Building a sustainable economy: market mechanisms, instruments and challenges of the German Energy Transition

Jonathan Tei Bergfeld

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Aarhus University, School of Business and Social Sciences: Department of Economics and Business

Academic supervisor: Jan Bentzen

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Abstract

This thesis investigates the instruments and market mechanisms of the German Energy Transition, as well as the challenges connected to these instruments and the Energy Transition in general. In the first part of the thesis an overview of the German electricity market and its development during the past 20 years is presented. After that the legal source of the Energy Transition, the Renewable Energy Act, and its instruments are described and discussed in more detail. In the second part of the thesis the focus shifts to the market mechanisms of the German electricity market and how these mechanisms are affected by the increase in renewable energy sources. Furthermore, the EU Emissions Trading System and its interaction with the Energy Transition in Germany are discussed. Finally, the end consumers’ involvement is investigated, including a discussion on the internalisation of external costs of fossil fuel-based energy generation.

The investigations and discussions are primarily based on existing scientific research on the German electricity market and general research from the field of energy economics. The investigation shows that Germany so far has achieved considerable results in terms of CO2 abatement and increase in renewable energy sources. Nevertheless, the instruments used have short comings as well. They do not lead to a sufficient market and system integration of renewable energy sources and allow for windfall profits for some market participants at the expense of the German end consumers. Looking at the market mechanisms it becomes clear that the increase in renewables lead to a significant price reduction in the electricity wholesale market via the merit order effect. However, this price decrease is not reflected in end consumer prices.

In addition there are interaction effects between the German, national renewable energy support scheme and the EU Emissions Trading System. The coexistence of the two instruments leads to a higher CO2 abatement. But here are also unfavourable interactions, such as a price reduction of allowances and an allocation rather than a reduction of EU-wide emissions. To draw a holistic picture, the end consumers’ involvement in the Energy Transition is investigated. The net benefit from avoided external costs of fossil fuel based electricity generation exceeds RES support payments from end consumers. However, the steady increase of the EEG allocation, partially due to the decreasing wholesale prices and industry discounts, leads to a higher, critical burden for end consumers and small and medium-sized businesses.

In conclusion it is argued that a constant revision and optimization of the instruments is necessary to provide a successful, financially feasible and socially fair Energy Transition. The ultimate goal must, however, be to integrate RES fully to the market, which makes support instruments superfluous.
Word List

**RES:** Renewable Energy Sources. Energy from resources which are naturally replenished within a short time frame (e.g. sun, wind, water)

**RE:** Renewable Energie

**FIT:** Feed-in-Tariffs. Remuneration RES owners receive for the production in order to make the investment economically profitable and increase RES deployment.

**EEX:** European Energy Exchange. Europe’s most important energy exchange in Leipzig, Germany.

**EU ETS:** European Union Emissions Trading Scheme. The biggest emissions trading scheme in the world, allowing participants to trade emissions allowances.

**EnWG:** Energiewirtschaftsgesetz. The fundamental law regulating electricity and gas supply in Germany.

**NTPA:** Negotiated Third Party Access. Institutional frame for the electricity supply industry which regulates the access to the electricity network.

**TSO:** Transmission System Operator. Entity organising the transportation of electricity on national level. In Germany also entrusted with the marketing of renewable energy (All in all four TSO’s in Germany)

**BnetzA:** Bundesnetzagentur. The regulating body in the German electricity market.

**OTC:** Over the counter. A trade which is done directly between two parties.

**EUA:** European Union Allowance. The certificates which are traded in the EU ETS

**GoO’s:** Guarantees of Origin. A label proving that electricity was produced by RES. GoO’s can be traded on the energy exchange.

**PHELIX:** Physical Electricity Index. Electricity index for Germany and Austria, representing the average spot market price

**GHG:** Greenhouse gas. Different gases which allow sunlight to enter the atmosphere but absorbs them when reflected from earth. Greenhouse gases, according to many scientists, are a major reason for global warming.
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I Introduction

As a result of the ever growing world economy there has been a dramatic increase in greenhouse gas (GHG) emissions. Scientists all over the world generally agree that there will be severe ecological consequences if nothing is done on this matter.

In 1997 the U.N. introduced the Kyoto Protocol, which required the industrialized countries to reduce their greenhouse gas emissions by 5% over 1990 levels, by the year 2012 (Prins & Rayner, 2008). In order for those states to fulfil the obligations, reforms on national level were necessary. In this thesis parts of the German electricity market will be examined, as they present a good example of how comprehensive reforms and a proactive political approach lead to a more sustainable economic growth. They also give an impression of the challenges, uncertainties and the costs that are connected to a transition to a “greener economy”.

Throughout the past 20 years the German electricity market has been through some major structural reforms. It started with the liberalisation of the national energy market, which was initiated by the EU liberalisation directive in the late 90s, followed by the introduction of the so called “Erneuerbare- Energien-Gesetz” (Renewable Energy Act, EEG) in the year 2000. The latest development, which also had a considerable impact on the market, was the acceleration of the nuclear-phase-out, triggered by the Fukushima nuclear disaster in 2011. The aim of the latest reforms is a transition to a more sustainable and environmental-friendly economy. This includes a substantial reduction in greenhouse gas emissions and a strong increase of renewable energy sources (RES), which shall displace conventional fossil fuel-based energy sources.

With the introduced reforms Germany became a pioneer in sustainable economic development. The EEG is the main feature and pillar of the so called “Energy Transition” (German: Energiewende), which is a commonly used term for the intended transformation to a greener economy. The most successful instruments in the EEG are favourable feed-in tariffs (FIT) for a variety of RES (Hildmann, Ulbig, & Andersson, 2013). These FIT guarantee owners of RES a fixed remuneration for each Kilowatt electricity their assets provide to the network. The amount paid out is usually higher than the spot price, which is settled on the European Energy Exchange (EEX) (Marcantonini & Ellerman, 2013). The reason why these support schemes are necessary is that it from an economic perspective it is not profitable to invest in RES. The FIT are giving investors the necessary incentive to invest in RES. As a result of the FIT, the share of RES increased from 6.3% in 2000 to 15% in 2008 and the target to reach a share of 12.5% by 2010 was reached in 2007 already (Büsgen & Dürrschmidt, 2009).
Even though the increase in RES and a subsequent reduction in CO2 emissions cannot be rejected, there are ongoing discussions on whether the used schemes and instruments are efficient and economically viable.

The transition to a greener economy is connected to considerable costs which are mainly covered by the end consumers, as the premium paid to RES producers is covered by the consumers via a surcharge on the electricity bill (EEG allocation).

Another topic of discussion is the interactions and coordination of the national EEG instruments with supranational EU policies targeted to reduce CO2 emissions – namely the EU Emission Trade System (EU ETS). Research has been done on these interaction effects and call for a more coordinated approach in order to keep the overall efficiency of climate policies high (Rathmann, 2007; Weigt, Ellerman, & Delarue, 2013).

Germany has set very ambitious targets in terms of CO2 reduction, increase of RES and an overall efficiency enhancement of the energy sector. The aggressive RES penetration initially leads to high costs for society. The integration of RES to a traditionally centralized electricity infrastructure brings many challenges and risks, which call for innovative solutions and new ways of thinking. A central concern is, therefore, whether the costs and investments undertaken to reduce CO2 emissions and transform the energy sector will ultimately exceed the actual intended benefit for society and the environment.

The aim of this thesis is to give a general overview and analysis of the German Energy Transition and its underlying market mechanisms and instruments. Furthermore, economic implications for the German electricity market will be investigated and challenges, short-comings and pitfalls will be discussed. The purpose of this thesis is, however, not to give an overall evaluation of the Energy Transition, as this is far beyond the scope of this investigation. Moreover, since the transition is still going on, an overall evaluation might not yet be possible.

To get a holistic understanding of the topic under investigation, a general description of the German electricity market will be given. Afterwards the EEG, its instruments, and the influence on the electricity market will be discussed. This includes a description of the EEX, which plays in important role in integrating RES into the market. As mentioned above, the repercussions the EEG has on the German market correlate with the EU ETS. This relation will also be analysed.

Although the thesis will mainly focus on market mechanisms and instruments of the EEG, a short insight to the implications the Energy Transition has for the German end consumers will be given. This is important as the end consumers currently carry the financial burden of the Energy Transition.
2 The development of the German electricity market after 1990

In order to understand the dynamics of the German electricity market it is necessary to know its major characteristics and recent history. Therefore, a brief introduction of the development of the market after 1990, including the liberalisation, nuclear phase out and Energy Transition will be given.

2.1 The liberalisation

Prior to the liberalisation the German electricity market was characterised by a monopolistic structure and was largely dominated by few, vertically integrated suppliers. This meant they controlled production, transport and distribution and the end consumer prices for electricity were determined by the cost-plus method (Erdmann, 2008). Those powerful players prevented other suppliers to enter the market and had control of their regional monopolies. Figure 1 shows a simple illustration of the value chain of the German electricity market:

![Figure 1: The value chain of the German electricity market. Source: Own illustration](image)

Following the EU liberalisation Directive 96/92/EC concerning the common rules for the internal market of electricity, the German Government adopted the “Energiewirtschaftsgesetz” (EnWG) in 1998. The EnWG translated the EU directive into national law and built the foundation for the liberalised German electricity market. Although the EU liberalisation directive only required at full liberalisation of the electricity market until the year 2007, Germany’s electricity market was theoretically fully liberalized by 1999 (Kemfert, 2004). The most essential step in this process was to unbundle the vertically integrated businesses of the dominating suppliers. The EnWG required those dominating utilities to separate the businesses of production, transportation and distribution into different accounts. In that way the areas of production and distribution were fully deregulated and open to competition. The operation of the grid (transportation of electricity) remained in the hand of the big utilities as it from an economic perspective would not be cost effective to open these essential facilities, which can be characterised as natural monopolies, to competition. However, these bottlenecks had to be regulated in order to ensure non-discriminatory network access for the other independent electricity suppliers (Wein & Growitsch, 2005). Unlike all other countries, Germany chose the so called Negotiated Third Party Access (NTPA) to regulate the network access. NTPA allows the network suppliers to negotiate the terms for access with the network demanders and there is no governmental regulation authority involved. Due to the lack of the intended level of
competition the European Commission abolished the NTPA and Germany consequently established the Bundesnetzagentur (BnetzA) as the regulating body for non-discriminatory access to the electricity grid.

2.2 After the liberalisation

Following the deregulation of the market, its landscape changed. After consolidations and mergers there are now four big utilities dominating the market. Even though the market theoretically is fully liberalised and there are more than 1000 different suppliers in the market, the so called “Big Four” (E.ON, Vattenfall, RWE and EnBW) still have considerable market power. They are still integrated throughout the value chain (the transmission networks, however, are now operated by subsidiaries, Transmission System Operators (TSO’s) and regulated by the BnetzA) and account for approximately 80% of the overall power generation in Germany. The capacity distribution and feed-in from 2007 through 2008 was as follows:

<table>
<thead>
<tr>
<th>Generator</th>
<th>Capacity distribution (MW)</th>
<th>Total electricity feed-in (TWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2007</td>
<td>2008</td>
</tr>
<tr>
<td>EnBW</td>
<td>11.199 (12%)</td>
<td>11.379 (12%)</td>
</tr>
<tr>
<td>E.ON</td>
<td>21.888 (23%)</td>
<td>21.912 (23%)</td>
</tr>
<tr>
<td>RWE</td>
<td>31.735 (34%)</td>
<td>31.755 (33%)</td>
</tr>
<tr>
<td>Vattenfall</td>
<td>15.606 (17%)</td>
<td>15.662 (16%)</td>
</tr>
<tr>
<td>Total</td>
<td>80.426 (85%)</td>
<td>80.709 (84%)</td>
</tr>
<tr>
<td>Market volume</td>
<td>94.433 (100%)</td>
<td>95.756 (100%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>EnBW</td>
<td>54.6 (12%)</td>
<td>49.2 (11%)</td>
</tr>
<tr>
<td>E.ON</td>
<td>106.9 (23%)</td>
<td>102.5 (22%)</td>
</tr>
<tr>
<td>RWE</td>
<td>164.7 (35%)</td>
<td>167.7 (36%)</td>
</tr>
<tr>
<td>Vattenfall</td>
<td>77.3 (17%)</td>
<td>71.0 (15%)</td>
</tr>
<tr>
<td>Total</td>
<td>403.6 (86%)</td>
<td>390.4 (84%)</td>
</tr>
<tr>
<td>Market volume</td>
<td>467.9 (100%)</td>
<td>465.1 (100%)</td>
</tr>
</tbody>
</table>

Figure 2: Capacity distribution and total electricity feed-in 2007/2008. Source: Bundeskartellamt

Figure 2 shows the generation capacity and the actual feed-in of the Big Four from 2007-2008. Even though the distribution today is a bit different, this is still a fair representation.

The large number of suppliers on the German market can be explained with the large number of smaller public utilities, mostly operating in their communal area or region as universal service providers for electricity, gas and water supply. The Big Four are often shareholders in those so called “Stadtwerke” or vice versa. However, it should be mentioned that the Big Four’s overall market share in the generation market has decreased as Germany has accelerated the nuclear phase-out, which will be further elaborated on in a later section.

The sustained dominance of the Big Four is the reason that some argue that the liberalization of the German electricity market failed at least it’s the first stage (Erdmann, 2008). Nevertheless, the Big Four are
also losing market share in the end customer business as regional and independent suppliers expand their businesses to national level, which is a clear sign of increased competition in the market. The following figure shows the market shares in electricity sales to end customers:

![Market share diagram](image)

**Figure 3: Market shares in 2009 (including consolidated subsidiaries) in electricity sales to final consumers (electricity sales to final consumers inside Germany – total electricity supply). Source: BDEW, 2009**

Since its adoption in 1998 there have been frequent amendments to the EnWG in order to adjust it to the changing market settings and requirements by the EU. However, in its essentials the EnWG is still the same today.

Another factor which had an immense impact on the landscape of the German electricity market is the politically initiated Energy Transition (“Energiewende”) which was instrumentalized in the Renewable Energie Act (EEG) in 2000. As a result of the EEG the RE share in the German energy mix has increased dramatically. This has had such a significant impact on the market that it will be described separately in the next section of this paper. Also, the EEG is one of the most essential topics of this paper.

### 2.3 The nuclear-phase-out

In 2000 the German government, consisting of a left wing socialism coalition of SPD and Alliance ’90/The Greens, announced the step wise nuclear-phase-out of the German energy sector by the year 2020. The power generated by the 17 nuclear plants should be gradually replaced by primarily RES. However, concerns arouse that the volatile nature of RES production could not replace the reliable and constant
energy supply of nuclear plants, which in turn would lead to an increase of conventional coal fired power plants with much higher CO2 emissions than nuclear plants. This argument, in combination with increasing prices of fossil fuels, led to the so called phase-out of the phase-out, initiated by the succeeding conservative administration of CDU/CSU and FDP, which extended the life time of the nuclear plants by 8-14 years (Www.bundestag.de.2010).

In 2011 the Fukushima nuclear accident changed the phase-out plans all over again as the administration reversed its policy due to rising safety concerns on nuclear energy supply. Of the existing 17 nuclear plants 8 were shut down immediately and the administration roughly went back to its predecessors plan and promised to shut down all nuclear power plants by the end of 2022 (Schreurs, 2012).

The nuclear-phase-out plays an important role in the German Energy Transition as it increases the need for additional RES penetration to compensate for the existing 16% (2012) of nuclear power production (Kirsten, 2014a). Furthermore, it adds to the complexity of a save and reliable national energy supply, due to the volatile nature of RES' electricity production.

Considering that electricity markets still are heavily regulated in many countries, the German market is fairly liberalized in comparison. The large number of suppliers, the increasing share of RES and its independence of nuclear production in the future has made the German electricity market a role model for sustainable growth and deregulation in the energy sector. Yet many challenges and uncertainties have to be overcome and continuous development and adjustment from the political as well as societal stakeholders are necessary in order to maintain and develop an efficient market.

3 Erneuerbare-Energien-Gesetz – The Renewable Energy Act

The legal source and centrepiece of the German Energy Transition is the EEG. The EEG was introduced in 2000 and followed the Stromeinspeisungsgesetz from 1991 (Büsgen & Dürrschmidt, 2009). According to article 1, paragraph 1 of the EEG (Http://Www.erneuerbare-energien.de/.2014a), the primary goals of the law, with regard to climate and environmental protection, are:

1. To facilitate a sustainable energy supply
2. To reduce the cost of energy supply, including long term externalities
3. To spare fossil resources
4. To facilitate the development of technologies for renewable energy production.

Paragraph 2 states that the share of RES in the overall German energy mix shall reach a minimum of 35% by 2020, 50% by 2030, 65% by 2040 and 80% by the year 2050. To reach those ambitious goals the EEG is concerned with two dimensions: rules for the preferred access of RES to the electricity network and
regulations for FIT for a variety of RES (Hildmann et al., 2013). In particular the law supports energy production of hydro, solar, wind, geothermal and biomass installations. Those two dimensions will now be explained in more detail, after which the impact of the EEG’s on the market briefly will be presented.

3.1 Preferred network access

According to article 2 of the EEG, all network operators are obligated to grant network access for new RE installations, as well as they are obligated to preferentially feed-in the production to the grid over conventional production (i.e. coal or gas fired plants), regardless of the actual electricity demand in the market (Http://Www.erneuerbare-energien.de/.2014a). At the same time the network operators has the responsibility to provide the necessary grid capacity to feed in the RE in its specific network area. Conversely the operators of RES are obligated to feed in the production to the respective network operator. Only if the energy produced by the installation is used for own consumption, or if the operator or a third party markets the production himself, this rule does not apply (Http://Www.erneuerbare-energien.de/.2014a). The network operators pass the electricity they received from RES and all the costs connected to it further on to the respective TSO. It is eventually the TSO’s task to market the electricity on the EEX where it will be sold as so called “grey electricity”, which means it is a mix of energy from renewable, as well as conventional production.

The RE producers receive feed-in tariffs which are set higher than the price that the TSO can earn on the energy exchange. The difference between the price the TSO earns on the exchange and the amount paid out to the producers is a major cost driver of the Energy Transition and topic of fierce discussion, as it is paid for by the end consumers via the electricity bill as the so called EEG allocation.

3.2 FIT and Market Premium Scheme of the EEG

As renewable energies at the current technological stage are not economically competitive (Gawel & Purkus, 2013) it is necessary to promote the feed-in of electricity of RES in order to give investors sufficient incentives to invest in RES. However, at the same time, in order to provide incentives for demand oriented production, efficient exploitation of existing capacities and supply security, the promotion schemes have to be designed so that they send effective short and long term market signals to the producers (Büsgen & Dürrschmidt, 2009). In the German market this is done by two different options from which the producers can freely choose on a monthly basis. On one hand the producers have the possibility to feed in the electricity production at a fixed price, which they receive by the TSO. This fixed FIT is higher than the
average spot price on the EEX, which means that the producers are earning a secure extra profit compared to the actual market price of electricity. The FIT is guaranteed for 20 years, but degressive in nature. That means that the amount decreases each year and the earlier an installation is build, the higher the remuneration. Also, the FIT is dependent on other factors such as the geographical location of the installation (wind and solar insulation can vary greatly depending on the location) and the technological specifications of the installation. The reason for those differences in remuneration is that they should give an incentive for technological innovation, and increased demand oriented and efficient production in the future.

The other option the producers can choose is the so called Market Premium Scheme, where the producer markets the production directly on his own. This feature was introduced in the latest amendment of the EEG in 2012 (Gawel & Purkus, 2013). The direct marketing approach bears higher risks for the producer but it also allows for extra profits. The differences between the two options are illustrated by the following figure:

![Diagram of the German market premium scheme](image)

**Figure 4: Overview of the German market premium scheme. Source: (Gawel & Purkus, 2013)**

Gawel and Purkus (2013) have in their case study on the German Market Premium Scheme used following equation to illustrate the earnings connected to the scheme:

\[
MPR_{Gross} = (FIT - MV)_{MPR_{Net}} + MPP
\]

where \(MPR_{Gross}\) is the total premium that can be earned in the Market Premium Scheme, \(FIT\) is the technology specific FIT that an installation could earn using the conventional approach with a fixed FIT received by the TSO, \(MV\) is the average spot price of electricity for a given month, and \(MMP\) is the Management Premium a producer receives for directly marketing the electricity in the market. \(MPR_{Net}\) is a
compensation the producer receives by the TSO for the loss of marketing the electricity directly compared to receiving the FIT. This means it is the difference between the monthly average spot price on the EEX and FIT. MV, the monthly average spot price (market value benchmark) is calculated monthly ex post, based on the hourly spot prices on the EEX (Bechberger & Reiche, 2004). In order to take the specific production patterns of different RE technologies into account, MV is adjusted accordingly. For instance, solar production will be highest at noon, where demand is high and prices subsequently as well. Wind production, on the other hand, is totally independent of actual demand and can thus have negative effects on the prices and grid stability. This gives solar energy in some aspects a higher market value than wind energy (Gawel & Purkus, 2013). MPP, the Management Premium for the direct marketing RE production, intends to cover additional costs the marketer incurs and is a fixed monthly amount. Those are for instance licence and IT costs for trading on the energy exchange, administrative costs and costs for developing prognosis of the production. Furthermore it covers balancing costs, as the producer has to buy balancing energy from the TSO as soon as the actual production deviates from the prognosis. MPP is also technology specific and distinguishes between dispatchable and intermittent RES. As intermittent RES are subject to forecast errors and consequently have higher balancing costs, the MPP is considerably higher for those technologies (Gawel & Purkus, 2013). The total premium paid to direct marketers thus consists of the variable difference between the average monthly spot price and the technology specific FIT, plus the Management Premium. Of course the producer also gets the earnings he generates by directly selling to the market.

As mentioned before the Market Premium Scheme allows for additional profits for the producers but it is also connected to a higher risk. In figure 4 on the right hand side the two profit options connected to the Market Premium Scheme are presented. If the marketer can place the production in the market for a higher amount than the monthly average spot price, the earnings will be higher than with the conventional FIT. If, on the other hand, the marketer is not able to place the electricity in the market at a higher price than the average spot price, the producer will experience a loss relatively to the FIT. This makes the Market Premium Scheme compelling for RES producers, of which many outsource the actual marketing of the electricity to external service providers which have high expertise and scalability in the field and can provide extra earnings with relatively low risk. Here the question must be raised whether it is desirable that private firms or investors have the possibility to earn windfall profits on the expense of end consumers, and on a scheme which originally was introduced for the greater good of society.

The Market Premium Scheme was introduced to create a more market oriented RE production, as well as to support efficiency improvements and technology innovation. It intends to turn producers of renewable energy from passive participants to active actors in the market and serves the overall system and market integration of renewables (Gawel & Purkus, 2013). The producers align their production decision to market prices which in turn increases the overall efficiency as well as it adds to grid stability. An important factor
why a demand oriented production in case of electricity is more important than for other commodities is that it cannot effectively be stored. This can lead to the phenomena of negative electricity prices, which occurrence is increasing as the share of intermittent RES is growing (Fanone & Gamba, 2013). Negative electricity prices can be the result of different things, for example sudden slumps in demand, network restrictions or inflexible power plants. But typically negative prices occur in situation of low demand and high supply. A typical scenario could be a stormy night where most industry and household consumption is low and wind generation is high. In order to keep the grid stable and to achieve a market clearing prices on the EEX will be negative, which has the controversial effect that electricity producers have to pay for their production.

The actual use of the Market Premium scheme turned out to be much higher than anticipated by the TSO’s, who initially expected that around 15% of onshore and around 33% of offshore wind producers would opt in to the scheme. In reality, in 2012 around 68% of on and off shore wind production was using the scheme to market the electricity production, which clearly stood out from the other RE technologies. Around 28% of Biomass producers used the scheme in 2012 and only 3% of PV producers were using the scheme. This can be explained by the decentralized and small nature of PV installation, which makes scalability low and transaction costs relatively high in comparison to the earnings connected with scheme (Gawel & Purkus, 2013).

Figure 5: Shares of different direct marketing options in RES electricity production. Source: (Gawel & Purkus, 2013)

Figure 5 shows the shares of the different technologies using direct marketing. Overall the direct marketing is most profitable for producers of wind energy. This is why wind production has the major share in the overall use of the scheme of all RES, as can be seen in figure 6:
When evaluating the Market Premium Scheme Gawel and Purkus (2013) distinguish between two factors/objectives of the scheme. Firstly, they argue that even though market integration in a larger sense is the goal of the EEG, i.e. letting the electricity price guide investments and determine the electricity mix, this cannot be the primary objective of the optional Market Premium Scheme. The reason is that the producers’ exposure to price risk, compared to the conventional FIT, would compromise investment incentives and thus contradict the ambitious RES expansion targets.

The incentives for changing distribution channels, meaning away from an economically inefficient FIT where TSO’s have to market the electricity, towards a direct marketing approach by active and market oriented producers is mentioned as one important evaluation factor. Here it is argued that the incentive for changing distribution channels is expected to not only be triggered by the possibility of extra profit by demand oriented production, but that the MMP plays an important role. It is said to be set too high, which allows for windfall profits especially for large-scale RES producers who benefit from increasing returns to scale and thus have a competitive advantage compared to small-scale RES producers. Furthermore the strong degressive nature of the MMP may incentivise producers to opt out of the Market Premium Scheme in the medium run and return back to the FIT, if this should prove more profitable. This clearly compromises the incentives for changing distribution channels in the longer run and is a weakness of the current system.

Secondly, it is important whether the Market Premium Scheme is setting incentives for improved system integration. It is argued that by encouraging demand oriented production, which means that producers can earn additional profits when aligning their production to short term market system, the scheme adds to the grid stability and system integration. This in return leads to savings on to balancing costs and means a direct economic improvement. However, the schemes incentives are not strong enough to encourage investments in for example flexibility adding storage system for intermittent RES. This still leaves the
problem of insufficient demand oriented production of the intermittent RES, resulting in high price volatility and thus high balancing costs.

In conclusion it is argued that the Market Premium was and still is successful in terms of the change of distribution channels and that it harmonizes with the overall goal of increasing the RES share in the electricity mix. However, the challenges are complex and many factors have to be taken into account when evaluating the scheme. Especially the inadequate system integration of intermittent RES and the high support costs connected to them (too high MMP) call for improvements of the scheme, whereas producers of dispatchable installations in principle are sufficiently incentivised to change to a demand oriented production (empirical support on dispatchable RES production yet missing). Gawel and Purkus (2013) say that in the longer run more holistic and systemic concepts, which take the intermittent RES, grid expansion, storage capacities and demand- side management into account, are required.

It is important to mention that this evaluation is concerned with the economic aspects of FIT and especially the Market Premium Scheme, not the Energy Transition and the EEG itself.

3.3 The impact of the EEG on the German electricity market

As mentioned before the EEG has had an enormous impact on the German electricity market and all parts of its value chain, from production to end consumers. In 1990, before the introduction of the first FIT scheme, the RES share of the overall electricity production was only at 3% and most of the electricity was produced by conventional and dispatchable, fossil fuel-fired or nuclear power plants. Following the introduction of the first FIT scheme in 1991, the Stromeinspeisegesetz, and the later introduction of the EEG and the Market Premium Scheme, the share of RES has risen to approximately 23.6 % of the total electricity production in 2012 (Http://Www.erneuerbare-energien.de/.2014b; Kirsten, 2014a; Kirsten, 2014b). Furthermore it is estimated that for the five years 2006 through 2010 a reduction of 35 to 60 Megatons or 10% to 18% of the normal CO2 emissions without RE incentives has taken place (Weigt et al., 2013).

The incentives given by the support schemes grant investors the necessary long term security and heavy investments in RES happened ever since. Looking at the RE share in the German electricity mix one could argue that the German Energy Transition has been a success until this stage, as the goal of reaching a RES share of 35% by 2020 seems realistic. Therefore, the German Energy Transition and the instruments used to enforce it are used as a role model by many other countries.

Figure 7 shows the development of the technology specific RE production from 1990 to 2011:
From figure 7 we can see that the technology that showed the biggest growth is wind energy. This can be explained by the favourable FIT which is technology adjusted and bears higher profitability for owners of wind energy installations, compared to other technologies.

The increase of RES changed the energy mix in Germany significantly. Figure 8 shows the energy mix in Germany in the year 2012:

![Energy Mix in Germany 2012](image)

**Figure 8: Gross electricity production in Germany 2012, total amount 618 TWh. Source: (Kirsten, 2014b)**
The share of RES in Germany’s electricity generation has increased to above 20% today, mainly replacing nuclear plants and coal fired plants, which is in line with the objectives of the Energy Transition and the nuclear phase out. Looking at the transformation from a simplistic view point, the Energy Transition has been a huge success so far. However, it is much more complex than that. Apart from the obvious measurement of RES share in the electricity mix or tons of CO2 abated, other factors in a larger economic context, for instance supply security, social costs, internalisation of external costs and end consumer prices have to be taken into consideration when assessing the German Energy Transition. To investigate all these factors is beyond the scope of this investigation. In the next part of the thesis some of the market mechanisms will be explained in more detail. This will help to understand the underlying processes of the Energy Transition, most importantly the price formation of electricity. Furthermore it is important how the EEG, which works solely on German national level, interacts with supranational abatement policies and whether this affects the functionality and efficiency of the EEG and the German Energy Transition in general.

4 The European Energy Exchange

So far an overview of the development and liberalisation process of the electricity market has been given. Also the Energy Transition, the nuclear phase out and the instruments used to enforce the Energy Transition have been explained. A central role in the Energy Transition plays the EEX. It is here the electricity produced by RES is traded either by the TSO or the direct marketers. Regardless whether TSO or the direct marketers trade the electricity on the EEX, it always has preferred access before the conventional plants. This creates complex effects in the price formation of electricity. In order to get a deeper understanding of the impact of the Energy Transition, it is important to understand the mechanisms and functions of the EEX.

The power generated in – or imported to Germany is either traded on the EEX as standardized products; or over-the-counter (OTC) on bilateral negotiated terms between two parties. The OTC market in contrast to the EEX is not regulated and the two parties can freely choose the conditions of the contract. Overall this market is called the electricity wholesale market and is depicted in the figure below. In this thesis the focus will be on the electricity traded on the energy exchange as there is no obligation to publish data on bilateral OTC trades and thus no reliable data exist. Furthermore, some important effects the RES have on the market can be explained by mechanisms taking place on the EEX.
The EEX is located in Leipzig, Germany, and is Central Europe’s most important energy exchange. It was established in 2002 and formed by a merger of The European Energy Exchange AG and Leipzig Power Exchange GmbH (EEX AND LPX TO FORM NEW POWER EXCHANGE.2001). The EEX has a key function in the liberalised electricity market, as it ensures a transparent way of energy trading, leading to more competition and lower prices for end consumers. Its purpose is thus to enhance the liberalisation and integration of the European energy market by connecting liquid and secure energy markets and products. This is done by offering standardized and transparent products and secure clearing processes for the participants.

On the EEX different commodities and products are traded. These are electricity (power), gas, coal, EU Allowances (EUA) and guarantees of origin (GoO’s). The EEX is operating several submarkets on which different commodities and products are traded. As this thesis covers the electricity market, the Spot market and the Derivatives market for electricity are the most important markets. However, as EUA’s have an impact on the wholesale electricity price, the EUA submarket and its function will also be described.

Before going into further detail with the single submarkets it is important to highlight the difference between physical and financial electricity trading. Physical trading, which is mainly conducted on the spot market, means that the electricity traded actually will be delivered e.g. the following day. Financial trading on the other hand is conducted on the derivatives market. The principle is the same as with derivatives on stocks, with the difference that the underlying asset in this case is electricity. The buyer can for instance buy an electricity future to fix the price for the electricity delivered at a certain time in the future. The actual
price of the electricity will most likely be different at the expiration date. The difference will be settled by a cash payment between the two parties instead of an actual physical delivery of the electricity. Another option is to exercise the contract prior to expiration and settle the difference in the prices in cash.

4.1 The Spot Market for electricity

Short term electricity trading is performed on the spot market, which is operated by the EPEX SPOT SE, a joint venture of the EEX and the energy exchange Powernext SA in France. The EPEX SPOT integrates the markets areas Germany/Austria, Switzerland and France. On the spot market day-ahead auctions are conducted every day, year round, in order to settle the electricity price for the following day. This is done by a closed bid auction and maximum and minimum prices are 3000 €/MWh and -3000 €/MWh, respectively (Graf & Wozabal, 2013). The auction method is the same as on general stock exchanges. Potential buyers of electricity place bid prices for a set of predefined products. The bid price represents the maximum price the buyer is willing to pay for the product. At the same time potential sellers of electricity place ask prices for a set of predefined products. The ask prices are the minimum price the seller is willing to sell the product for. The products traded can be individual hours of the day (i.e. the hour 01, which means a steady flow of a certain amount of MW in the hour 00:00 to 01:00) or so called pre-defined or user-defined blocks. A Block is a steady delivery of electricity in a combined set of hours. The minimum price increment for both individual hours and blocks is 0.1 €/MWh and the minimum volume increment is 0.1 MW. For the individual hours the prices entered must be between -500 €/MWh and 3000 €/MWh. This gives a maximum of up to 256 price/quantity combination. The prices for the individual hours can vary substantially (Www.epexspot.com.2014). In the German Austrian Transmission System Operators’ (TSO’s) zones the auction takes place at 12:00 every day. The bids and asks in the order book are matched by a complex mathematical algorithm. The result is the market clearing price and market clearing volume. Each hour can take individual prices. However, each buyer pays the same price for the individual hour. The following graphs illustrate the above explanation. Note that the market clearing price can take negative values as shown in the left hand side. The orange lines show the aggregated bid curves, and the grey lines show the aggregated ask curves:
In the rare case that the bids and asks doesn’t match, the order book will be reopened and a second round auction will be started. However, this case barely happens as the Spot market on the EEX has a very high liquidity. Furthermore so called intraday trading is conducted on the EPEX SPOT. It allows the purchase and selling of electricity up to 45 minutes before its physical delivery and enables utilities and electricity suppliers to optimize their consumption portfolio in the short term. An example could be an unplanned power plant shut down or a change in the consumption prognosis. Trading companies use the intraday market for generating profits by taking advantage of arbitrage possibilities. Intraday trades can be conducted starting at 15:00, for the following day. The spot market is the market for physical electricity trading. This means that the electricity traded will also be physically delivered.

Due to the increase in RES and other unpredictable circumstances such as the amount of sun and wind or the shutdown of power plants, the price volatility in the spot market in steadily increasing. This exposes all participants to risk in connection with the buying and selling of electricity. In order to manage the risk and hedge positions, many of the participants also engage in the derivatives market. The below figure shows the volatility in spot prices for the year 2011:

![Figure 10: Matching of aggregated bid and ask curves at the MCP and MCV. Source: EPEX SPOT SE](image)

![Figure 11: Base and peak load spot price volatility in 2011. Source: Regulatory Commission of Energy](image)
In 2013 the overall volume traded on the EPEX Spot was 346 TWh (Www.eex.com.2014a).
The average spot price for a day in Germany/Austria is called the Physical Electricity Index (PHELIX) and it is the so called “underlying” for financial electricity derivatives such as futures and options traded on the EEX’s derivatives market.

4.2 The Derivatives Market for electricity

Power derivatives are traded on the EEX Power Derivatives GmbH, which is a subsidiary of the EEX. By buying/selling power derivatives, market participants can fix the price for future electricity deliveries today. This concept is important as electricity can’t be effectively stored. This means that the electricity consumed in a given moment has to be produced at the exact same moment in order to keep the electricity grid stable and avoid black outs.
The product portfolio of the derivatives market consists of power futures and options on PHELIX futures, which mainly are financially settled (Www.eex.com.2014b).
The participation in the derivatives market allows suppliers to actively manage their risk exposure in the market. Furthermore it is an important tool for electricity suppliers which they use to fix prices for the end consumers for a longer term. The figure below shows the price for the year-ahead electricity future. It can clearly be concluded that it is less volatile than the spot price for the same period:

Figure 12: Annual power future price on the EEX for the year 2011. Source: Regulatory Commission of Energy

Power derivatives maturities in the derivatives market comprise Day, Weekend, Week, Month, Quarter and Year Futures. However, even though the accumulated trading volume on the derivatives market with 1,264 TWh is considerably higher than in the spot market (Www.eex.com.2014b), the spot market is of greater importance as the influence of RES on the wholesale price of electricity is being investigated. This is because the actual auction/pricing is taking place in the spot market, whereas the derivatives market only represents the anticipated average spot price in the future.
4.3 EUA’s on the EEX and the EU-ETS in general

There can be unintended interaction effects if multiple schemes for emissions reduction are independently enforced at the same. In Germany there is an interaction effect between the national FIT scheme and the supranational EU ETS. It is therefore important to briefly explain the EU ETS and its principles and how it is related to the electricity market.

In order to meet the targets of the Kyoto protocol the EU has chosen a proactive approach to reduce GHG emissions on a collective basis for all its member states. With the aim to reduce GHG emissions by 20% compared to levels of 1990 the EU has deployed a union wide emissions trading scheme (D’haeseleer, Delarue, & Van den Bergh, 2013). The idea behind the scheme is that chosen emission intensive industries need a certificate (emission allowance) for each ton CO2 they emit. As the certificate has a price, the industries will be incentivised to abate emissions in order to reduce operational costs. The system chosen by the EU was a so called cap-and-trade system which is divided into several phases. Initially in each phase a fixed amount of allowances are auctioned and issued free of charge to the chosen installations participating in the scheme. Afterwards the participants can freely trade the certificates. This means that if an installation emits less than predicted, it can sell the excess certificates in the market. At the same time, if an installation is short of certificates due to higher emission, it needs to buy extra certificates in the market.

In the first phase from 2005 to 2007 emissions were capped at 2.1 billion tonnes CO2 annually (Parsons, Ellerman, & Feilhauer, 2009). At the launch in 2005 the scheme included around 11.500 industrial installations in 27 member countries, which were accountable for around 40% of the overall CO2 emissions in Europe. The EU ETS was the world’s first and largest international emissions trading scheme (Convery, 2009; Parsons et al., 2009). Looking at the spot price development of the allowances shows a dramatic peak and drop in the first phase of the scheme from around 30 €/ton CO2 at its peak, to effectively zero in January 2008:

![Figure 13: EU ETS spot and future price development 2005 - 2008. Source: Point Carbon](image-url)
This can be explained partly by an over-allocation of allowances, and partly by CO2 abatement greater than anticipated, especially by the power industry (Parsons et al., 2009). Another reason is that the certificates from phase I couldn’t be allocated to the second phase and simply expired at the end of phase I, which created an excess supply of allowances. But also the increase of RES plays a decisive role as will be explained later.

In the next two phases from 2008 to 2012 and from 2013 to 2020 the cap is further reduced in order to meet the agreements of the Kyoto protocol of 1997. Furthermore, a larger share of allowances will be auctioned instead of freely allocated and the air transportation industry was included to the scheme in 2012.

Similar to electricity EUA’s are traded OTC and on the EEX. The EEX is the auction platform for both the primary allocation in the beginning at each phase as well as it is the platform for the secondary market where participants can freely trade the allowances. The basics for EUA trading are the same as for electricity. There is a short term spot market, as well as a long term derivatives market for allowances.

The emergence of an emissions trade scheme has a direct impact on the wholesale price of electricity as it increases the variable cost of power plant operators. This means that the ETS increases the electricity price. However, the interaction does not solely affect the wholesale price but also the CO2 abatement. This will be examined in the next section, together with the impact RES have on the pricing mechanism of the electricity wholesale price.

5 The Merit Order Model – How RES and the EU ETS affect the spot price

The EEX and its underlying markets have now been introduced. This leads to an important part of the ongoing debate on the Energy Transition. This is, how or does the increase in RES influence the spot price or more importantly, how does the Energy Transition affect the end consumer price for electricity, which in theory is closely related to the wholesale price.

5.1 The Merit Order Model – general price formation in the spot market

In order to understand the influence of RES on the wholesale price, the price formation in the spot market has to be further investigated. It has already been explained that the price is settled via an auction where bids and asks are matched and the corresponding optimal price for each individual hour is calculated. However, to see the effect of RES deeper look is necessary. A look at the single hour and how the suppliers, which mean the operators of power plants, determine their ask prices in the spot market is necessary.
The prices set by the plant operators are set in a short term perspective. This means that the ask prices equal the variable cost of operating the plant (Nicolosi & Fürsch, 2009). Those variable costs include for instance fuel costs and EUA prices as the operator has to pay for the emissions caused by the production of electricity. As there are different technologies in the market, for example gas, oil and coal fired plants as well as nuclear plants; there are big differences in the variable costs of the individual plants depending on the technology, the age, the emissions level and so forth. The power plants are activated in ascending order of their short-run marginal costs of production, meaning the plant with the lowest marginal costs will be activated first and the ones with the highest marginal costs are the last to be activated. New plants are activated until the demand is covered and the marginal cost of the last plant activated determines the overall price for the specific hour – the market clearing price.

For the German market Figure 14 shows the typical merit order:

![Merit Order of the German conventional power plant fleet in the year 2008. Source: Forschungsstelle für Energiewirtschaft e. V. (FfE)](image)

The figure shows that nuclear energy clearly has the lowest marginal costs. This is partly because nuclear plants have no emissions and thus doesn’t have to pay for allowance certificates. Also, nuclear plants produce a constant base load, so no ramping costs are incurred. Lignite is the next in order, followed by coal, combined cycle and the highly flexible, but more expensive gas turbines. Oil fuel plants are typically old installations and have low efficiency high marginal costs. This logically results in rare activations. If a hypothetical line was drawn along the x-axis, following the marginal costs of the plants, the merit order curve can be determined. This merit order curve would be the same curve as the grey curve in figure 10, or simply the supply curve of electricity.
5.2 The Merit order effect

Earlier in this thesis, when the principle of preferred network access for RES was explained, it was stated that the electricity generated by RES will be fed into the network regardless the demand in the market and whether it is marketed on the EEX by the TSO’s or by the producer. This practice has large implications on the merit order and thereby on the electricity price (Sensfuß, Ragwitz, & Genoese, 2008). The production from RES can easily be incorporated in the merit order model, as it is illustrated in figure 14. As RES in principle have no marginal costs once the initial investment is done (maintenance costs are ignored in the theory) and because they have preferred network access, they will be placed first in the merit order and displace conventional power plants. This is called the merit order effect. The result is a reduction of the electricity price. The mechanism is illustrated in the figure below:

![Merit-order effect of renewable electricity generation. Source: (Sensfuß et al., 2008)](image)

For this model is assumed that in the short term perspective of the day-ahead spot market the demand for electricity is inelastic. The fact the EEG requires that RE production is preferentially bought by the companies has the effect of a reduction in the electricity demand from $D_1$ to $D_2$ (Sensfuß et al., 2008). Consequently the price is reduced from $P_1$ to $P_2$. The total price reduction is the green shaded area. The blue shaded are represents the market value of the RES. This indicates clearly that the merit order effect has an economic value, which can distinctively be measured by the total price reduction.

In their paper on the merit order effect Sensfuß et al. (2008) estimate the value of the merit order effect based on a model which simulates prices in the spot market under influence of RES. They find that in the year 2006 the reduction of the unweighted average price was 7.8 €/MWh. Furthermore, they estimate the total value of the merit order effect in 2006 to range from 3-5 billion €. Taking the costs of RES support
into consideration (payments for EEG allocation, MMP etc.) it is argued that in the year 2006 a net
profit occurred, meaning that the benefits of the merit order effect succeeded the support costs for RES,
shifting profits from generation companies to consumers (Sensfuß et al., 2008). It is important to mention
the short term horizon of the research paper. In the longer term, additional factors would come into play
and have an impact on the magnitude of the merit order effect. Amongst others it is assumed that the
power plant mix in the long term would adjust to the given market settings and thus reduce the merit
order effect (Sensfuß et al., 2008). In addition of mentioning the short term nature of their conclusion,
Sensfuß et al. (2008) also points out that it depends on the competitiveness of the consumer market
whether the savings created on the wholesale market are passed on to the end consumers. In another
research paper on the potential of wind energy Weight (2009) concludes from a simplified simulation of
the market, that wind energy reduces the wholesale price by approximately 10 €/MWh, not taking other RES
into account. This exceeds the increase of consumer prices from the renewable support mechanism of 5.4
€/MW h in 2006 and 7 €/MW h in 2007 and thus also results in a net gain for the end consumers.
The above research argues that the merit order effect yields a direct saving for end consumers as it
surpasses the consumers’ payment for the EEG allocation. However, some argue otherwise. Marcantonini
and Ellerman (2013) argue that the savings from the merit order effect should not be fully accounted for
when analysing the effect of RES on end consumer prices. It is argued that the loss incurred by generators
will lead to the retirement of existing, unprofitable capacity or to a higher threshold to invest in new
capacity. This is likely to lead to a new regulatory treatment that compensates generators for providing
sufficient dispatchable capacity to meet demand in the absence of intermittent RE generation. This is a
plausible argument. In fact, many of the big electricity operators in Germany now experience losses as they
have to amortize large power plants which due to high RE injections no longer are profitable (Germany : RWE releases outlook for 2014.2013). However, this argument has more of a long term perspective and
doesn’t consider the short term implications on the end consumers’ electricity price. Still it is a fact that
even though it is proven that the wholesale price in Germany is reduced by RES in-feed, end consumer
electricity prices in Germany are among the highest in Europe. Many different factors of which some are
difficult to calculate or quantify come into play when it should be determined if the savings caused from the
merit order effect are directly passed to the consumer. Further research must show how the support
schemes in Germany affect the end consumer prices in the long run and to which extend impacts on the
wholesale market are reflected and taken into consideration in the end customer business. In order to
unburden the end consumers and distribute the positive effects of increasing RE production, it is the
politician’s obligation to make sure that possible gains do end in higher margins of electricity suppliers or
trading companies, but are passed on to the end consumers.
5.3 Interactions of the EEG and the EU ETS

RES deployment reduces the wholesale price of electricity as RES have zero marginal costs replace conventional power plants with higher marginal costs. At the same time the emergence of the union wide ETS has the exact opposite effect on the price. As plant operators need to buy allowances in order to produce electricity, their variable costs increase and thus the price in the spot market rises. This relation is relatively straightforward. But even though the price reduction stemming from RES succeeds the price increase from the ETS (Weigt et al., 2013) and there thus is a net decrease in price, this contradicting effect raises questions on efficiency matters if national and supranational CO2 mitigation policies are enforced simultaneously. But there are more implications that have to be addressed. One problem that arises in a closed cap-and-trade system like the EU ETS is that any external factor (like the EEG) influencing emissions in the system, has a direct impact on the demand on allowances and consequently on the price (D’haeseleer et al., 2013; Weigt et al., 2013). In the year 2007 the allowance price went to zero. Although over allocation and efficiency gains were reasons for this price development it cannot be ruled out that the increasing RES share in the generation mix lowered the price additionally, as conventional plants were displaced and demand for allowances decreased. In a simulation by D’haeseleer et al. (2013) RES injections reduced the EUA price by maximum 15€ t/CO2 in 2007, 46 € t/CO2 in 2008 and more than 100 € t/CO2 in 2010. Furthermore, in a closed trading system the lower price simply signals a lower demand for allowances in one end of the ETS and thus the need for less abatement elsewhere in the system. In practice this means that all the CO2 emissions mitigated in Germany will simply be emitted elsewhere in Europe and there will be no net reduction in CO2 emissions. The problem is that the EU only set a target for the total reduction of emissions, not setting specific targets for the single member states. It is decisive that the EU incorporates initiatives that changes in emissions by single countries such as Germany, when setting the cap for the overall allowances. Kirsten (2014b) argues that trading of certificates and national policy should be combined and that all certificates which are correlated to national measures to reduce emissions and are paid for by taxes, fees, money of administration etc. should be removed from the market.

Weight (2009) looked more specifically into the German market and investigated how the EU ETS is correlated to the merit order effect which was described earlier in this thesis. In their simulation of the German electricity generation market they made some interesting findings regarding CO2 abatement. In particular they found that there is an interaction effect between RES deployment and the ETS which meant that in the years 2006 through 2010, CO2 abatement attributable to RES was higher in the presence of an allowance price (except from 2007 where the allowance price was effectively zero). At the same time CO2 abatement from allowances was higher with RE injections than without. In the considered years the interaction effect had a magnitude of 0.5% to 1.5%. Their research stands in contrast to others’ where it is
argued that fuel inefficiencies arising as a result of intermittent RE injections in integrated electricity grids lead to no net reduction in CO2 emission and well as emission prices (Lang, 2009). In their approach to investigate the interaction effect, Weight et al. (2013) built a simplistic model of the electricity generation market in Germany consisting of one lignite plant, one nuclear plant, 5 coal fired power plants (varying in efficiency and size) and 6 gas fired power plants (also varying in efficiency and size). They then modelled the merit order with and without the presence of RE injection and a carbon price of 0€ t/CO2 and 15€ t/CO2, respectively. The result is depicted graphically in figure 16:

![Figure 16: Merit order of the methodological system, 1500 MW of RE injection and CO2 price of zero (LHS figure) and 15 €/t (RHS). Source: (Weigt et al., 2013)](image-url)

The dotted line shows the total demand with RES in-feed (including merit order effect) and the solid line without. The left hand side shows the merit order without a carbon price and the right hand side with a carbon price of 15 € t/CO2. On the right hand side it is seen that a carbon price increases the marginal costs, which has an effect on the dispatching order of the plants. Some of the coal plants are replaced by gas fired plants, which have lower CO2 emissions. The RE injection then displaces those coal plants, resulting in a lower CO2 emitting mix of power plants being activated. The emissions price re-orders the dispatching order in a way that the abatement from the same amount of RE feed-in is higher.
Interestingly their research shows that the CO2 abatement from using both RE in-feed and ETS at the same time is greater than the sum of using either instrument alone:

![Schematic representation of the observed interaction dependence between ETS and RES. Source: (Weigt et al., 2013)](image)

The first column shows the emissions without any political instruments. The second and third column shows emissions reduction with the lone existence of ETS and RES respectively. In the fourth column we see the emissions reduction stemming from a coexistence of the two instruments, which corresponds to the real world situation. It can clearly be seen that the abatement of using both instruments at the same time is higher than the sum of either one. At the same time it can be seen that the CO2 reduction of RES is higher than the CO2 reduction from ETS. This can be easily explained looking at figure 16. Whereas ETS only rearranges the dispatching order and replaces some coal fired plants with gas fired plants, which have lower emissions than coal fired plants, RES in-feed displaces either one and thus leads to a higher emissions reduction than the ETS. This has important implications on the policy making and it contradicts other research suggesting that overlapping climate instruments are superfluous or redistributive (Weigt, 2009).

It is important to stress the limitations of the highly simplified models used in the research in the interactions of ETS and RES. Factors such as the power plant mix, the price spread between coal and gas, the efficiency of the power plants, the demand in the system etc. play an important role as they have an impact on the merit order (Weigt, 2009b). Also the simplified models can never represent a fully realistic market, as many unknown factors and variables are excluded, of which some may have influence on the results. Nevertheless the existing research clearly indicates that better coordination in policy making can increase efficiency of climate instruments. Therefore, policy makers should find a way to integrate national and supranational mitigation policy or find a collective approach on EU basis instead of risking further diversity if all member states develop their own instruments for the future.
6 The end consumer perspective

So far this thesis focused on the market mechanisms and instruments connected to the German Energy Transition. However, in order to get a holistic impression of the evolutinal process the German electricity market is in, it is very important not to forget the end consumers’ role. Although it is the policy makers who set rules and regulations fostering the growth of RES, this would not be possible without the consumers’ consent. The majority of the German population supports the transition towards a greener economy and an increase in RES (Gerken, 2012) and in fact directly pays for it via the EEG allocation, mentioned earlier when the market premium model was described. Therefore, a brief description of end consumers’ involvement with focus on the EEG allocation will follow.

6.1 EEG allocation and industry-discounts

Looking at the numbers, it can be observed that end consumer electricity prices in Germany have constantly risen over the past few years (Steigende EEG-umlage.2012). Having this in mind, one should remember one of the goals of the liberalisation of the electricity markets, which amongst others was to increase competition and thereby lower end consumer prices. Nevertheless Germany has the second highest electricity prices in Europe and the prices will most likely continue to rise in future, which partly is because of an increasing EEG allocation (Gerken, 2012). In 2012 the EEG allocation amounted to 3.59 cent/KWh with an additional 0.68 cent/KWh in VAT and it increased to 5.28 cent/KWh in 2013. For an average household with two children this is an increase of a payment of 125€ to 185€ annually, only attributable to the Energy Transition (Nagl & Paulus, 2013). This is a considerable amount especially for low income households which are struggling to cover the increasing costs. On the other hand, huge profits are generated by investors of RES and energy trading companies, taking advantage of the regulative schemes in the market. The Energy Transition itself is thus no longer only a matter of energy economics and technological aspects; it has become a matter of social welfare and justice.

There are two main reasons for the rising EEG allocation. Firstly, there is the decrease in the wholesale prices, obviously due to a rising RES share. However, other factors also contribute to declining prices on the exchange. For instance, the lack of adjustment of the number of EUA’s in the market and the subsequent heavy decrease of allowance prices has flooded the market with cheap coal electricity (not to mention the heavy emissions from coal plants, compromising Germany’s climate goals). Furthermore, there is still a lot of cheap nuclear electricity in the market. Nuclear plant operators are currently neither charged a risk premium for the dangers of the technology, nor for final disposal of nuclear waste. The cheap electricity from coal and nuclear plants could be argued to be a competitive distortion. On the other hand it is very difficult to define a competitive distortion in theoretical liberal, but still highly regulated market.
Also, it could be argued that the suppliers simply do not pass the reduced wholesale prices sufficiently on to the end consumers. This would indicate a lack of competition in the end consumer market, which partially can be explained by the consumers’ reluctance to change supplier. Many consumers are used to buy electricity from their local supplier and this adds to the market power of the suppliers.

The decrease in wholesale prices being one of the reasons behind the increasing EEG allocation, the other highly discussed topic are the so called EEG “industry-discounts” for selected energy intense industries and companies granted by the government (Groth, 2014). In the last amendment of the EEG in 2012 new rules were stated which partially exempts energy intense industries and companies from paying the EEG-allocation. The rationale behind it was that those companies and industries should be able to compete internationally and would have a considerable competitive disadvantage if they had to handle the increased production costs due to EEG-allocation payments. Considering that the German economy is extremely export driven this seems like a valid argument. But looking at the number of companies that utilised this rule draws a different picture. Whereas in 2012 only 803 companies were exempted from the payment, the number increased to 2055 in 2013. For the year 2014 a total number of 2379 companies applied for exemption (Groth, 2014). A reason for the increase of companies using the exemption rule was that the government decreased the minimum electricity consumption to apply for the exemption from 10 GWh annually to only 1 GWh annually. This has led to increase in the EEG allocation for the end consumers. Of the approximately 220€ the end consumers pay in EEG allocation in 2014, around 45€ are due the industry-discounts (KREUTZFELDT, 2014). This development, again, has serious implications especially for the low income households and contributes to ever greater disparities between high and low income groups. But also small and medium sized enterprises are paying the higher EEG allocation and thus experience a competitive disadvantage. Government must ensure not to give the industry discounts away to easily as the end consumers have to take the burden. It must be ensured that payment exemptions are only granted to relevant companies and industries and that the exemption does not develop into a covered governmental subsidy for companies.

Even though the EEG allocation is an important factor in explaining the high electricity end consumer prices in Germany, there are other factors contributing to the relatively high prices. The end consumer price consists up to 40 % of government taxes, concession fees, fees for network expansion to handle the increasing RES production etc. Incompetent decisions in politics have to be avoided in order to drive the transition forwards and avoid price increases. Just one example was the decision to grant exceptional high remunerations for off shore wind mills, not taking the lack of sufficient network expansion into account. Investors built giant wind parks in the North Sea. The network expansion could not keep up and as a result the end consumers have to pay guarantees for off-shore wind mill owners via the electricity bill.

It is of utter importance that the German Energy Transition is backed by the consumers; otherwise there will be no foundation for the evolution towards a greener and sustainable economy. As the consumers
directly pay for the transition via their electricity bills, it is very important to constantly thrive to optimize inefficiencies in the system and keep the costs for the consumers as low as possible. Most importantly, low income households for which the additional payments can lead to serious challenges have to be taken into account, when designing and optimizing future instruments for the Energy Transition.

6.2 The internalisation of external costs

Whereas the EEG allocation has become a big topic of concern and discussion in politics and society, Kriwitt (2007) has a different opinion about it. In his research where he quantifies the external costs from renewable electricity generation compared to fossil and nuclear technologies, he comes up with a surprising conclusion. The avoided external costs of German fossil electricity generation and the connected emissions due to RE generation in 2007, such as damage on agricultural and material goods, lower life expectancy, higher mortality rates, increased medical costs, noise emissions from power plants, damage of ecosystems and some other factors, are calculated. They are than measured against the total costs of RES support in the same year. The result shows that the support costs for RES are lower than the avoided external costs. Relating this to the above discussion about the end consumers it means that the end consumers in principle are achieving a net benefit by paying the EEG allocation. However, this approach can only partially be related to the real world situation. This is because many of the avoided costs have a rather long term perspective and the consumer paying for it will most likely not harvest the actual benefit. Furthermore the calculation bears high uncertainties as many external costs are extremely difficult to quantify and predict. Nevertheless, this interesting perspective is very important as one of the major goals of the EEG, stated directly, is to reduce the cost of energy supply, including long term externalities.

The EU ETS could be seen as an approach to internalise external costs into conventional electricity production. But the nature of the cap-and-trade system makes the price of EUA’s not reflect real external costs of CO2 emissions which according to Kriwitt (2007) are difficult to determine, but lie around 85€ t/CO2. The EUA price, which effectively went to zero in 2007, and largely depends on mechanisms such as demand/supply rate, is thus likely not to sufficiently internalise the external costs of fossil energy generation.
7 Conclusion

The purpose of this thesis was to give a general overview of the German electricity market and the Energy Transition which is currently taking place. By analysing the instruments and market mechanisms connected to the Energy Transition the purpose was to point out challenges and shortcomings of the Energy Transition. Several interesting findings were the outcomes of the thesis:

When the instruments of the transition (FIT and the Market premium Scheme) were analysed it was seen that they so far have contributed to a significant increase in RSs. However, some shortcomings of the instruments were revealed. The problem with the fixed FIT is that it makes RE producers to passive participants in the market and the TSO’s have to market the produced electricity. This is not efficient and leads to no demand oriented production. To tackle this problem the Market premium Scheme was introduced in 2012. Although it clearly incentivises producers to market their production independently, it also has shortcomings. The MPP is set too high which allows windfall profits for producers. Also, producers might just switch back to the FIT as soon as the MMP decreases to a degree where the desired profits no longer can be realized. The Market premium Scheme intended to improve system integration and thereby reducing, among others, balancing costs. However, its incentives are not strong enough to encourage investments in, for example, flexibility-adding storage systems. As the majority of direct marketing users are intermittent RES producers, the Market Premiums Schemes does not lead to sufficient system integration.

Looking into the market mechanisms it was shown that RE in-feed significantly reduces wholesale prices of electricity through the merit order effect. The merit order effect also reduces CO2 emissions on a large scale. Even though the price reduction could potentially lead to a net benefit for end consumers, German end consumer prices are the second highest in Europe. Politicians have to make sure that everyone harvests the benefits of renewable energy production, and that the gain levels of RES do not end in higher margins of suppliers, investors or traders. In the longer run the market is likely to adjust to the new situation, for instance through a change in generation capacities.

As both national and supranational instruments for CO2 mitigation exist, in this case the EEG and EU ETS, the interactions between those two was investigated. An interesting interaction effect between the two exists, which actually means that the co-existence leads to higher CO2 abatement in Germany. However, the two instruments are rather counterproductive in other areas. For instance the possibility of CO2 abated in Germany to simply be emitted somewhere else in Europe due to the cap-and-trade system. Also, the RE increase in Germany has a negative impact on the price of EUA’s, which makes the operation of conventional coal fired power plants more advantageous. It is of uttermost importance that national and EU wide climate policy is aligned and streamlined in order exploit potential efficiency gains.

The consumers’ role in the Energy Transition was also briefly discussed, as they carry the financial burden via the EEG allocation. As the payments keep increasing due to lower wholesale prices and partially
doubtful industry discounts, lower income households and small and medium-sized enterprises are running into trouble. It is, therefore, important to restrict the industry discounts and secure an equal distribution of the burden of the energy transition.

EAU prices are likely not to reflect real external costs of fossil fuel-based electricity generation and are influenced by several mechanisms in the market. Even though research shows that the benefit from avoided external costs due to reduced emissions exceed the payments for RES support, certain measures have to be taken in order to secure a socially just energy transition. (Krewitt, 2007)

The discussion of some selected important aspects of the Energy Transition in this thesis has shown the complexity of the topic. The nature of electricity, the fact that it cannot be effectively stored, as well as society’s incomparable high dependence on it, makes energy economics one of the most important fields of our time. In addition, electricity production is one of the biggest drivers of greenhouse gas emissions and thus a transformation of the world’s energy sectors is inevitable if the emissions reduction targets are to be reached. Germany has taken a very proactive approach and is leading by example on how to take responsibility on climate issues, and on how to translate CO2 reduction targets into concrete climate policy. This thesis has shown that Germany so far has reached tangible results in its effort to transform the energy sector and lead the economy towards a greener future. But it has also shown short comings of the instruments used to reach this goal and challenges connected to them. As mentioned before, the electricity market and its mechanisms are in many ways different, and its dynamics more complex than other markets. There is no “best practice” as an Energy Transition on this large scale has never happened before.

There is no doubt that CO2 mitigation comes with a cost. Major challenges for German legislators will be to design policies and instruments which keep the costs as low as possible and distribute them among all participants fairly, not only among households. Constant revision and amendments of the EEG and its instruments will be necessary in order to make this possible. It is important that researchers actively engage in this process in order to avoid political decisions be based on interests of single lobbyists such as the ones used by large electricity producers. The liberalisation of the electricity market has led to many participants in the market taking advantage of every possibility to earn profits, which leads to higher costs for others. Legislators have to be aware of this when instruments such as the Market Premium Schemes are optimized and developed in future.

The ultimate goal of a liberalised market must, however, undoubtedly be that instruments such as FIT or the Market Premium Scheme become superfluous and RES get fully integrated to the market, where they compete with conventional power generation technologies. This can only be achieved through the development of technologies for renewable energy production into more efficient ones, or by effectively internalising long run external costs to conventional electricity generation. Both approaches will make RES competitive in the market. It is of uttermost importance that the political, science, and the private sectors
work together in this gigantic project, leading the energy sector of one of the world’s leading economies to a sustainable and more environmental friendly future.

The underlying theme of this thesis is rather broad, which meant the research was bound by some limitations. The author of this thesis tried to cover the most important aspects of the Energy Transition. The conclusions drawn are, to some extent, generalist and do not entail concrete suggestions on how to optimize or improve single instruments or mechanisms of the Energy Transition. The reason for this is that each component of the Energy Transition is very complex. More extensive research on the single components such as FIT or the merit order effect would be necessary to draw more concrete conclusions. Nevertheless, this thesis gives a thorough and solid overview of the Energy Transition, points out important challenges and raises concerns on some aspects. It can thus be seen as introductory literature on the topic and can be used as basis for future research on the single components of the Energy Transition.
References


