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Recent Developments and Future Trends in Germany's Electricity Market

An assessment of recent market developments on electricity prices and market stakeholders

by

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Master Thesis within the profile of Energy, Natural Resources and the Environment

Abstract

As Europe's largest economy and as one of the most industrially and technologically advanced countries in the world, Germany has long been at the forefront of managing and implementing change in the electricity sector. With the nation's plans to phase-out nuclear energy by 2022 following the Fukushima Daichii Nuclear Disaster in conjunction with its own ambitious Energiewende goals of transitioning towards renewable energy, the market has been put under considerable pressure. Further supported by the rise of Smart Grid, increased decentralized generation and the interconnection with other European markets, key market participants are being considerably affected by the scale of change.

To understand the implications of these recent trends, the authors examine the development of wholesale and retail electricity prices over an eight years period since 2006. They further assess the impacts on electricity generators and German households as the key market stakeholders who are affected by the diverging wholesale and retail electricity prices. As a result of the developments, the authors believe the role of municipalities and cities to be an increasingly integral part of an effective electricity market in achieving the nation's goals.

The authors find that as a result of market intervention, the market mechanism upon which generators have traditionally relied faces considerable pressure. As a direct result, Germany's four largest electricity producers are under substantial financial pressure and have had to drastically redefine their businesses. Moreover, despite the low wholesale price of electricity, German households are paying amongst the highest prices for electricity in Europe. This is mainly attributed to the Renewable Energy Surcharge (EEG Umlage), which has increased by 500% since 2006 and in 2015 accounted for more of the household electricity price than the procurement of electricity itself.

In summary, the authors conclude the paper with an assessment on how the recent market developments will continue to affect the German electricity supply, demand and prices in the future.

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Table of Abbreviations

BDEW	Bundesverband der Energie und Wasserwirtschaft translated to the German Association of Energy and Water Industries
BGO	Balancing Group Operators
Bundesnetzagentur	Federal Network Agency
CHP Surcharge	Combined Heat and Power Surcharge
CWE	Central Western Europe Price Coupling project
DA	Day Ahead
DR	Demand Response
DSO	Distribution System Operator
EEG	Erneubare Energien Gesetz translated to Renewables Energy Act
EEG Umlage	Erneubare Energien Gesetz Umlage also referred to as GEC (Green Energy Contribution)
EEX	European Energy Exchange
Energiewende	German Energy Transition
EPEX	European Power Exchange
FOU	Full Ownership Unbundling
GEC	Green Energy Contribution also referred to as EEG Umlage
GHG	Greenhouse Gases
GW	Gigawatts
ISO	Independent System Operator
ITO	Independent Transmission Operator
KWh	Kilowatt Hours
KWp	Kilowatt Peak
NWE	North Western Europe Price Coupling project
Ökosteuer	‘Eco Tax’ (Energy Efficiency Tax)
PS	Planned Schedule
REA	Renewables Energy Act

SO	System Operator
Stadtwerke	Municipality owned utilities
TOU	Time of Use
TSO	Transmission System Operator
TWh	Terrawatt hours
UK	United Kingdom
VAT	Value Added Tax

1 Introduction

1.1 Background and Research Question

With the fourth largest economy and as one of the most industrially and technologically advanced countries in the world, it is unsurprising that Germany's electricity market is a particularly interesting and popular research area. This paper aims to contribute to the vast research on Germany's electricity market and bring up to date and combine a number of different research areas within the electricity market itself. Specifically, this paper will answer the question:

How have recent developments in the German electricity market affected electricity prices and key market stakeholders?

To do this, we will be providing an analysis of the wholesale and retail electricity price development and its implications on key stakeholders in Germany. In doing so, we will investigate the impact this has had on the main German electricity generators, German households as well as on the role of cities and municipalities. Through this analysis we will also make an assessment on the likely future developments we expect to see.

Specifically, we will consider the implication of the high end-user retail prices and the markets role in contributing to this. We hypothesize that with the German market set-up and tax mechanisms in conjunction with the ever-increasing level of interconnection and market coupling across Europe, it is actually German households which are, and will continue to be, disproportionately subsidizing the widespread use of renewable energies in the generation of electricity.

To answer the research question, data has been collected from the European Power Exchange (EPEX Spot, 2015) on the day-ahead spot market prices, which serve as an indicator for interpreting the wholesale electricity prices, as well as household pricing data provided by the Bundesverband der Energie und Wasserwirtschaft (BDEW, 2016a), Germany's leading Association of Water and Energy Industry. Further analysis is conducted based on projections and future capacity scenarios as obtained from IHS (IHS, 2014).

In gathering data to test our hypothesis we encountered a number of challenges that serve as potential limitations to our analysis:

Firstly, there is a relatively small amount of research in Germany on the specific subject matter presented in this paper, which evaluates both the demand and supply side of the market. While models and comparisons are justifiably drawn from comparable markets such as Norway and the United Kingdom where similar research does exist, it is the case that they do not exactly reflect the case of Germany. Where necessary, this has been specifically referenced and all analysis conducted has considered and reflected this limitation in it.

Secondly, end-user retail electricity prices in themselves are not publicly available as this is the function of electricity retailers which are predominantly private. While there also exists a difference between types of end users and the contracts they have, this distinction is clearly made in this paper. Nonetheless, given the size and competitive nature of the market, different grid operators, retailers and contract types exist (in Germany there are over 800 retailers with over 30,000 customers). Each of these factors contributes to the complexity of determining actual retail prices paid by German households. Nonetheless, the data provided by the BDEW is widely supported and referenced both in literature and in industry.

To address these shortcomings, where necessary, we have made use of assumptions based on other relevant literature that has been conducted on different aspects of the German electricity market.

1.2 Relevance

The electricity grid is considered to be one of the foundations of a modern economy and fundamental to its future development. While per capita electricity consumption in developed countries has been relatively stagnant and even declining over the past decade, Germany, with the second largest net immigration level in the world, is an example of how growth trends which affect predominantly developing economies can still pose significant challenges to a well-established and highly developed electricity grid (World Energy Council, 2013). With the still ever increasing trend of urbanization, the requirements for a larger, more sophisticated and dynamic electricity grid still exists (World Energy Council, 2013).

This area of research is particularly timely given the recent events and undertakings in energy markets around the world, which have had direct impacts on electricity markets. Most recently, major factors and trends include but are not limited to the threat over security of supply (particularly in Europe), increased end-user consumption efficiency and above all the continuous technological advancements in both the extraction of resources and the generation of power (World Energy Council, 2013). With the ever-growing world population and continuous increase in wealth, it is the energy sector that is at the forefront of this development as the demand for increased energy infrastructure and levels of consumption is a challenge being addressed around the world (World Energy Council, 2013).

At the time of writing, the authors consider the energy industry to be characterized by drastic developments in both conventional and traditionally unconventional sources spanning the globe. We consider the following to be the most significant changes to the macro environment:

- Shale oil and gas revolution in the US, now encompassing the globe, which has led to an unprecedented increase in world energy reserves;
- Oil prices dropping by up to 50% in a six month period in the last 12-18 months;
- There is a continuous push for renewable energy sources as a response to the threat of climate change;
- Drastic technological developments in power markets and grid networks have resulted in the evolution of the 'Smart Grid'.

Renewable energy in itself poses many challenges to the electricity grid, which will be further considered throughout this paper. However, it is important to acknowledge here that one of the main driving forces behind this is the level of awareness for the threat and implications of climate change and the subsequent response by both people and governments in varying capacities.

In Germany specifically, we consider a number of key factors that have driven change in the energy industry throughout this paper including, the phase out of nuclear energy, Germany's deep historic dependence on coal, the implementation of policy instruments to achieve renewable energy and carbon emission targets, the coupling of markets and the ever increasing integrated nature of the European electricity grid and technological developments within the grid.

We consider the implication of each of these in the context of our research question and hypothesis in order to assess the impact prices have on key market stakeholders.

1.3 Paper Structure

This paper is split into five chapters that together offer a comprehensive assessment of Germany and the status of its electricity market. **Chapter One** offers the insight into the relevance of this paper and how macro trends affecting energy relate to Germany. It also offers a literature review of the relevant research into the German electricity market and in particular the reasons behind electricity price developments. As previously mentioned, this paper combines the research of a number of distinct fields within electricity markets in order to present a holistic assessment of the German power market.

Chapter Two provides a more detailed background to the research paper and introduces the necessary information regarding the German deregulated electricity market and its structure. This includes a broad overview of the German energy mix and the development of electricity prices in Germany. Furthermore, the chapter explores the four key developments in Germany, which form the foundation of the analysis to be conducted in Chapter Four.

Chapter Three then provides the theoretical insight into the electricity market mechanism and how price formation works in both the short and long run. It further considers the competitive construct of the market, its potential for abuse and the impact this has on the market mechanism. By introducing the methodology used, this section of the paper will clearly define what will be measured and how the research question will be answered. In doing so, it introduces the types of data used and interprets the various components of electricity prices.

Chapter Four presents an assessment of the electricity price data collected and analyzes the effects of recent policy and technology changes on each of the market stakeholders including producers, consumers and municipalities. This will follow the methodology set out in the previous section and apply the author's own analysis supplemented by extensive research on pricing data and forecast data of Germany power production and installed capacity.

Chapter Five will then collate these findings and summarize the implications of the developments on both the future market setup and the future prices. In conjunction to answering the research question, it is the authors' hope that the research and analysis conducted will be valuable and provide a degree of transparency into not only the price developments, but most importantly the implications this will have on key electricity market stakeholders in years to come.

1.4 Literature Review

In examining the literature on the specific topic of electricity price formation in Germany, it is immediately apparent that while price behavior and fluctuations in each of the wholesale and retail prices has been extensively analyzed, the connection between the two together has not been. As Mirza & Bergland (2012) acknowledge, it is quite surprising that the relationship and pass through of prices between the two markets has remained little researched and relatively unexamined for many markets despite the magnitude of change the industry is undergoing. The lack of research here is in fact one of the key motivating factors behind the research presented in this paper.

In order to understand and be able to effectively analyze the German market, the scope of this literature review has been expanded to incorporate analysis of comparable markets, namely the Norwegian and the UK markets. With the existence of transmission capacity, comparable market structure and comparable regulatory environments within these electricity markets, these two particular markets are frequently referenced for comparative purposes and are therefore highly relevant to this research (Matallana-Tost, Boßmann, Pfluger, & Elsland, 2014; Seeliger et al., 2011).

The following table provides an overview of the underlying literature into the subject that forms the basis of the work undertaken in this paper and presents the key relevant findings used in the analysis of the German market:

Table 1: Applicable Literature Sources

Author	Market	Topic	Key Takeaways/Findings
(Littlechild, 2003); (Blumstein, 1999)	General	Wholesale spot pass through	How to pass on prices to maximize social welfare
(Brigham & Waterson, 2003)	UK	Strategic behavior of retailers in the UK	Despite competition in retail market, it remains not perfectly competitive
(Lewis, Johnsen, Wasti, & Narva, 2004)	Nordics	Wholesale and end-user price in Nordic market	Retailers have been efficient in passing on price developments in wholesale market
(Johnsen & Oslon, 2008)	Nordics	Wholesale and retail prices in Nordic market	Retailers pass through costs and price movements to customers in an asymmetric way
(Mirza & Bergland, 2012)	Norway	Wholesale vs. Retail prices	Smart grid to be utilized to address asymmetric pricing between the two markets
(Matallana-Tost et al., 2014)	Germany	German retail price development	Retail electricity prices are developing differently across key European markets

(Brunner, 2014)	Germany	German wholesale price formation	Renewable energies are having a considerable impact on spot price formation
(Seeliger et al., 2011)	Germany	Energy costs in Germany	There are five key measurable drivers of electricity prices
(Davies, Hounsell, & Robinson, 2014)	Germany	German energy policy	German policy has had considerable impact on retail electricity prices
(Möst & Genoese, 2009)	Germany	Market power in wholesale market	Considerable market power exists in the German wholesale market
(Koschker & Möst, 2015)	Germany	Influence of renewables on market power	An increasing renewable feed-in tariff reduces the ability to exercise market power
(Keles, Möst, & Fichtner, 2011)	Germany	Energy market development until 2030	Increase in renewables have a large impact on the market mechanism in Germany

In analyzing the development of costs for different energy sources in the German market, Seeliger et al., (2011) identify that retail prices for most customer groups have been amongst the most expensive in Germany relative to similar international counterparts since 1998. They further identify the four main drivers that lead to the differences in prices between comparable countries: taxes and duties, network tariffs, political interference with retail prices and the level of end customer competition. These areas form the basis of the price analysis utilized in Chapter Three and Chapter Four of this paper.

While different energy sources are affected by different trends, both Seeliger et al. (2011) and Davies et al. (2014) acknowledge that, in absolute terms, no other energy source has seen a higher price increase than electricity prices to household customers which has risen at a consistent rate annually even through the financial crisis. While the electricity price increase for industrial customers is also significant, the absolute price increase is relatively smaller over the same period. Different regulation that applies to industry, specifically energy intensive industry, makes the comparisons even more difficult.

For these reasons, this study remains relevant to the current state of Germany in the midst of its rapidly evolving energy transition period (known as the ‘Energiewende’). The authors’ goal is therefore to contribute in enhancing the degree of transparency in the German electricity price developments both in terms of the producers and the retail end users who are the most affected by these developments.

As explained by Wilson (2002) in examining the architecture of power markets, wholesale markets remain an interesting point of research given that they remain incomplete under a deregulated market for three key structural reasons:

1. They cannot be perfectly monitored
2. Storing of energy is difficult and expensive
3. At a retail level, variable pricing is not matched with flexible spot pricing

While continuous developments are being made in each of these areas, the pricing discrepancy at the retail level has in itself led to a number of deficiencies in the market. The impact of this is specifically examined by Seeliger et al. (2011) who draw attention to the price variations in the retail market as a result of their connection to the price fluctuations in the wholesale markets. While the factors contributing to and influencing electricity prices, such as an evolving generation mix and newly introduced taxes, have changed, the clear link that exists in theory between the two different markets underpins the rationale for this study.

It is important to particularly emphasize the fact that retail customers with low consumption levels (e.g. households) are not necessarily charged by their actual consumption level (load profile) but rather their 'estimated load profile' (Biggar & Hesamzadeh, 2014; Matallana-Tost et al., 2014). The implication of this will be considered further in our analysis; however, as Mirza & Bergland (2012) and Borenstein, Bushnell, & Knittel (1999) acknowledge, the restricted ability for customers to respond to wholesale market prices increases the ability for producers to exercise market power. This not only leads to a wealth transfer from consumers to producers but also in considerable price volatility. This will be further discussed in Chapter Three and Chapter Four of this paper when examining the shortcomings of the market mechanism.

In considering the Norwegian market, a key factor that Mirza & Bergland (2012) draw attention to is that prices are essentially signals for efficient resource allocation. This is primarily attributed to the fact that consumers' demand is inelastic and respond only to a very limited extent to the fluctuating electricity prices. As a result of this and the absence of real time pricing, end consumers 'over-consume' in expensive periods and 'under-consume' in the cheaper periods from a demand-side perspective (Mirza & Bergland, 2012).

As a result of the higher demand, peak hour consumption periods require additional peak load production. The impact of which results in a higher electricity cost due to the operation of the more expensive power generators for these hours (Biggar & Hesamzadeh, 2014). Given the fact that retail customers do not react to day-ahead price signals or adjust their consumption profiles, the prices in the retail market do not convey or adequately represent the potential scarcity in the wholesale market. For this reason we see retail customers, specifically households, as particularly relevant to our analysis given the challenge this poses in the delivery of a service traditionally carried out by a public utility (Biggar & Hesamzadeh, 2014).

Following the significant liberalization of electricity markets throughout Europe it is interesting to note that the structural changes exhibited in the generation sector have not transcended to the retail sector (Biggar & Hesamzadeh, 2014). As Mirza & Bergland (2012) point out, this can be seen clearly in the way that metering and contract types in general have remained relatively unchanged. Mirza & Bergland (2012) found that considerable asymmetry exists in the passing on of price changes in the Norwegian wholesale market by the retailers to their end customers. It is considered likely the case that some of the larger, more dominant players in the retail sector are exercising market power in the retail market too. This is not a unique scenario to Norway and can be considered in the German market given the similar market structure. To adequately address this, they proposed that end consumers should make use of emerging smart grid technologies and adopt spot price contracts (Mirza & Bergland, 2012).

Finally, we consider the impact of taxes and tariffs on power prices. Seeliger et al. (2011) draw attention to the fact that energy tariffs in Germany are amongst the highest in Europe for both households and industrial customers. The country is also considered to have one of the most reliable networks in the world, which is the result of increased network maintenance predominantly financed through Germany's high network charges (Davies et al., 2014). As part of its network charges Germany also includes a cost for the renewable energy integration into the grid, which will be further explained in the following chapters. However, it is interesting to observe that Germany has relatively low switching rates between electricity suppliers, which is a phenomena that the Federal Network Agency (Bundesnetzagentur) attributes to the fact that end users may not be informed about the potential savings available or the ease of actually switching suppliers (Appunn, 2015a). This is an area of increasing relevance in the wake of the changing relationship customers have with the electricity market, which will be further explained throughout this paper.

Taken together, we see all these key findings presented in this section as highly relevant to the analysis in this paper and in ultimately assessing the implications of developments in the German market on key stakeholders.

2 Background

The main objective of this chapter is to provide the reader with a general understanding of the German power market and the current developments that have impacted its operations and functions in varying capacities. This chapter also lays the basis for the analyses conducted in the subsequent chapters of this paper. It begins with a brief overview of the current German power market and how it is set up. It then explains the four key developments that this paper will analyze, including the effects of the Fukushima Daiichi nuclear disaster on German policy, the introduction of the Energiewende, which is the policy framework that is the basis of Germany's energy strategy, the market coupling and interconnection across Europe and finally the introduction of 'Smart Grid'.

2.1 The German Power Market

The first part of the chapter focuses on the current setup of the German energy market while looking at each of the current energy and electricity mixes. The key stakeholders, regulators and power market participants are summarized in Table 1 below, which provides a general overview of how the sector functions and is regulated in Germany.

The most important point to be made here is that despite the power market being deregulated it remains highly structured. Germany's geographic positioning in the center of Europe has led to the potential for integration and interconnection with neighboring markets, which is something Germany has actively supported (Autran, 2012). As a result, Germany has transmission capacity with nine of its nearby countries and the construction of an interconnector to Norway is currently underway. While this paper focuses on Germany, it is impossible to do this without considering to some degree the integrated nature of the European electricity grid.

Table 2: Overview of the Framework in Germany (Freehills, 2015)

General	National Regulatory Authority	Federal National Agency (Bundesnetzagentur), Network Agencies of the Federal States
General	Unbundling regime • Full Ownership Unbundling 'FOU' • Independent System Operator 'ISO' • Independent Transmission Operator 'ITO' Model	FOU, ISO, ITO
Elect ricity	Principal Electricity Generators	EnBW, RWE, Vattenfall, and municipality owned companies (Stadtwerke)

	Transmission System Operators	50Hz Transmission, Amprion, EnBW Transportnetz, TenneT TSO
	Electricity Distributors	Approximately 850, more than 700 have <30,000 customers
	Principal Electricity Suppliers	EnBW, RWE, Vattenfall, and municipality owned utilities (Stadtwerke)
	Interconnections	Austria, Switzerland, France, Luxembourg, Belgium, Netherlands, Denmark, Poland, Czech Republic

2.2 Setup of German Electricity Market

a) Electricity Market Design

Currently, the German electricity market is Europe's largest with an annual power consumption of close to 550 TWh and a generation capacity of 125 GW (IHS, 2015). Since the Energy Industry Act was introduced in 1998, the German electricity market became fully liberalized and different suppliers have been subsequently introduced into the market. As a result, competition has been introduced in both the generation and the retail fields; however, transmission and distribution remain centrally managed and regulated.

The German electricity market is characterized as a rather typical deregulated system whereby the generation, transmission, distribution and sale of electricity are 'unbundled'. Nonetheless, the four main utility companies have a large presence throughout multiple parts of the market (generation, distribution and retail) as demonstrated in Figure 1 below. The implication thereof will be further considered throughout this paper and is particularly relevant to understanding the importance of the market mechanism and the way in which the market functions.

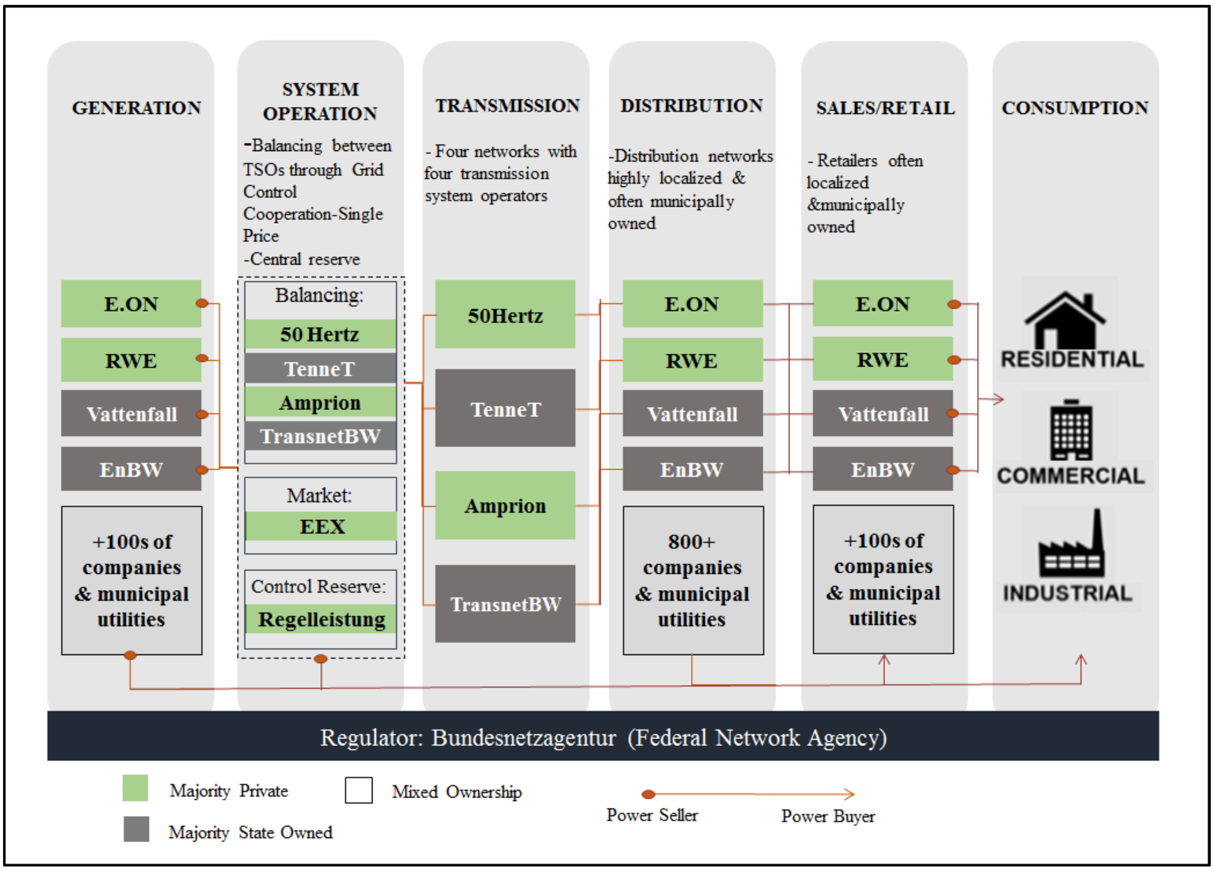

Figure 1: German Market Setup (Davies et al., 2014)

There are four transmission system operators (TSO) for electricity in Germany which operate in the areas depicted in Figure 2 below; Amprion GmbH, Tennet TSO GmbH, 50Hertz Transmission GmbH and TransnetBW AG. The TSOs transport electricity from the site of production and ensure that the electricity grid always remains stable in each of their respective control areas.

Figure 2: TSO Setup in Germany (Müsgens, Ockenfels, & Peek, 2014)

Internal transmission capacity within Germany is an increasingly important area of research and debate. This is predominantly associated with the discussion surrounding the proposed split of the market into different price regions as today the price across Germany is uniform (Gerbert, Rubner, Herhold, & Steffen, 2014). If the total of all generated power differs from the actual load, control power is required. This situation can occur for example because of sudden weather fluctuations especially when using a high level of renewable energy sources or because of issues from the generation side for example failures of power stations. We therefore consider how electricity supply and demand is balanced in the market.

b) Balancing Market

While electricity markets are efficient in many ways, the market itself cannot facilitate the required level of balance between electricity generation and consumption on its own. Therefore, balancing markets play a key role in deregulated electricity markets and since 2002 this function has been liberalized and managed competitively through auctions in Germany.

In a power market as large as Germany's, the role the balance group play is vital in the service provision of electricity. According to (Müsgens et al., 2014), balancing power is defined as "*The electric power required to counterbalance short-term differences between generation and consumption of electricity in a grid*." (Müsgens et al., 2014, p. 2). The following diagram presents an overview of the German electricity markets and how different markets interact with one another. It is important to note the distinction in responsibility between the balancing group operators (BGO) and the centrally managed system operator (SO).

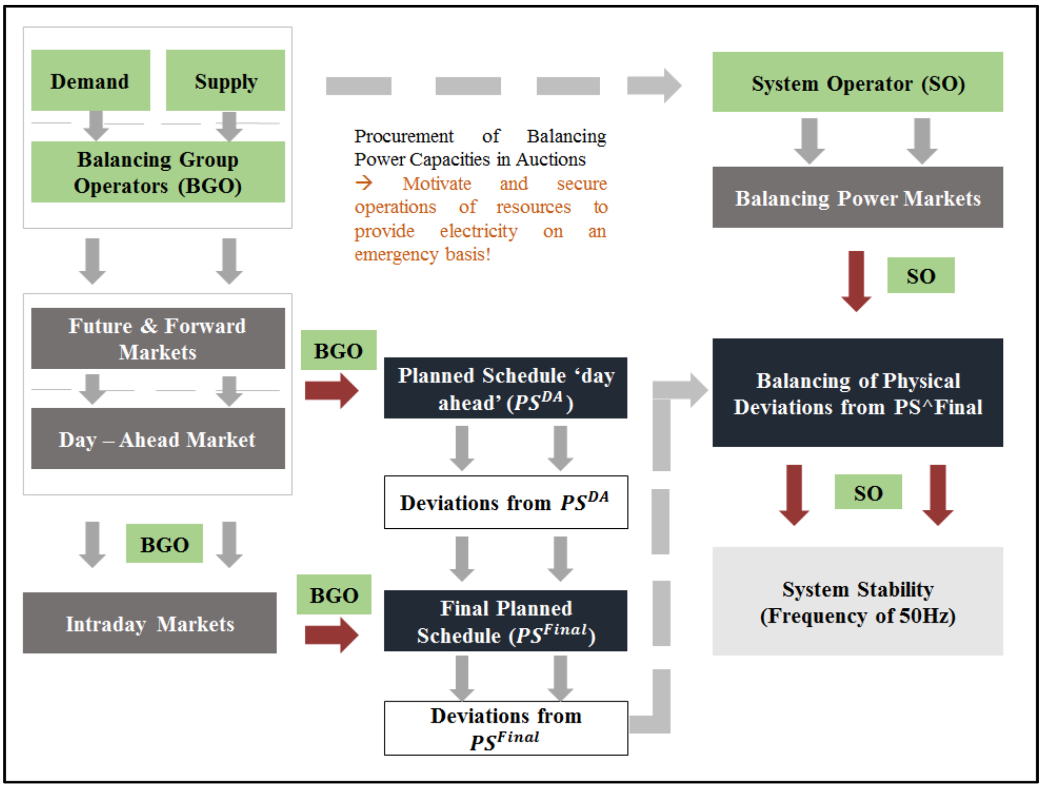

Figure 3: Electricity Markets and Responsible Parties in Germany (Müsgens et al., 2014)

The integrated nature of these markets means that it is impossible to consider the function of one market in isolation without making assumptions about the impact of other interconnected components of the market. The majority of the balancing activity in Germany between planned generation and consumption is done in the day-ahead (spot) market; however, it is also carried out in the intraday market (Müsgens et al., 2014).

The German TSOs differentiate between three different types of balancing capacity; the primary balancing capacity is required to be fully available within 30 seconds of being requested, the secondary balancing capacity within five minutes and the tertiary balancing capacity within 15 minutes (Müsgens et al., 2014).

c) Electricity Trading for Market Participants

German electricity is traded both on an exchange and over the counter. While standardized products are traded on the European Energy Exchange (EEX) in Leipzig as well as the European Energy Exchange (EPEX) Spot in Paris, many companies enter into a direct supply contract with electricity producers (Weigt & Hirschhausen, 2008). This paper will utilize data of physically delivered electricity from the EPEX spot market to make an assessment of wholesale price developments.

Electricity trading takes place on three different markets: the forward, the day ahead and the intraday markets. The forward market allows contracts for delivery up to six years in advance while the spot market includes both the day-ahead market as well as the intraday market (Federal Ministry for Economic Affairs and Energy, 2014). The day-ahead market requires both suppliers and buyers to submit their bids by noon the day before. In order to ensure a balanced market, market participants are allowed to trade on the intraday market on a short-term basis. The intraday market closes 45 minutes before the actual delivery period. Companies can also participate in over the counter trading up to 15 minutes before delivery (Federal Ministry for Economic Affairs and Energy, 2014).

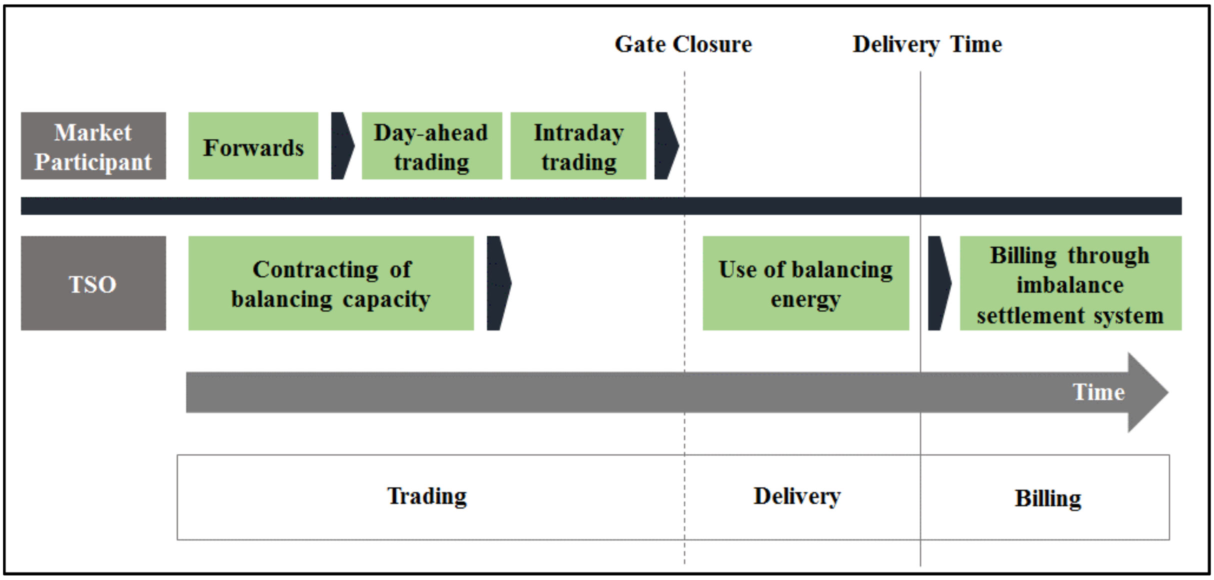

Figure 4: Submarkets of the German Electricity Market (Federal Ministry for Economic Affairs and Energy, 2014)

2.3 Current Energy Mix

Germany has the largest national economy in Europe, is the sixth largest energy consumer in the world (EIA.gov, 2014). Understanding the energy mix of a country, and where the energy is sourced from, is particularly relevant to understanding the dynamics of that market and how it addresses the eminent concern of security of supply. The correlation between the energy mix and the power market underpins the industry and factors such as commodity prices, supply and demand impact directly on electricity prices.

Germany currently relies heavily on fossil fuels, which account for the largest proportion of the nation's energy mix. Based on the published data, fossil fuels account for 80% of the energy mix with oil alone accounting for 35%, natural gas for 20% and coal for 13% (AGEB, 2015). While oil is used predominantly in transportation, natural gas and coal are used for heating and electricity generation purposes. Renewable energies, which have been on the rise since 2000, account for slightly over 11% of the current energy mix; Germany's main sources for renewables consist of wind power, biomass, solar power and hydropower (BMUB, 2013). This can be seen in the following chart:

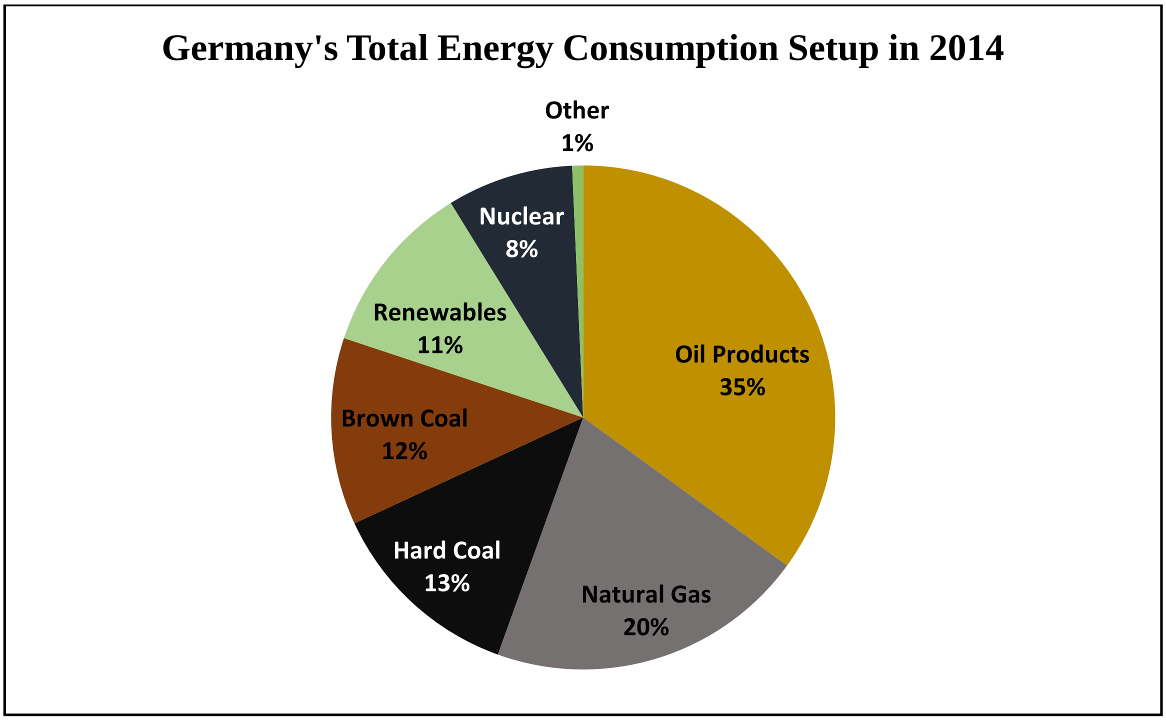

Figure 5: German Energy Consumption Setup in 2014 (AGEB, 2015)

In 2014 nuclear power accounted for 8% of the primary energy production in Germany. However, as will be further explained throughout this paper, nuclear power is subject to a phase out strategy as set by the German government and the challenge of replacing such a significant proportion of the energy mix has had widespread implications.

In line with global trends amongst other highly developed economies, energy consumption remains at a relatively stable level with Germany's 2014 consumption even decreasing slightly compared to 2013 (AGEB, 2015). The composition of the energy consumed changed slightly between 2013 and 2014; the percentage of renewables as part of the total German energy consumption increased to 11.1% as opposed to 10.5% (AGEB, 2015). Unfortunately, if the renewables share of the total energy consumption continues to grow at this slow rate (approximately 0.7%), the country will not be able to meet its 2050 goal of reaching 60% renewable energy. In order for Germany to meet its 2050 energy goal, the growth rate should be at least 1.7%, which is double the current growth rate. Germany's energy goals will be discussed further throughout this paper, but it is clear that there is a requirement and plan to increase renewables in the years ahead.

It is interesting to note that the percentage of nuclear energy actually increased slightly between 2013 and 2014. This is due to the fact that the overall German energy consumption level decreased by 4.7% between the year 2013 and 2014 causing the proportion of nuclear power to slightly increase despite the fact the country generated less nuclear power (AGEB, 2015). The same explanation applies to the consumption of oil that fell even as its share increased (AGEB, 2015).

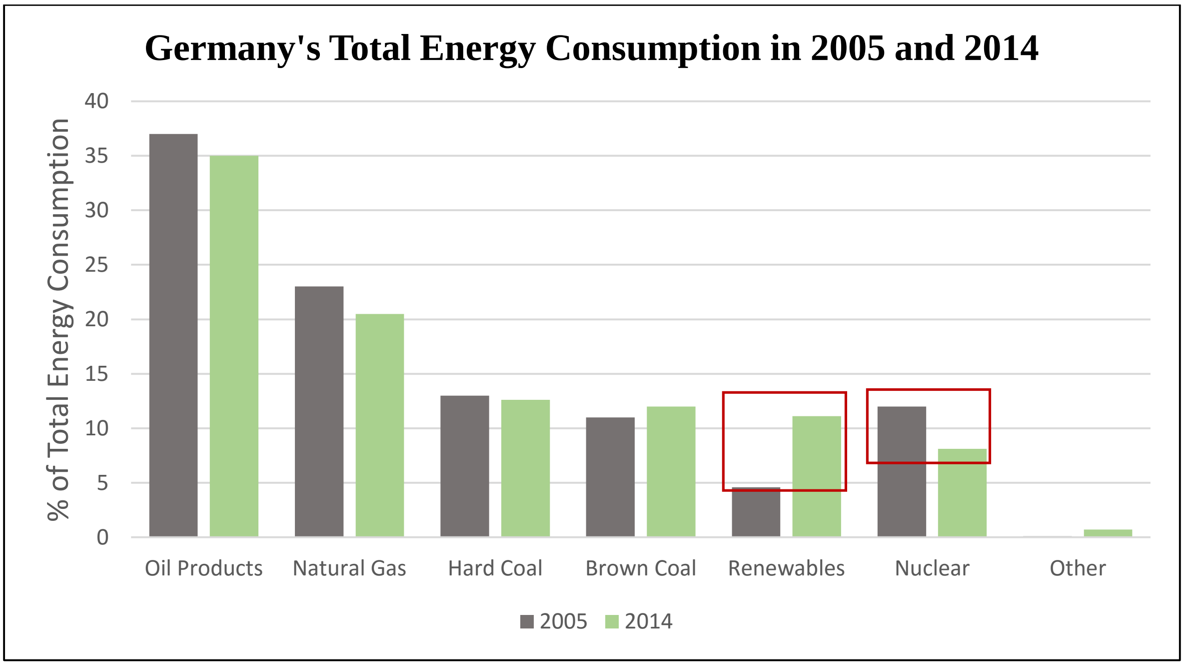

Figure 6: Germany's Total Energy Consumption Setup (AGEB, 2015)

Figure 6 shows the changes in the Total Energy Consumption in Germany between 2005 and 2014. Most relevant are the changes in the levels of renewables as well as the levels of nuclear, which will be explained in the following chapter of this paper.

2.4 Current Electricity Mix

As previously mentioned, the setup of Germany's electricity mix can have a large influence on the market and prices. Factors such as who is producing the electricity and from which sources play an important role in understanding the particulars of an electricity market and ultimately the price formation.

In 2013 Germany's gross inland electricity consumption was 596TWh (Fraunhofer Institut for Solar Energy Systems ISE, 2015). That same year, the country produced approximately 627 TWh and had an export surplus of 31.4 TWh, which is much higher than the 6 TWh surplus in 2011 and the 23.1 TWh surplus in 2012 (BDEW, 2015); this important trend of increased exports will further be considered throughout this paper.

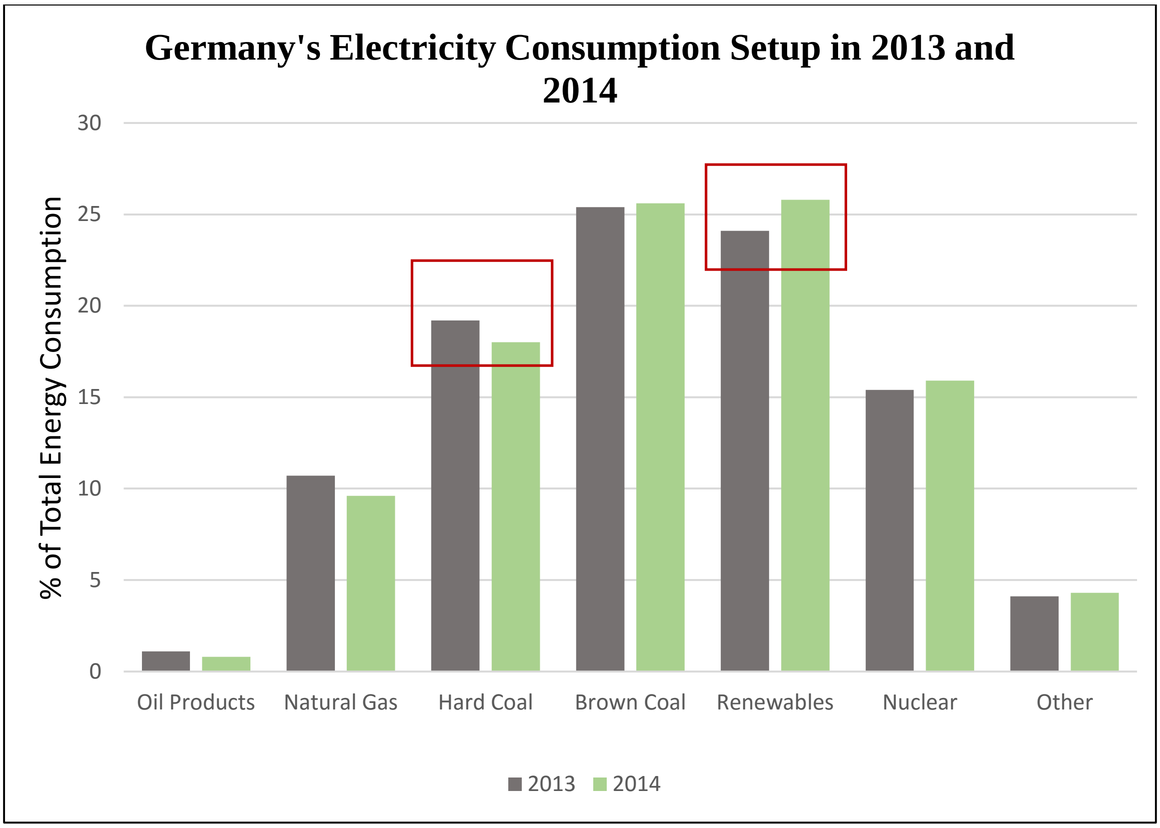

Figure 7: Germany's Electricity Consumption Setup in 2013 and 2014 (AGEB, 2015)

As shown in Figure 7, the electricity mix in 2013 consisted predominantly of coal (hard coal and lignite), which accounted for over 53% of the country's electricity production. Nuclear power accounted for 15.4% while natural gas accounted for only 10.5%. The percentage for natural gas has dropped around 21% from the year before. This is largely due to the cheap coal prices relative to the high natural gas prices (Fraunhofer Institut for Solar Energy Systems ISE, 2015). In 2014 the gross electricity consumption for Germany totaled 576TWh, a four percent decrease from the 2013 total. The total share of renewable electricity increased at a similar rate to the increase in total energy consumption.

It is relevant to draw attention to the fact that the use of coal has increased considerably over the past years despite its use being counterproductive to achieving the country's CO2 emission reduction targets. This particular increase is significant to this papers analysis and can directly be attributed to not only Germany's nuclear phase out policy but also its historic dependence on the commodity (Keppler, 2012). The electricity mix of Germany will be further discussed throughout this paper, as it is a key factor in understanding electricity price development and behavior.

2.5 Current Developments

In recent years there has been a vast range of policies, incidents and projects that have each affected the existing power market and energy mix in Germany either directly or indirectly. The following section will describe four of the most prominent factors including the effects of Fukushima, the Energiewende policy framework, market coupling and the transition to 'Smart Grid'.

2.5.1 Fukushima

Germany's policy regarding nuclear energy has continuously evolved since the year 2000 when it was first decided that the country would start the phase out of all its nuclear power plants by 2022. However, in the fall of 2010, the parliament and the government extended operations for nuclear power plants by at least 14 years to the year 2036 (Nestle, 2012). This was largely based on the results of several studies conducted in 2009 and 2010 that showed that an earlier phase out of nuclear power plants would lead to higher electricity prices, decrease in GDP and loss of jobs (Nestle, 2012).

Nevertheless, this decision was reverted back to the initial target following the Fukushima Daiichi nuclear disaster in Japan a few months later. The Fukushima incident occurred in March 2011 and involved a meltdown of three nuclear reactors after a nuclear power plant had been hit by a tsunami (Kurokawa, 2011). The nuclear meltdown caused substantial amounts of radioactive materials to be released into the air. While there were no fatalities directly associated with the incident, the area had to be evacuated and around 300,000 people were displaced due to the meltdown. Following this, an investigation commission agreed that the nuclear disaster was 'manmade' and could have been avoided with the right precautions (Kurokawa, 2011).

In July 2011, four months after the Fukushima disaster, the German government decided to revert back to its goal of phasing out all nuclear energy by 2022 in a controlled manner as depicted below in Figure 8. Currently, nuclear energy power plants are only used as a ‘bridge technology’ while the intermittency issues that are related to renewables such as solar and wind are being addressed (Fischer, 2011). Given the important role that nuclear energy has played in Germany as a low variable cost, low carbon emitting option capable of supplying a steady base load of electricity, widespread implications were of course anticipated following the proposed removal of the 8% nuclear energy proportion from the total energy mix in the coming years.

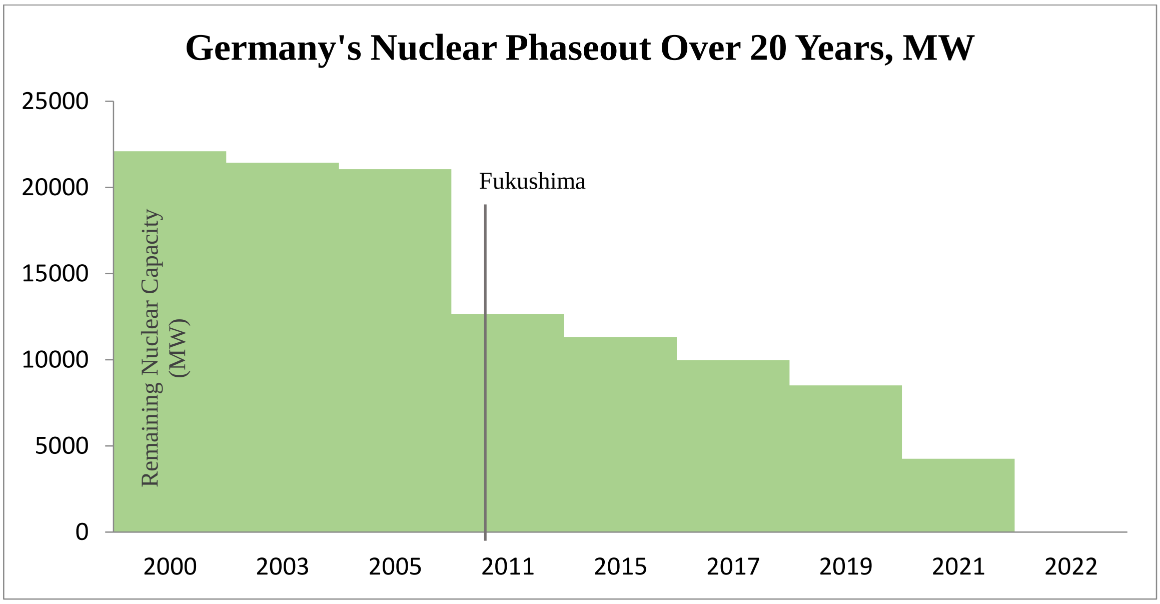

Figure 8: Phasing out Nuclear Energy (Energytransition.de, 2015)

Supporters of nuclear energy have constantly been promoting the idea that nuclear energy use would lower electricity prices given its low variable cost. It is of course worth mentioning that markets and prices for electricity in Germany do not include many of the different societal costs associated with energy production. This is partly due to the fact that there are several state subsidies that have funded the development of the nuclear power market in Germany by up to several hundred billion Euros (Nestle, 2012). However, there are also associated external costs, known as externalities, which are part of energy production that are effectively not priced in. The two areas that are mainly affected by these costs are climate change and the risk of using nuclear power, none of which are fully borne by either suppliers or consumers of the energy. The costs of climate change, which are in particular caused by electricity production by fossil fuels, are not fully covered by the European CO2 emission trading. This is because permit prices in the scheme have generally been low and rarely exceeded 20 Euros per ton CO2 emitted (EEX, n.d.). However, some estimates have shown that costs of climate change are estimated requiring a price as high as 70-85 Euros per ton CO2 (Stern, 2006).

External costs of electricity production using nuclear power are difficult to estimate. However, despite all available precautions if a severe nuclear incident did occur in Germany, the country would be faced with both staggering economic costs as well as an everlasting societal impact. Furthermore, the costs for developing renewable energy's play a role. The lifespan of nuclear power plants has an impact on the development of renewables given the need to substitute nuclear energy with an alternative source. A faster phase out of nuclear plants would also mean a possible increase in renewables as part of the energy mix. An extended lifespan of nuclear power plants would affect the mid to long-term pace of the development of renewables negatively. "*As a consequence the additional costs for the supply - which in Germany have to be paid by consumers - were likely to decrease with longer operating times for nuclear power plants.*" (Nestle, 2012, p. 152)

All these external costs are currently not priced into the spot market electricity prices and are not accounted for in any of the electricity market models used in Germany. There have been many studies that have analyzed electricity spot prices after the German government closed down several nuclear power plants. However, there has been to date been no noteworthy increase in the electricity price on the spot market. "*While short time changes in the nuclear capacity could have an influence on spot market prices, long term nuclear policy might have an influence on the electricity prices on the future markets.*" (Nestle, 2012, p. 157) The reason behind the unexpected prices and its impact will be further discussed throughout this paper in various capacities as the impact of the decision to reverse nuclear energy production is evaluated in Chapter Four.

2.5.2 Energiewende & Projected Electricity Mix

While there are many key milestones in the development of the German electricity market and mix, understanding the impact that each of these milestones have had cannot be done without considering the context of each change. The Energiewende ('energy transition') is the term describing Germany's environmental policies during its transitional period to a more sustainable energy status quo. The history of the Energiewende is long and the impact of its policies trace back to the 1970's when Germany initially decided to build nuclear plants and ultimately rely on them for a stable base-load electricity supply. This is a stark contrast to some of the more recent proposals and targets, which sees the nuclear phase-out to be completed by 2022 (Nestle, 2012).

The year 2000 saw the first German Renewable Energy Act (REA), which followed only two years after the liberalization of the electricity market. In 2002 with a competitive market, fossil fuel prices at an all-time low and a wealth of coal reserves, there was no expectation that anything other than fossil fuels would be seen as the preferred generation source (Deutsche Bank, 2014). So much so, that this in fact led the way for the initial plan to phase out nuclear power and despite the government's efforts to try and persuade large companies to invest in wind energy, fossil fuels were the preferred substitute to nuclear due to the low returns and high risk nature of the subsidy-based business models behind renewables. In order to encourage the production of electricity from renewable energy sources, the German government introduced the concept of feed in tariffs (FITs) as part of the Renewable Energy Act. *"FITs put a legal obligation on utilities and energy companies to purchase electricity from renewable energy producers at a favorable price per unit, and this price is usually guaranteed over a certain time period."* (E-Parliment, 2014) In the case of Germany, prices are guaranteed over a time period of 20 years (BMUB, 2013).

To address this, feed-in tariffs have been a mechanism favored by the German government as a method for stimulating investment in renewable energies. In 1991 the first feed in law was introduced and offered subsidies for renewables with the idea to double the share of renewables by 2010. At the time, as a result of the deregulation it was expected that this initiative would not cost Germany more than €600 million annually (Davies et al., 2014).

Following the introduction of the EU 20-20-20 targets, which include cutting greenhouse gas emissions by 20% compared to the levels in 1990, reaching a total of 20% renewable energy in the energy consumption mix, and increasing energy efficiency by 20% Germany set out its own targets to beat this (European Commission, n.d.). The main objective of the Energiewende is to increase renewable energy sources through promoting measures to increase energy efficiency and sustainable development and reach an 80% CO2 reduction by 2050 with several milestones in that timeframe. As specific goals in that period, Germany aims to consume 10% less energy by 2020 as opposed to the 2008 levels. Another goal is for renewables to make up 35% of the electricity mix by 2020 and continue to increase until they reach 80% by 2050 as shown in Table 2 (Agora Energiewende, 2013). As mentioned previously, Germany also aims to phase out all nuclear power plants by 2022. This particular goal has been the focus of much scrutiny due to fact that the natural alternative for a cheap baseload supply is typically coal, which has considerable externalities.

Table 2: Goals of the Energiewende; Adapted from (Agora Energiewende, 2013)

Energiewende Goal	2020	2030	2040	2050
Greenhouse gases (compared to 1990)	-40%	-55%	-70%	-85%
Renewables a part of the electricity mix	35%	50%	65%	80%
Electricity consumption (compared to 2008)	-10%	-	-	-25%
Nuclear energy production	-70%	-	-	-

The scale of change required to achieve Germany's target of 80% renewable electricity by 2050 can be visualized below in Figure 9.

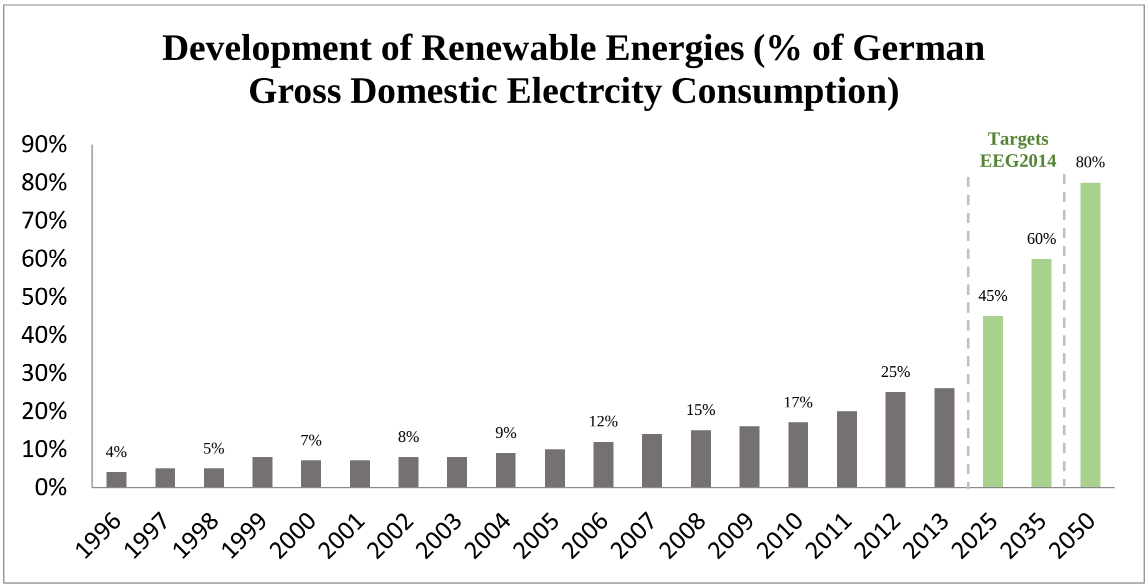

Figure 9: Development of Renewable Energies (BDEW, 2016a)

Germany's decision to implement the Energiewende policies and pursue its goals is mainly due to the fact that domestic carbon-based energy sources are becoming increasingly scarce. As previously mentioned, carbon-based energy sources also have environmental side effects associated with them especially in regards to climate change that are largely attributed to the burning of fossil fuels (Agora Energiewende, 2013).

One of the biggest concerns with the energy transition period is the potential negative effect on employment given that the conventional energy sector is a large employer. However, the

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety confirmed that one of its main priorities in the energy transition is to maintain the country's economic competitiveness and ensure that the overall levels of employment are not affected negatively (Morris & Pehnt, 2015).

2.5.3 Market Coupling and Interconnection

Market coupling, whichever way it is done, aims to distribute scarce cross border grid capacity in the most efficient way by connecting markets (Ondrich, 2014). Some of the benefits of market coupling and increased interconnection include increased transparency, lower transaction costs and a decreased administrative burden in trade which leads to lower risk, increased market efficiency and ultimately lower consumer prices (Ondrich, 2014). As a result, a common and integrated electricity market has therefore been a key goal of the European Commission (Nepal & Jamasb, 2013). The Commission has established a number of directives aimed at opening markets and guaranteeing network access (2003/54/EC) and improving cross border connectedness (2009/72/EC) (Nepal & Jamasb, 2013). These key steps taken are evidence of the commitment to reaching a common European market and given Germany's size and geographic position, the country has played a central role in leading this (Gerbert et al., 2014).

In the European and German context, price coupling is usually the option being discussed when considering how to improve security of supply and stable prices through cross border interconnection. Price coupling involves an agreement between the TSOs of two or more countries to initially set the area price in each country based on the merit order in each respective area and then calculate the trading capacity between the two areas in order to even out the price and create the so called system price (Ondrich, 2014). Using the concept of a 'price independent' transaction, the price in the high price zone is lowered and that of the low price zone is increased. However, if the needed trading capacity is higher than the agreed upon capacity, the markets are decoupled and no system price is created.

Germany and Austria have been acting as a single price zone for several years; however, the uniform wholesale prices are only possible because the regional grid bottlenecks are assumed to be a temporary problem that will be solved in the future. Therefore an expansion of an interconnected grid, as is happening across Europe, is considered the basis for maintaining a single bidding zone (Federal Ministry for Economic Affairs and Energy, 2014).

In 2010, the Central Western Europe (CWE) Price Coupling project was launched between Belgium, France, Germany, Luxembourg and the Netherlands (Autran, 2012). In 2014, the four power exchanges and the 13 TSOs in North-Western Europe entered a day ahead coupling project, the so-called North Western Europe (NWE) Price Coupling project (Autran, 2012). This project aims to increase efficiency and social welfare. It ensures a more efficient utilization of any available cross border capacity. The electricity prices converge only when there are no bottlenecks in the system (Nordpool, n.d.).

Trading electricity affects not only the cost of electricity consumption but also the revenues of electricity producers. On one hand, in the case of importing electricity into Germany, the German customers would benefit from lower electricity prices while some German producers will be pushed out due to competition from abroad. On the other hand, when electricity is being exported out of Germany, foreign electricity customers are the ones benefiting from cheaper prices while German electricity producers benefit from additional revenues by pushing out some of the international competitors.

In recent years, Germany has been able to benefit from the exchange of electricity. When compared to electricity prices in the rest of the CWE region, German wholesale electricity prices are lower than those of the other countries. For example, in 2013 the average day ahead (spot) electricity price in Germany was €37,8/MWh versus the French price of €43,2/MWh and the Dutch price of €52/MWh (EPEX Spot, 2014). This has caused German electricity to be used more frequently than electricity produced in the other CWE countries and German electricity exports to continuously increase as seen in Figure 10 below:

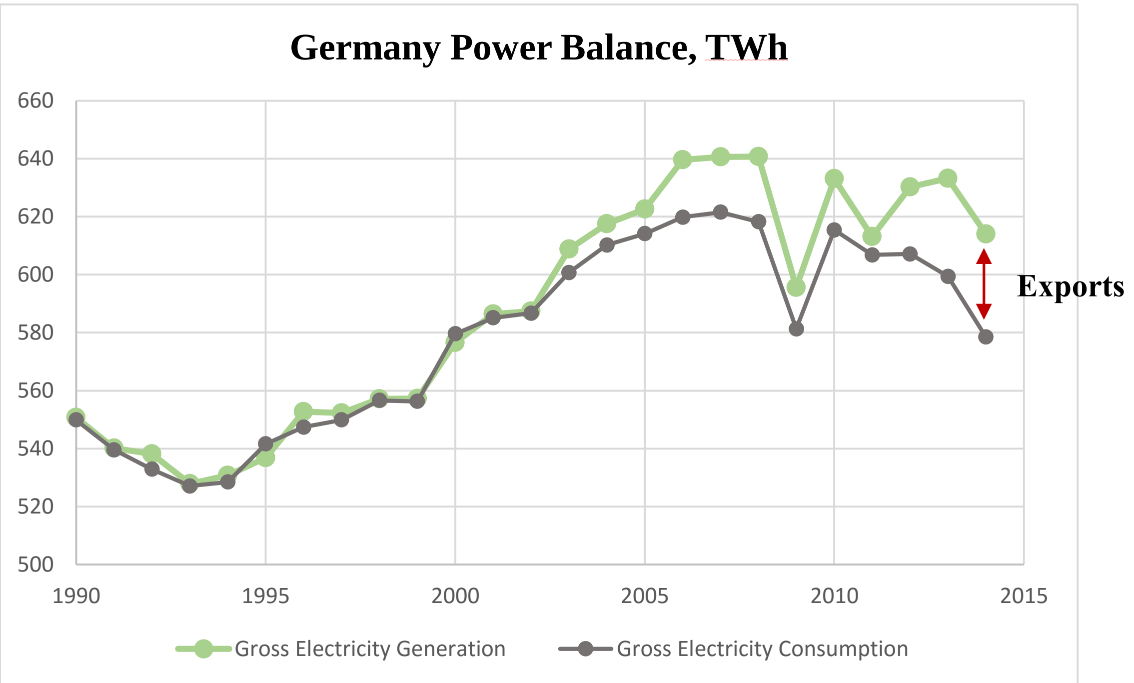

Figure 10: Germany's Electricity Exports & Imports (BDEW, 2015)

Exporting electricity has proved to be an important flexibility option as it provides a solution to ramping down production of not only nuclear and coal fired power plants, but also renewable ones. It is expected that the German security of supply will continue to increase and that the country will continue to be an electricity exporter in the European context even with the phase out of nuclear power plants and the reduction in the number of fossil fired power plants as a result of the increase in renewables (Federal Ministry for Economic Affairs and Energy, 2014).

2.5.4 Smart Grid and Decentralized Generation

An increasingly prominent focus of research into electricity markets is the development of a 'Smart Grid'. Smart Grid as broadly defined by Sioshansi (2011) is taken to mean: "*Any combination of enabling technologies that collectively make the power sectors delivery infrastructure more reliable, versatile, secure, accommodating, integrated, resilient and useful to the consumer."* (Sioshansi, 2011) A Smart Grid includes an upgrade and a modernization of the grid, as it currently exists; it aims to increase reliability, address intermittency, and enhance integration of the system and energy sources. Its role is to make the current grid more intelligent in order to allow both producers and consumers to benefit from it even more. It also integrates consumer consumption as well as feed in behavior of all market participants connected to it.

A Smart Grid is also self-healing, which means it would identify problems such as outages in real time and react to them, it will anticipate larger disturbances and attempt to fix them as we all as isolate the parts of the system that are experiencing issues from the rest of the system in order to avoid a spread to the rest of the grid. This is particularly relevant in the wake of increased cross border interconnection and market coupling. Most importantly, a Smart Grid will benefit customers by "measuring how and when consumers use the most power", which will help electricity providers offer variable rates based on both supply and demand (IEEE, 2013). This will be especially important during peak times when demand and the cost of electricity is high (IEEE, 2013). In a liberalized market, the new tariffs offered to customers will not only be based on the competition in the market but also on the demand response that would occur as result of the transition to a smarter grid.

Furthermore, the idea of Smart Grid is usually combined with the emergence and development of more flexible retail pricing options. 'Time of Use' tariffs for example, which are different prices for different times of day, provide a number benefits for the customers. Another pricing option would be a critical peak-pricing tariff that would combine both the time of use tariff with different prices for critical days that are announced by the electricity supplier. This option has proved to lead to customer savings in the international markets it was introduced in for example in California State in the US (PGE, 2015). Another option is the real time pricing tariff, which presents the price information to the customers in real time. In this case the customer has the option of choosing whether or not to use electricity at any given point and at any given price, which would enable the perfect alignment between wholesale and retail prices (Pratt, 2011).

Other benefits that can be derived as a result of a smarter grid will depend on the cost benefit analysis for each one of the market groups, and whether or not the benefits reach the end users. Given the lack of transparency and uncertainty in how benefits would be shared between different stakeholders, there is no clear answer to the question of who should pay for the implementation of Smart Grid (Policy Department Economic and Scientific Policy, 2012). This will be further discussed in the context of the markets inability to operate efficiently on its own and the resource inadequacy that has complicated and delayed progress.

In most instances, it is accepted that consumers bear some of the short-term costs during the rollout phase because a majority of the investment costs are passed onto them. However, in the long term consumers are able to reap considerable benefits by utilizing the overall reduction in energy costs. The impacts of this will be further analyzed in Chapter Four of this paper (Policy Department Economic and Scientific Policy, 2012).

While it is possible that smart meters along with newly introduced tariffs encourage customers to benefit from energy savings, the overall electricity saving potential for Smart Grid is hard to quantify especially given the fact that it will differ from one end user to the other. The effects of smart meters on a system based on conventional power plants are different than their effects on a system with a high share of renewables (Biggar & Hesamzadeh, 2014). Since Germany's energy mix includes a high level of renewable energy sources that is constantly on the increase, the effects of the latter option will be discussed. It is expected that the wholesale electricity prices in such a system will decrease due to the low marginal costs of renewables. However, the other effect is a high increase in prices during peak hours due to the fluctuations occurring in the energy production (Biggar & Hesamzadeh, 2014).

A key reason for Smart Grid development in Germany is to integrate renewable energy sources to the grid. As of 2010 all new and remodeled buildings in Germany are required to include smart meters. As of 2011, German electricity providers have been required to offer their customers variable electricity rates (SAIC, 2011). In recent years the European Union has adopted the Third European Energy Liberalization Package whose main goal is to install smart meters in 80% of households by 2020 (Giglioli, Panzacchi, & Senni, 2011). As can be seen in Figure 11, Germany is considered to be one of the market drivers when it comes to the status of smart meters deployment.

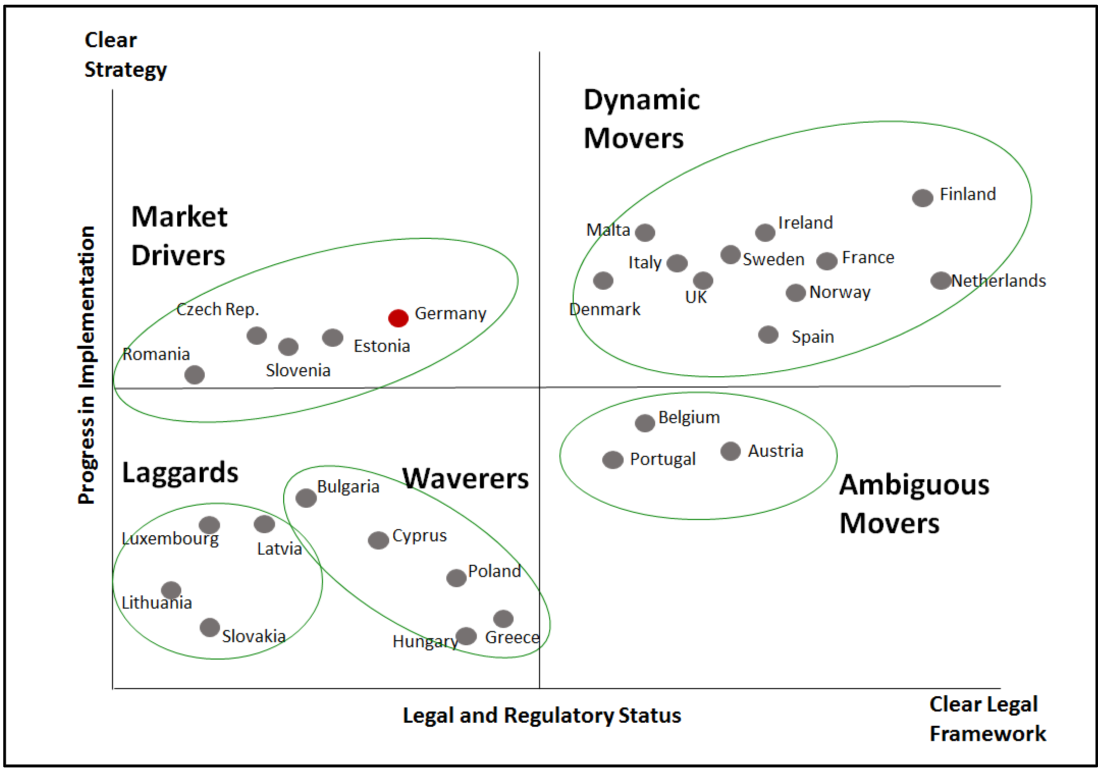

Figure 11: EU status on smart meters deployment (Vogt, n.d.)

A topic closely related to Smart Grid and examined by Biggar & Hesamzadeh (2014) is the rapid growth in decentralized generation. This is particularly relevant for consideration in Germany given the incentives offered under the feed in tariff policy. Unlike the traditional scenario of having power produced at large and centralized, but often distant, power plants the idea of decentralized generation suggests that the energy is to be produced close to where it is consumed (EON, 2015). Decentralized generation is especially important in Germany since the country introduced the German Renewable Energy Act that, among other things, subsidizes smaller users who produce their own electricity from renewables which feeds it into the grid.

By 2025, it is expected that power generation units with a capacity of equal to or less than 10 megawatts will make up 50% of the country's power; this is a 30% increase from current levels (Spross, 2014). Currently, the German government has 20 year contracts with wind and solar suppliers to guarantee them high prices and grid access as part of their policies for encouraging renewables. However, once those contracts end in 2020 and later, it is possible that the considerably lower wholesale electricity prices affect residential costs thus lowering them as well (Spross, 2014). The emerging trend is that “the German energy transition encourages the retail customer to become a ‘pro-sumer’” (Parkinsons, 2014). This is an area that will be examined in Chapter Four of this paper given the implication the rise of decentralized generation has had on both the grid itself and on the renewable energy subsidies and budgets.

3 Theoretical Insight

This section of the paper begins by introducing general economic theory that underpins the functions of a market. It then explores the specific electricity market theory in order to understand the basis by which the wholesale and retail prices are calculated. By delving deeper into market competition, the section provides a basis for analyzing the market mechanism specific to Germany and identifies a number of challenges it faces. It will finally address the methodology on which this paper bases its analysis in order to formulate assumptions on the future implications of market trends.

3.1 Economic Theory

The basic principle that underpins the functions of a market is the relationship between the supply and demand of goods and services (Wangensteen, 2005). The relationship is such that as the price of goods and services increase, so does their supply while their demand decreases (Wangensteen, 2005). A market is considered to be in equilibrium when supply is equal to demand and this is how the price and the quantity are determined. Figure 12 shows the relationship between supply and demand and how they are balanced through the market mechanism.

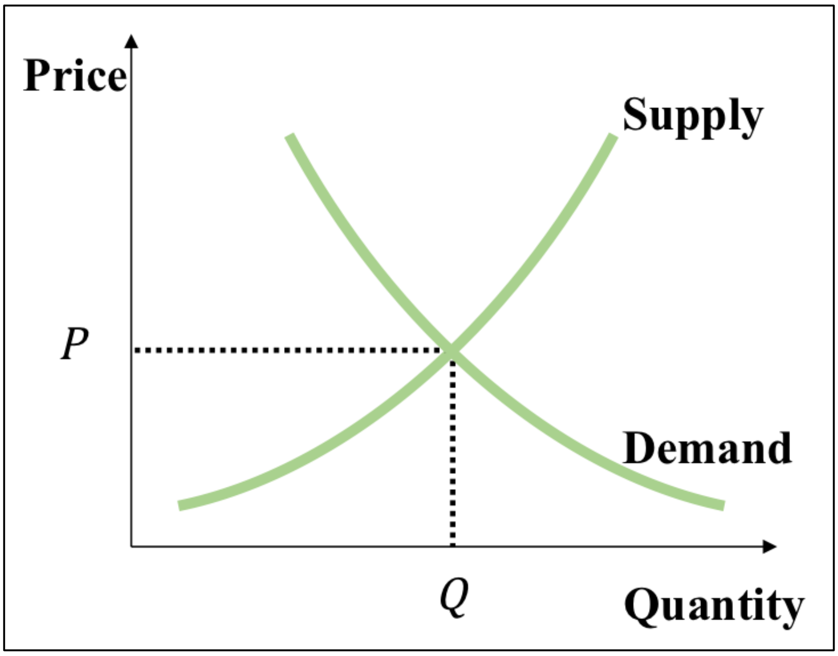

Figure 12: Supply & Demand Curves

In a perfectly competitive market without externalities and without imperfections, the market would result in economic efficiency and maximize overall societal welfare on its own (Wangensteen, 2005). In this scenario, the basic notion of societal welfare can be simply represented through the sum of consumer surplus and producer surplus as shown below in Figure 13.

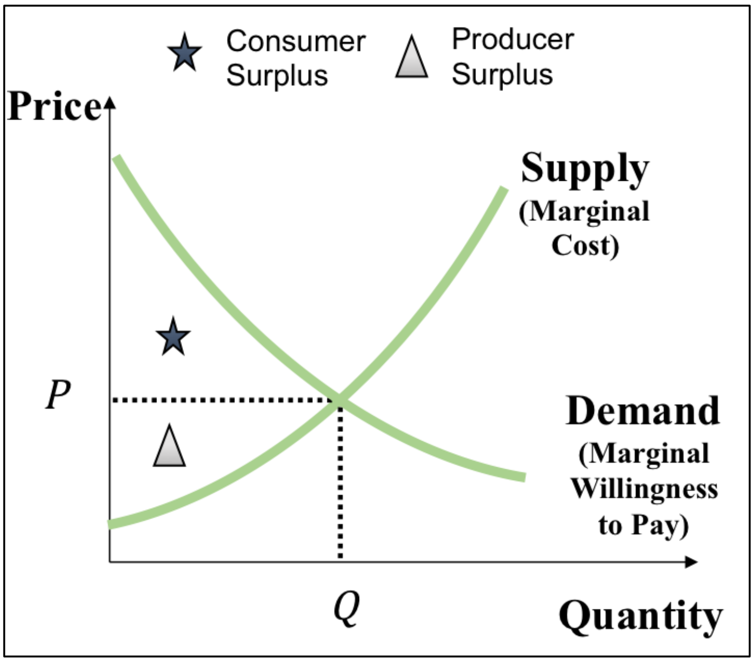

Figure 13: Consumer & Producer Surplus

While perfectly competitive markets are able to achieve maximum economic efficiency, there are other factors that must be considered which will be further analyzed throughout this chapter. However, a key point to make here is that in order for this to happen, there must be no externalities as previously introduced. Specifically, we consider that as a result of externalities and market power for example, there is a need for intervention in the market and in practice it is considered that perfectly competitive markets do not really exist (Wangensteen, 2005). As a result of these imperfections private marginal costs (producer price) and social marginal costs (i.e. total cost to society) are different. In many instances this discrepancy is the result of a tax, tariff or subsidy on a good or service, which has the effect of intervening with the market mechanism (Narbel, Hansen, & Lien, 2014).

This is exhibited in the electricity market given that the production of energy has by-products that are not on their own being compensated for yet cause a cost to other entities (Narbel et al., 2014). While this has long been the center of much discussion, in its simplest form we can consider that certain commodities are themselves cheaper than others and are hence capable of being utilized for electricity production at a low cost (Narbel et al., 2014). From a profit maximization perspective, these commodities would therefore be overconsumed as the cost of the commodity alone does not reflect their full cost to society (social marginal cost) (Mirza & Bergland, 2012). The full cost should incorporate the externalities that among other things impact on the environment and health. Put simply, the implications of an increased penetration of carbon dioxide for example are widespread but are not on their own 'internalized' in the structure of the electricity market (Narbel et al., 2014). While this is just one example of an externality, the underlying principle is that there is a need to somehow incorporate them into the market and thereby 'internalize' them. As shown in Figure 14 below, a tax is capable of doing this by raising the private marginal cost to the social marginal cost (known as a Pigovian Tax) (Narbel et al., 2014).

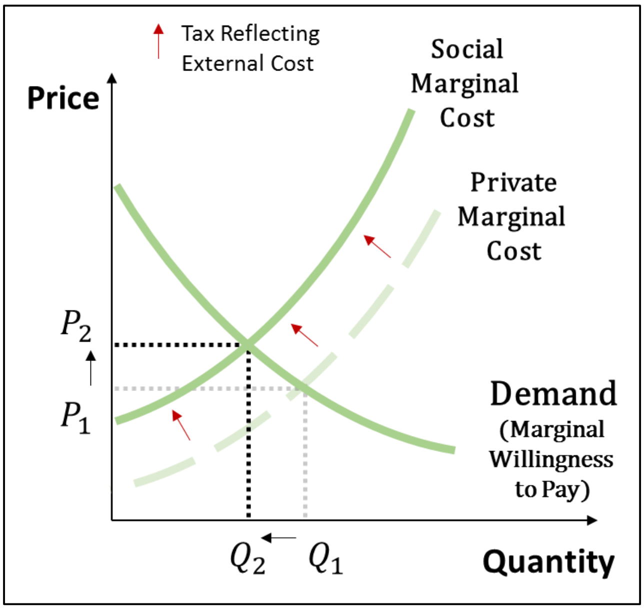

Figure 14: Taxation reflecting external cost

There are again a variety of ways in which externalities can be internalized and while this discussion is outside the scope of this paper, we acknowledge the rationale behind the policy decisions in Germany. In many instances, such as a tax on carbon for example, policy makers adopt what is considered the Polluters Pay Principle (PPP) whereby those causing the pollution pay a tax for doing so (Wangensteen, 2005). However, in the instance where demand is inelastic, such as in electricity markets, tax can passed onto consumers and still achieve its desired outcome (Parry, Norregaard, & Heine, 2012). This is visible in the case of electricity markets and the reform currently underway in Germany, which uses tax revenue to fund new renewable energy production assets. The opposite would be true if demand was elastic and tax would therefore be placed on the producers.

The complexities of electricity are further made apparent when we consider that the consumption of electricity is continuous yet uncertain and variable over time (for example time of day and season) (Rud, 2009). Other unique characteristics include its limited-storability and therefore instant generation and consumption, non-traceability and dependence on a common grid (Rud, 2009). That is, electricity is in itself a bundled commodity of both energy and transportation given that it is delivered to the point of use and only consumed then (Rud, 2009). Given these factors, we must therefore consider in greater detail the specifics of the economics behind the electricity market.

3.2 Electricity Market Theory

In order to understand the way in which the recent trends are affecting the electricity market, it is important to consider the underlying principles of the electricity market and price formation that underpin it. Through exploring the research question and addressing the implications of diverging electricity prices the authors acknowledge that price is not in itself a stand-alone construct, but rather it is the direct result of the balance in supply and demand level of producers and consumers alike (Biggar & Hesamzadeh, 2014).

3.2.1 Short Run Market Operation

The wholesale electricity price is the price producers sell electricity on the power exchange and should, in theory, represent the intersection (equilibrium) between the supply and demand functions. On one hand, supply is the volume of electricity produced by all parties connected to the electricity grid while demand represents user requirements and preferences for use of electricity. Every market has different generation capacities from different sources and the output produced can be highly dependent on uncontrollable factors, such as weather for example. Therefore the wholesale price also represents the variable cost of the generation plant with the highest variable cost that is currently in use (Biggar & Hesamzadeh, 2014).

In order to understand how the electricity mix can influence the wholesale electricity price, the merit order curve is used to depict the cost of different energy sources as a function of the available capacity (Appunn, 2015b). A merit order curve ranks all available energy sources from the cheapest to the most expensive. At any point the sources with the lowest marginal costs will be utilized initially before proceeding to use the more expensive ones. Depending on the demand quantity, some of the more expensive sources may never be used.

Since renewables are considered the cheapest option on Germany's merit curve (see Figure 15 below) with very low marginal costs, a constant increase in renewable sources as part of the energy and electricity mix will, in theory, cause a decrease in the wholesale electricity price.

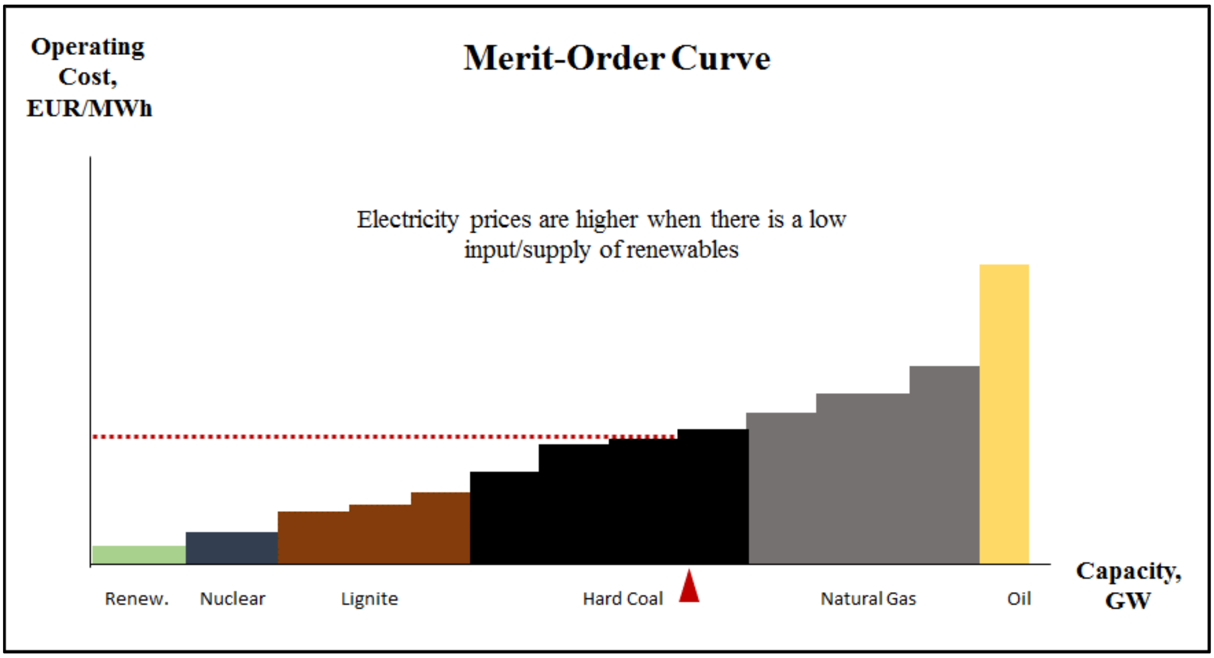

Figure 15: Electricity Price due to merit order effect (Appunn, 2015b)

In the unbundled electricity market, the consumption of electricity is charged to end-users on the basis of retail electricity prices. While the wholesale electricity price forms a core component of the end user price there are other, increasingly prevalent, factors that influence the price in Germany (Seeliger et al., 2011).

One of the components includes all state levys and taxes, which the electricity provider needs to pay as a fixed amount for every kWh consumed. The grid costs are also passed on as the electricity providers receive them. The part that may be affected by the electricity provider is the energy supply cost, which determines how much of a margin the company makes as profit (Matallana-Tost et al., 2014). Favorable electricity tariffs are characterized by constituting a lower proportion of the price; in this case the supplier waves some of their possible margin compared to a higher tariff (Matallana-Tost et al., 2014). While we assume the operation of the electricity market in the short run follows the basic profit maximization objective of producers and that they will continue to supply until their marginal cost is equal to the wholesale price, in the longer run we must consider other objectives too.

3.2.2 Long Run Market Objectives and Resource Adequacy

The distinction between short run and long run objectives is central to evaluating economic efficiency in the market. As discussed, short run efficiency is concerned with allocative efficiency given a set of consumption preferences and production assets. However, in the long term the market must consider dynamic efficiency whereby the development of new or the disposal of old assets are decisions to be made in the context of economic efficiency (Biggar & Hesamzadeh, 2014). Specifically, the electricity market mechanism must facilitate efficient investment in each of production resources, consumption resources and network resources (Biggar & Hesamzadeh, 2014). Most relevant for this paper is its ability to facilitate efficient investment in new production capacity in the wake of the recent developments.

Since the deregulation process took place, many internal market developments have followed, including some of which are being considered in this paper. However, directly related to the market mechanism is the challenge of funding the continuous development of the integrated, yet individually operated, functions of the deregulated electricity market (Wilson, 2002). This is a notion, known as resource (in)adequacy, that stems back to some of the most comprehensive evaluations of electricity markets architecture and in particular Wilson (2002) who in outlining key issues faced by a deregulated market, acknowledged the constraints of such a market to be in: *"Sustaining incentives within smart markets in which optimization is used to allocate multiple scarce resources and to account for other constraints that are not priced explicitly."* (Wilson, 2002, p. 1304)

Understanding resource adequacy is an important part of the analysis in this paper as it seeks to not only understand what the implications of diverging prices at the beginning (production) and at the end (sale) of the value chain are but also how different parts of the value chain interact with each other in between. With a split between some competitive and other regulated parts of the market, the question that often remains is who has the responsibility to implement change? And most importantly, how is this financed?

Answering these questions will form a key part of the analysis in Chapter Four of this paper as we consider the investment requirements in things such as smart grid technologies, security of supply, market coupling, renewable energy integration and decentralized generation that effect more than one part of the value chain.

3.2.3 Competition in Electricity Markets

For the sake of simplicity, most market models today assume perfect competition whereby all power production facilities would, subject to price, offer electricity so long as they are available (e.g. not closed for maintenance) (Biggar & Hesamzadeh, 2014). If the prices offered are reasonable and exceed the marginal cost of production, including all necessary ramp up and ramp down costs, the electricity will be produced and sold. For the plants with higher production costs, they sell only what capacity is demanded at specific hours in line with the merit order curve of production.

In this perfect market, monopolies or quasi-monopolies that can manipulate the prices should not exist and the market mechanism would be able to facilitate a pareto optimal situation (Biggar & Hesamzadeh, 2014). That is, in the scenario where both the producers and consumers are price takers and the 'invisible hand' ensures welfare is maximized. However, as previously acknowledged, the electricity market is subject to considerable external factors and regulations, on one hand due to constraints and requirements for the market to operate a certain way as it is provided to the entire pubic. But on the other hand, it is also largely due to the externalities attributed to the production and supply of electricity that requires intervention as previously discussed in the context of climate change and emission reduction targets.

The German electricity market is far from what can be categorized as a perfectly competitive market, particularly on the generation side. The four largest electricity producers in Germany (EnBW AG, E.ON AG, RWE AG, and Vattenfall Europe AG) are together, considered an oligopoly given that their combined generation accounts for over 80% of Germany's electricity production (Davies et al., 2014). With this dominant market share, it is therefore accepted that the oligopoly has the ability to, in some capacity at least, illegitimately influence the market price of electricity (Nestle, 2012).

While examining the relationship that exists between Germany's four largest generators is outside the scope of this paper, it is a topic that has been extensively analyzed in the context of game theory and understanding the oligopolistic nature of the German market is relevant. This is due to potential incentive problems and the way in which the pricing mechanism can be influenced and discriminated by the leading generators through the exercise of market power. Given that this paper seeks to understand the implications of current developments in the electricity market and evaluate the impact on different stakeholders, understanding the competitive nature of the market and its key participants is important.

3.2.4 Market Power

Coinciding with, and indeed a product of, the deregulation and liberalization of electricity markets is the discussion on market power. Extensive research has been conducted on the matter focusing predominantly on the generation side of the electricity market and its subsequent relation to the wholesale market price. This can be seen in one of the most researched areas within the subject matter, the California Energy Crisis in 2001, which emphasized market power and its potential for abuse as one of the key reasons at the forefront of the markets collapse (Joskow & Kahn, 2002; Kim & Knittel, 2006). Given its significance, understanding how developments within the market impact on market power is central to understanding price formation particularly in Germany, where the large utilities are heavily integrated throughout different aspects of the market.

While many definitions and characterizations of market power exist, in its most simplest form it is exhibited when a firm is not a price taker (Biggar & Hesamzadeh, 2014). Therefore, any producer that has the ability to influence price is considered to have market power. The significance of market power to the supply side of electricity markets is widely acknowledged and leading scholars have argued that there is no other market more prone or susceptible to it than electricity markets given that *"it possesses virtually all of the product characteristics that enhance the ability of suppliers to exercise unilateral market power"* (Wolak, 2005, p.4). Biggar & Hesamzadeh (2014) in providing a theoretical insight into electricity markets more broadly, clearly acknowledge that the exercise of market power in wholesale electricity markets does take place. For these reasons, market power forms an important part of the analysis in this paper and understanding its relevance to not only Germany specifically but also price formation more generally is imperative.

3.2.5 Market Power in Germany

To what extent German producers exercise market power has been the focus of extensive research. One of the most recent and comprehensive studies on market power was conducted by (Wozabal & Graf, 2013), which, similar to this paper, examines the prices in the EPEX spot market for the years 2007-2010. Similarly Weigt & Hirschhausen (2008) and (Möst & Genoese, 2009) have found market power abuse through using each of a linear model, a mixed integer model and an agent based simulation model respectively. Based on the findings from an overwhelming amount of research, it is widely agreed and empirically supported that market power abuse in the German wholesale electricity market has taken place over the last 10 years and will likely continue to do so in the future in some capacity at least.

However, as Ockenfels (2007) identifies, one of the main considerations in assessing market power in any market, but specifically electricity markets, is not whether there is a difference in the actual prices and the model price, but rather whether or not it is substantial enough to constitute abuse. Investigating this however is out of the scope of this paper and it is used as a basis for understanding the dynamics of market and how generators have to date profited from it. This paper will rather utilize existing research and the understanding of it in the current market in order to make an assessment of its likely future implication as the increase in renewable energies have restricted their abilities to do this (Koschker & Möst, 2015).

3.3 Methodology

In order to understand how recent developments are impacting the electricity market, the wholesale and retail prices are used as a comparison. Quarter-hourly data on the wholesale electricity prices have been obtained from the EPEX for the period 01/01/2006 to 31/12/2014 and form the basis of the analysis on implications to producers. Retail pricing data for the corresponding period from the BDEW is used for comparison.

Seeliger et al., (2011) presents five drivers of the retail electricity price that are used in understanding its construct, which are the wholesale price, duties and taxes, network tariffs, political influence and end customer competition. The inclusion of the wholesale price in this model connects the analysis as it allows for a direct comparison to be made between the two metrics and offers insight as to the markets (in)ability to operate efficiently. This can be measured by its capacity to pass-through fluctuations in wholesale and retail prices, representing the producers and consumers respectively, and evaluating how other factors are affecting the stakeholders too.

Adapted from Mirza & Bergland (2012), the relationship between wholesale and retail prices from a retailer's perspective can be explained as follows:

$$\Pi_{it} = P_t^r\,(Q_t) q_{it} - C_{it}(q_{it}, P_t^w)$$

Where:

Π_{it} = Profit of retailer i at time t

$(Q_t) = \sum_i^n q_{it}; i = 1, \dots, n$ Total power sold at time t

P_t^r = Retail electricity price at time t

C_{it} = Cost of retailer i at time t

P_t^w = Wholesale electricity price at time t

$q_{it} = q_i(q_{1t}, \dots\ q_{(i+1)t,}\ q_{(i-1)t} \dots\ q_{(n)t})$ Quantity sold (subject to volume sold by all other retailers)

While retailers cannot influence the wholesale electricity price, it is worth noting that based on this profit maximization scenario, retailers do not have an incentive to pass through a decrease in wholesale prices. This paper therefore also examines the relationship between wholesale electricity price and the procurement cost of electricity for the retailers. In any case, by combining the wholesale and retail price data, the authors' objective is to examine the impact that the four key developments in Germany have had on the electricity prices. Coupled with the understanding of the German market structure, this will be used as a basis to make an assessment of future implications.

3.4 Data Overview

As previously mentioned, data has been collected from the European Power Exchange as the metric for interpreting wholesale electricity prices, BDEW as the price index for measuring retail prices and IHS for generation and installed capacity projects in Germany. While the EPEX and IHS data is straight forward, the retail data must be further contextualized.

This paper focuses specifically on households given how recent policies have impacted this sector and therefore the largest proportion of the German population. While acknowledging the widespread implications of recent developments on other sectors, different regulations and characteristics mean that the trends have had distinctly different impacts. For example, industrial end-users are exempt from a number of taxes households are charged and have, for the most part, actually experienced a decrease in electricity prices as measured by the decreasing spot market prices which they are more aligned too.

While this contrast is in itself interesting, the future of German policy on other segments of end-users is uncertain and is therefore difficult to predict. It is further the case that the impacts of this on German industry are widespread and electricity prices often formulate an important part of an investment decision for many businesses. While this is outside the scope of this paper, the demand of industrial customers is more elastic than households who have far more inelastic demand and, for comparison, would likely not evaluate their decision to live in Germany on the basis of electricity prices. However, many energy intensive industries do in fact make business and investment decisions based on electricity prices. In doing so they typically engage in direct contract negotiations for electricity supply. Given that pricing information for this is often not disclosed, it would be even more difficult to make assumptions and predict the trend in supply contracts to this segment of end-users based solely on spot market data.

Specifically dealing with the household segment of end users, for consistency and simplicity in the analysis, this research uses a price metric that is based on household prices. While the authors acknowledge the impact of this in limiting the direct relation between the different market segments, the reliability of the metric, which is devised by BDEW data on electricity, offers legitimacy to do so. It is further the case with households that many different contract types exist (e.g. variable or fixed), the level of competition in delivery (i.e. Germany has 800+ suppliers with over 30,000 customers) and individual household electricity bills are undisclosed by both the supplier and households. Therefore, a reliable index which is used as a basis for decisions being made by the government and their policies is the preferred way to capture the real prices households pay for electricity. Further supported by the fact the households are, in most cases, charged electricity based on an estimated load profile and not their actual consumption, it is most appropriate that a pricing metric be used as a measure of household electricity prices (Biggar & Hesamzadeh, 2014)**.**

This paper analyzes pricing data from the years 2006 to 2014 given that it is a consistent basis for comparison of different pricing components. This is because prior to 2006, procurement costs and grid charges were aggregated and charged as a single price component on the retail side. Furthermore, the eight year period considered is robust enough to draw statistically significant insights from and is in fact longer than much of the research presented in the literature review.

3.4.1 Household Electricity Price Components

The set-up of the electricity price will now be introduced. Table 3 shows the six main components of electricity prices that retail end-users are faced with in Germany. As can be clearly seen from the table, Germany's pricing and tax mechanism on the power market is more extensive than other comparably sized European markets.

Table 3: Residential Electricity Price Components (Matallana-Tost et al., 2014)

Price Component	Germany	France	Italy	UK
Supply (Procurement)	Wholesale price + other supply costs before network charges and taxes			
Grid Charges	Charges for maintenance and development of electricity network			
Concession	Local taxes	CSP	N/A	N/A
Energy Tax	Eco-tax	Local taxes	NCT	CERT
Green Energy Contribution (GEC)	EEG Surcharge	N/A	A2, A3, UC7	RO
VAT	National taxes			

a) Grid Charges, Billing and Metering Costs

The electricity price consists partially of a fee that is paid to the network operators in the respective grid area. The grid charge is set and regulated by the Bundesnetzagentur (Federal Network Agency) given the fact that there is only one agency in each grid area, which acts as a monopoly. The network charge covers both the costs of the construction and operation of the power lines but also any issues that arise for network operators such as the cost of balancing energy. Billing and metering charges cover costs related to meter readings and billing summaries.

b) Concession, Green Energy Contribution and EEG Surcharge

A number of charges are included in this section ranging from the fee that needs to be paid for using the public roads for the power lines to the EEG Surcharge that is collected to promote the environmental friendly generation of electricity. This support system set out by the Renewable Energy Act, is financed through the revenues made by selling renewable electricity on the spot market as well as the EEG Surcharge, which is added to the electricity price for all residential and commercial customers and some industrial customers. The price of the EEG Surcharge is based on the level of the feed in tariff as well as the changes in the added capacity of renewable power plants, the feed in given by renewables, and the wholesale price of electricity (ÜNB, n.d.). The EEG Surcharge in Germany has increased by 408% between 2002 and 2012 and is related to the increase of electricity from renewables. Not all end consumers have to pay the EEG Surcharge; 39% of the German industrial customers are exempted from paying the tax (CREG & PWC, 2015), thus adding more burden on the rest of the end users who are still required to finance the feed in tariffs.

c) Value Added Tax (VAT) and Eco-Taxes

Furthermore, the retail electricity price consists of a component for taxes. This component not only includes the regular sales tax (VAT) of 19%, but it also includes the Ökosteuer (Eco-tax) which costs 2.05 Euros per kWh (Thalman, 2016) and which Germany introduced as a way to reduce the activities that cause pollution as well as introduce economic incentives for energy efficient undertakings. Overall, it is noticeable that the electricity price is becoming more non-transparent. Figure 16 represents the composition of the German power price for households in 2015:

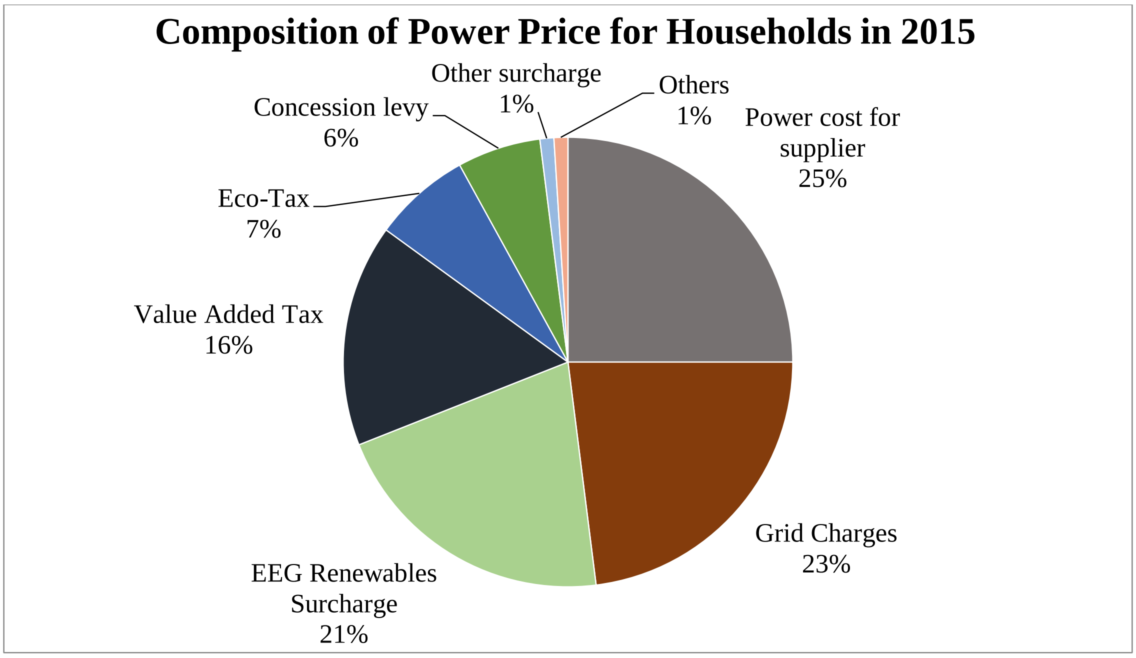

Figure 16: Composition of power price for households in 2015 (BDEW, 2016b)

In 2008 the electricity price consisted of seven different components and by 2015 three new parts were added. These constant additions ultimately cause the retail electricity price to be more difficult to understand. Our analysis in Chapter Four will therefore examine each of these components in order to understand exactly where changes are occurring.

4 Analysis

Chapter Four is divided into four subsections which aim to answer the main research question of this paper. Chapter 4.1 looks at the impacts of the recent market developments on wholesale prices and producers who are affected by these prices. Chapter 4.2 analyzes the impacts of the recent developments on residential prices and end consumers. Chapter 4.3 focuses on the impacts of the recent developments on municipalities and cities. Lastly, Chapter 4.4 presents a concise summary of the findings from Chapter.

4.1 Effects of Recent Developments on Wholesale Prices & Producers

4.1.1 Effects of Recent Developments on Wholesale Prices

By examining the wholesale electricity prices in Germany, it is clear that they have been declining in recent years. Figure 17 below was constructed by calculating a monthly average of quarter-hourly data for the period based on data from EPEX Spot (2015). Not only have average prices dropped 60% since 2008 but so have peak period prices as well. Since 2012, monthly prices have stayed consistently below 50 Euros per MWh. This can be directly attributed back to the implications of the increase in renewable energy sources (Institute for Energy Research, 2014).

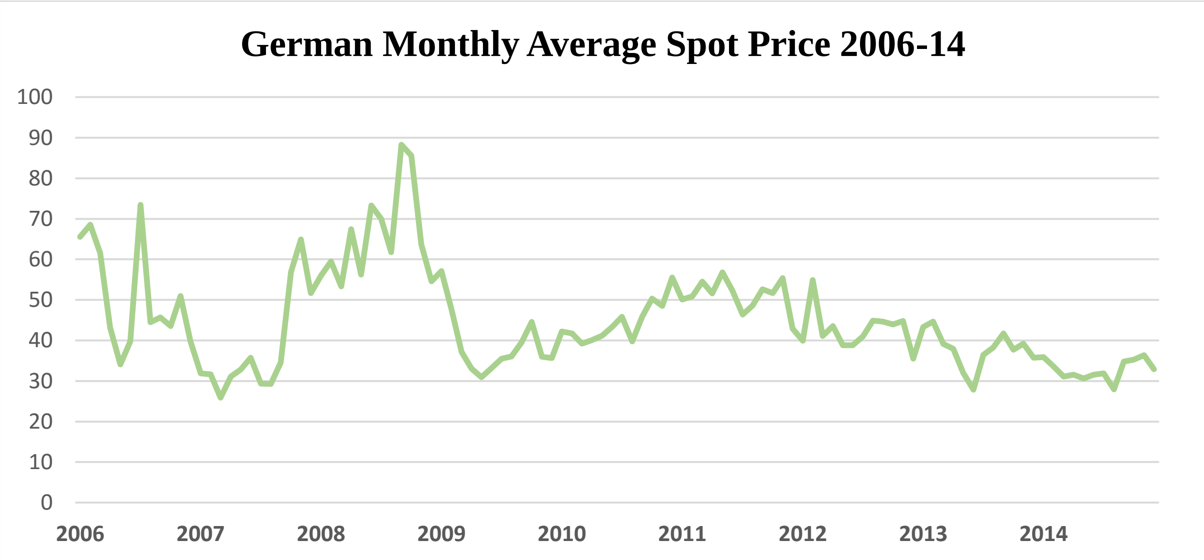

Figure 17: Monthly Average Spot Prices

It has been expected that the policies introduced by the German government after the Fukushima disaster would affect the German wholesale electricity prices. This is due to the fact that the nuclear energy phase-out goals have affected and will continue to affect the German energy and electricity mix. Since nuclear power plants have low generating costs and are considered one of the basic sources on the merit curve for providing baseload electricity, one would assume that the closeout of all nuclear power plants by 2022 would have an upward pressure on the wholesale electricity price in Germany while the country tries to find substitutes for its nuclear energy sources. However, as we have observed, the prices have in fact decreased. In conjunction with the other trends and developments we have considered, we attribute this partially to the fact that the German government has balanced some of its nuclear phase out with newly installed coal power plants as seen below in Figure 18 (which has been adapted from IHS 2014 data).

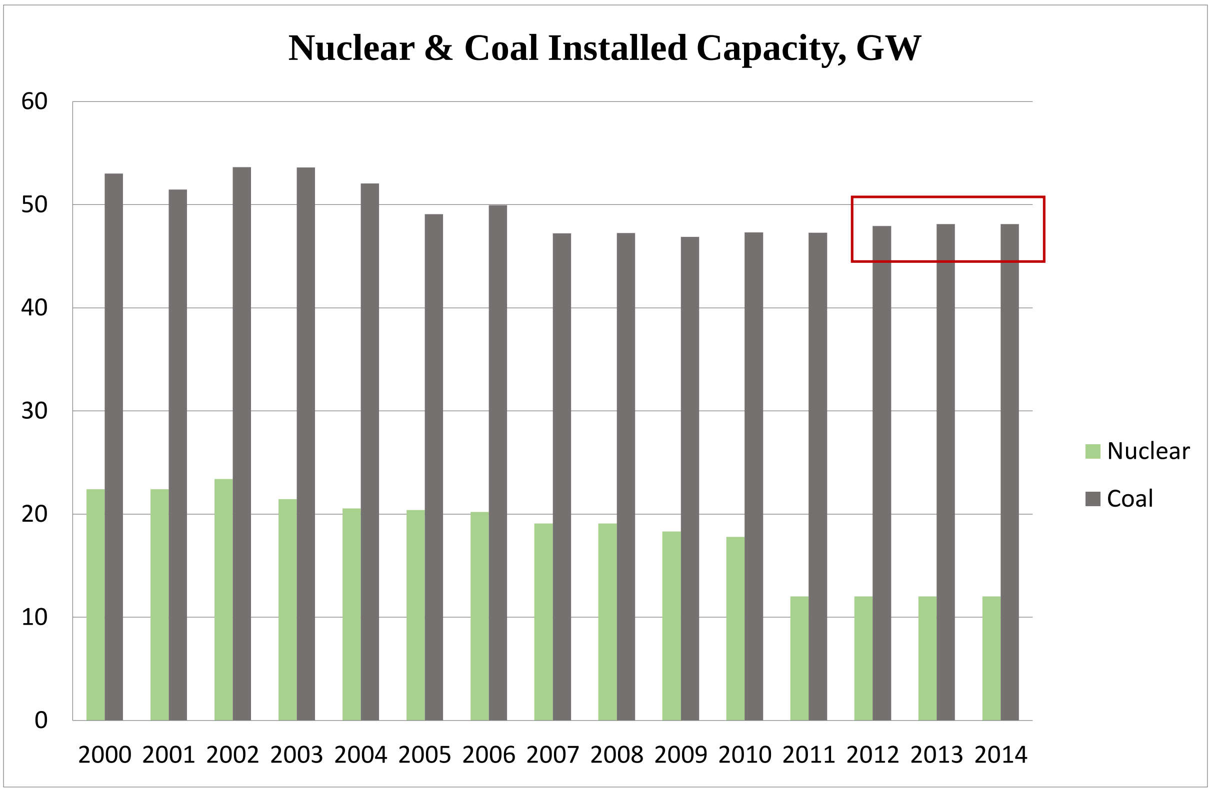

Figure 18: Nuclear and Coal Installed Capacity in Germany

Another cause for the decrease of wholesale prices is attributed to the Energiewende. As mentioned in Chapter Two the main goal of the Energiewende is to increase renewables as part of the energy mix. Given the low marginal costs of renewables and their prominent location on the merit order curve, an increase in renewables in the energy and electricity mix leads to lower the wholesale electricity price in the merit order effect (Friege, 2014). The case of Germany is illustrated in Figure 19 below which was adapted from Appunn (2015b) and Friege (2014). Nuclear has been replaced by additional renewable capacity as well an increase in the use of coal.

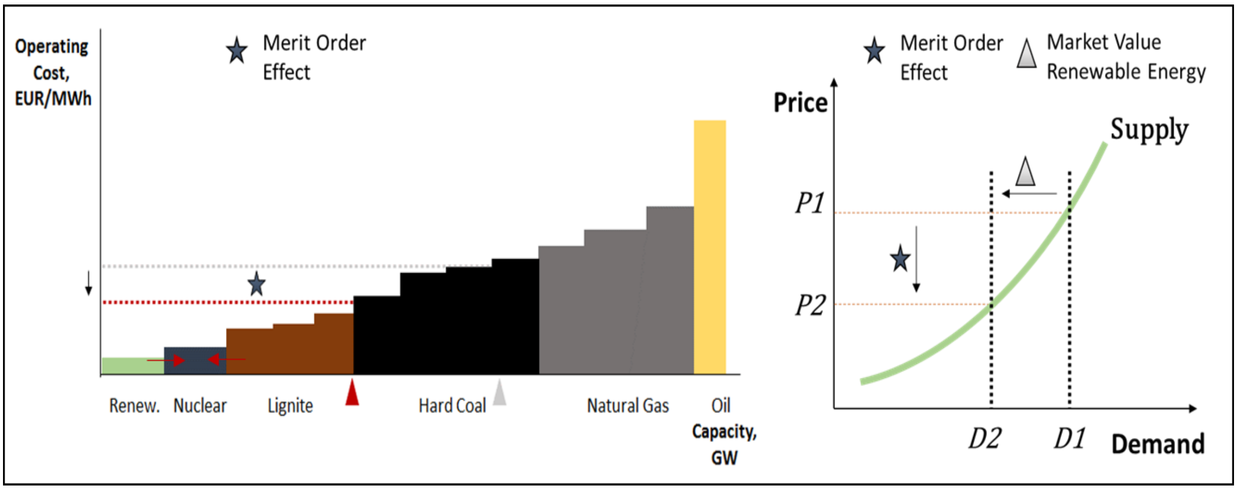

Figure 19: Merit Order Effect in Germany

An increase in renewables also means that there is constant variability in the wholesale electricity price in the market depending on how much renewable energy is available at that moment and needs to be used. Since electricity cannot be easily stored, wholesale electricity prices have reached zero or even negative prices in times where too much renewable energy is available and demand is low (EPEX Spot, 2015). Hence, we consider that with additional interconnection capacity with foreign markets, Germany will be able to benefit from being able to balance peak price periods as well as periods of extremely high renewable energy supply (Ondrich, 2014).

Smart Grid and decentralized generation also help in times where supply is fluctuating and demand is high. In this scenario the wholesale price might increase due to the limited supply; however, more individuals are able to decrease demand in response to the market pricing as well as act as ‘pro-sumers’ and feed in to the system thus lowering the risk of a potential outage. The transition towards decentralized generation allows more individuals and non-traditional generators to produce and use their own energy thus decreasing the demand on the market. This, in turn, affects the electricity wholesale price, as it is a function of supply and demand. For a country like Germany where the system consists of a high share of renewables it is expected that the wholesale electricity price will continue to decrease once a Smart Grid is fully utilized as a result of the very low marginal costs of renewables.

Taken together, we see the recent developments in the market having different impacts on the wholesale price formation. However, the overarching trend of decreasing average and peak period prices is a clear outcome and this in turn impacts on generators whose revenue is dependent on these electricity prices.

4.1.2 Effects of Recent Developments on Producers

The nuclear energy phase-out has affected those producers who were heavily invested in nuclear energy and who had and will have to close all of their nuclear power plants by 2022. In order for these producers to survive the changing energy mix, they will have to invest in new energy sources that are taking over and replacing the percentage of nuclear energy as part of the total energy mix.

The Energiewende goal of increasing renewables in the energy mix has also affected and will continue to affect the producers in Germany. Given the risk free definitive access to the grid as well as an upfront-determined price per unit, which covers the costs connected to the electricity production, most producers now consider an investment in renewables to be a secure investment. This is the reason why additional producers have been joining the market on a constant basis by only providing electricity that is generated from renewables. The concept of the feed in tariffs is the main reason why the Energiewende goals have been so successful.

Figure 20 (which has been adapted from IHS 2014 data) shows how successful the Energiewende goals have been; most additional capacity that has been introduced in the last few years, especially in the period from 2010 to 2014, stems predominantly from investments in wind and solar power.

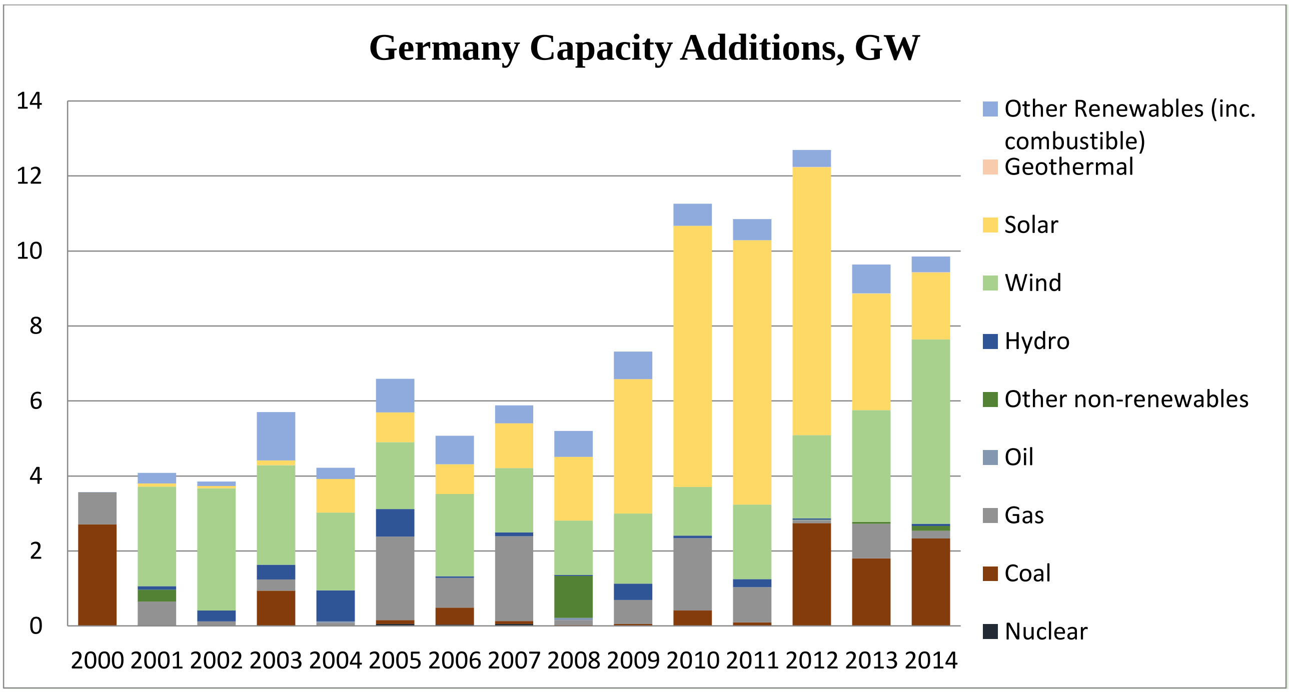

Figure 20: Capacity Additions in Germany

The combination of the nuclear phase-out alongside the new policies introduced by the Energiewende has had major effects on German producers. Ultimately, as the main source of revenue for producers, the fall in wholesale electricity prices has the direct effect of lowering revenues for these companies. E.ON has been the largest player in the German energy market since 2000 following the merger of energy companies VEBA and VIAG. However, the company's share price has dropped by 64% since the Fukushima incident in 2011 given its large holding of nuclear assets (Houston-Waesch, 2015). Most recently, in 2014 the company announced that it would split into two independent companies. Starting January 2016, E.ON has focused on the renewables and energy efficiency operations, while the newly established Uniper has taken control of all the companies' fossil fuel and hydro assets (Timperley, 2016). Following the announcement of the split, E.ON's share price dropped 37% (Andresen, 2016) and the company recorded an even larger loss of 7 billion Euros in 2015 as opposed to 3.16 billion Euros in 2014 (Chazan, 2016).

In order to survive all the developments and new policy changes, E.ON, as well as the second largest generator RWE, have split their businesses to be able to adjust to the new realities of the market. The decision taken by E.ON and RWE clearly shows how the pressure has affected producers in recent years and the long-term viability of large producers has seriously been brought into question. While the phase-out of nuclear energy is on its own significant, the need for these companies to split their business is evidence of the shifting dynamics within the market mechanism and not just production assets. The poor profitability of the companies today is a direct result of the low wholesale electricity prices and as such they have not only had difficulty in maintaining their operations but are no longer able to carry out long term functions of the market on their own (Friege, 2014).

The implications of this are widespread and stem from the lack of resource adequacy of the traditional generators to support the transition to renewable energies. In the case of Germany, Davies et al. (2014) point out that over the last twenty years, funding from the EEG Surcharge alone led to the development of approximately 45% of installed capacity and nearly 25% of actual generation. In other words, funding external to the ordinary market mechanism has been the key driver in increasing generation capacity and production. This has had such a profound impact on the market that Gerbert et al. (2014) consider the impact of this scale of intervention in the market to be the 're-regulation' of the German electricity market.

The market is being considered 're-regulated' because it is structured in such a way that generators are earning a smaller share of the already declining revenue and it is increasingly being taken by the government through intervention and other newly emerging market participants who are being supported. With new electricity demand being satisfied almost entirely by new build, we consider that future revenues from generation will also continue to facilitate the shift of dynamics in the market. This has a sustained impact in the long run on producers who require the market mechanism to make investment decisions as well as invest in research and development (Biggar & Hesamzadeh, 2014). Taken together, these factors make it more difficult to achieve German government and EU 202020 targets and as previously acknowledged, Germany will not achieve its 2050 renewable energy goal at the current growth rate.

Historically, low levels of correlation and interaction between wholesale and retail electricity prices have been attributed to market power abuse. However, we no longer consider this to be the main threat given that the decrease in wholesale electricity price has restricted the ability of generators to influence the price (Koschker & Möst, 2015). While the mitigation of market power risk through increased renewables is positive for market efficiency and overall welfare, the scale and scope of the change is having an impact on generators ability to survive. This in itself bring with it a number of new challenges that must be addressed and will increasingly be a research topic of interest in the context of future market developments.

4.2 Effects of Recent Developments on Residential Prices & End Users

4.2.1 Effects of Recent Developments on Residential Prices

Putting the wholesale price into context we can consider how it has developed against the household price over the same period. As is clearly depicted in Figure 21 (which has been adapted from EPEX 2015 and BDEW 2016 data), it is obvious that while the wholesale price continues on its downward slope, the household price has done the exact opposite approaching a 50% increase in price over the same time period. The absolute prices have a medium negative correlation of -0.518, which in itself does not represent a strong relationship between the two prices.

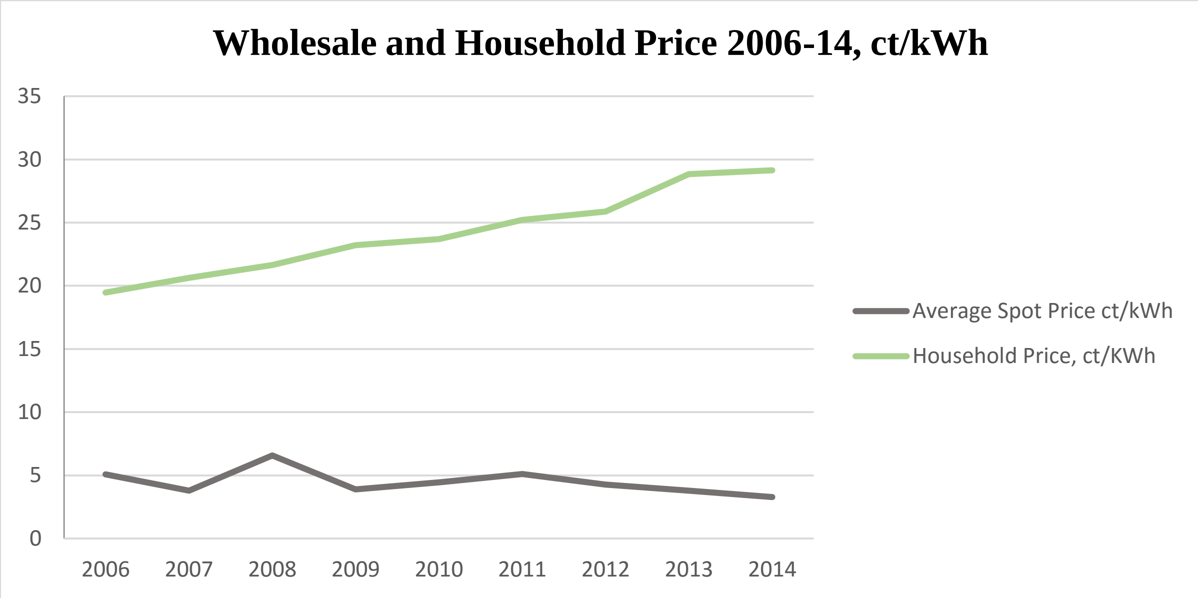

Figure 21: German Wholesale and Household Electricity Prices

This is made further apparent by the fact that household and procurement price over this time period also have a very low correlation of -0.189 (see Figure 22 which has been adapted from EPEX 2015 and BDEW 2016 data). This reveals that the wholesale price is not correlated to the price being charged to the households for purchasing electricity. This is a significant observation, and we therefore acknowledge that there is something else considerably influencing the pricing mechanism and its ability to react to market developments. We must therefore consider what is influencing the household price.

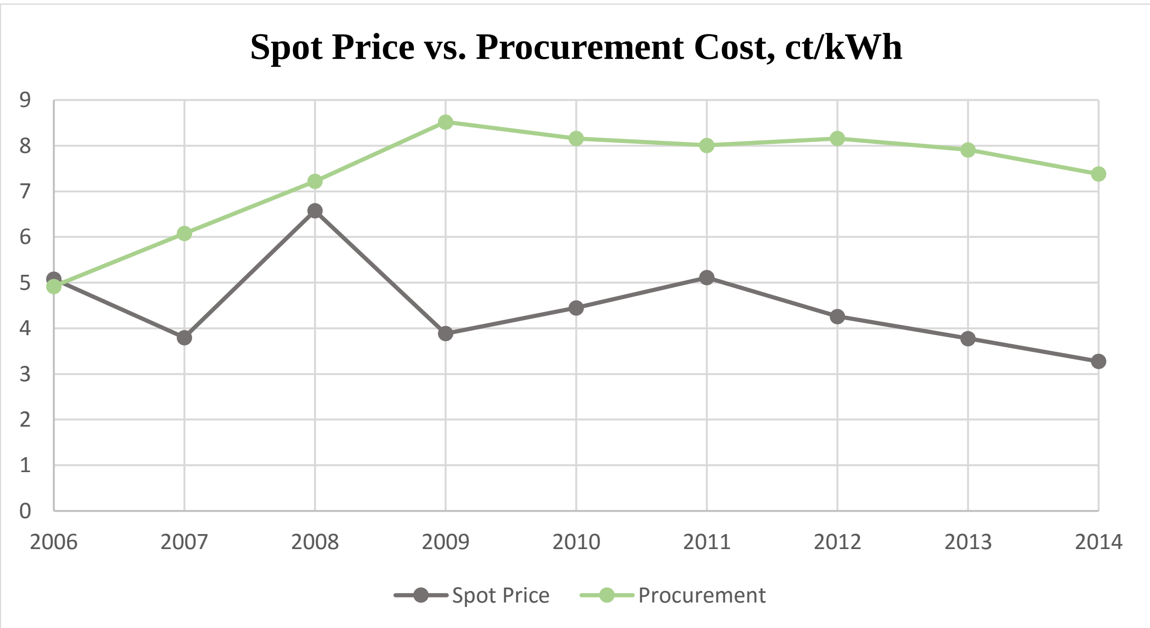

Figure 22: Spot vs. Procurement Costs

As opposed to the effects of the recent policy and technology changes on the German wholesale electricity prices, the effects of those same policy and technology changes on residential electricity prices are not as obvious in the short term. This is partly due to the fact that most residential electricity customers are on yearly contracts with a set price per kWh that has been determined prior to the wholesale prices' increase or decrease. Furthermore, while it is expected that the nuclear phase out will have an upward pressure on wholesale electricity prices and therefore also on residential prices in the longer term, other factors have led to the decrease of wholesale prices causing the expected effects of the phase out to disappear. Lastly, market coupling does not necessarily have a direct impact on the residential electricity prices given the fact that residential prices are determined in advance as part of the yearly contracts. However, if Germany continues to remain in a low price zone and the German electricity price is adjusted higher to even out the electricity price with the other price zones, the rate used in the yearly residential contracts will continue to be higher than it would be without market coupling.

Figure 22 represents the breakdown of the household electricity price over the last 11 years. Additional costs for the end users have been introduced in the form of taxes that are added to the price per kWh, which is the reason why residential electricity prices have increased so drastically in the German market in the last few years as seen in Figure 23 (which has been adapted from BDEW 2016 data). Worth noting is that the combined procurement and grid charges have remained relatively stable over the eight years period below 15 cents per kWh.

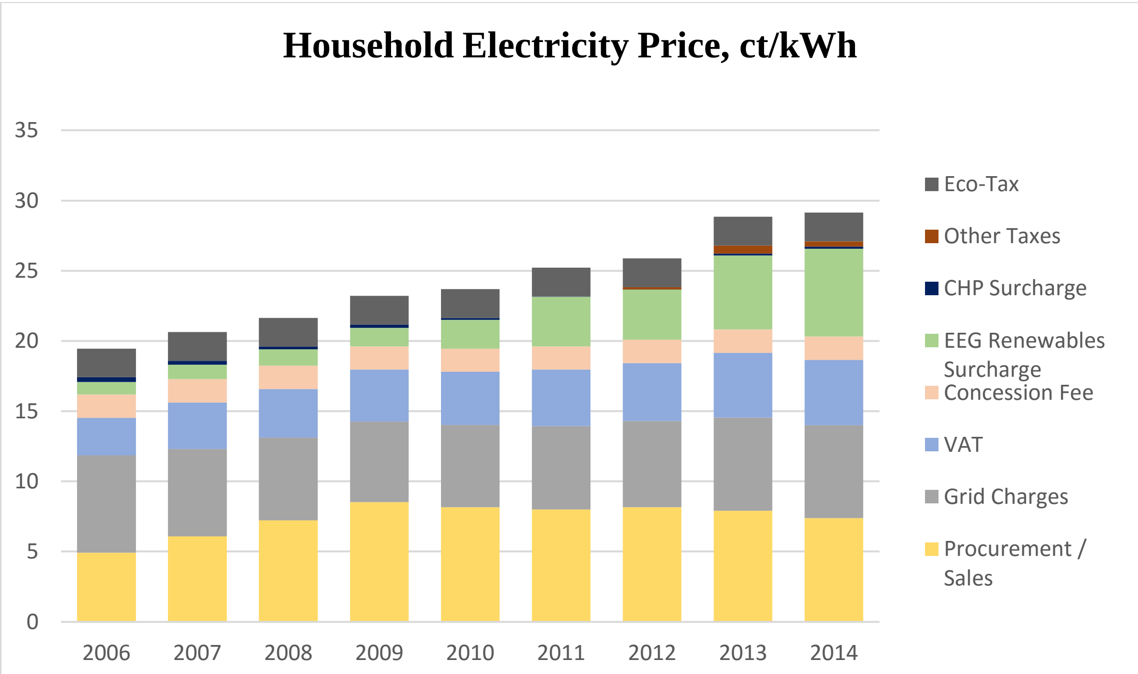

Figure 23: Household Electricity Price Components (for 3,500 kWh per year usage) (BDEW, 2016b)

Therefore, to further understand which component is affecting the increase in household prices the most, the data has further been studied by excluding the procurement and grid fees price components and focusing solely on the tax/charge components. We refer to Appendix A for a more comprehensive analysis and assessment of the pricing relationship between the different components of prices.

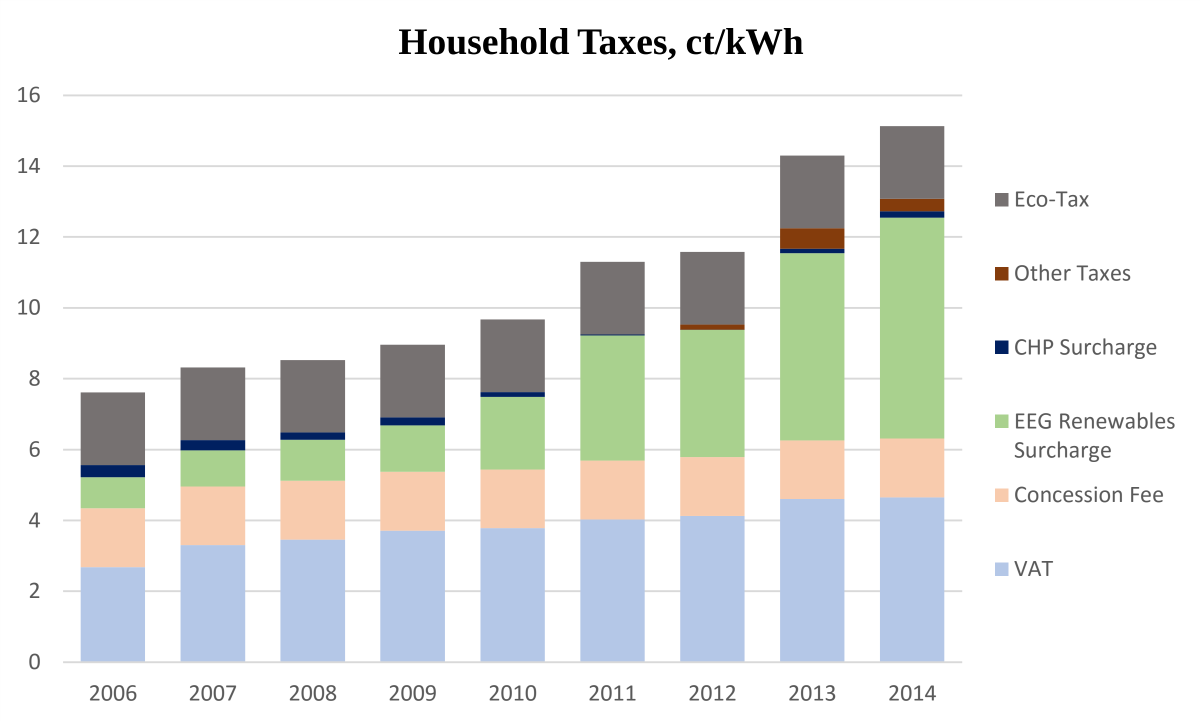

Figure 24: Development of Household Taxes (2006-2014)

As depicted in Figure 24 (which has been adapted from BDEW 2016 data), the VAT tax has remained consistent over the examined time period accounting for between 30 - 40% of the total household taxes. Of specific interest is the EEG Surcharge, which has disproportionately increased from 1 cent per kWh in 2006 up to over 6 cents per kWh in 2014 as seen in Figure 25 (which has been adapted from BDEW 2016 data). In other words, in 2006, the EEG surcharge represented 11.6% of the household price and has grown up to 41.2% of the price by 2014. The rise of the EEG Renewables Surcharge firstly shows the disproportionate burden being placed on German households since they are paying increasingly more tax to subsidize the country's transition to renewables. We further consider that an increasing proportion of Germany's electricity is being exported and it is hence households that are supporting the export of electricity from increasingly renewable sources to neighboring countries. Most importantly however, the market mechanism and how generators make money is coming under threat as a result of a taxation mechanism that circumvents the traditional generators.

We therefore have a 're-regulation' of the market whereby German generators do not have the capacity to themselves invest in new generation capacity. Moreover, the disproportionate increase in the percent tax of the electricity price households pay means the government is getting a larger share of the money and is being relied on for new investment.

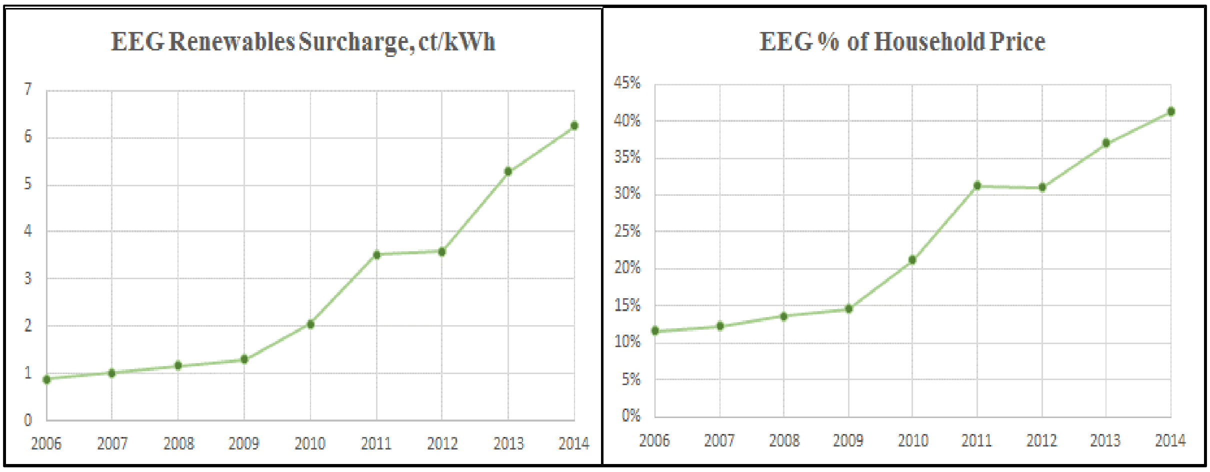

Figure 25: EEG Surcharge as part of the Residential Electricity Price

As depicted in Figure 26 (which has been adapted from EPEX 2015 and BDEW 2016 data), the EEG surcharge has increased so drastically over the last eight years that in 2014 it is actually higher than the spot price itself.

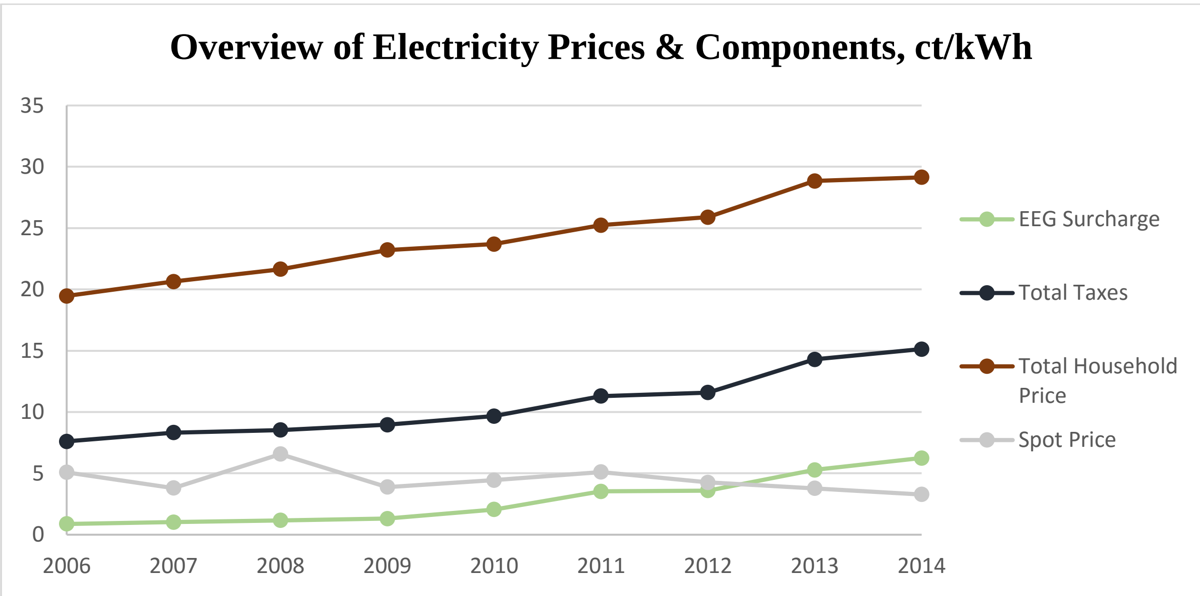

Figure 26: Overview of Electricity Prices and Components

Table 4 below has been created based on the available EPEX data and clearly depicts that the EEG is the key driver of the total households' electricity tax (correlation: 0.995). This in turn is a key driver of the total household's electricity price per kWh (correlation: 0.963). This is further supported by the very strong relationship (correlation: 0.979) between the overall taxes that households pay and the total price they pay per kWh. The low correlations between the EEG, the tax paid by households and also the total household price, with the spot price is evidence of the market mechanisms inability to adequately function.

Table 4: Summary of Price Correlations

EEG Correlation		**Actual**	**% Change**
	Correlation EEG and Total Tax	0.995153	0.706722
	Correlation EEG and Household	0.963826	0.270682
	Correlation EEG and Spot	-0.50932	0.20787
Total Tax Correlation		**Actual**	**% Change**
	Correlation Total Tax and Household	0.979249	0.734715
	Correlation Total Tax and Spot	-0.53197	-0.14012
Total Electricity Price Correlation		**Actual**	**% Change**
	Correlation Household and Spot	-0.51817	-0.15489

2013 was an important year for the price development of retail electricity prices in Germany; in 2012 electricity users paid 3.59 cents per kWh, in 2013 this number increased to 5.28 cents per kWh. During that same timeframe an additional offshore liability levy of 0.25 cents per kWh was added to the bill. Furthermore, between 1998 and today, the surcharge for renewable energy has increased by more than tenfold causing it to represent 22 percent of the residential price per kWh versus 1 percent in 1998. This surcharge, which is *"the difference between the wholesale price and the higher, fixed price for green energy, guaranteed by law to renewable power producers"*(Thalman, 2016), is being passed on from the grid operators to the end consumers. As opposed to the commercial customers, households have to pay all levies and taxes.

Consumer advocates and antitrust groups have long been criticizing the current price development. Electricity providers are also being accused of using the government levies as the basis for unnecessarily high price increases. However, while retail electricity prices have increased for many electricity providers in 2014, 2015 marked the first time in over a decade, where the residential prices decreased (Thalman, 2016). This is partly due to the EEG Surcharge that has decreased for the first time since its introduction and now costs 6.17 cents per kWh (Thalman, 2016). Still, the more favorable procurement prices are often not passed along to the end users; only few companies have passed those price cuts along to the retail customers in 2015, which caused the gap between the prices offered by local utilities and other big national companies to widen.

4.2.2 Effects of Recent Developments on End Users

Given that the Energiewende policies require an increase in renewable energy sources, it is important to understand who pays for the initial investments. In the case of the German market, it is the residential customers that indirectly bear most of the costs as shown in the analysis presented in Chapter 4.2.1. Germany's implementation of the Renewable Energies Act has been the main driver of the electricity price increase in the last ten years (BDEW, 2011).

An average German family of four members using approximately 5000 kWh per year paid 382 Euros more for its electricity bill in 2015 compared to 2008 (Check24.de, 2015) and the price a family of three pays for its 3,500 kWh of annual power consumption today is 70% what a same sized family used to pay in 1998 (Thalman, 2016). This constant increase in price has caused the number of German households that cannot afford paying off their electricity bill to increase by more than double over the course of one year between 2011 and 2012. Overall however, the German population has been very supportive of the country's energy transition towards a low-carbon economy because the overall percent of disposable income spent on electricity has remained consistent over the years (Thalman, 2016).

Another reason for the people's support of the Energiewende is that a big part of the population is engaged in the transition. Millions of Germans have become energy producers themselves by investing in solar panels for their own households or buying shares in wind energy farms. An example would be a household that has invested in 44 square meters worth of solar panels which produces around 5,000 kWh per year. Given the current prices, the household would be paid 51 cents by the power provider for each kWh it feeds into the grid (Borchert, 2015). Since the price is guaranteed for 20 years, the household should expect to cover its initial costs in the first 10 years and make profit thereafter (Borchert, 2015). This has only been possible because decentralized generation is becoming the norm in Germany. According to a study conducted by the Leuphana University of Lueneburg, "*citizens owned almost half the country's installed biogas and solar capacity and half the installed onshore wind power capacity*" (Borchert, 2015).

An increasing number of companies have planned to reduce prices by an average of 2.2% (Check24, 2015). Based on this, it is clear that there is more competition between the producers in the market who can use their lower electricity prices to attract new customers. While historically research has shown that most customers tend to stay with their long-term suppliers and contracts, it is expected that in the future a higher number of customers change their electricity providers, especially when the switch between companies could save some customers up to 30% of their bill (Check24, 2015).

Furthermore, the introduction of Smart Grid in conjunction with the current growth in decentralized generation is expected to reduce household prices and positively affect end users the most if used correctly. As previously discussed in Section 2.5.4 Smart Grid and Decentralized Generation, the installation of smart meters will allow utility companies to charge customers variable electricity prices as opposed to the set yearly rates that are determined in advance. This can lead to different results for different customers. Customers who are educated about the new electricity rates and attempt to adjust their demand based on the different rates and time of day will benefit and save the most from Smart Grid.

Customers who continue to behave like they did before the introduction of smart meters and variable rates might be worse off if their demand occurs during peak hours. This is especially relevant given that as previously mentioned, residential demand is inelastic and end users respond only to a very limited extent to the fluctuating electricity prices. This is also due to the fact that end users have traditionally been charged by their estimated load profile which caused them to 'over-consume' in expensive periods and 'under-consume' in the cheaper periods from a demand-side perspective (Mirza & Bergland, 2012). With electricity demand being inelastic in the short term, it is expected that most customers would not considerably change their demand patterns in the short term; however, with the right customer education and awareness, more customers should be able to benefit from Smart Grid in the long term.

As for end users who utilize decentralized generation, they would be able to produce some of their demand thus lowering their utility bill. As previously mentioned, the typical electricity consumer could become a 'pro-sumer' and thus an individual who is actively involved in the energy supply. This will be further addressed in the upcoming subsection 4.3. Overall, it still remains unclear who will bear the initial Smart Grid installation costs in the case of Germany, and whether it is mostly the end user who will have to pay for it.

4.3 Effects of Recent Developments on Municipalities and Cities

Given the recent developments in Germany and the shift in market dynamics, the question of how, and by who this transition will be managed is increasingly relevant. We consider municipalities and cities to be at the center of this and to date a number of municipalities and cities have already realized their critical role in making the energy transition successful. Previously, most cities have been highly dependent on fossil fuel resources that originate from centralized power plants far beyond their city limits. Given that Germany's energy transition is based on a decentralized renewable energy system, consumers' and cities' will play a role in generating renewable energy in their immediate surroundings. According to the former German parliamentarian Hans-Joseph Fell, this new role for the cities will not only reduce their environmental impact but also help the cities through improving their economies, and allowing them to become 'more energy resilient and self-sufficient' (Boselli, 2015).

As seen in Figure 27, by the end of 2014, more than 130 German districts, municipalities, cities and regions had started their own energy transitions using national feed in tariffs and high residential electricity prices as their motivation to achieve their goals:

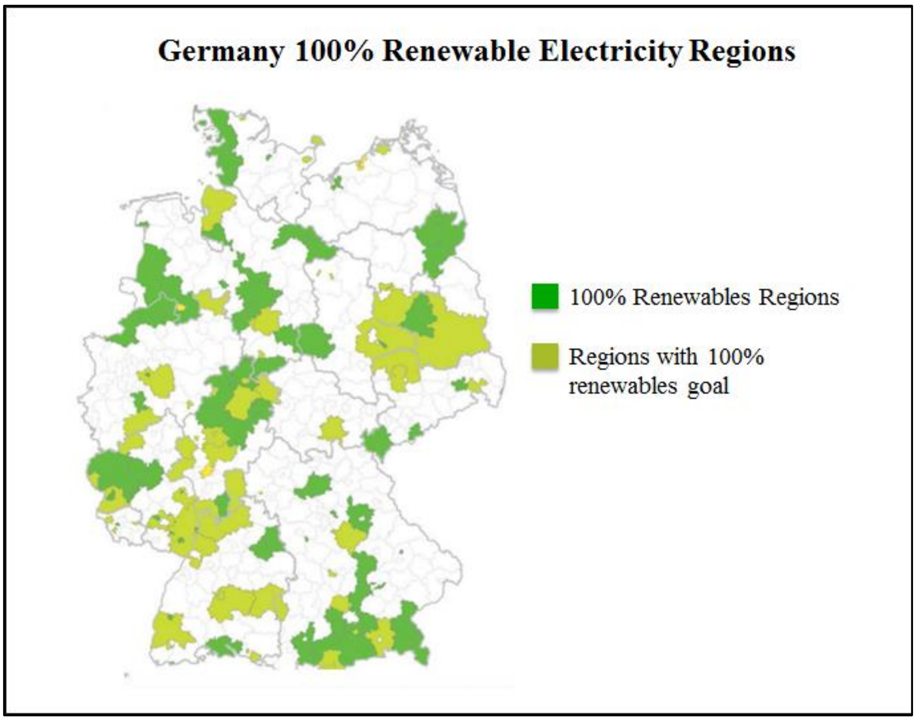

Figure 27: German Regions with 100% Renewables Goals (Ohlhorst, 2015)

Some places have even been acting as 'test sites' in order to experiment new technologies in energy efficiency and other system innovations (Ohlhorst, 2015). Furthermore, the concept of the 're-municipalisation' of energy utilities is also becoming more widespread: some municipalities are repurchasing the distribution grids and utilities companies from private companies (Ohlhorst, 2015). Between 2007 and 2011, the country has seen 44 new local public utilities (Stadtwerke) established as well as the return over 100 distribution network and service delivery contracts, which were previously private, to the public (EPSU, 2011). In addition, some public regional authorities have acquired entire regional networks from large energy corporations.

This shows once again that the main driver behind the success of the Energiewende so far has been the people and the communities as opposed to the large electricity companies, which Germany has traditionally been so heavily reliant upon. To explain this further, the district of Rhein Hunsrück is considered as an example of how the development has and will continue to affect municipalities across the country.

4.3.1 Case Study: Rein Hunsrück

Rhein Hunsrück is located in southwestern Germany and has approximately 103,000inhabitants. In recent years the district had been spending close to 290 million euros on importing energy before it decided in 2011 to use its budget to build renewable energy assets locally and switch its entire energy system to clean and efficient sources by 2020. Through improving its energy efficiency and introducing more renewables into its energy mix, the district aims to convert current energy costs into an opportunity for economic growth and regional employment. Not only is the district aiming to reduce the total household energy use by almost 50% by 2050, but it also aims to source the household electricity from 100% renewable sources versus the 66% in 2011 (Fleck, 2014).

Rhein Hunsrück’s ultimate objective is to have a 100% neutral energy supply, 100% decentralized production and to reduce the district’s energy expenses. In comparison with Germany’s goals of reaching 20% energy efficiency, a 35% share of renewables in electricity and 40% less CO2 emissions by 2020, Rhein Hunsrück’s goals are far more ambitious. Surprisingly enough, the district has been successful in reaching its goals so far; more specifically by 2010 the district already had 66% of its electricity sourced from renewables including solar, wind and biomass (Fleck, 2011). Rhein Hunsrück's success in leading the energy transition in comparison to the rest of Germany can be seen below in Figure 28:

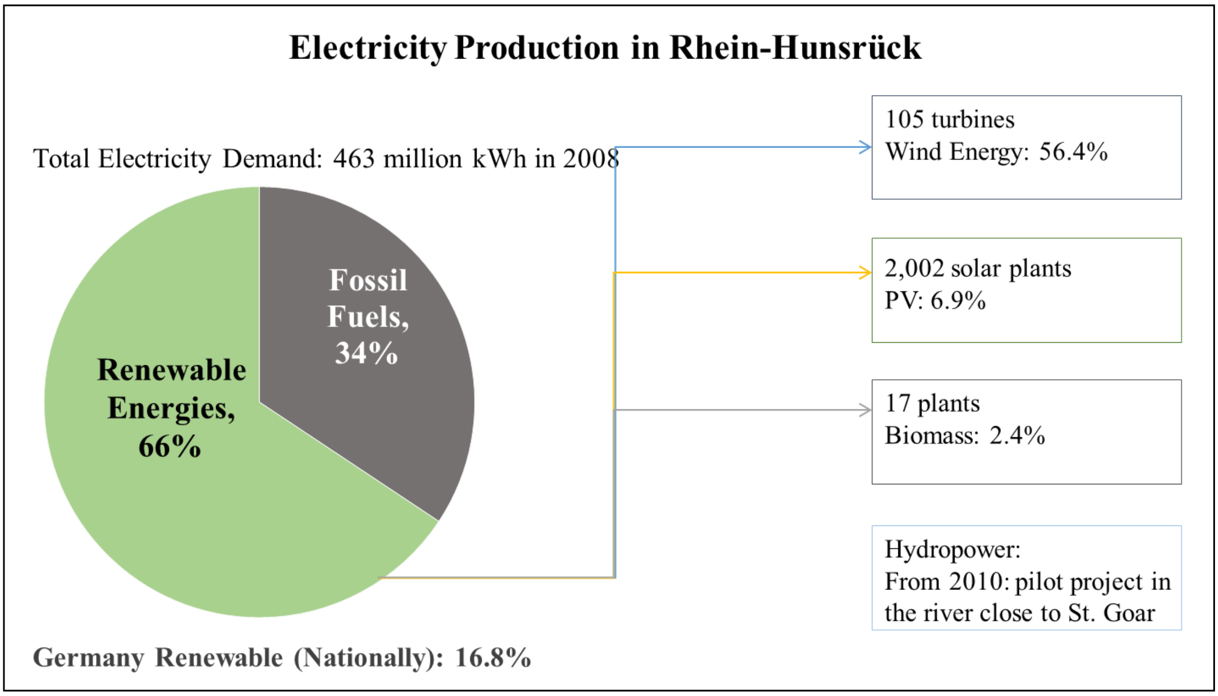

Figure 28: Total Electricity Production in Rhein-Hunsrück (Fleck, 2011)

By 2012, Rhein Hunsrück became an energy exporter, and it is expected to increase its exports in the upcoming years. This has been mainly achieved by installing 16 new biomass plants, almost 3,100 solar panels and 169 wind turbines up until that point (Leidreiter, 2014). The district's goal is to reach 507% renewable power by 2020, 828% by 2050 and reach 100% net zero emissions heat and transportation by 2020 (Go100percent.org, 2011).

The following Figure 29 represents the development of GHG emissions in the district of Rhein Hunsrück. The GHG emissions associated with the district's electricity are represented by the green bars and have been on the decrease since 1990. Overall, between 1990 and 2011, the district was able to reduce its total GHG emissions by 20%, which equals to a reduction of 309 thousand tons of CO2 (Rhein-Hunsrueck-Kreis, 2011).

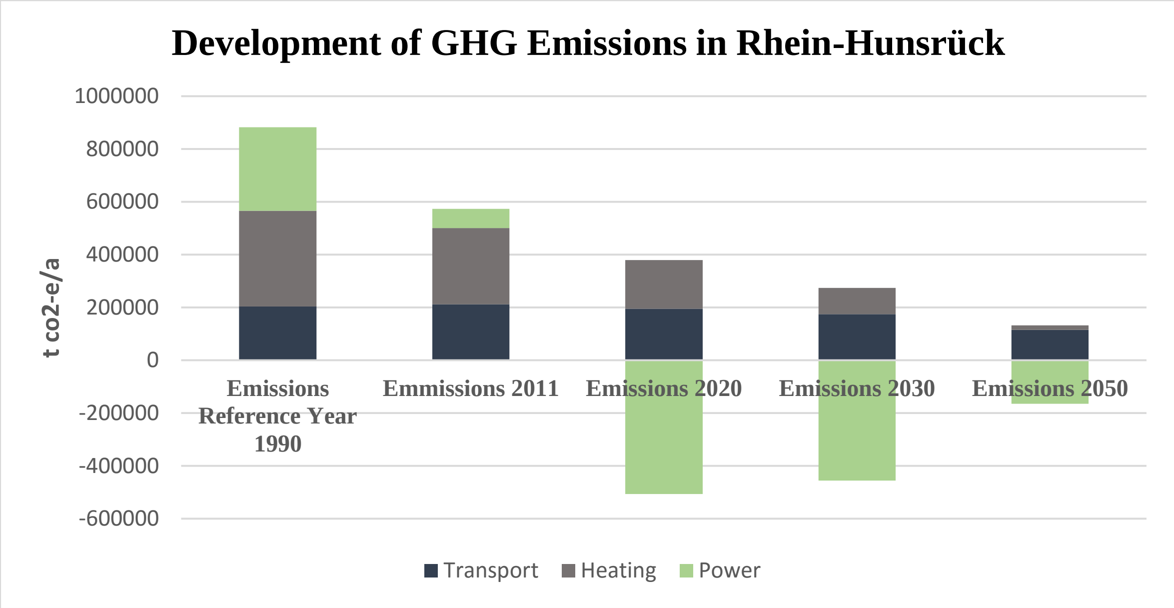

Figure 29: Development of GHG emissions in Rhein Hunsrück (Rhein-Hunsrueck-Kreis, 2011)

For the district to be able to reach its goals, it had to invest heavily in a number of changes over the course of the initial phase of the project. In the years from 1999 to 2006, for example, Rhein Hunsrück invested in solar projects and heat pumps that are connected to ground heat collectors. The district also invested in the retrofitting of heating systems in public buildings and in energy efficient construction including the construction of zero emission and even energy generating buildings. Other measures that the district implemented included the usage of both dry and wet residual biomass and the creation of a bio-heating network.

Especially of interest for the purpose of this paper is how Rhein Hunsrück has managed to monitor the district owned buildings since 1999 to reduce its energy consumption. The district has been able to reduce its heat demand by 25%, its electricity demand by 5% and its CO2 emissions by close to 5.5 tons (Fleck, 2011). This is largely because of the introduction of multiple energy efficiency programs as well as the implementation of thousands of solar panels on buildings across the district. Out of the 80,000 rooftops in the district, 58,636 were suitable for photovoltaic technologies; this accounts for a usable surface area of 4,622,652qm and a total achievable overall performance of 519,014kWp. Based on these numbers it is possible for the district to cover its entire electricity demand just through the photovoltaic capacity on the rooftops (Rhein-Hunsrueck-Kreis, n.d.).

Given the fact that household electricity tariffs have increased by approximately 50% between 2000 and 2013 and that solar electricity costs have decreased by an estimated 80% during that same period as displayed in Figure 30, the district was able to make use of its savings for other projects. The investment into the photovoltaic technologies for Rhein Hunsrück has originally been calculated by considering the criteria of the grid fee and compensation fees of the EEG. However, system prices have decreased so much that the electricity created onsite costs 17 cents per kWh, which is relatively low compared to the average 25 cents per kWh charged as the residential electricity price (Rhein-Hunsrueck-Kreis, n.d.).

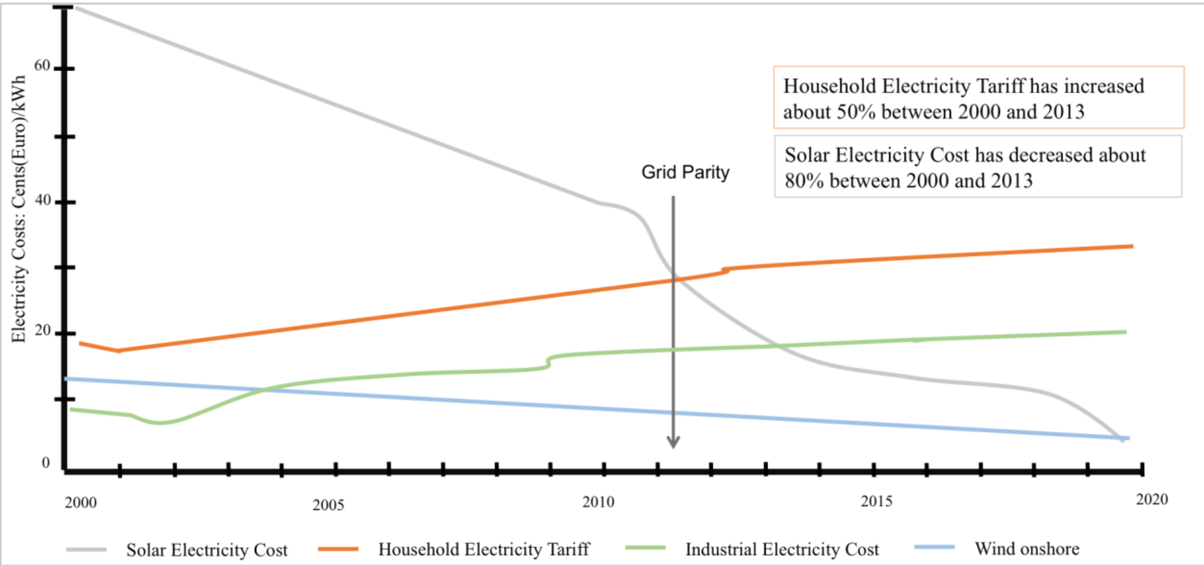

Figure 30: Development of Electricity Prices (Fleck, 2014)

Some of the energy efficiency programs that the district introduced consisted of verifying that all public buildings' electricity usage is optimal. These buildings include all offices and production facilities, social facilities, schools, daycares etc. The energy savings in such buildings are especially high and valuable even without the presence of storage batteries due to the fact that their peak operation hours coincide with the time of day where sunlight is most abundant (Rhein-Hunsrueck-Kreis, n.d.). However, residential homes are different; the electricity usage in residential homes depends largely on the number of devices a family owns and how long these devices are in use. A household of four individuals for example can consume anywhere between 2,200 – 4,400 kWh per year (Rhein-Hunsrueck-Kreis, 2014).

The district is especially working on promoting the concept that lowering a household's energy consumption does not necessarily mean a reduction of the family's quality of life. On the contrary, a reduction of a household's energy consumption from 4,400 kWh to 2,200 kWh can save a family up to 550 Euros per year in electricity costs and potentially even more as electricity prices continue to increase (Rhein-Hunsrueck-Kreis, 2014). This is why Rhein Hunsrück offers customers energy efficiency expert visits to their houses for a small charge of 10-20 Euros; these experts assess the energy usage of the household and provide tips and modifications that the customers could follow to reduce consumption (Rhein-Hunsrueck-Kreis, 2014).

In addition, big cities have also been participating in their own energy transition; for example the city of Frankfurt has a goal of reaching a 100% renewable energy by 2050 in all sectors including electricity, heating and transportation (Stryi-Hipp, 2015). Another goal of cities is to ensure that the energy produced within the city is prioritized, which requires considerable of coordination between the municipalities and the regional governance. While the complexity of the electricity market is therefore only expected to increase, there are many opportunities and benefits that can reaped as well. Municipalities and cities have been activing in pursuing these; a trend we only see increasing as the Energiewende continues to unfold.

4.4 Summary of Findings

The tables below summarize the findings of Chapter Four, namely the effects of the recent market developments on wholesale and residential electricity prices as well as on the different market players.

Table 5: Effects on Prices

Effects on German Wholesale Electricity Prices	• Average prices have dropped by 60% since 2008 and continue to do so. • Peak period prices are also decreasing.
Effects on German Residential Electricity Prices	• Prices have increased by 50% since 2008 • EEG Surcharge has increased from 10% of the residential electricity price in 2006 to almost 45% of the price in 2014

Table 6: Effects on Market Players

Effects on Producers	• Developments have reshaped the market mechanism • Several big producers split into two companies in order to support the divergent business strategies of fossil fuel sources and renewable energy sources. • Feed-in tariffs continue to encourage new small producers to join the market, which is increasing competition • Decentralized generation continues to pose a risk for established big companies since it represents increased competition.
Effects on Consumers	• The number of German households that cannot afford to pay their electricity bill has doubled over a year (2011-2012) due to increasing residential electricity prices. • However, most of the German population is supportive of the country's energy transition since it encourages them to become "pro-sumers" and benefit from the feed in tariffs as well.
Effects on Municipalities	• The role of municipalities and cities in the electricity market is increasingly important. • By the end of 2014, more than 130 German districts and municipalities adopted their own version of the Energiewende. • Rhein Hunsrück is an example of how a district has been able to capitalize on the opportunities emerging from the Energiewende.

5 Future Outlook of the German Electricity Market

While Chapter Four focused on the impacts of the recent market developments on both prices and market players up until now, Chapter Five analyzes the impact of the market developments into the future. Chapter Five is divided into four main subsections: Chapter 5.1 focuses on the future supply, Chapter 5.2 on the future demand, Chapter 5.3 on the future price formations and lastly Chapter 5.4 on the future market setup.

5.1 The Future Outlook: Supply

As per Figure 31 (which has been adapted from IHS 2015 data), forecasts project a continuous year on year growth of the German power capacity, where there is a steady increase of renewables specifically wind and solar. This is attributed to the success of the feed in tariffs policy as they continue to encourage more producers to enter the market and existing producers to invest in renewable technologies.

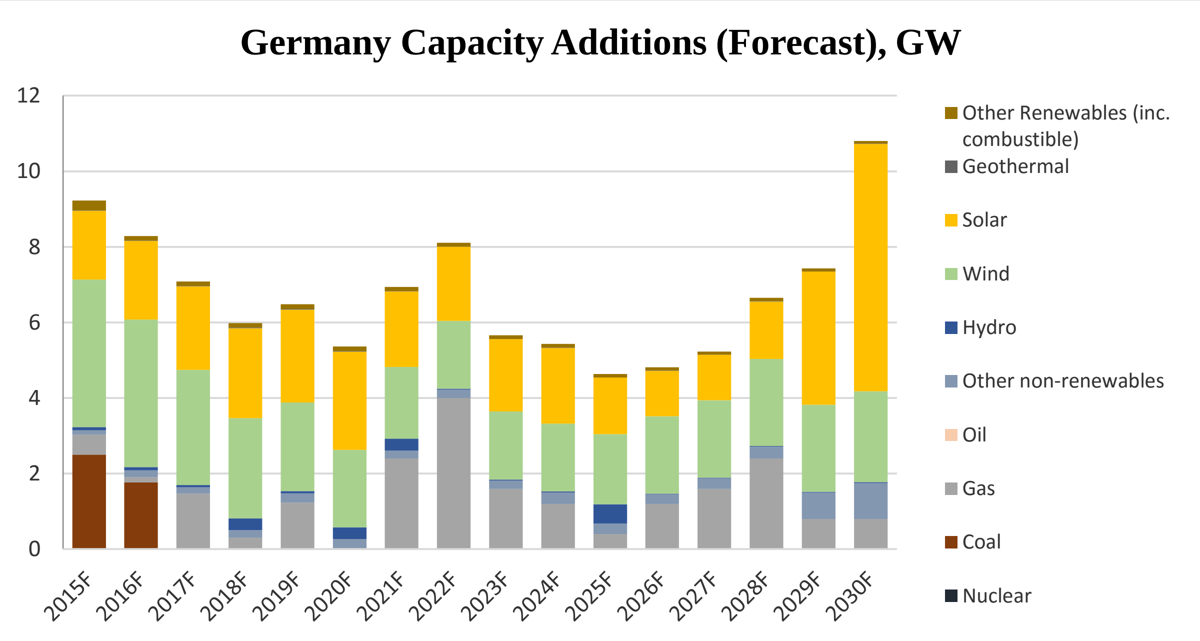

Figure 31: Forecasted New Capacity in Germany

However, the feed in tariff policy is expected to be updated starting 2017; instead of including a market premium that is set by law, the feed in tariffs will be determined based on competitive auctions (Appunn, 2016). This future change may in turn affect the number of new capacity additions or the speed thereof. Given the predictability challenges of renewable power sources, additional gas power plants will be introduced in the market starting 2025 to complement the introduction of renewables. By 2025, the installed capacity will exceed 200 GW, and by 2050 it will exceed 250 GW. This means that capacity will have grown by approximately 50% between 2011 and 2050.

Interestingly enough, the increase in generation capacity is not accompanied by an increase in actual electricity generation, which will follow a relatively flat and steady longer term trend as shown in Figure 32 (which has been adapted from IHS 2015 data). The notable key trends include the fact that the nuclear power being phased out by 2022 will be largely replaced by renewables. In 2014, this included 12 GW of capacity and 92 TWh of nuclear production. Furthermore, from 2025 onwards, gas-fired power plants will gain competitiveness due to higher and stricter regulation. It is expected that 118 TWh will be produced from gas-powered power plants by 2030. Lastly, wind power and solar PV installations will continue increasing in the coming years accounting for almost 40% of the electricity mix by 2030.

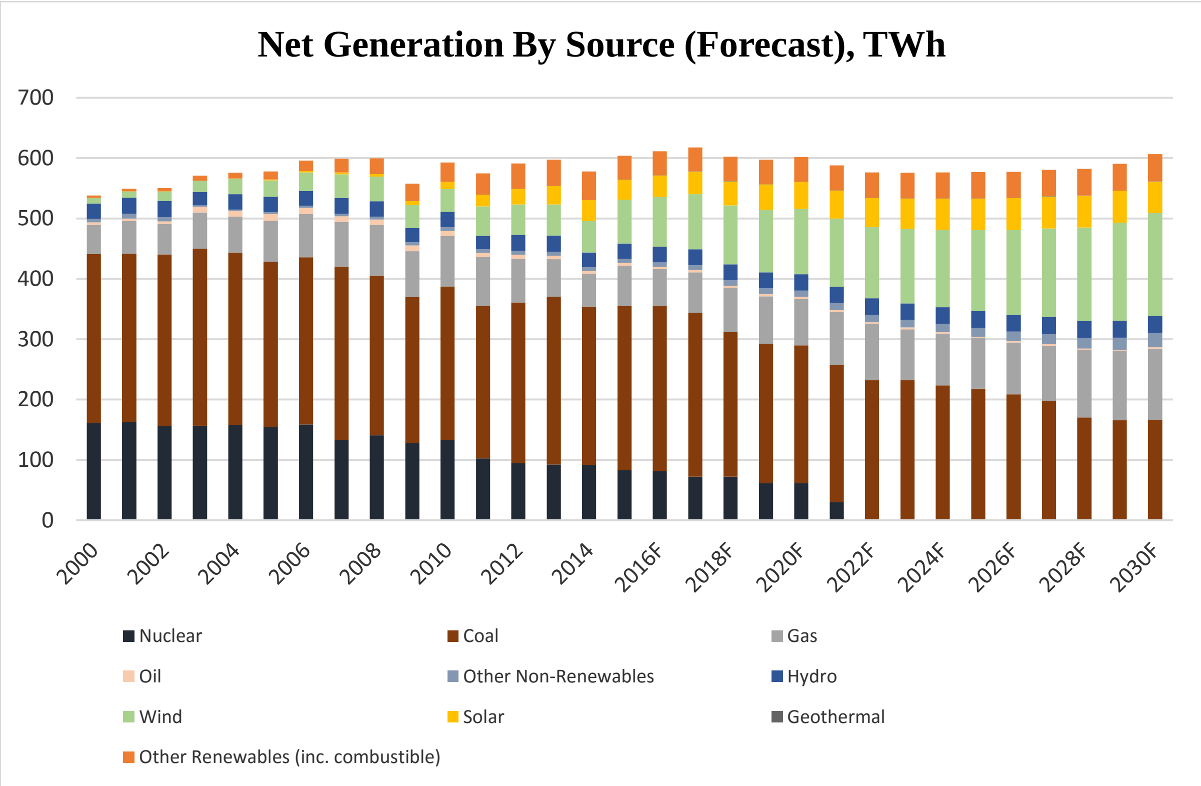

Figure 32: Gross Electricity Generation Forecast (by source)

Nonetheless, based on Figure 33, it is clear that it is practically impossible to replace the electricity gap created by the nuclear phase-out by renewables alone. Instead, this electricity gap up until 2035 will need to be filled by fossil fuels including coal and gas. Hence, some conventional power plants will need to remain in operation in order to supply the missing capacity.

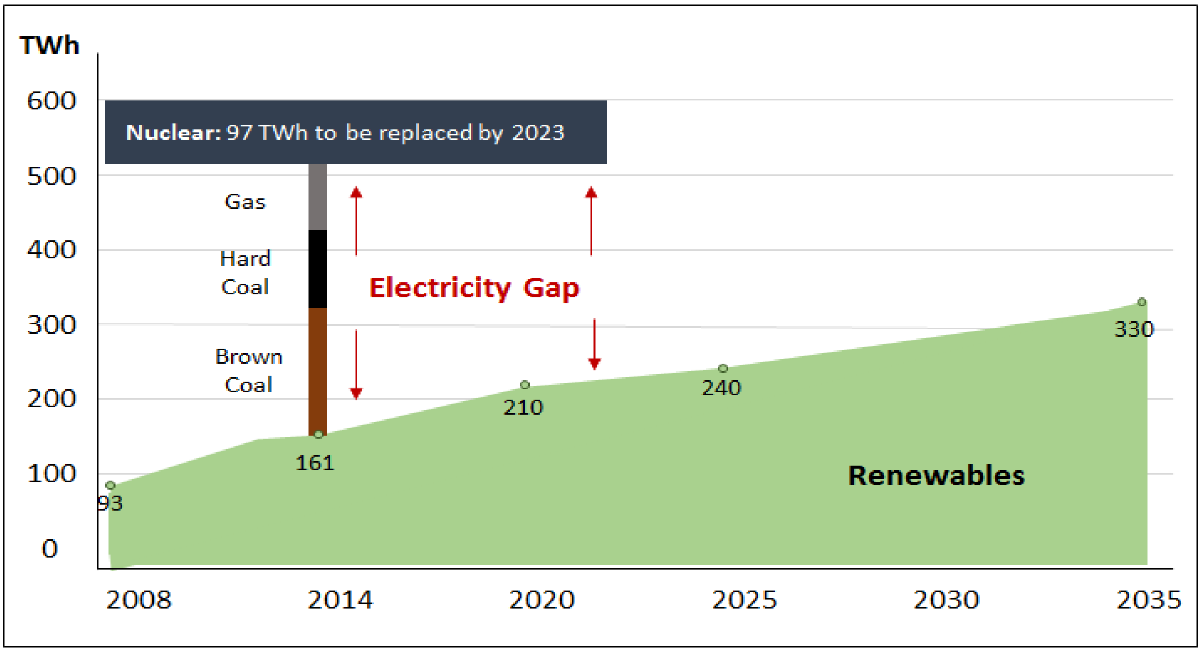

Figure 33: German Electricity Gap (Tagesfragen, 2015)

Figure 34 (which has been adapted from IHS 2015 data) displays the forecasted installed capacity of renewables versus non-renewables over the next few years. As mentioned, the increase of installed renewables capacity will be supported by only a slight decrease in non-renewables capacity in order to guarantee security of supply. The only slight decrease in non-renewables capacity is considerable however given the fact that this includes the complete phase-out of nuclear energy and the decommissioning of nuclear plants. While the energy transition is well underway, there is clearly still a need for non-renewables in Germany. A further assessment of this depicting the need for non-renewables is shown in Appendix B.

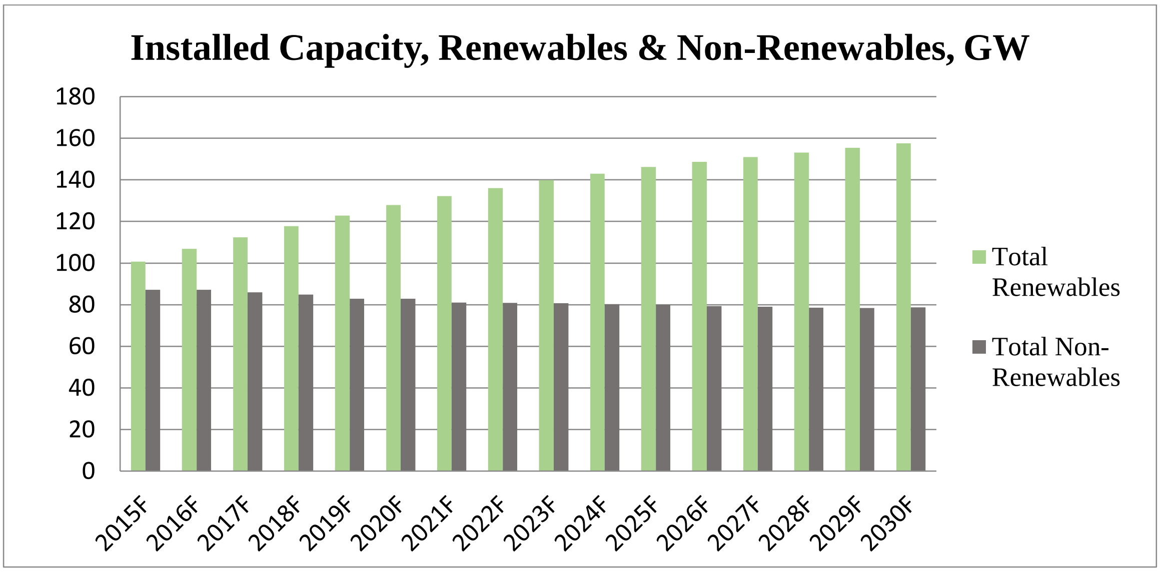

Figure 34: Installed Capacity in Germany

From a capacity additions perspective, new and more efficient power plants (including coal) will replace old power plants to maintain a high level of energy security. The plan for this to be implemented can be seen in Figure 35 (which has been adapted from IHS 2015 data). There are currently 5,110 MW worth of non-volatile generation capacity under construction that are expected to be completed by 2019 including 2,591 MW of hard coal and 1,954 MW of natural gas.

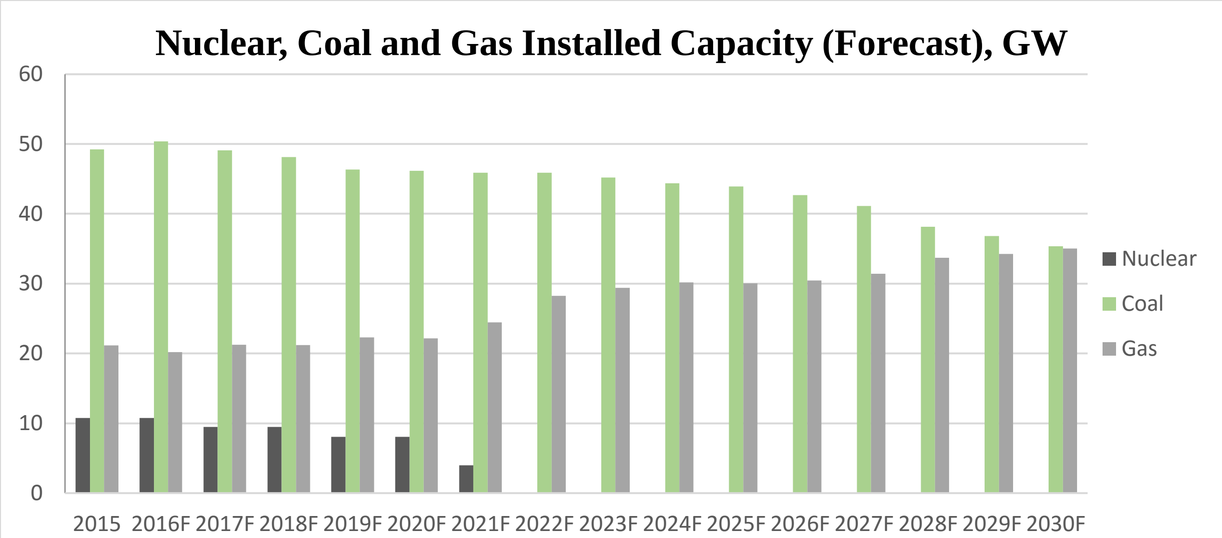

Figure 35: Nuclear, Coal and Gas Installed Capacity

In order to reach its Energiewende goals, Germany faces two main challenges: ensuring that the grid can deal with the fluctuating renewable energy sources as well as having a flexible fossil fleet to balance the fluctuating renewable generation. Given those two problems, Germany has two alternatives: one is to expand its interconnections with the rest of Europe and rely on its neighbors to support balancing generation. This option on its own seems unlikely however given the increasing net electricity export balance of Germany in recent years, the scale of new capacity being built and the desire to be self-sufficient in power generation. The other alternative is to extend its own grid and utilize the geographically diverse potentials of the country, specifically those of wind power in the north and solar power in the south for example. While technically complex, capital intensive, and time consuming, this alternative offers many benefits to Germany and is a key factor in the discussion on whether or not to split the German market into different price zones. Particularly with the increasing role of municipalities and cities in the grid and the rise of decentralization, we consider that a combination of these options will be pursued.

5.2 The Future Outlook: Demand

Overall, as seen in Figure 36 (which has been adapted from IHS 2015 data), despite the slight dips attributed to reduced economic activity in 2004 and 2008, the German electricity demand is expected to remain quite stable and is anticipated to stay below 550TWh.

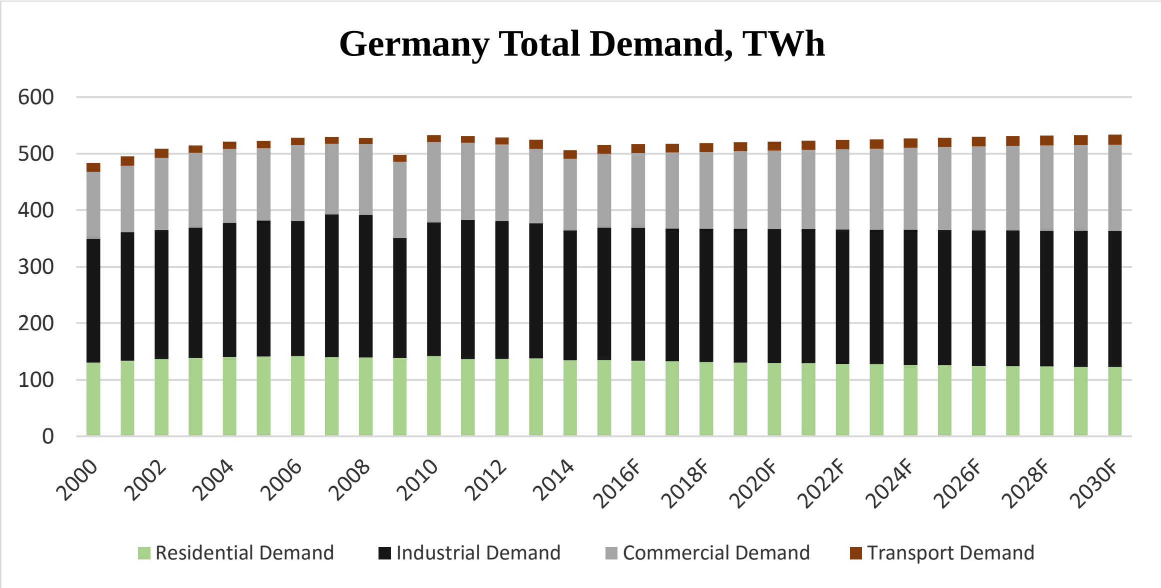

Figure 36: German Electricity Demand

However, as per Figure 37 (which has been adapted from IHS 2015 data), the residential electricity demand is expected to decrease in Germany. It is the only sector in the country, where this is predicted despite a growth in population. The implication of this is further explained in Appendix C. This is attributed to several factors including increased energy efficiency programs as well as demand response programs and the rise in the number of 'pro-sumers' who are no longer in need to constantly draw electricity from the grid.

Figure 37: Residential Electricity Demand in Germany (IHS, 2015)

Figure 38 (which has been adapted from IHS 2015 data) depicts the projected responsiveness to peak load prices over the next 15 years. The graph represents the difference between peak load demand excluding the results of demand response and the actual demand levels when accounting for demand response. The level of demand response is forecasted to more than triple by 2030. Based on these forecasts, it is obvious that the end consumers will play a big role in decreasing the demand levels during peak load times through different demand response programs and therefore aiding the decrease of residential electricity demand in general. As a consequence, the concept of Smart Grid and 'pro-sumers', in combination with the increase of renewables in the energy mix and the decreasing wholesale electricity prices, will continue to challenge traditional generators such as E.ON and RWE in the years ahead as demand decreases.

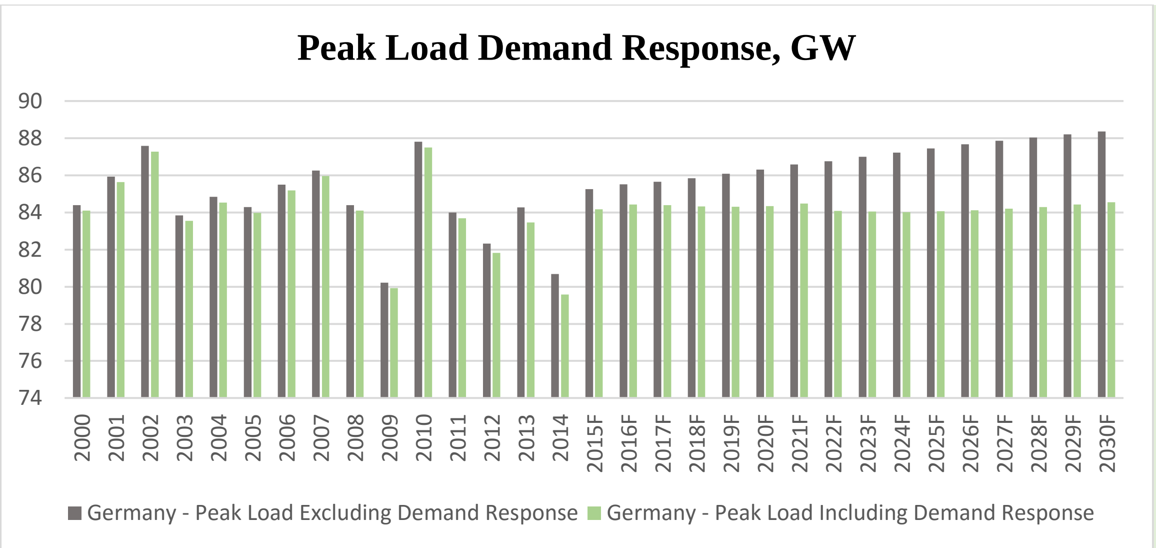

Figure 38: Peak Load Demand Response, GW

5.3 The Future Outlook: Electricity Prices

Taking the above-mentioned future supply and demand forecasts into account, wholesale prices of electricity are expected to continue to fall until 2020. This is mainly due to the feed in tariffs provided to producers of renewable energy and the increase of low marginal cost electricity being supplied. Following that initial decrease, wholesale prices are expected to rise due to the increase of costs of fuel supplies as well as the price of CO2 certificates as seen in Figure 39.

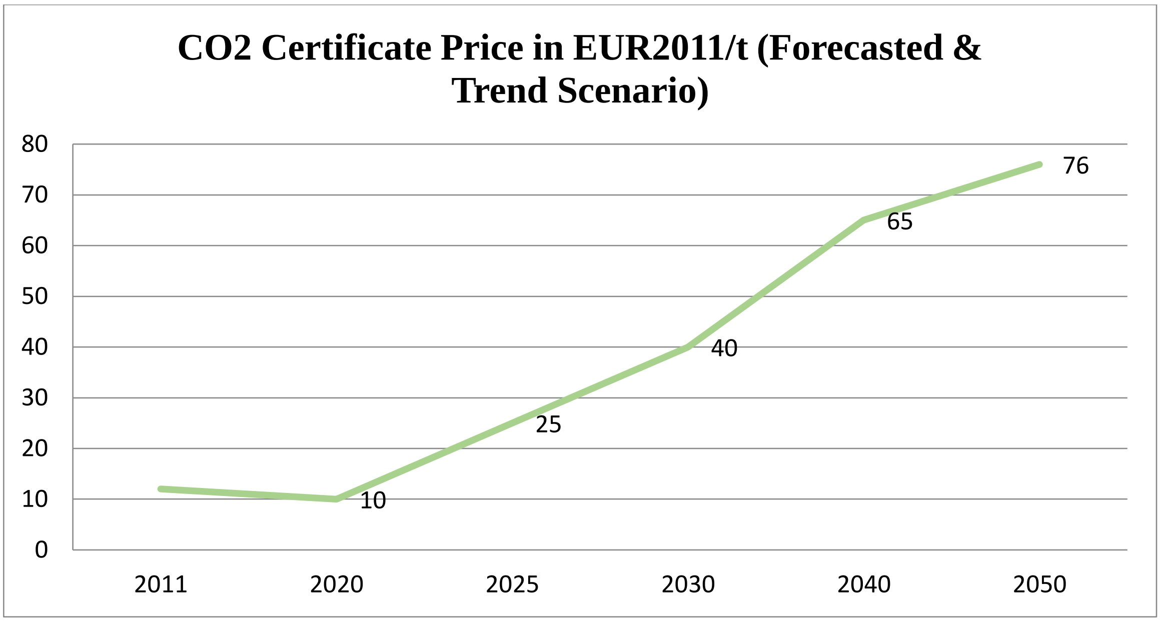

Figure 39: EU ETS Carbon Price Forecast (Schlesinger, Lindenberger, & Lutz, 2015)

Given that the renewables expansion will continue in the upcoming years, the EEG Surcharge that is added to the residential electricity price for end users is still expected to generally grow until 2020, causing the residential electricity price to continue rising until 2020. Eventually, after 2025 it is expected that the EEG Surcharge will start to decrease as shown in Figure 40:

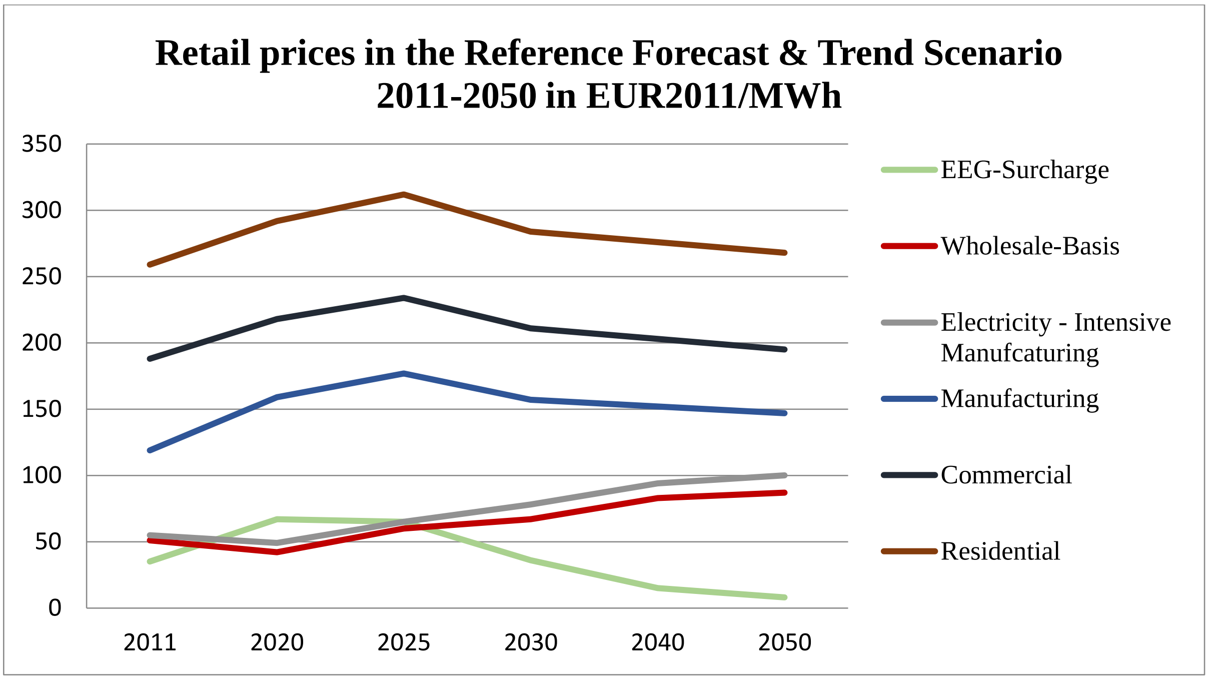

Figure 40: Forecasted Electricity Price Development (Schlesinger et al., 2015)

5.4 The Future Outlook: Market Setup

Over the next few years, Germany will continue with its Energiewende goals of increasing renewables even further and phasing out its nuclear capacity while ensuring that the grid becomes smarter and that demand response is available to German end users. In order to do so, Germany needs to ensure that there is constant security of supply and that the grid is able to support all the new changes.

There are currently two opposing views on how electricity markets should be further developed in Europe. On one hand, most European countries are supporting the idea of a capacity market that rewards the availability of generation capacity. They believe that the current low wholesale prices are too low to cover the cost of conventional generation and that governments should reward the power generators for their "potential to produce" (BMWI, 2015). This would guarantee sufficient power generation and security of supply. On the other hand, Germany argues that the current low wholesale prices are a clear indication of abundant generation capacity and that countries should therefore continue paying for electricity that is produced and sold on the market. This leads to the development of what the German government refers to as the 'Electricity Market 2.0'

If Germany continues on the path towards the Electricity Market 2.0, where prices are formed freely, we expect a number of developments to take place. The expansion of wind and solar power in Germany will continue to affect the electricity merit order curve by lowering the point at which the German wholesale electricity price is set. This is due to the fact that the addition of wind and solar power alongside modifications to the power plant fleet will lead more residual demand to be covered by peak load capacity as opposed to base load capacity. Since the variable cost of renewables is close to zero but that of the peak load capacity is much higher, it is expected that the electricity price continues to experience fluctuations that are more volatile and frequent. When renewable power is abundant, electricity prices will remain low; otherwise when there is no wind or sunlight for example, electricity prices will be set by the high marginal costs of the more expensive flexible capacities.

Given that solar power is expected to remain abundant during the middle of the day, it is expected that price peaks will tend to occur more often in the early evening hours. These price peaks will help the rarely used capacities to partially cover their fixed costs. This is due to the fact that at times where demand is very high, the system encourages producers with higher marginal costs to participate in the bidding process. Otherwise, the balance between the electricity supply and demand can also be covered with demand side management.

The German government considers the Electricity Market 2.0 scenario to be the cheapest solution especially for the integration of additional renewable energy sources. The concept of competition between the different market players will guarantee that the cheapest source is always selected first. The increased demand side management in the future will further guarantee that there is a system where all flexible consumers, flexible producers and storage systems will be able to respond to the intermittent supplies of renewables. This will not only be beneficial for the above mentioned groups, but also for companies who could reduce their energy and production costs if they choose to switch their operation hours to times with low electricity prices.

In 2015, the German government published a report where it stated: "*We forego the implementation of capacity markets, which can be expensive and inefficient and instead rely on the power of the markets*" (Appunn & Amelang, 2015). This statement is evidence of Germany's continued support for the Electricity Market 2.0 as opposed to capacity markets. However, based on the analysis provided in Chapter Four and Five of this paper, it is clear that while Germany is currently on its way to increase its renewables share in the electricity mix even further, the industry cannot survive without a share of fossil fuels. Given the German governments specific opposition to the introduction of a capacity market, the task of balancing supply and demand at all hours of the day will remain a key challenge in the future.

6 Conclusion

The recent developments in the German electricity market have had a profound effect on prices, which have in turn put a strain on the market mechanism and affected key stakeholders. While the German government's goals are clear in their objective to transform the market, the implications of the diverging electricity prices are that the large players, which have traditionally dominated the market, do not have the ability to carry out this transition on their own.

In order to fully understand the implications of the diverging prices, we first investigated why they are in fact diverging. From our assessment, it is clear that the mechanism by which wholesale prices are passed through to retail prices is not effective and the market is no longer able to respond quickly enough to the significant and continuous changes occurring. This is evidenced by the low correlation in general between the price in the two markets as well as between the wholesale price and the procurement component of retail prices. With the retail price increasing disproportionally, its correlation to the change in the EEG Surcharge supports the rationale that it is the market intervention driving change in the market.

The impact of market intervention can further be seen through the challenges faced by the traditional generators as their main revenue streams have decreased yet their investment requirements remain high. While the developments have led to the reduction of their ability to influence prices, a problem which has historically existed in the market, producers are facing significant financial trouble as a direct result of the developments. All of these factors have together led to a form of 're-regulation' of the electricity market given the way by which new, predominantly decentralized, capacity is being financed and maintained through intervention and not directly through the market itself.

Ultimately, it is German households who are disproportionally paying for the market developments and the energy transition. While the case for this is supported from an economic perspective given their inelastic demand, it must be considered in the context of the wider implications. With Germany's role as a net exporter of electricity, this means that it is essentially German households who are financing not only the energy transition of the German market but also to, some extent at least, the markets of neighboring countries. In theory, there are benefits to this, but in practice the disproportionate burden placed on German households is expensive and they are paying among the highest prices for electricity in Europe despite the wholesale price being amongst the lowest.

At this stage, increased renewables, decentralized generation and Smart Grid are the only certainties in the future. The main intersection of these aspects is no longer the traditional generators who despite operating in a deregulated electricity market have historically dominated most aspects of the value chain. Instead, it is in fact municipalities and cities that will be responsible for shaping the future of the German electricity market with a more regional focus, which supports bringing production closer to the point of consumption. As this trend towards decentralization increases and the role of consumers evolves into 'pro-sumers', the role of municipalities will be continue to be significant and support the country in achieving its ambitious goals.

Finally, we consider the transition to Electricity Market 2.0 to be a significant development for Germany in the future that will continue to evolve. The challenge that ultimately remains in the market is in maintaining the continuous balance in supply and demand across the entire grid. Inevitably, non-renewable energy sources still play an important role in electricity generation and in ensuring security of supply. However, as different technologies continue to evolve and with all the developments that have been observed, the dynamics of the market have certainly changed and will continue to do so in the years ahead.

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8 Appendix A: Wholesale and Retail Electricity Prices

The graphs below provide additional breakdowns to support the analysis in Chapter Four.

1. Spot Price vs. Procurement & Grid Cost

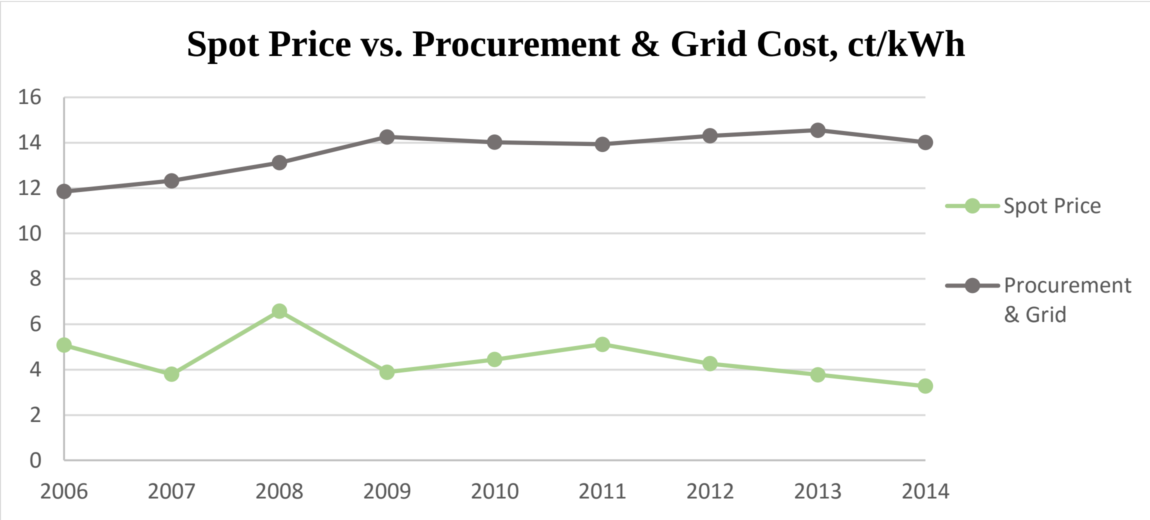

Figure 41: Appendix: Spot Price vs. Procurement & Grid Cost

The spot and the combined procurement & grid costs still have a very low correlation of: -0.355 over this time period. Given that the pricing behavior isn't the result of the procurement charge alone we can breakdown the household price into these two components as well as the additional taxes.

2. Procurement & Grid Costs vs. Other Taxes

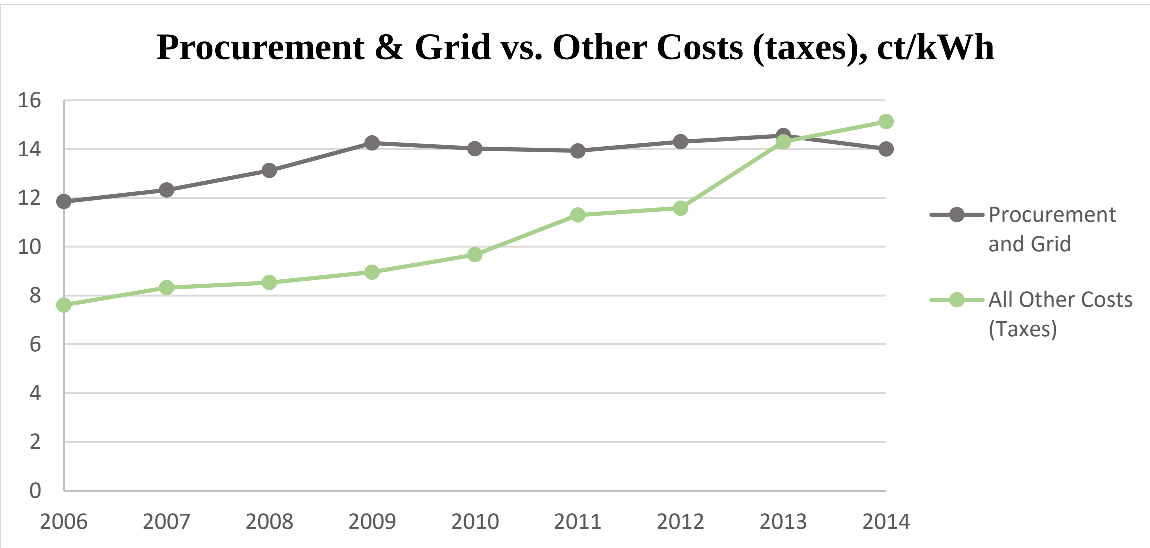

Figure 42: Appendix: Procurement & Grid Costs vs. Other Taxes

The above graph clearly depicts that it is mainly the taxes that are the cause for the continuously increasing German residential electricity price.

3. Household Price Components

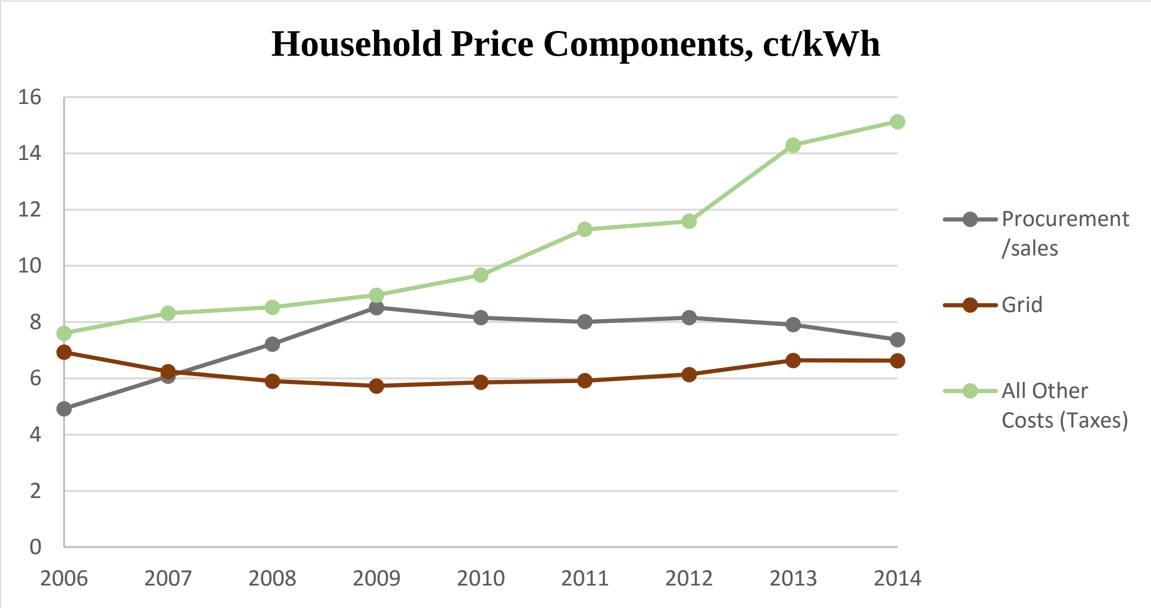

Figure 43: Appendix: Comparing Household Price Components

This is another graph that shows how in the timeframe from 2006 – 2014 both procurement and grid costs remained more or less equal while the tax components of the residential electricity price increased drastically.

4. Key Household Price Components

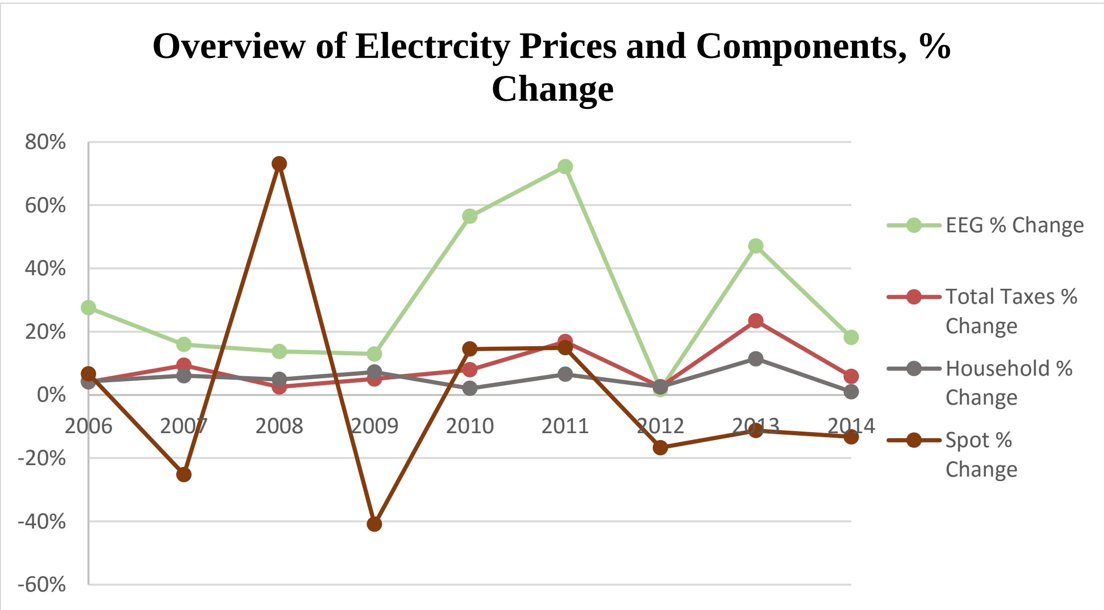

Figure 44: Appendix: Overview of Electricity Prices and Components

Based on the graph above, it is clear that the spot price percentage change does not correlate with the residential electricity price percentage change or any of its components. The relationship between the changing prices is therefore not clear.

5. EEG Surcharge vs. Residential Electricity Price

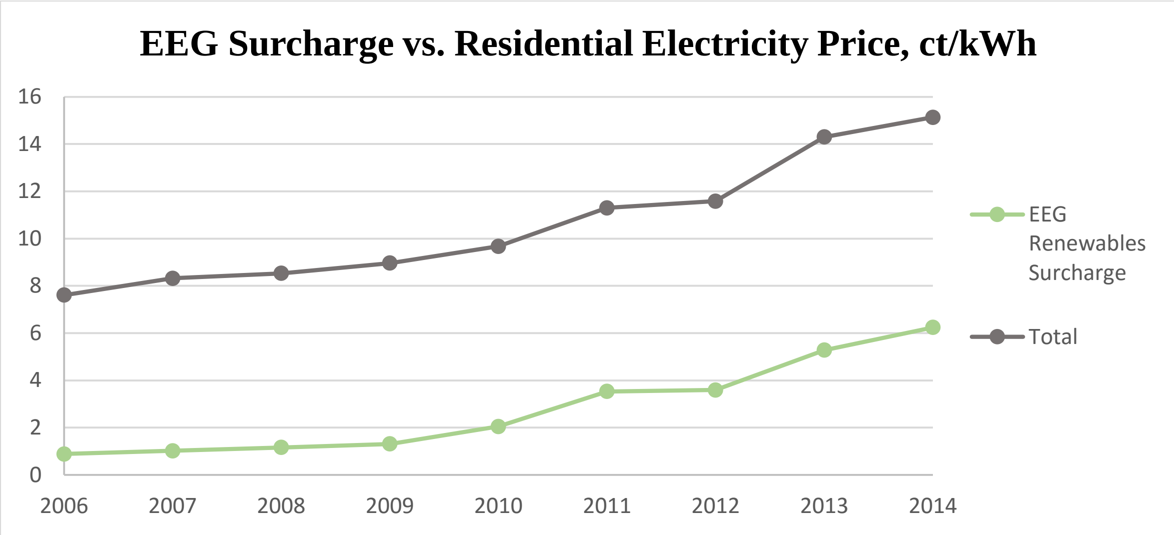

Figure 45: Appendix: EEG Surcharge vs. Residential Electricity Price

The graph above clearly depicts that the continuous increase of the total residential price is directly correlated to the increase in the EEG surcharge over the time period from 2006 until 2014. The correlation between the EEG Surcharge and the total residential electricity price is 0.995.

6. Residential Electricity Price (excluding EEG Surcharge) vs. Spot Price

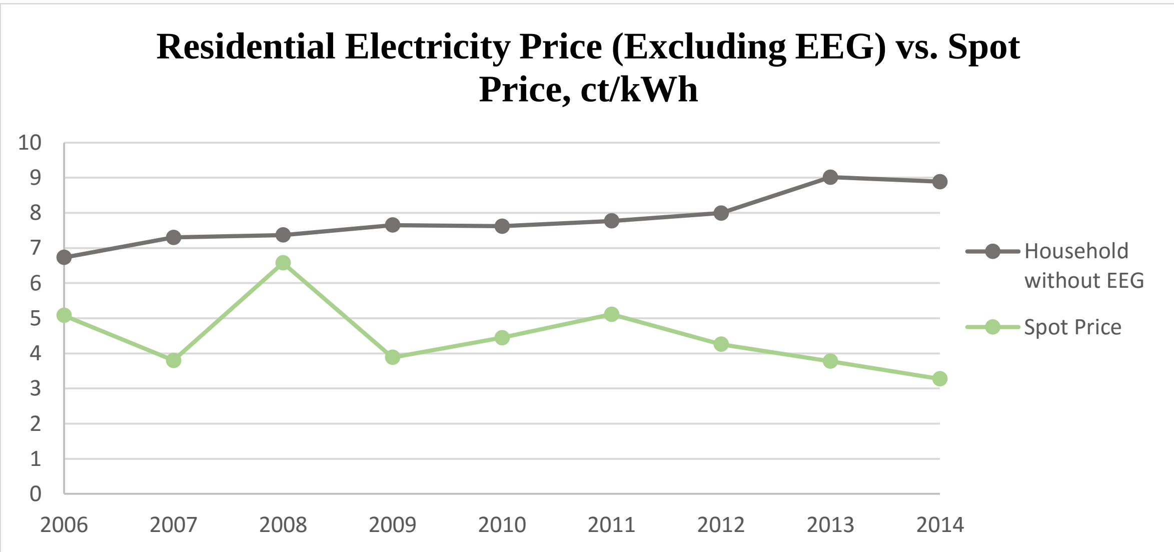

Figure 46: Appendix: Residential Electricity Price (exc. EEG) vs. Spot Price

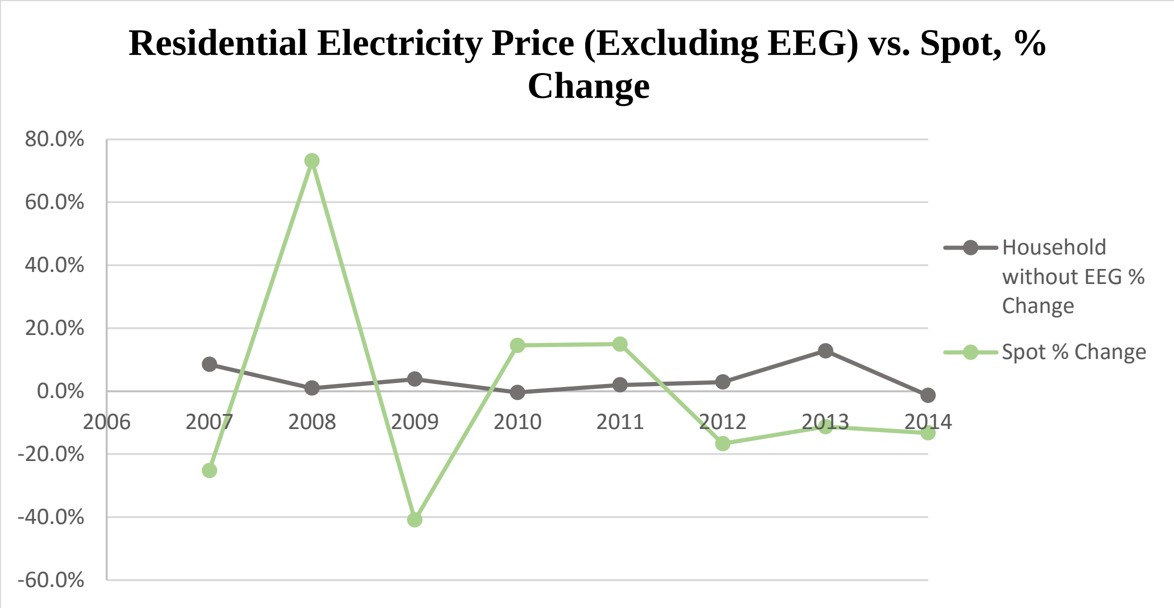

Figure 47: Appendix: Residential Electricity Price (exc. EEG) vs. Spot Price (% Change)

To further prove that the increase in the EEG surcharge is the main cause for the increase of the residential electricity price, the above graphs were created to compare the residential electricity price (excluding the EEG surcharge) to the spot price. It is clearly visible that the two sets are not correlated.

7. Price Comparisons: 2006, 2010 and 2014

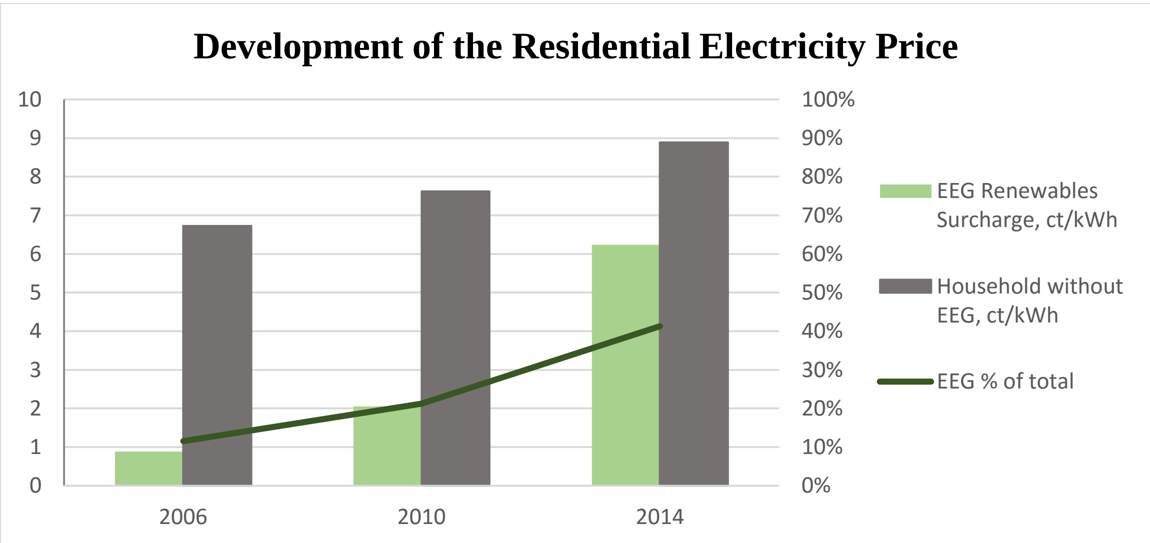

Figure 48: Appendix: Development of the Residential Electricity Price

The graph above depicts the development of the residential electricity price over the time period considered for this paper. At this rate of growth, the EEG Surcharge would cost more than the entire remaining household bill by 2018.

9 Appendix B: Supply and Capacity Data and Forecasts

1. Renewable vs. Non-Renewable Generation

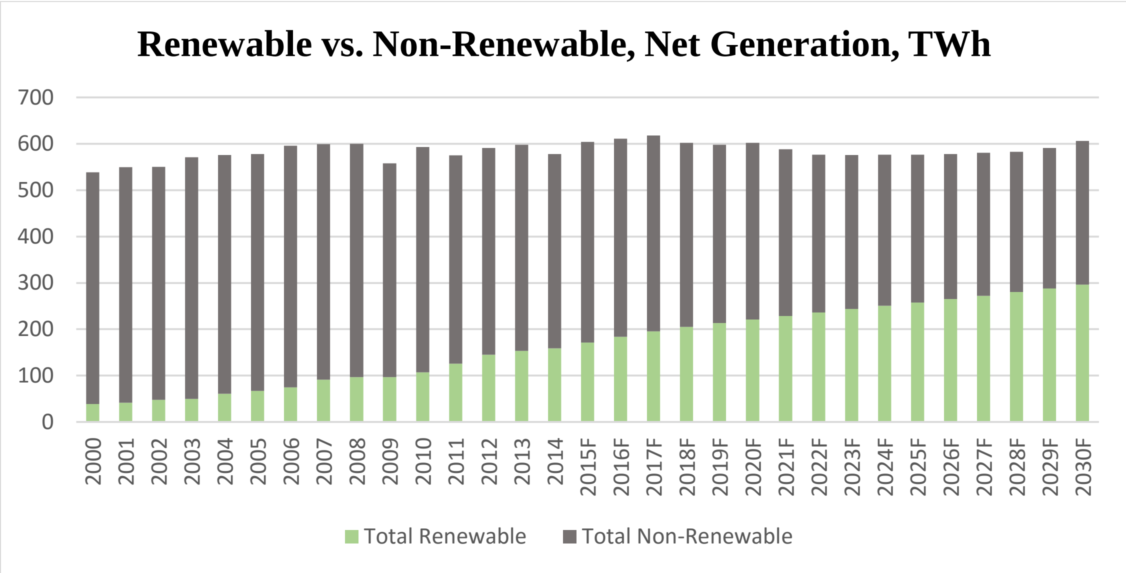

Figure 49: Appendix: Renewables vs. Non-renewables

Approaching Germany's 2030 target, the country will see renewables producing 48.8% of generation as opposed to the 28.3% in 2015. However it is clear that in terms of actual generation, there is still an overwhelming need for non-renewable energy. While the growth in installed capacity is a positive sign of investment in technologies the drawback of renewables is their comparably low utilization rates. Installed capacity can be seen in the following graphs:

2. Installed Capacity by Source

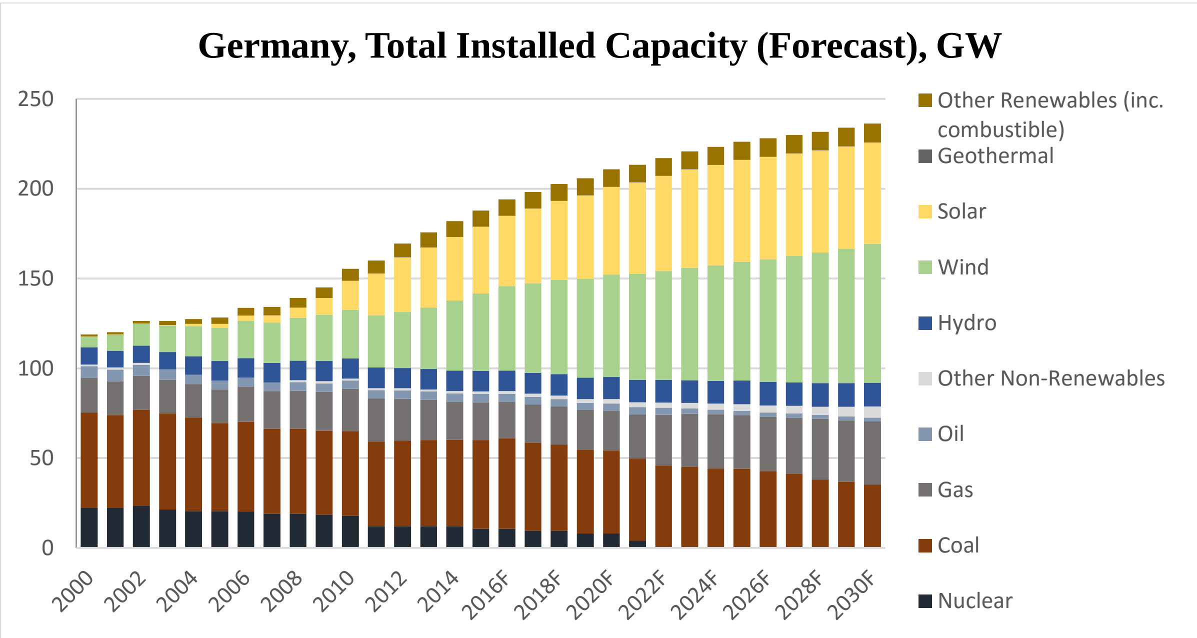

Figure 50: Appendix: Total Installed Capacity in Germany

3. Nuclear and Coal Installed Capacity

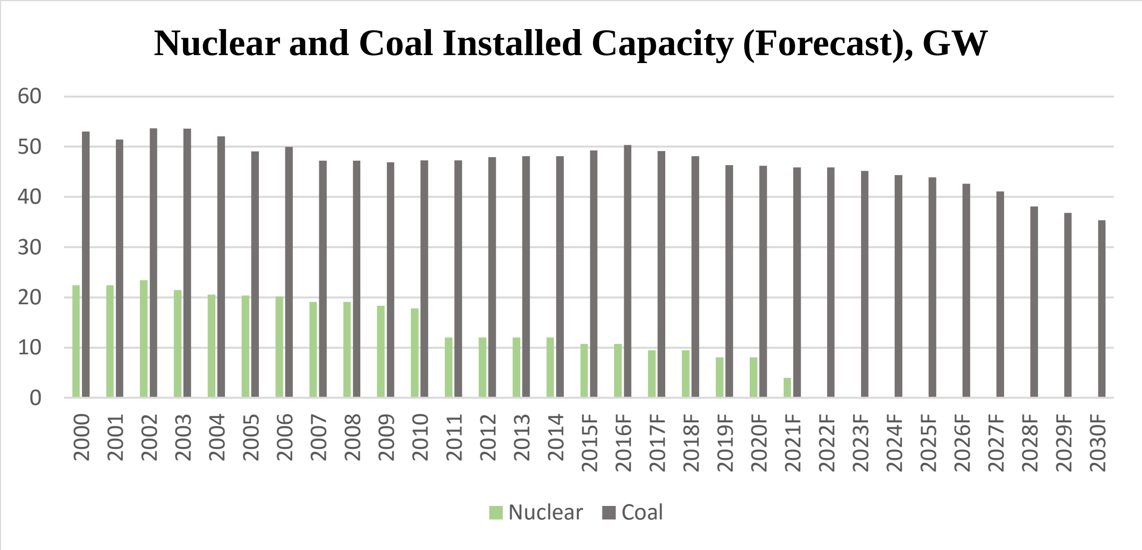

Figure 51: Appendix: Nuclear and Coal Installed Capacity

4. Installed Wind and Solar Capacity

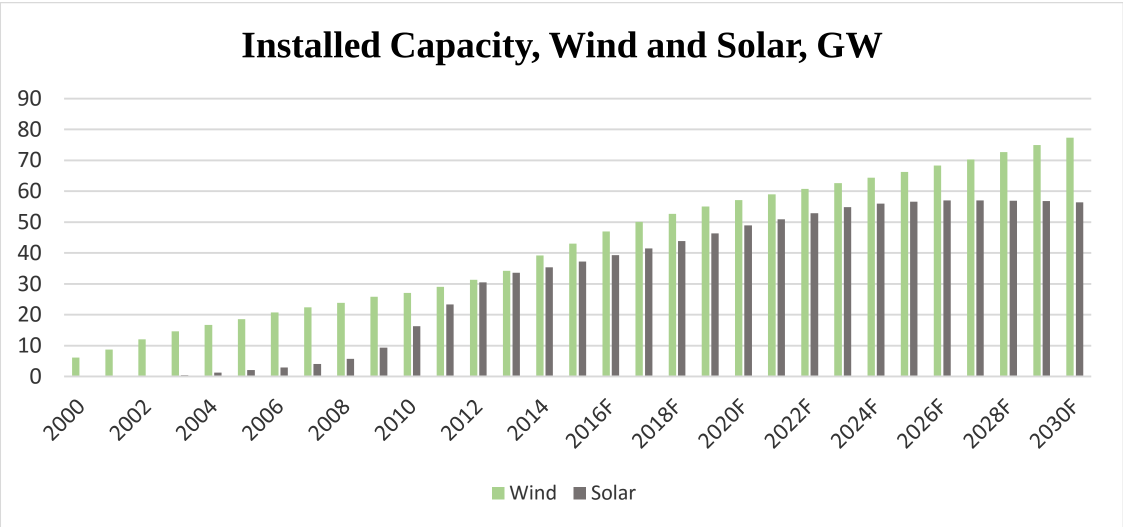

Figure 52: Appendix: Wind & Solar Installed Capacity

The peak in coal capacity in Germany is forecasted for 2016. This is clearly being used to counteract the decrease in nuclear energy given the intermittency of renewable power sources which cannot completely replace the phased out nuclear capacity. As a result of the Renewables Energy Act we can see the rise of both solar and wind energy sources and the projected capacity development in Germany but ultimately production from non-renewables remains high until 2030.

10 Appendix C: Demand Data and Forecasts

1. Industrial and Commercial Electricity Demand

Figure 53: Appendix: Industrial and Commercial Electricity Demand in Germany

As mentioned in Chapter Five, the residential sector is the only that has a decreasing electricity consumption forecast. This is made evident through the increasing industrial and commercial demand for electricity which despite being subject to economic trends, are projected to increase as the German economy continues to grow.

While an increasing amount of electricity is being used by these sectors it is worth reemphasizing the fact that there are many exemptions on taxes and charges that apply, particularly to the industrial sector. While these sectors, and society as a whole, also benefit from the increased generation of electricity from renewable sources, there is a disproportionate burden being placed on the residential sector to actually finance the transition.