported fossil fuels mainly oil, coal and natural gas as details given in Germany's Energy Profile chapter. Germany still needs years for decreasing imported fossil fuel dependency.

The *second research question* is about challenges of Energiewende. Answers of the first research question shapes some of the challenges of it. Germany is about the fail in 2020 climate and energy efficiency targets. Those targets are becoming a challenge for Energiewende. If Germany will fail in those targets, that data shows those targets are going to fail, Germany should review its goals, take precautions and should work for achieving 2030 targets for recover failed targets of 2020. Beside this, Germany has high electricity prices because of feed-in tariffs and other support mechanisms. Higher prices are burden for consumers as Frondel, Sommer & Vance (2015) states. Still Germany's grid expansion is underdeveloped, Germany has not carried Northern wind energy power to Southern cities. Also 7 nuclear power plants are going to shut down. Germany will lost 9500 MW of clean electric source and there will be also decommissioning process of those power plants.

The *third research question* is about public support for Energiewende. According to most of the polls, Energiewende has a huge support from majority of people (Amelang, Wehrmann & Wettengel, 2019). Same article also mentioned about people who are not happy about how Energiewende progressed. People has still support for Energiewende however they are aware of its failures, too. Beside local conflicts as mentioned in previous chapters, Energiewende has the support of people in the end.

Before finding answers of the last research question, it is important to analyze Energiewende according to methodological framework of this study. According to Table 1, scholars have five common definitions three common findings for a successful energy transition. The first definition was *decrease in usage regarding older energy sources.* Figure 14 demonstrates that, there is not a major decrease in fossil fuels. Even, share of natural gas increased in 2017. Energiewende is not passed from first common definition. The second common definition requires *major changes for energy systems.* Germany is building smart and advanced grid for transmitting its renewable energy. Moreover, Germany is promoting photovoltaic installations and offshore wind energy. Germany is fulfilling the second common energy transition definition. The third common energy transition definition is about cheaper prices. Whereas, scholars also define, in modern low carbon energy transitions, people willing to pay higher prices. Because of that, the third common energy transition definition is not valid for Energiewende. The fourth common definition is *reducing carbon emissions.* This definition is also for modern low carbon energy transitions. Germany is going to missing its 2020 GHG target whereas, the EU's 2020 target was achieved. Energiewende fulfills fourth definition too. The last common definition is *switching to an economic system.* Energiewende including EEG for providing an economic system for the transition. The last definition is fulfilled, too.

**Figure 14: Germany's Primary Energy Consumption by Years (Source: BP Stats, 2018)**




The common findings of scholars are also definitive for Energiewende and they are helpful to explain challenges of Energiewende. Energy transition takes time and late adopters having faster transition may explain Germany's situation. Germany is not a late adopter and experiencing prolonged stage of energy transition is accepted by the scholars. Also, the latest finding of the scholars is underlining the importance of *cooperation between people and government.* This finding also clarifies disputes between people and German government over energy transition as mentioned in previous chapters.

The *fourth research question* is determining the points where Energiewende is successful or not. According to first three research question methodological framework of this study, Energiewende has both successful and not-successful points. Germany is going to fail reaching 2020 climate targets including energy efficiency target. Also, Germany is still dependent on imported fossil fuels and older energy sources are still important place in primary energy sources. However, Energiewende is not completed yet. It has 2020, 2030 and 2050 goals. It is not wise to say Energiewende is a failure or success. Data to be obtained about the long-term goals in following years would be more explanatory about the process.

# CHAPTER 7

## Conclusion

After analyzing Energiewende according to methodological framework, evaluating situation considering social, political, economic and technologic aspects could draw a clearer picture. Actually, all these aspects are related each other and examining them individually could not give an accurate result. For instance, as Sovacool (2016) agrees with mainstream view about energy transition which clarifies that energy transition takes time. Whereas Sovacool (2016) also refers cooperation between people and government promote energy transition. In other words, cooperation between social and political aspects accelerates energy transition. Wilson & Grubler (2011) mention social elements shape technology and technology shapes market. As schoolers define, successful energy transition requires harmony between social, political, economic and technologic aspects.

In Energiewende's social side, there are still some problems even if they have been seen minor. Engelsbrand issue showed that, how dispute between people and government could has gone far. Beside Engelsbrand, history of nuclear phase-out shows that how German people unite around energy related problems and shapes politics. Energy democracy and cooperation between government and people should eliminate further problems and promote energy transition.

In Energiewende's economy side, as seen in Chapter 6, Energiewende has working economic tools. Beside this, economic and technological situations are related each other. As mentioned in Chapter 3, shifting to renewable energy creates its own economy and employment opportunities. Germany also produces and exports its own technology. Energiewende seems successful according to economic and technological perspective.

Energiewende's fails lie beneath political side. Germany's failing GHG and energy efficiency targets are related with political decisions such as continuity high dependency to fossil fuels and abandoning GHG friendly energy source nuclear. But in Germany's situation there is a dilemma about this decision. As stated in Chapter 4, nuclear phase out policy is consequence of environmental justice instead of energy security concerns as Bruninx et al. (2013) stated. This side of Energiewende makes it special and puts it in a more challenging situation.

Germany is a country which has experienced lot of difficulties throughout the history and found the way overcame of them. As seen in previous chapters, Energiewende has a wide acceptance around people and politicians of Germany. There are some disputes about German people directly affected from downsides of Energiewende like NIMBY.  Even so, Energiewende has wide acceptance among German people and despite the failing parts of Energiewende, German people still believe into Energiewende as Amelang, Wehrmann & Wettengel (2019) put forward. As seen in historical development of Energiewende, German people are highly aware of importance of clean energy systems and public opinion was the main driving actor of nuclear phase-out. Renewable energy is the only option for Germany because of awareness of German people.

Failing 2020 targets could create a negative perception but it is early to consider Energiewende as a failing energy transition. Germany set its 2020 GHG target at a very challenging point. Reducing GHG by 32% in 2020 is acceptable when the EU's target of 20% considered. In energy efficiency point, there is still need for a progress. However, Germany is not alone for missing energy efficiency targets of 2020. The EU is also going to miss energy efficiency targets due to rising energy consumption according to European Environment Agency Report (EEA, 2019).

Beside the failing parts of Energiewende, increasing renewable energy share is still promising as well as solar and wind installation momentums. With considering Germany's next grid expansions, the EU's energy market targets, technological developments and future energy storage technologies could boost Energiewende in the next years for reaching 2030 and 2050 targets. Watching Energiewende' progress for the next years will be exciting.

As Germany and majority of countries who are parties of Paris Agreement (COP 21) agreed to keep global warming maximum at 2 degree centigrade. For keeping this promise, shifting from fossil fuels to renewable energy sources will protect its importance as seen in both Germany's and the EU's climate targets. The EU, Germany and world together should take lessons from Germany's failures in energy transition. Because as Wilson & Grubler (2011), Sovacool (2016) and Miller et al. (2010) put forward, late adopters have advantages in energy transition. Germany's energy transition case presents lessons for current and next energy transitions. Thus, in following years, with the helping of technological development, productivity of renewable energy sources and energy efficiency should increase. With correct political implementations and along with cooperation of people could provide better solutions for future of low carbon energy transitions.

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