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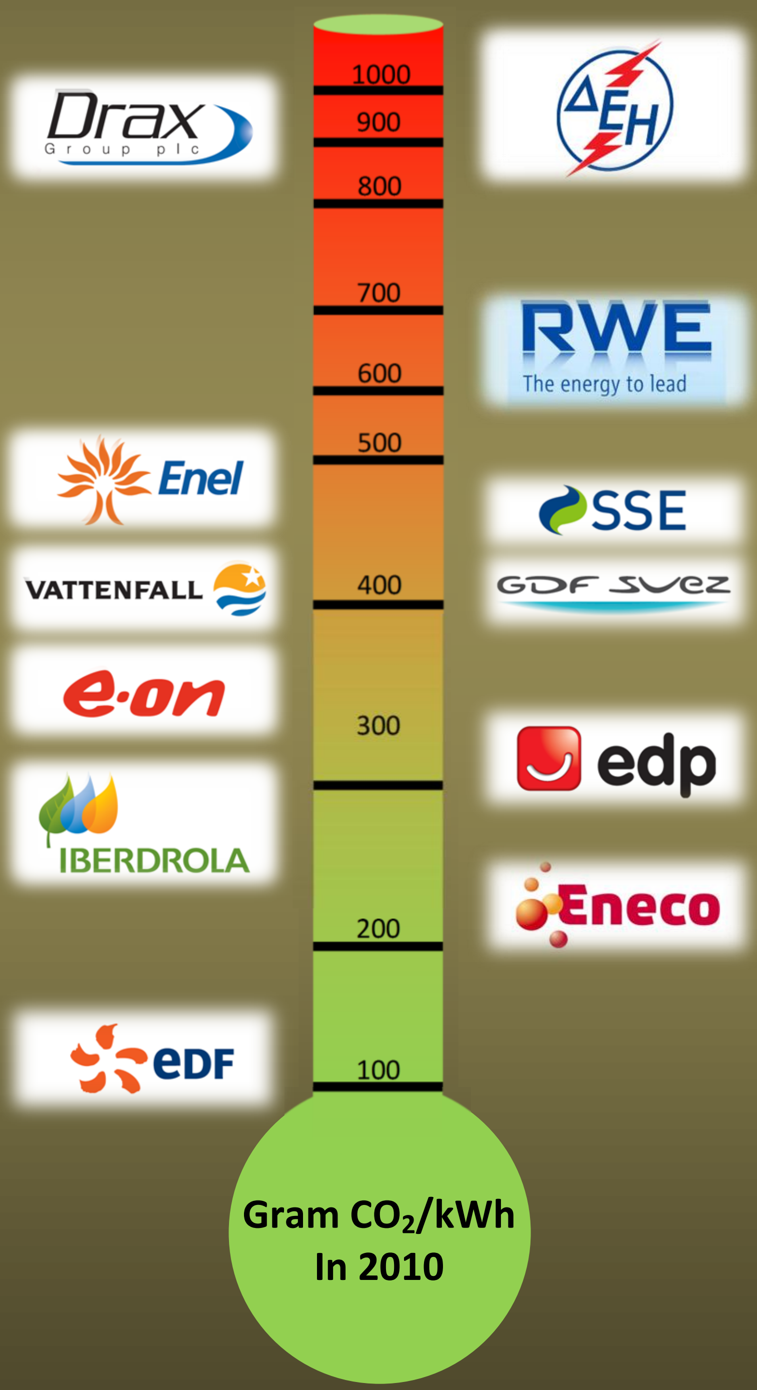
Benchmarking the CO_2 intensity and analysing the CO_2 reduction strategies of utilities in Europe



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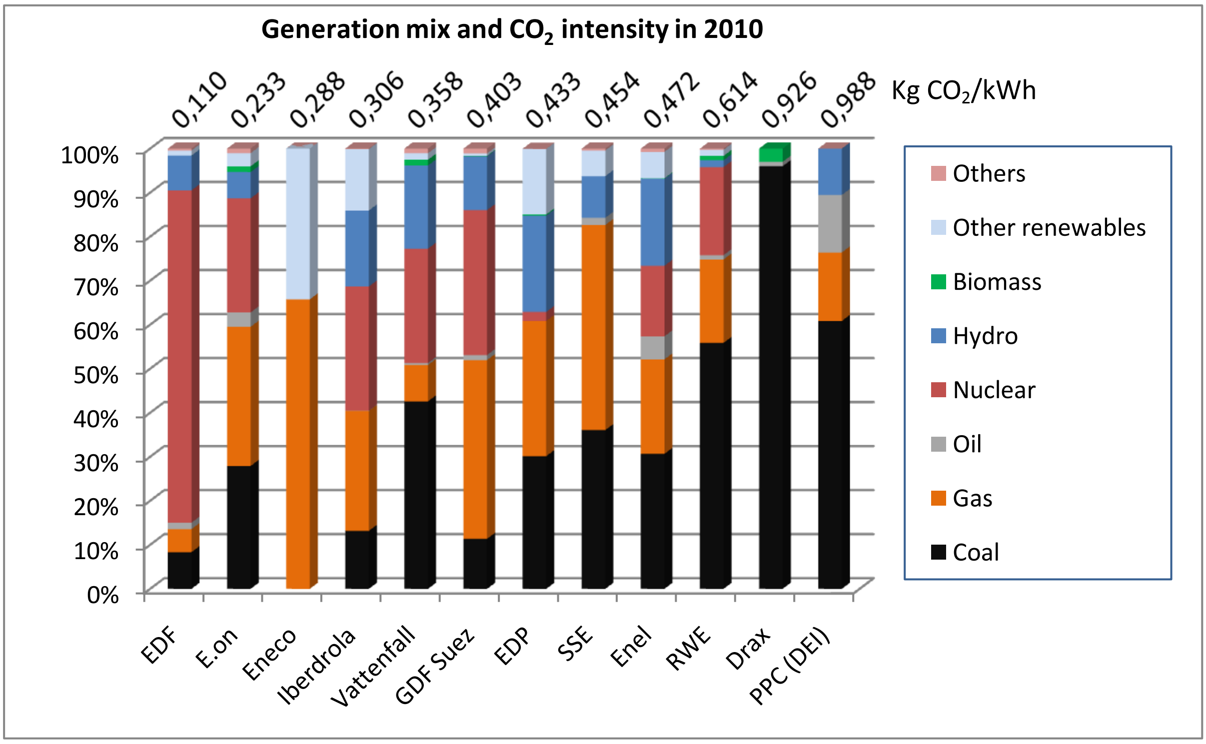
Executive summary

Electricity can be produced by many different technologies, each of which has a different CO_2 intensity. The CO_2 performance of a utility depends to a large extent on the technologies used for electricity generation. Because utilities have different electricity generation portfolios, their CO_2 performance also varies. It is not known how utilities in Europe perform relative to their peers. Furthermore, there is no good analysis available of which strategies are used by utilities to make investment decisions for new power plants. Investment strategies are important for the reduction of the CO_2 intensities of electricity generated by utilities. For this reason an analysis of the factors which have an impact on these strategies is interesting.

The aim of this study is to show what the CO_2 emissions per kilowatt-hour are of various utilities and how this compares to their peers. Additionally, the CO_2 reduction strategy of utilities is analysed to see how utilities take up the challenge of reducing CO_2 emissions and whether and how external factors such as policies, economics, social structures, technology, environment, legal issues and competition influence this strategy.

First a benchmark methodology is developed to calculate the current CO_2 intensity, the CO_2 intensity of the past decade and expectations of the CO_2 intensity of the upcoming decade of utilities. Second, this methodology is applied to twelve utilities, which results in an overview of the CO_2 performance of the utilities compared to their peers. Finally, the strategy of utilities is analysed, also by using the results of the benchmark. Two case studies on the investment decisions of E.ON and Vattenfall are part of this strategy analysis.



The benchmark results show that there are large differences between the current CO_2 intensities of the twelve selected utilities, ranging from about 100 gram CO/kWh to 1000 gram CO_2/kWh, as shown in the figure below. Most utilities have strong ambitions to reduce their CO_2 intensities. Based on their investment plans, many utilities are expected to reduce their CO_2 intensities, but most are not expected to reach their own reduction targets. Also, as a result of the expected growth in the electricity supply, the total CO_2 emissions of most utilities are expected to increase.

The strategy analysis showed that utilities try are developing a strategy to reduce their CO_2 emissions, be competitive and maintain the security of electricity supply. The economic analysis of the CO_2 costs showed that the emission trading system has a significant impact on the profitability of a utility. Utilities are making investments in natural gas-fired power plants and renewable energy to reduce their CO_2 costs. Investments in coal-fired power plants are also made because utilities point out the necessity to maintain their competitive position and to secure their supply of electricity.

As a strategy to create competitive advantage, utilities are diversifying their generation portfolio. This decreases the financial risks of policies and high fuel prices. The investments in renewables are used to create a positive brand image, but also to keep the option open to make larger investment in these technologies in the future. To enhance their brand image, utilities emphasise the positive aspects of their investments, but also explain what they do to reduce the negative impacts of these investments.

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1. Introduction

In the 1990's, a large part of the European electricity market was liberalised. As a result several utilities have grown to become international players on the electricity market, but new utilities have also taken the opportunity to get a market share. Now utilities make the investment decisions for new power plants, instead of governments. This changes the factors which are taken into account for investments in new power plants. Because utilities operate in a competitive environment, the generation costs of a power plant have become the most important factor. Before liberalisation, factors such as the reduction of environmental impacts, reduction of the dependency on fossil fuels and security of energy supply were taken into account when investing in power plants. These factors must now be achieved by other forces, such as government policies and regulation.

Electricity generation accounts for one-third of the total CO_2 emissions in Europe (Chappin & Dijkema, 2008). Because of this high contribution of the electricity sector to the total greenhouse gas emissions, several policies and subsidy schemes are put in place. The EU has set the 20-20-20 targets to reduce CO_2 emissions, strengthen competitiveness and increase energy security of the Europe (European Commission, 2010b). The targets are:

- A reduction in EU greenhouse gas emissions of at least 20% below 1990 levels
- 20% of EU energy consumption to come from renewable resources
- A 20% reduction in primary energy use compared with projected levels, to be achieved by improving energy efficiency

The emission trading scheme (ETS) is an important policy instrument which has already been implemented. The ETS can contribute to meeting the greenhouse gas emission reduction target. At the moment, CO_2 emission allowances are allocated to the utilities at no cost. From 2013 onwards, the utilities will have to buy the allowances at an auction (European Commission, 2008). Therefore it is expected that it will become more costly for utilities to emit CO_2 (Cozijnsen, 2010). Next to this the renewable energy target and the energy efficiency target also have to be met. Many countries have national policies and subsidy schemes in place to meet the 20-20-20 targets (Hohne et al., 2010).

This research is performed for Ecofys and the University of Utrecht. Both these institutions are interested in the reduction of greenhouse gasses, energy efficiency and renewable energy. Because utilities are responsible for large shares of the energy use and greenhouse gas emissions in Europe it is interesting for Ecofys and the University of Utrecht to develop a good overview of the performance and the strategy of utilities. Ecofys can give advice to utilities how they can reduce the environmental impact of electricity production. For the University of Utrecht, the developments of the electricity market are interesting for making models of future energy use and CO_2 emissions.

1.1 Problem definition

This research indicates two main problems. The first problem is that there is no good analysis of the CO_2 performance of utilities. Because utilities have different electricity generation portfolios, their CO_2 emissions per kWh and their share of renewables vary. Therefore it is valuable to know what the environmental performance of a utility is compared to other utilities. The second problem is that there is no good overview of the strategies used by utilities to make investment decisions. An overview these strategies can make it clear why utilities make certain decisions to invest in coal, gas or wind power. These two problems are discussed further below.

1.1.1 Benchmark of utilities in Europe

There is no good comparison of the CO_2 performance of utilities in Europe. A benchmark is a useful tool for comparing this CO_2 performance. Together with an analysis of the generation portfolio, a benchmark can give a good overview of the environmental performance of utilities. Currently such a benchmark is to a large extent non-existent in Europe. In the U.S.A., a good benchmark of the air emissions of utilities is available (Van Atten et al., 2010). This was made by the non-profit organisation Ceres and intends to bring investors, environmental groups and other stakeholders together to encourage companies and capital markets to incorporate environmental and social challenges into their day-to-day decision-making (Ceres, 2011). However, some research on the CO_2 intensity of utilities in Europe has been performed, for example by the Centre for Research on Multinational Corporations (Wilde-ramsing et al., 2009). This research centre has performed a study on the sustainability of the Dutch power sector. The research was funded by Greenpeace and had the aim to increase public awareness of the sustainability of the Dutch power sector. It gives a good overview of the CO_2 intensity of Dutch utilities. However, as a basis for strategic decisions and strategy analysis it is less useful because such analysis requires more detailed information.

1.1.2 Strategy analysis of utilities

Many factors have an impact on the investment decisions of utilities. Studies have analysed the effects of some of these factors, but a complete overview of the investment strategy of utilities is lacking. With a complete strategy analysis some decisions made by the utilities can be explained, for example why Vattenfall is building a gas-fired power plant at the Eemshaven and Eon a coal-fired power plant at the Maasvlakte. Some examples of factors which have an impact on the investment strategies are given below. These are examples of factors which are used for the complete strategy analysis of utilities.

An example of a study which looks at an aspect of the strategy of utilities is the paper by David Jennings (1999). In this paper, the corporate planning process of PowerGen (now E.ON UK) was analysed and the decision-making structure was explained (Jennings, 1999). In the article by Stenzel and Frenzel (2008), the influence of policy on investment strategy was analysed. This article showed why there where large differences in the diffusion of wind energy in the UK, Spain and Germany, and how the strategies of utilities influenced this diffusion (Stenzel & Frenzel, 2008). The literature study on strategy explained some decisions made by utilities, but for a full understanding of the strategy a more comprehensive analysis of all factors which are important for the strategy is needed.

Utilities have strategies to make profits and to keep their company healthy financially. Such a strategy is usually briefly described in the annual report of the utility. However, how the strategy is developed, what the strategy exactly is and which factors influences the strategy is largely unknown. An important factor which can have an impact on the strategies of utilities is the introduction of policies to reduce CO_2 emissions. The EU set the target to reduce greenhouse gas emissions by 20% from 1990 to 2020 (European Commission, 2010b). For the electricity sector, a cap will be set by the ETS. This cap is an emission limitation for the whole sector and not for individual utilities. Because utilities have no individual targets they are not obligated to reduce their CO_2 emissions. Some utilities can make the decision to make a large reduction in their CO_2 emissions and other utilities can chose continue emitting the same amount of CO_2. Because of this problem, a discussion has arisen whether individual targets for utilities should be introduced. An idea which received much attention is the introduction of an emission performance standard (EPS). In this system, individual targets can be set, based on the CO_2 intensity of the utilities. This is closely related to this report, because in this report a benchmark is made based on the CO_2 intensity. The introduction of an EPS could have an impact on the strategies of the utilities, which is also relevant for this research. As a reaction to external factors, many utilities have set CO_2 emission reduction ambitions, e.g. RWE has the goal to reduce the CO_2 intensity from 800 gCO_2/kWh in 2009 to 450 gCO_2/kWh in 2020 and SSE want to reduce their carbon intensity by 50% between 2006 and 2020 (RWE, 2009), (SSE, 2009b).

1.2 Research aim

This research has two main research aims. The first is to provide a benchmark which gives detailed information on the CO_2 emissions as a result of the production of electricity by the utilities. The second research aim is to provide an overview of the strategy of utilities. For the benchmark, twelve utilities are compared and the electricity generation portfolios of these companies are analysed. This benchmark will be made for the years 2008, 2009 and 2010 and should be easily updatable in the upcoming years. For this purpose a structured way of gathering, processing and organising data is provided. For this analysis a good overview of the current situation of the power sector is needed. Information is needed about which technologies the utilities now use to generate their electricity and what the electricity generation mix is. A utility can, for example, choose to increase the load factor of gas-fired plants and lower the load factor of coal-fired plants, and thereby decrease the CO_2 intensity with the same installed capacity. When information on the load factors, installed capacity, CO_2 emissions and generated electricity is known the CO_2 intensities of the utilities can be calculated.

The second research aim is to provide an overview of the investment strategy of utilities. This strategy is important for the future CO_2 performance of the utilities and therefore it is interesting to know what factors influence the investment decisions. Many external factors influence investment decisions of utilities and this research aims to give an overview which factors played an important role of E.ON's investments in a coal-fired power plant and Vattenfall's investment in gas-fired power plants in the Netherlands. These two case studies should provide an insight into the investment strategy of utilities. From these two research aims the following research questions are formulated:

1.2.1 Research question

What are the CO_2 emissions per kWh of the selected utilities, how does this CO_2 intensity compare to other utilities, what is the strategy of utilities and (how) do external factors influence the strategy?

1.2.2 Sub-questions

- What is the generation portfolio of the selected utilities and how do the used fuel types contribute to the total CO_2 intensity of the utilities?
- What are the differences between the CO_2 emissions of the utilities?
- Are the utilities able to meet their CO_2 reduction ambitions when looking at the current situation and their future plans?
- What is the strategy of the utilities, which factors are important for the development of the strategy and how do external factors influence the strategy?
- Why do utilities make decisions to invest in certain types of power plants and which factors influence this definition?

1.2.3 Research boundaries

This research will focus on twelve utilities in Europe. Of these utilities, only the direct CO_2 emissions from electricity generation are calculated. Indirect emissions, such as emissions from construction or mining activities, are not taken into account. The net electricity production of facilities will be used for the benchmark. The net electricity production is the electric output minus the electrical power utilized in the plant by auxiliary equipment such as pumps, motors and pollution control devices (Graus & Worrell, 2010). The transmission and distribution losses will not be taken into account in this research, because these are not part of electricity generation by utilities.

A clear distinction has to be made between the produced and the sold electricity of the utilities. This report will only calculate the CO_2 emissions of produced electricity of utilities. The CO_2 emissions of the produced electricity are dependent on the installed capacity of the utilities. The CO_2 emissions of the sold electricity can be influenced by trade in electricity and green certificates. Utilities sell renewable energy to their customers and need guarantees of origin to prove that they deliver green electricity. Because trade in these certificates is possible, the share of renewable energy which is sold to the customers can be different than the share of renewable energy in the generation portfolio of the utility. Trade in electricity can also have an effect on the CO_2 intensity of the sold electricity of the utility. For example, if a utility buys electricity from a utility with a higher CO_2 intensity, this can increase the CO_2 intensity of the sold electricity of the utility.

The reduction of the CO_2 emissions from electricity production require a long term strategy because of the long construction time and life time of power plants. Because the CO_2 emissions of the produced electricity is dependent on the installed capacity, it is possible to make an estimation of the CO_2 emissions of the upcoming years of a utility based on the investment plans of the utilities, which is not possible for the sold electricity.

1.3 Relevance

1.3.1 Sustainable Development master program

The electricity sector is a very interesting sector for the track Energy and Resources of the Master's program Sustainable Development, because it includes both the use of energy and resources. In the EU-27 electricity generation accounts for about 40% of the total final energy use, which shows the relevance of this sector to the total energy use (Graus & Worrell, 2009). The use of sustainable energy is still small, but this share is growing (International Energy Agency, 2010). Large improvements in the sustainability of the electricity sector are possible, which makes this sector an interesting sector for sustainable development.

For the generation of electricity, large amounts of coal, gas and oil are used. Electricity generation is contributing to climate problems because of this use of these fossil fuels. About one-third of the total CO_2 emissions in Europe are caused by electricity generation (Chappin & Dijkema, 2008). A more sustainable resource use is important to tackle the negative effects of the use of fossil fuels, and to meet the emission goals set by the EU.

The insights gained by this research can contribute to a better understanding of the electricity sector and thereby lead to a more sustainable use of energy and resources. This research will give a solid analysis of the current electricity generation portfolio of the twelve selected utilities in Europe. The results of this research can be used for other research, for example for the analysis of the effects of policies, an analysis of the differences of electricity generation of European countries, an analysis of how policies can be more effective and for strategies for more sustainable electricity generation. The results of this benchmark can also be used for NGOs to create more public awareness of the sustainability of the utilities.

The research at Copernicus Institute at the University of Utrecht covers a wide range of issues related to sustainable development. The benchmark of this research fits best in the research area “Energy supply and system analysis” of the Copernicus Institute. In this research area, models and analyses are made of the energy supply system. The information generated by the benchmark can be used for the research area “Energy and global change”. This research area can use the information for providing strategies, policies, instruments and scenarios (Copernicus Institute, 2010). One example of research done at the Copernicus Institute is an analysis of renewable electricity in the Netherlands (Junginger et al., 2004). This paper analysed is the impacts of policies and the potential of renewable electricity in the Netherlands. With the results of this benchmark a comparable study can be made for renewable electricity generation in Europe. A relevant study from the Copernicus Institute which can be used for this benchmark is the analysis of the trends in efficiency and capacity of fossil power generation in the EU (Graus & Worrell, 2009). This study assessed the efficiency and capacity of installed power generation facilities, which can be used in this research to calculate the CO_2 emissions of the utilities. A comparable study is an international comparison of energy efficiency of fossil power generation (Graus et al., 2007). In this research a benchmark was made of the energy efficiency of electricity generation in several countries. Some of the methodology used in this article can be used for this benchmark. The report of Graus (2010) gives a detailed description of methods for calculating CO_2 intensity of power generation (Graus & Worrell, 2010). The calculations for the benchmark of the CO_2 intensity of utilities are based on this report.

1.3.2 Knowledge gap in literature

This research aims to add knowledge to the existing literature on strategies of utilities. In the current literature there is a large focus on the modelling of generation capacity, reduction of CO_2 emissions and electricity production security. An example is a study by Pereira (2010) which presented a model for making decisions on generation expansion, mainly based on economic and reliability considerations (Periera & Saraiva, 2010). Delarue (2010) focused on the reliability of electricity production, where the variability of renewable energy and the ramp limits of conventional power plants were taken into account for optimising the electricity generation mix (Delarue et al., 2010). Odenberger (2007) performed a study on the ability of the electricity sector to meet the reduction targets of the UK government. In this research a model was made which took the imposed limitations set by the current generation system into account. One scenario showed that it is possible to reduce the CO_2 emissions of the electricity sector of the UK by 90% compared to 1990 levels.

Chappin (2009) shows the impacts of CO_2 emission trading on the total CO_2 emissions of electricity production. In this study the effects of CO_2 emission trading on the generation portfolio were analysed and showed that the absolute emissions under most scenarios will still rise (Chappin & Dijkema, 2008). These studies are very relevant, but do not take the complete strategies of utilities into account. They analyse or model the impact which certain factors can have on CO_2 emissions, reliably electricity supply and the generation portfolio of utilities, but do not show how these factors relate to the strategies of the utilities. The strategy of the utilities has a big impact on the CO_2 emissions of a utility, because the investment plans of a utility are based on this strategy. As a result the CO_2 emissions of a country or region are dependent on these strategies. Therefore it would be useful to gain understanding of the strategies of the utilities. There is no literature available which provides a full analysis of the strategies of utilities, only smaller parts of the effects of the strategies of utilities are explained. This research will try to add this knowledge to the existing literature on strategies of utilities.

1.3.3 Use of research by Ecofys

This research will be conducted for Ecofys. Ecofys is interested in the CO_2 performance of utilities. This question was put forward because Ecofys aims to consult electricity producing companies on their strategic road map towards a cleaner electricity generation portfolio. The results of this research will be used by Ecofys to interact with utilities. The benchmark will give information on how the utility is performing compared to its peer group. With this information Ecofys can select the most interesting utilities and approach them with the results of the benchmark. Ecofys can generate profitable projects in which they deliver an advice to the clients on the most efficient road map strategies for a low carbon performance. Not only utilities can be approached by Ecofys, but also other companies who might benefit from the results of this benchmark, e.g. companies who invest in utilities. If investors prefer utilities with a good CO_2 performance, Ecofys can give advice on which utility to invest in. Ecofys can show which utilities have a long way to go to lower their CO_2 intensity, based on the detailed generation portfolio from the benchmark. The benchmark can also be interesting for NGOs to raise public awareness of the climate footprint of utilities.

1.4 Outline of report

In chapter two the research methodology of the benchmark and the strategy analysis is explained. In the third chapter the results of the benchmark are presented. In the first part of this chapter the results of the twelve individual utilities are given. The second part of this chapter compares the twelve utilities based on their CO_2 intensity and their share of renewable energy. Trends in the electricity production portfolios are pointed out and expectations of the developments of the electricity market of the next decade are given. Chapter four provides a discussion of the benchmark results. Chapter five gives a strategy analysis of utilities. Factors which have an impact on investment decisions are identified and an analysis is given of the market factors for utilities. Chapters six and seven give an analysis of the strategy of E.ON and Vattenfall, with a focus E.ON's investment in the newly built coal-fired power plant at the Maasvlakte and Vattenfall's investment in the Magnum gas-fired power plant. Chapter eight provides the results of the strategy analysis and gives a discussion of these results. The final chapter will give the conclusion of this research.

2 Methodology

The benchmark should give an insight to the CO_2 emissions and the electricity generation portfolio of the selected utilities. With the results of the benchmark, an analysis of the CO_2 reduction strategy of E.ON and Vattenfall is made. This report has the following seven main research steps:

Step 1: Selection of utilities.
Step 2: Analysis of the installed capacity
Step 3: Analysis of the generated electricity
Step 4: Analysis of the CO_2 emissions
Step 5: Allocation of CO_2 emissions to heat and power
Step 6: Analysis of the benchmark results
Step 7: Strategy analysis

In the first step the utilities are selected. In the next four steps an overview of the CO_2 emissions and the generation portfolio is made. In these steps the benchmark methodology is developed and tested. In the sixth step the results of the benchmark are evaluated and the last step is the strategy analysis of the utilities. This is accomplished by using literature and applying this to the utilities. A case study will give more insights into the CO_2 reduction strategies of E.ON and Vattenfall.

2.1 Step 1: Selection of utilities

The first step in the development of a benchmark for utilities is to make a selection of utilities that are analysed. The main selection criteria are:

1. Size of the utility
2. CO_2 reduction strategy
3. Generation portfolio
4. Attractiveness for Ecofys

2.1.1 Size of the utility

The first criterion for selecting utilities is their size. The size of a utility can be expressed in many ways. It can be based on revenue, installed capacity, number of customers or generated electricity. In this report, the size of the utilities is expressed in total generated electricity in 2009 in Europe. This method is chosen because this has the strongest relation to the CO_2 emissions of the utilities. In figure 1, the generated electricity of the largest and several other interesting utilities is shown. Data is extracted from annual, corporate social responsibility and sustainability reports of the utilities.

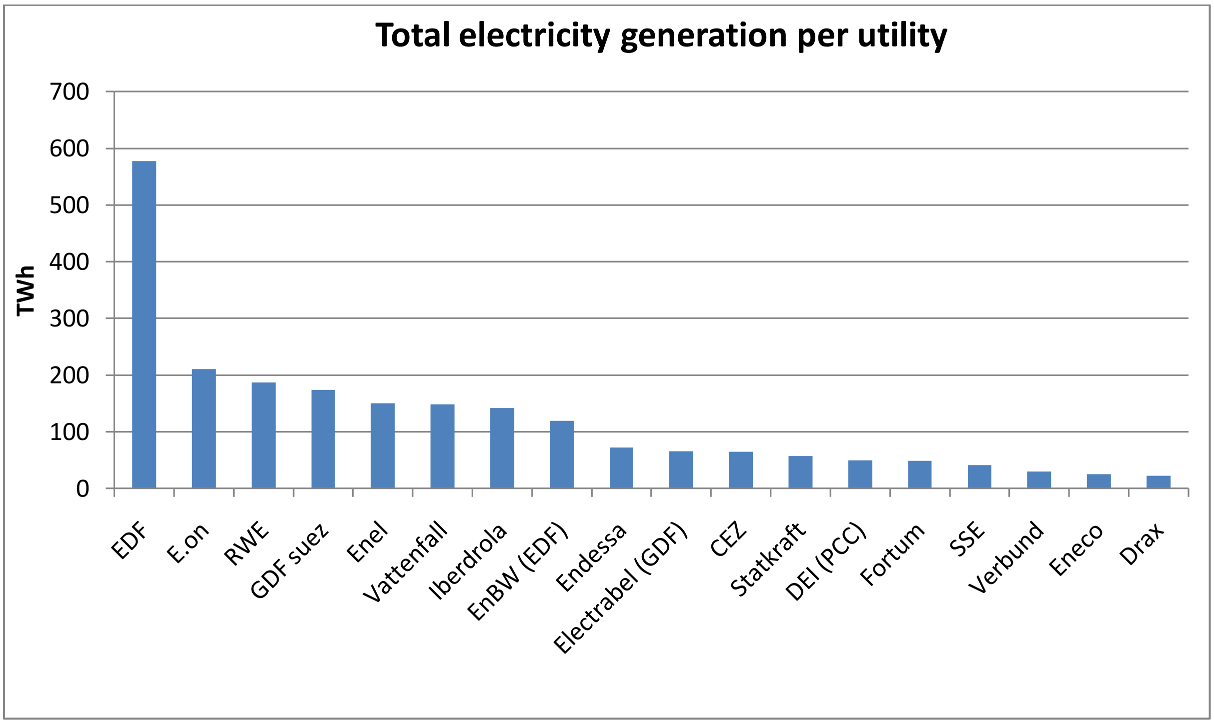


Figure 1: Total electricity generation of 2009 in Europe per utility (EDF Group, 2009b),(E.ON, 2009a),(RWE, 2009) ,(GDF Suez, 2009),(Enel, 2009) ,(Vattenfall, 2009),(Iberdrola, 2009),(EnBW, 2009), (Endesa, 2009b),(Electrabel GDF Suez, 2009),(CEZ Group, 2009),(Statkraft, 2009),(PPC, 2009),(Fortum, 2009),(EDP, 2009),(SSE, 2009a),(Verbund, 2009),(SOMO, 2010b),(Drax Group, 2009)

Based on this information, the utilities which generated more than 100 TWh in 2009 are selected. The exception is EnBW, which generated more than 100 TWh in 2009, but is not selected for the benchmark. The reason for this is because EnBW was still merged with EDF at the time of the selection. EDF has sold a large share of EnBW to the German state at the end of 2010 (Financial Times, 2010). Thus, the utilities which are selected based on the size criterion are the following seven utilities:

- EDF
- E.ON
- RWE
- Enel
- GDF Suez
- Vattenfall
- Iberdrola

2.1.2 CO_2 reduction strategy

Of the other utilities the generation portfolio and the CO_2 reduction strategies are analysed to see if there are some interesting utilities for the benchmark. In figures 2 to 18 the generation portfolios and the investment plans are shown. The figures give an indication of the investment plans of the upcoming 10 years and give an indication of the CO_2 reduction strategies of the utilities.

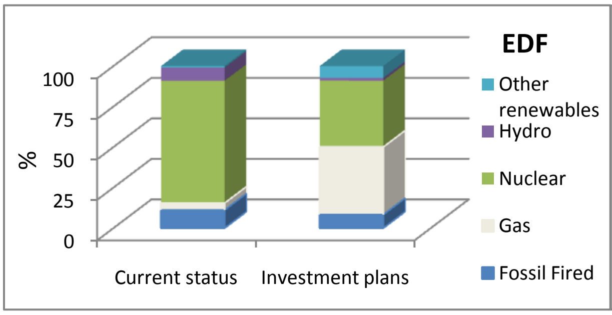


Figure 2: Generation portfolio and strategy of EDF (EDF Group, 2009b), (SOMO, 2010a)

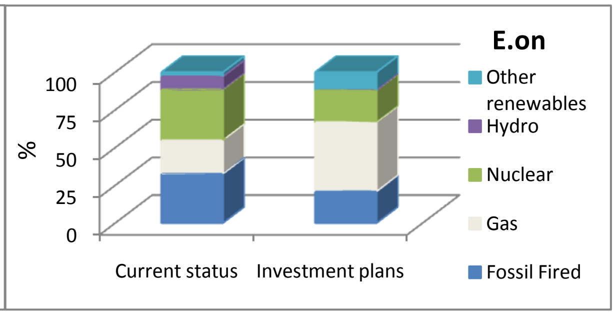


Figure 3: Generation portfolio and strategy of E.ON (E.ON, 2009a), (E.ON, 2009c), (SOMO, 2010a)

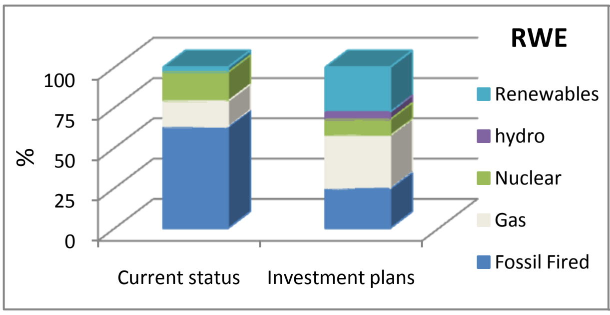


Figure 4: Generation portfolio and strategy of RWE (RWE, 2009), (SOMO, 2010a)

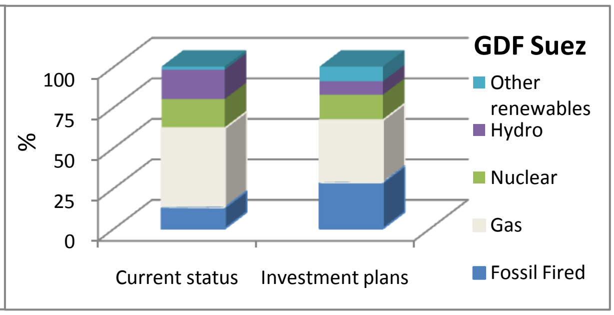


Figure 5: Generation portfolio and strategy of GDF Suez (GDF Suez, 2009), (SOMO, 2010a)

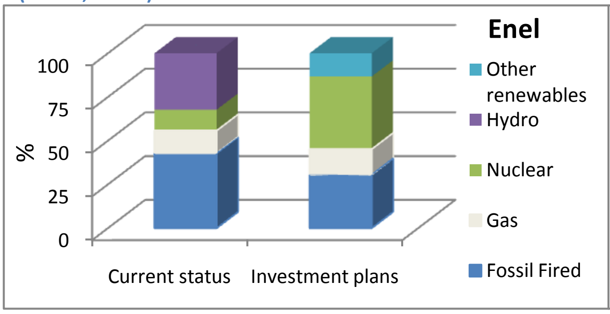


Figure 6: Generation portfolio and strategy of Enel (Enel, 2009), (SOMO, 2010a)

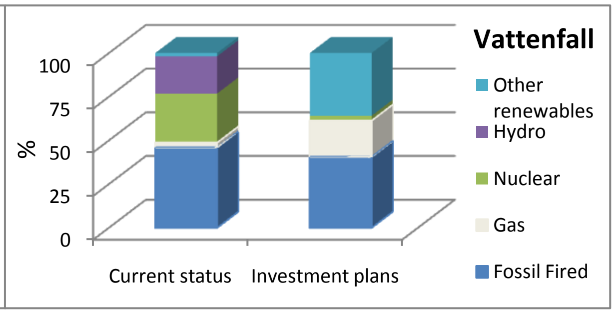


Figure 7: Generation portfolio and strategy of Vattenfall (Vattenfall, 2009), (SOMO, 2010a)

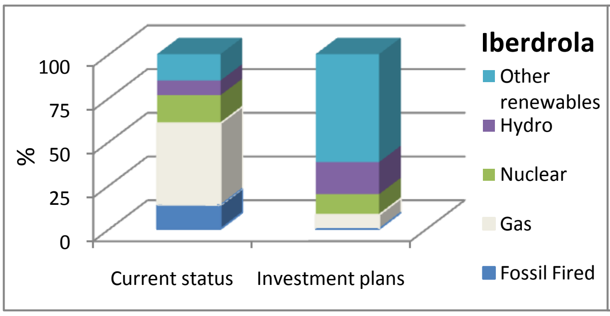


Figure 8: Generation portfolio and strategy of Iberdrola (Iberdrola, 2009), (SOMO, 2010a)

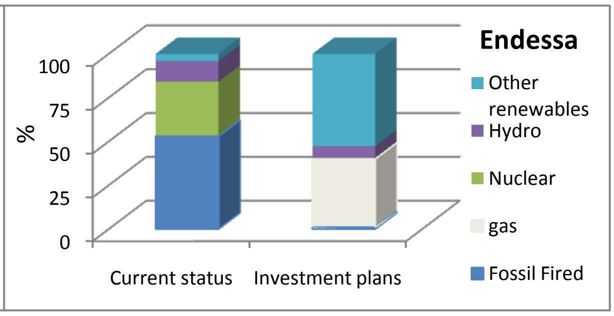


Figure 9: Generation portfolio and strategy of Endesa (Endesa, 2009b)

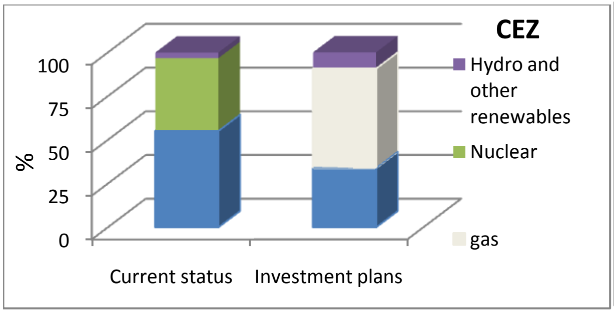


Figure 10: Generation portfolio and strategy of CEZ (CEZ Group, 2009)

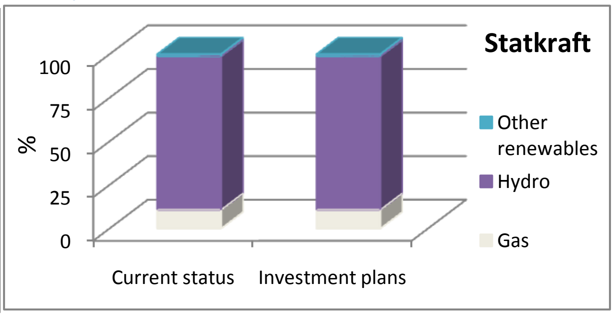


Figure 11: Generation portfolio and strategy of Statkraft (Statkraft, 2009)

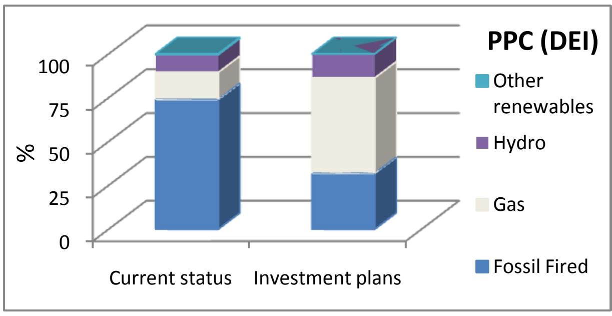


Figure 12: Generation portfolio and strategy of PPC (PPC, 2009)

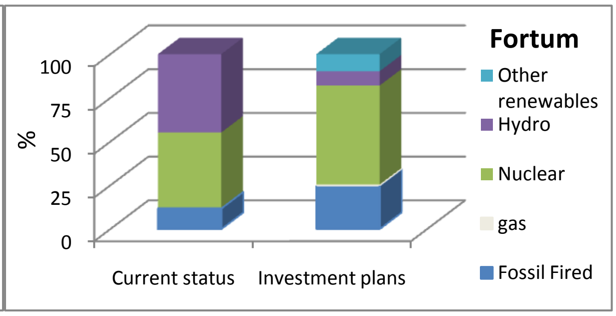


Figure 13: Generation portfolio and strategy of Fortum (Fortum, 2009)

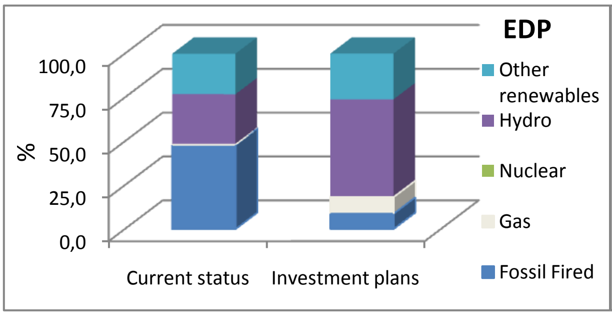


Figure 14: Generation portfolio and strategy of EDP (EDP, 2009)

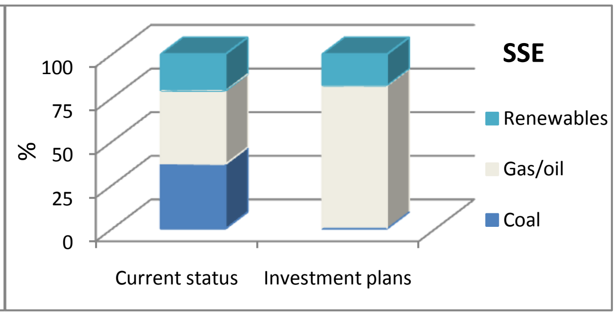


Figure 15: Generation portfolio and strategy of SSE (SSE, 2009)

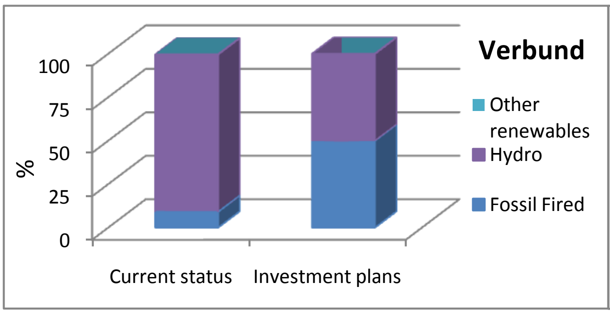


Figure 16: Generation portfolio and strategy of Verbund (Verbund, 2009)

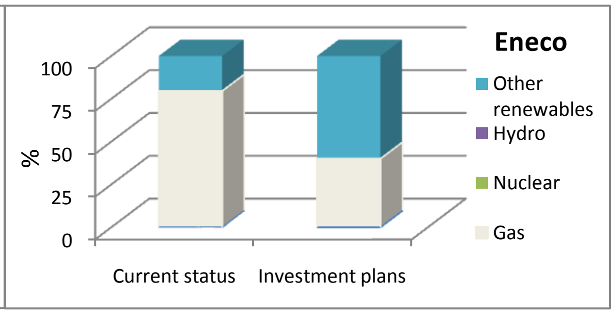


Figure 17: Generation portfolio and strategy of Eneco (Eneco Holding, 2009), (SOMO, 2010b)

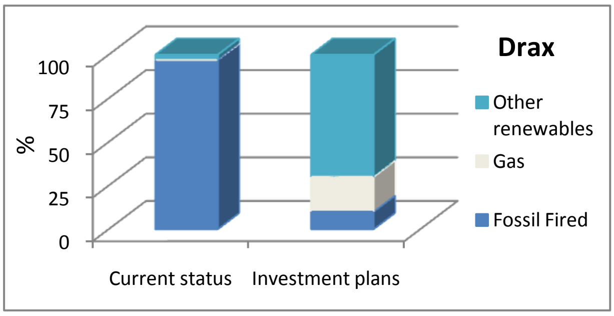


Figure 18: Generation portfolio and strategy of Drax (Drax Group, 2009)

With the information from figures 2 to 18 the utilities SSE and EDP are selected. SSE is an interesting utility for the benchmark because of their CO_2 reduction strategy. SSE is aiming to reduce their CO_2 emissions by 50% from 2006 to 2020, and will do this mainly by replacing coal for gas (SSE, 2009a). EDP is selected because of their high investment in renewable energy. With these investments they will try to reduce their CO_2 intensity by 70% from 400 gCO_2/kWh in 2008 to 120 gCO_2/kWh in 2020 (EDP, 2009b). EDP was recognised as the sustainability leader of the electricity sector by the Dow Jones Sustainability index in 2010 (SAM Indexes GmbH, 2010). This is another reason to select EDP, because it would be interesting to compare the current and future CO_2 intensity of EDP to other utilities. This comparison can show if EDP is working more on sustainability than the other utilities.

2.1.3 Generation portfolio

In figure 19, the CO_2 intensity of the utilities is given. The CO_2 intensity of a utility is a direct result of the generation portfolio of the utility. The two utilities with the lowest CO_2 intensity are Statkraft and Verbund. These utilities have a generation portfolio which is mainly based on hydro power. These utilities are not selected because their CO_2 reduction strategy is not interesting for this research. The utilities are likely to not change their generation portfolio because they already have a low CO_2 intensity. The utility which is selected on basis of the generation portfolio is PPC, because of its very high CO_2 intensity. This high CO_2 intensity is a result of the large share of fossil-fired power plants in their generation portfolio, as shown in figure 12.

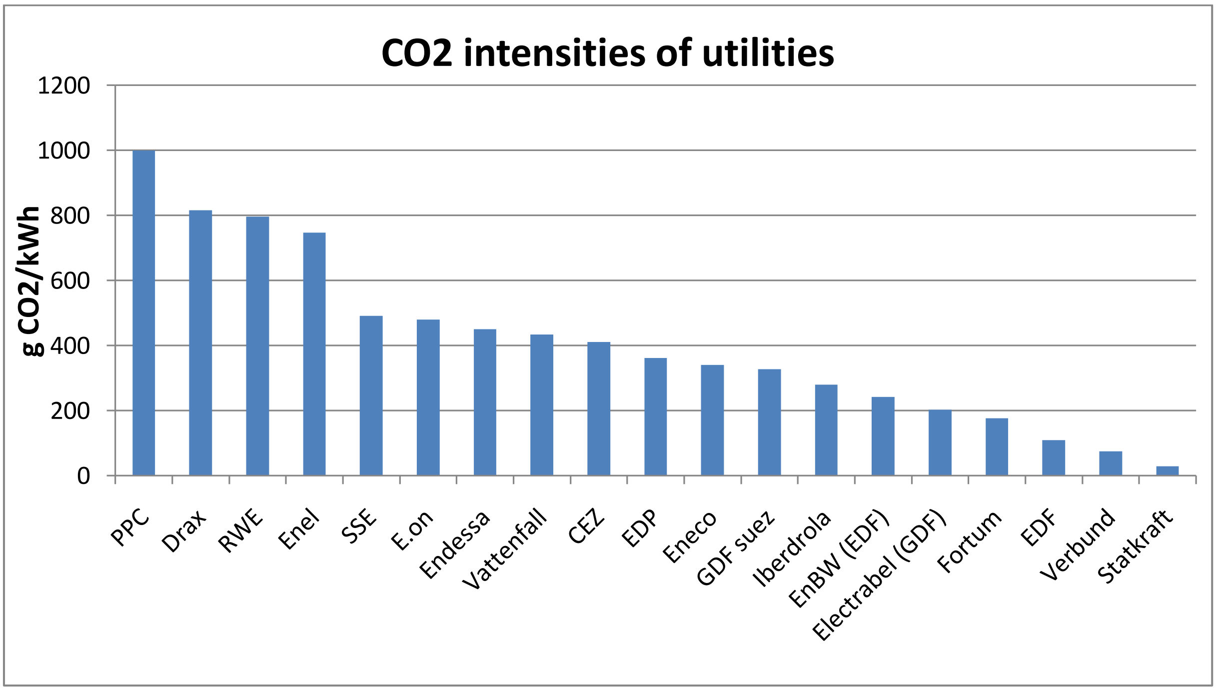


Figure 19: CO_2 Intensities of utilities (EDF Group, 2009b),(E.ON, 2009a),(RWE, 2009) ,(GDF Suez, 2009),(Enel, 2009),(Vattenfall, 2009),(Iberdrola, 2009),(PPC, 2009),(SSE, 2009a),(EDP, 2009) ,(Eneco Holding, 2009),(Drax Group, 2009)

2.1.4 Attractiveness for Ecofys

Of the remaining utilities, Eneco and Drax are selected because they are already relations of Ecofys. This makes them interesting because Ecofys could straightforwardly do more work for these utilities. Because of the existing connections to these utilities, information is more easily obtained.

2.1.5 Selected utilities

This results in a selection of 12 utilities, which are shown in table 1. This selection has a high diversity of CO_2 intensities and generation portfolios, which makes the benchmark and the strategy analysis of the utilities more interesting. The total net electricity generation in the EU-27 was 3046 TWh in 2009 (Eurostat, 2010a). The selected utilities had a combined electricity generation of 1756 TWh and therefore the selection accounts for about 58% of the total electricity generated in the EU-27.

Table 1: Overview of the selected utilities (EDF Group, 2009b),(E.ON, 2009a),(RWE, 2009) ,(GDF Suez, 2009),(Enel, 2009),(Vattenfall, 2009),(Iberdrola, 2009),(PPC, 2009),(EDP, 2009),(SSE, 2009a), (Drax Group, 2009),(E.ON, 2009c) ,(Eneco Holding, 2009)

Utility	Total electricity generation in Europe (TWh)	CO_2 emissions (g/kWh)	CO_2 reduction strategy
EDF	577	109	N/A
E.ON	211	480	330 g CO_2/kWh in 2020
RWE	187	796	450g CO_2/kWh in 2020
GDF Suez	174	327	N/A
Enel	171	746	N/A
Vattenfall	149	434	260 g CO_2/kWh in 2020
Iberdrola	143	279	CO_2 intensity 20% below the recommended EU average in 2020
EDP	42.0	362	120 g CO_2/kWh in 2020
PPC (DEI)	50.1	1000	900 g CO_2/kWh in 2015
SSE	41.2	491	308 g CO_2/kWh in 2020
Eneco	9.5	340	70% sustainable in 2020
Drax	0.7	815	N/A

2.2 Step 2: Analysis of the installed capacity

Of the selected utilities, all the electricity generating facilities are indicated. The main source of information is the Platts Powervision database (Platts, 2010 Q1). This database gives information about most of the power plants in Europe. All the power plants above 5 MW installed capacity are included, but some power plants below this level are not included. The database gives information about the holding company of each power plant and the ownership share. The ownership share is used to allocate only this share of the installed capacity to a utility. Other data which is included in the database is the installed electric capacity (MW_e), installation year, decommissioning year, plant location, plant type, primary fuel and operation status. With this information the current installation portfolio of a utility is calculated, showing how much capacity per fuel type is available. Figure 20 shows how this data is used for the benchmark calculations.

Because closed down power plants, power plants under construction and planned power plants are included in the Powervision database, this information can be used, together with the installation year and the decommissioning year, to analyse the past and future installed capacity of the utilities. One factor which makes this analysis of the installed capacity of the previous decade more difficult is the changes in ownership of power plants due to acquisitions of power plants or utilities. An example is the acquisition of Nuon by Vattenfall in the year 2009 (Nuon, 2011b). Because these changes are not included in the Powervision database, older versions of the database are used to track the changes in the ownership status of the power plants. This will result in an overview of the development of the installed capacity of the utilities over the years. This information is used to analyse the investment strategies of the utilities and to calculate the electricity generation portfolio, which is the next research step.

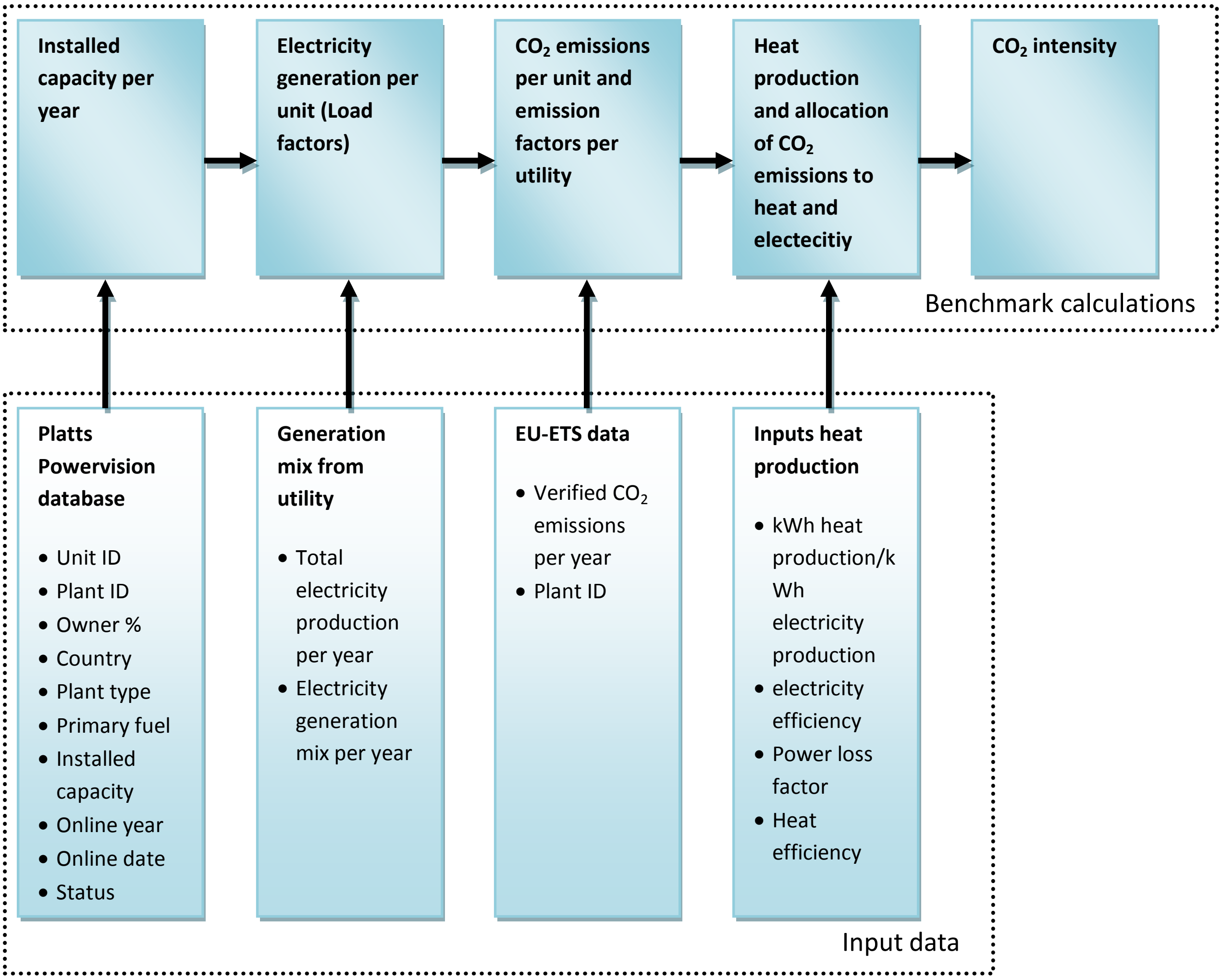


Figure 20: Database scheme for the inputs and calculations of the benchmark

2.3 Step 3: Analysis of the generated electricity

Because there is no public information available about the electricity generation of individual power plants, assumptions of the load factors are made. The electricity production is calculated by:

$$P = UC \times LF$$

- P is the power production (GWh)
- UC is the unit capacity (MW_e)
- LF is the load factor (h/year).

The unit capacity is known from the step 2 and the load factors are estimated by using the total generation mix of the utility. The generation mix of utilities is found in annual reports of the utilities and in the Carbon Disclosure Project database and is shown in appendix 1 (Carbon disclosure project, 2008). The load factors are set to the level for which the calculated generation mix matches the generation mix from literature. Some of the data given by utilities is not very specific, for example, EDF specified the fossil power production in only two categories, namely fossil-fired and gas. The fossil fires share of EDF consists of several fuel types, namely hard coal, soft coal, heavy oil, process gas and waste. Because the generation mix of these fossil fuels is not known the ratio between the load factors is based on load factors found in literature (Graus et al., 2004).

There is no literature available for all the years of the past decade. For most utilities data is available since the year 2007. For the previous years, an average is taken of the load factors of two least recent known load factors to make assumptions for the generated electricity. For upcoming years the average load factor of the two most recent known years is used.

2.4 Step 4: Analysis of the CO_2 emissions

The CO_2 emissions of the utilities are based on the European Emissions Trading Scheme (EU-ETS) database (European Commission, 2010a). This database gives information about the verified CO_2 emissions of all the power plants which fall under the EU-ETS for the years 2005 to 2010. Some power plants are not in the EU-ETS database and the CO_2 emissions are estimated for these power plants. No public information is available about the CO_2 emissions during the years 2000 to 2004 and of upcoming years and therefore these emissions are estimated.

The methodology for estimating the CO_2 emissions uses the CO_2 emissions from the EU-ETS database to make estimates of the CO_2 emissions which are not in this database. Per utility, an estimate of the CO_2 intensity per fuel type of produced electricity is made. This is done by adding up the EU-ETS CO_2 emissions of power plants of one fuel type from a utility and dividing this by the sum of the electricity generation of these power plants as estimated in step 3. This results in a CO_2 intensity per fuel per utility and this CO_2 intensity can be multiplied by the estimated electricity generation of power plants to make an estimate of the CO_2 emissions of this power plant. To sum this up, the CO_2 emissions are estimated per utility with the following equations:

$$\text{Estimated } E_i = P_i * \text{estimated } C_i$$

$$\text{Estimated } C_i = \sum E_i \text{ from EU-ETS} / \sum P_i \text{ where } E_i \text{ from EU-ETS is available}$$

- $_i$ is the fuel source 1,...., n
- E_i the CO_2 emissions per fuel source (gram)
- P_i the power production per fuel source (kWh)
- C_i the CO_2 emission factor per fuel source (gram CO_2/kWh)

For the years 2000 to 2004, the average estimated CO_2 intensity per fuel of the years 2005 to 2007 is used. For the years 2011 to 2020 the average estimated CO_2 intensity per fuel of the years 2008 to 2010 is used.

Apart from this methodology, two other methodologies were analysed which are described in appendix 2. As shown in Appendix 2, these methodologies did not result in accurate estimates of the CO_2 emissions and therefore these methodologies where not used.

2.5 Step 5: Allocation of CO_2 emissions to heat and power

In step 4, the CO_2 emissions of the power plants are calculated, but some of these CO_2 emissions have to be allocated to the heat production of the power plants, if this heat is used usefully. For these types of power plants, which are called combined heat and power (CHP) or cogeneration plants, the CO_2 emissions can be allocated using several methods. For all of these allocation methods four types of data input are needed regarding CHP plants, namely the generated electricity, the total CO_2 emissions, the fuel use and the heat production. The generated electricity and CO_2 emissions are calculated in steps 3 and 4. The fuel use is estimated by using the electricity conversion efficiency and the electricity production. The heat production is estimated by using data from utilities. Utilities are contacted to provide information on the total electricity and the total heat generated with CHP plants. Because this data is confidential it is not presented in this report. Due to confidentiality issues, some utilities did not provide information. For these utilities the heat production is estimated based on the data of other utilities. Because data is available from the largest heat producing utilities, the deviations because of estimations of the heat production are expected to be small.

In the next section, an allocation methodology is chosen from several methodologies which are available in literature. In the section after that, an overview is given how the chosen methodology is applied in the benchmark.

2.5.1 Selection of the methodology to allocate CO_2 to heat and electricity production

Some of the CO_2 emissions have to be allocated to the heat production, and there are several methods available for this, namely the economic, substitution, power and heat generation, exergy and power loss factor method (Graus & Worrell, 2010).

2.5.1.1 *Economic allocation method*

The economic method allocates the CO_2 emissions on basis of the economic value of both heat and electricity, which can show the economic preference of both products as shown in the equation below (Graus & Worrell, 2010).

$$CO_2 \text{ emissions of } P_i = P_i \left((C_i I_i)/(V_p P_i + V_h H_i) \right) \text{ (economic method)}$$

- $_i$ is the fuel source 1,...., n
- C_i the CO_2 emission factor per fuel source (tonne CO_2/TJ)
- P_i the power production per fuel source (GWh)
- H_i the heat output from CHP plants (GWh)
- I_i is the fuel input power of CHP plants
- V_p is the value of the produced power
- V_h is the value of the produced heat

The value of a product is not always representative for the actual CO_2 emissions caused by the production of heat or electricity. For example, if the demand for electricity is very high, this will increase the price of electricity. If the electricity price increases, more CO_2 emissions have to be allocated to electricity production. This is not correct because there is no increase in the resource use for the production of electricity. The volatility of the value of electricity and heat would mean that the same amount of electricity can have several CO_2 intensities over time and place. This is not useful for making a benchmark of the CO_2 emissions of utilities, because external factors would have an impact on the CO_2 emissions, which cannot be influenced by a utility. Next to this, the prices are not always known. This is because the electricity and heat are sometimes not sold, but are directly used by the producer. An artificial price can be used for these energy streams, but this would give an extra uncertainty for the allocation of the CO_2 emissions (Blok, 2007).

2.5.1.2 *Power and heat generation allocation method*

In the power and heat generation method, CO_2 is allocated to the heat and electricity output on the basis of the energy content, which is shown in the equation below (Graus & Worrell, 2010).

$$CO_2 \text{ emissions of } P_i = P_i \left((C_i I_i)/(P_i + H_i) \right) \text{ (power and heat generation method)}$$

- $_i$ is the fuel source 1,...., n
- C_i the CO_2 emission factor per fuel source (tonne CO_2/TJ)
- P_i the power production per fuel source (GWh)
- H_i the heat output from CHP plants (GWh)
- I_i is the fuel input power of CHP plants

The energy content of electricity is more useful than that of heat, because the exergy content is higher. The exergy of a system is the maximum useful work possible during a process that brings the system into equilibrium with a heat reservoir (Graus & Worrell, 2010). This is not taken into account in the power and heat generation method and therefore this method is not used.

2.5.1.3 *Exergy allocation method*

The exergy method does allocate the CO_2 emissions on the basis of the exergy output. The equation for the exergy method is given below (Graus & Worrell, 2010).

$$CO_2 \text{ emissions of } P_i = P_i \left((C_i I_i)/(P_i + CaH_i) \right) \text{ (exergy method)}$$

- where $_i$ is the fuel source 1,...., n
- C_i the CO_2 emission factor per fuel source (tonne CO_2/TJ)
- P_i the power production per fuel source (GWh)
- H_i the heat output from CHP plants (GWh)
- Ca is the Carnot factor
- I_i is the fuel input power of CHP plants

This method does take into account that the value of electrical energy is higher than that of heat energy, because electricity can deliver more work. It also takes the quality of the heat into account. While this is a useful method from a thermodynamic point of view, the usefulness for a benchmark is limited. This is because the exergy method is a theoretical approach and calculates maximum useful work possible, while in practice the useful work will be lower. For this reason this method will not be used in this report.

2.5.1.4 *Substitution allocation method*

The substitution method calculates how much CO_2 emissions are avoided because the heat is not separately produced. The CO_2 emissions are allocated according to the following equation (Graus & Worrell, 2010).

$$CO_2 \text{ emissions of } P_i = P_i \left((C_i (I_i - H_i/r)/(P_i) \right) \text{ (substitution method)}$$

- where $_i$ is the fuel source 1,...., n
- C_i the CO_2 emission factor per fuel source (tonne CO_2/TJ)
- P_i the power production per fuel source (GWh)
- H_i the heat output from CHP plants (GWh)
- r the reference efficiency for heat generation
- I_i is the fuel input power of CHP plants

With this method, the assumption is made that that a CHP plant is used instead of two separate plants which produce heat and electricity. This method is selected as a method which is used in the benchmark, because it takes into account the external benefits: the reduction in fuel use compared to separate heat generation.

2.5.1.5 *Power loss allocation method*

The power loss method is based on the fact that the electricity output of a CHP plant is lower than a power plant where no useful heat is generated (Blok, 2007). A correction factor is used to calculate the amount of electricity which would have been produced if no heat was generated, as shown in the following equation (Graus & Worrell, 2010).

$$CO_2 \text{ emissions of } P_i = P_i \left((C_i I_i)/(P_i + sH_i) \right) \text{ (power loss method)}$$

- $_i$ is the fuel source 1,...., n
- C_i the CO_2 emission factor per fuel source (tonne CO_2/TJ)
- P_i the power production per fuel source (GWh)
- H_i the heat output from CHP plants (GWh)
- s is the correction factor
- I_i is the fuel input power of CHP plants

This method is a more realistic method than the exergy method, because it compensates for the actual efficiency drop caused by the production of heat. This makes the CO_2 emissions of CHP plants comparable with power plants without heat production. This is why this methodology is the second method which is selected for the benchmark of the CO_2 intensity.

2.5.2 Use of the power loss method and substitution method

The power loss method and the substitution method are selected to allocate the CO_2 emissions to heat and power production. The reason why two methodologies are selected is because the methodologies are applied to several power plant types. For some installations, the power loss method will be used, and for other installations the substitution method will be used. Below, an explanation is given which methodology is used for what type of power plant and why.

2.5.2.1 *Steam turbine*

The power loss method will be used for steam turbines, where the heat is extracted before all the heat is turned into electricity, as shown in Figure 21. The heat is extracted from the turbine at point 1 in the figure, based on the heat requirements of the external user. If the heat demand is higher than the heat which can be extracted from the turbine at point 1, the temperature of the heat stream can be increased by the heater. If no heat is required, all heat will be used by the turbine and the waste heat will leave at point 2. The electric efficiency of the turbine drops when heat is extracted at point 1. This drop in electric efficiency will increase the CO_2 emissions for the electricity production. This increase in CO_2 emissions is compensated by using the power loss method.

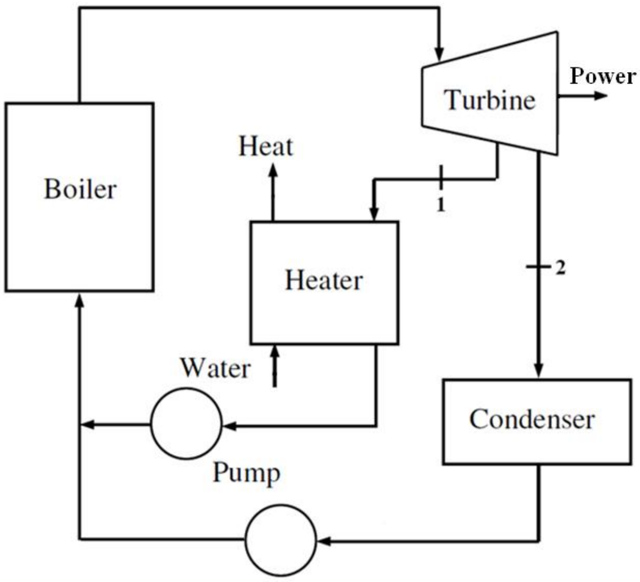


Figure 21: a cogeneration steam power plant (Kanoglu & Dincer, 2009)

2.5.2.2 *Gas turbine*

Figure 22 shows the flow scheme of a CHP based on a gas turbine. The large difference between the steam and the gas turbine is that in a gas turbine the fuel is directly fed into the turbine. In the steam turbine steam needs to be produced before electricity can be generated in the turbine. The most important difference for the method of allocation of CO_2 emissions is that the heat produced by a gas turbine can be used without decreasing the efficiency of the electricity production. This is because the exhaust gases, which are of very high temperature, are used to supply the required heat. To compensate for the beneficial effect of not having to produce the power and heat separately, the CO_2 emissions will be allocated using the substitution method.

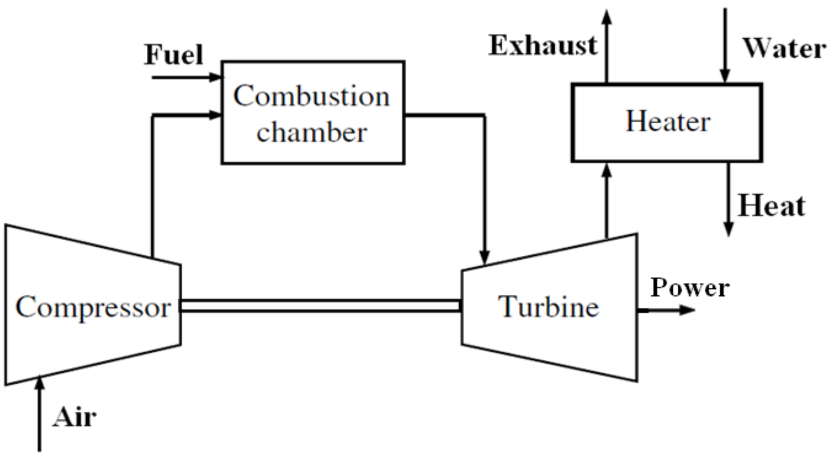


Figure 22: a cogeneration gas-turbine engine plant (Kanoglu & Dincer, 2009)

2.5.2.3 *Cogeneration engine generator*

Figure 23 shows a flow scheme of a cogeneration diesel power plant. In this power plant, the hot exhaust gases are used to heat water which can be used for other processes. A heater is added to increase the temperature when there is a higher heat demand than the diesel engine can deliver. The use of the heat from the exhaust gases of the diesel engine does not have an impact on the efficiency of the power plant and therefore the substitution method will be used to allocate the CO_2 emissions to the electricity and heat output.

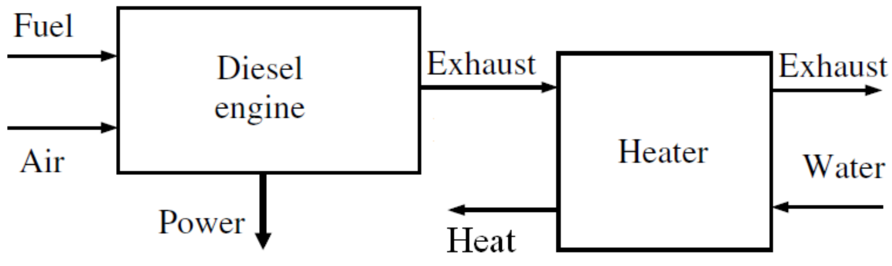


Figure 23: a cogeneration diesel-engine power plant (Kanoglu & Dincer, 2009)

2.5.2.4 *Combined cycle power plant*

The exhaust heat of a gas turbine can be used to produce electricity in a steam turbine, which is called a combined cycle. The flow scheme of this cycle is shown in figure 24. The advantage of this configuration is that the electric efficiency can be very high, but therefore the amount of heat which can be produced is lower. The heat is extracted in the same way as described for the steam turbine. In the configuration depicted in figure 24, two steam turbines are installed. One steam turbine works at a high pressure, and the other at a lower pressure. Heat can be extracted from both turbines. The advantage for the heat extraction of this configuration is that high quality, high pressure heat and lower quality heat with a lower pressure can be extracted, based on the needs of the end user. The extraction of heat from the steam turbines will reduce the efficiency of these turbines and therefore the CO_2 emissions of a combined cycle CHP are allocated using the power loss method (I-DACTA, 2007).

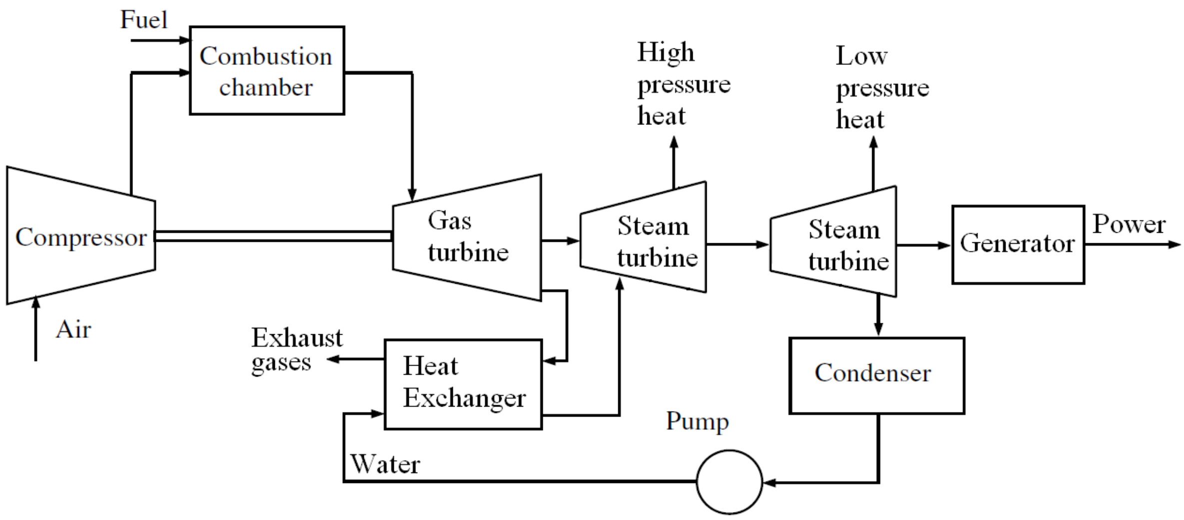


Figure 24: cogeneration with a combined gas-steam power plant, based on (Kanoglu & Dincer, 2009), (Ouwehand et al., 2005) and (Cengel & Boles, 2007)

2.5.3 Use of the allocation methods in the benchmarks

The electricity production, electricity production efficiency, heat production, heat production efficiency, CO_2 emissions and the fuel use are needed to allocate the CO_2 emissions to the heat and power production of a power plant. The electricity production and the CO_2 emissions of the power plants are calculated in steps 3 and 4. For the electricity production efficiency the same assumptions are used as for the calculation of the CO_2 emissions. For the heat production efficiency of the substitution method a reference efficiency of 90% is used and a correction factor of 0.20 is used for the power loss method (Graus & Worrell, 2010).

2.6 Step 6: Analysis of the benchmark results

In this step the outcomes of the benchmark are presented and evaluated. A comparison of the CO_2 intensity and the fuel mix of the selected utilities is made. There can be large differences between the CO_2 intensities of the utilities. These differences are analysed and explanations will be found why these differences exist.

2.7 Step 7: Strategy analysis

In the last step, the strategies of the utilities are analysed. The strategy analysis will focus on the electricity generation by the utilities. The strategy is analysed by using literature on corporate and business strategies, literature on strategy analysis of utilities and a case study. The general idea is that the literature gives insights and understanding in the strategy of the utilities. This information is used in the case study to come up with relevant questions which can be answered by the case study. During the case study, new insights are gained which are verified by looking into existing literature. In this way the literature study and the case study are combined to come up with a good overview of the way utilities develop and use strategies for generation portfolio planning and the reduction of the CO_2 intensity.

The first step of the strategy analysis is to describe how strategies are developed and what factors have an influence on the development of a strategy. This description is made by using general literature about strategy analysis. In the book Contemporary Strategy Analysis, Grant shows a model which can be used for strategy analysis, which is shown in figure 25 (Grant, 2010).

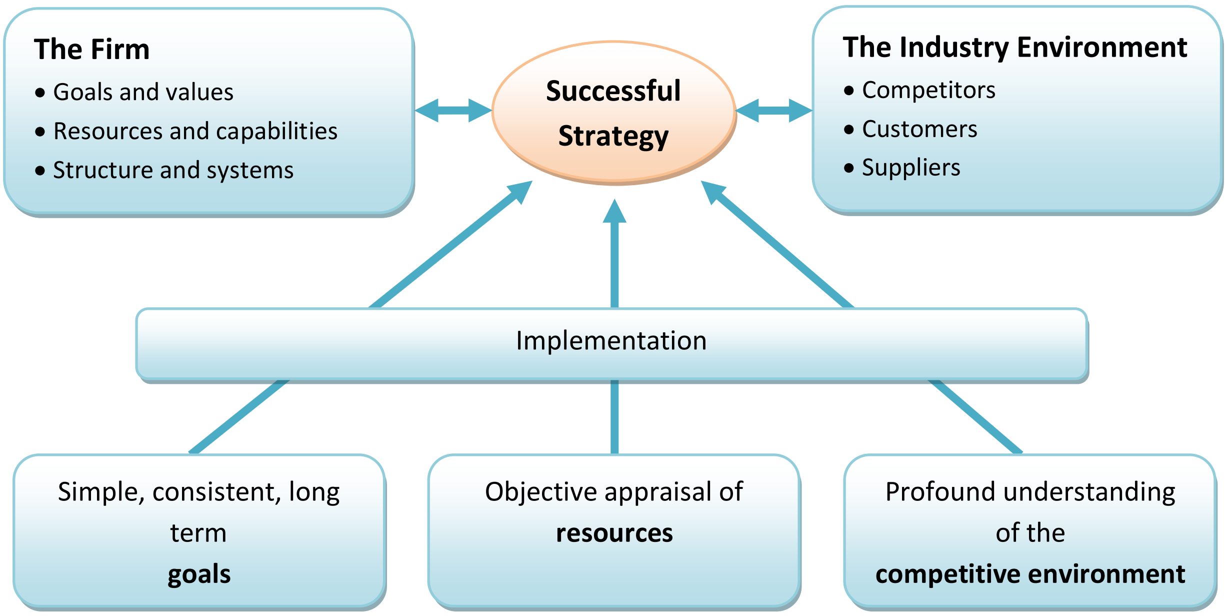


Figure 25: common elements for successful strategies, based on (Grant, 2010) and (Heuvel, 2011).

This figure shows that the goals, resources, capabilities, structure and the competitive environment are important factors to develop a successful strategy. Each of these factors is analysed for the strategy analysis of the utilities. The long term goals are found in annual reports of the utilities. For an analysis of the available resources, the benchmark database is used. The database shows the specialisation of the utility. For example, EDF has a large share of nuclear energy in their generation portfolio, and therefore they also have knowledge in-house on nuclear reactors. These are resources which are important for the development of a successful strategy. The benchmark gives some information about the competitive environment of the utilities, like the environmental performance and the investment plans of other utilities.

To get a profound understanding of the competitive environment more information is needed. This information is gathered by using Porter's five forces of competition (Porter, 2008). In this framework the profitability of an industry is determined by five forces of competition, namely: The bargaining power of suppliers, the threat of substitutes, the bargaining power of buyers, the threat of new entrants and the rivalry among existing firms (Porter, 2008). Information about these five forces is gathered for the analysis of the competitive environment.

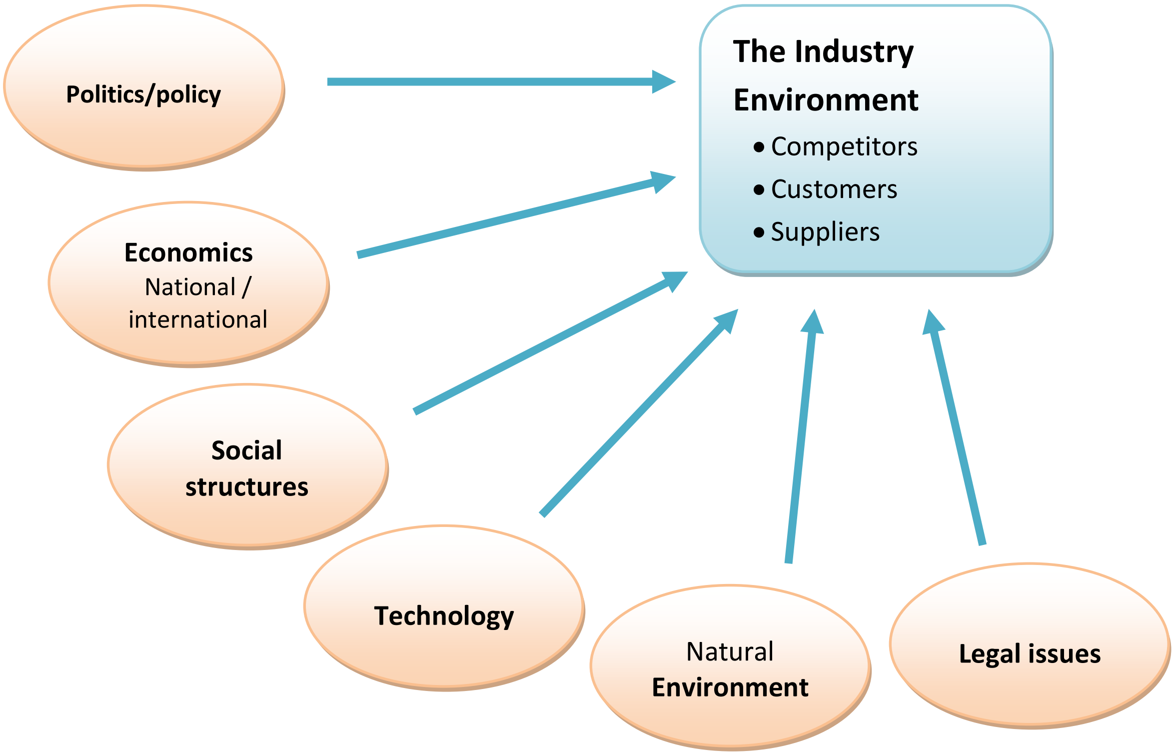


Figure 26: The six factors of a PESTEL analysis influencing the industry environment (Grant, 2010, pp.64-65), (Heuvel, 2011).

The external factors influencing the strategies are assessed by a PESTEL analysis as depicted in figure 26. This figure shows external factors which have an influence on the strategy of utilities. All these factors are analysed by using literature studies which analyse the effects of these separate factors. The information from the Porter analysis and the PESTEL analysis are used to make a strength, weakness, opportunities and threats (SWOT) analysis.

The knowledge found in literature is used for the case study to analyse the strategies of two utilities. In this case study, the question is asked why Vattenfall and E.ON made the decision to each build a new coal- of gas-fired power plant in the Netherlands. Utilities use their strategies to make the investment decisions for new power plants. The case study tries to evaluate how the decision of building a new coal- or gas-fired power plant fits into the strategy of the utilities.

In figure 27, a case study methodology is shown (Yin, 2003). The first step is this methodology is the development of a theory. This step includes the strategy analysis which is described above, where literature is used to analyse the strategy of utilities. The development of a theory also includes drawing up a hypothesis which is tested by the case study.

The hypothesis of this case study is that investing in a coal power plant is strategically not a good option. This hypothesis is put forward because the factors influencing the industry environment have a negative impact on the investment of a coal fires power plant. For example, the government sets strict emission standards which are difficult and expensive to meet for coal power plants. Generating electricity from coal will become more expensive because utilities have to buy emission allowances from 2013 and onwards. Building coal-fired power plants has a negative impact on the reputation of the utilities, because they have a large contribution to climate change caused by CO_2 emissions. Because of all these negative factors of a coal-fired power plant the question is posed why utilities have made the decision to continue building these power plants and which factors were important for this decision.

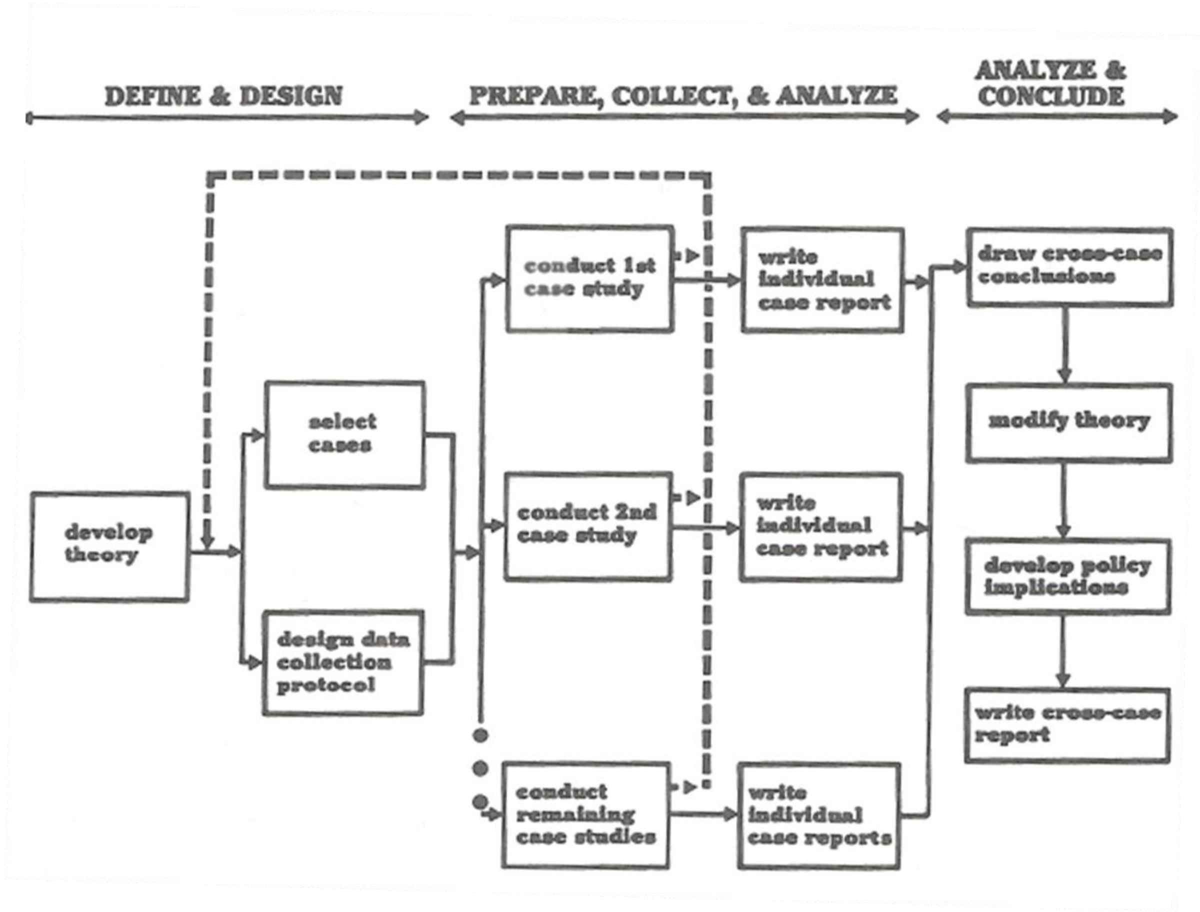


Figure 27: case study method (Yin, 2003)

The next step, as shown in figure 27, is the selection of cases. For this case study, the new coal-fired power plant at the Maasvlakte of E.ON and the Magnum gas-fired power plants of Vattenfall are selected. A multiple-case design is chosen because this improves the reliability of the case study over a single-case design. This is because there is a chance with a single-case design that an exceptional case was selected, which cannot be checked by another case (Yin, 2003). Both cases are located in the Netherlands and therefore most of the external factors for both case studies should be the same. The main difference could be the strategy of utilities, and therefore there could be a difference between these companies about how and why they made the decision to build a coal- or gas-fired power plant. For both case studies, data is collected concerning the decisions and strategies of the utilities.

The first step is the strategy analysis of Vattenfall and E.ON, where the theory found in literature is applied to these two utilities. With the information found in the literature, annual reports and data from the benchmark an analysis can be made of what the expected strategy of the utility is. With this exercise, insights will be gained into the strategy of the utility, and also about the decision to build a new coal- of gas-fired power plant.

News articles from newspapers, utilities, NGOs and governmental organisations can be used to gain information about how external factors influenced the decision to build a coal-fired power plant. For example, some interesting subjects for this case study where shown at the Dutch television program EenVandaag about the coal-fired power plant of E.ON at the Maasvlakte. In this program it was demonstrated that coal-fired power plants are not economically interesting, but because the government has signed a contract to compensate for the increased costs by the emission allowances, this power plant could be build (Eenvandaag, 2010).

Figure 27 shows a feedback loop after conducting the case study. This feedback loop is important because the case study can bring up new information which can change the original theoretical propositions. When this happens the case study should be redesigned and an alternative hypothesis and data collection method should be developed. This is to ensure objectivity in reporting data and not ignoring data which does not fits the original design (Yin, 2003).

3 Benchmark results

The benchmark results consist of two parts. The first part provides an overview of the installed capacity, generation portfolio, CO_2 emissions and CO_2 intensity of the twelve selected utilities. The results show some interesting developments which are analysed and explained. The EU-ETS data is used to make estimations of the CO_2 emissions in the years where no ETS data is available. Before the year 2005, no ETS data is available and therefore the total CO_2 emissions of these years are based on assumptions, which are indicated with the hazed section in the graphs. For the generated electricity not all data for the past decade was available. The years which are based on assumptions are here also indicated by a hazed section.

In the second part of the benchmark result, the utilities will be compared. The CO_2 performances of the utilities are shown in a benchmark. By giving an overview of the CO_2 emissions and CO_2 intensity, interesting trends can be seen.

3.1 Électricité de France (EDF)

Figure 28 shows the development of the installed capacity of EDF. The generation mix as shown in figure 29 is derived from the installed capacity, combined with the generation mix and the total produced electricity from annual reports of EDF. The effects of the economic crisis can be seen in the years 2008-2009. In 2009, the installed capacity increased, but the produced electricity decreased.

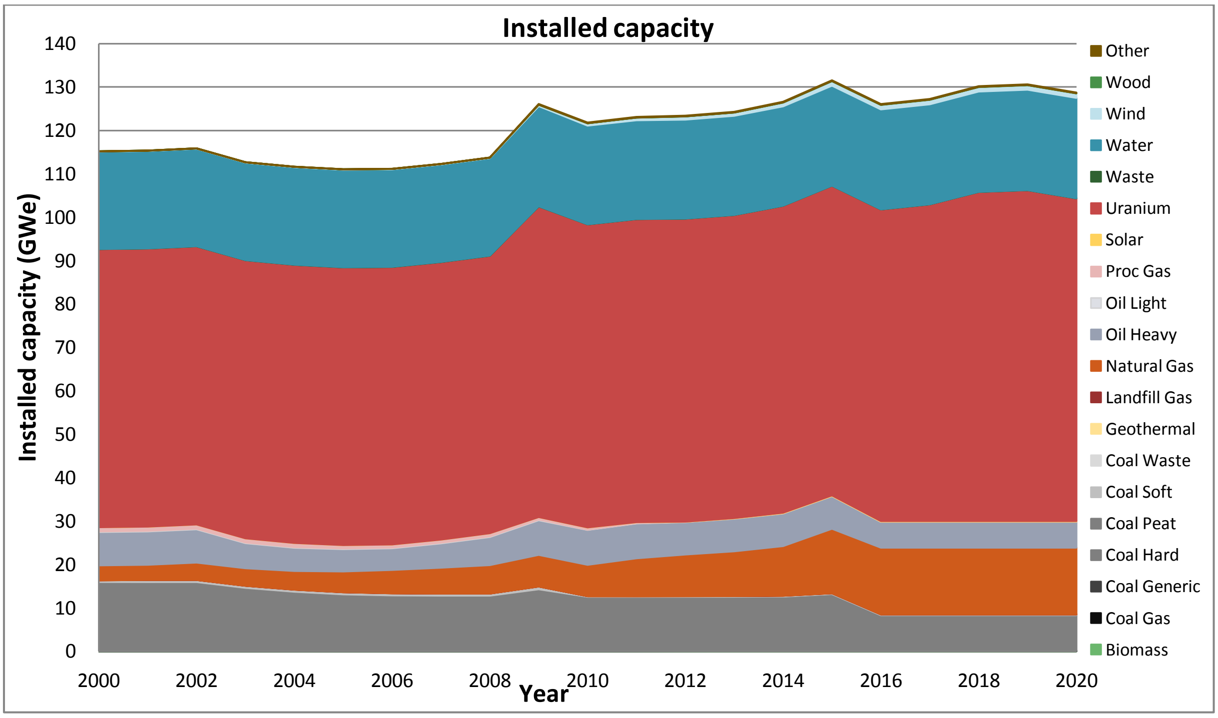


Figure 28: Development of the installed capacity of EDF (Platts, 2010 Q1)

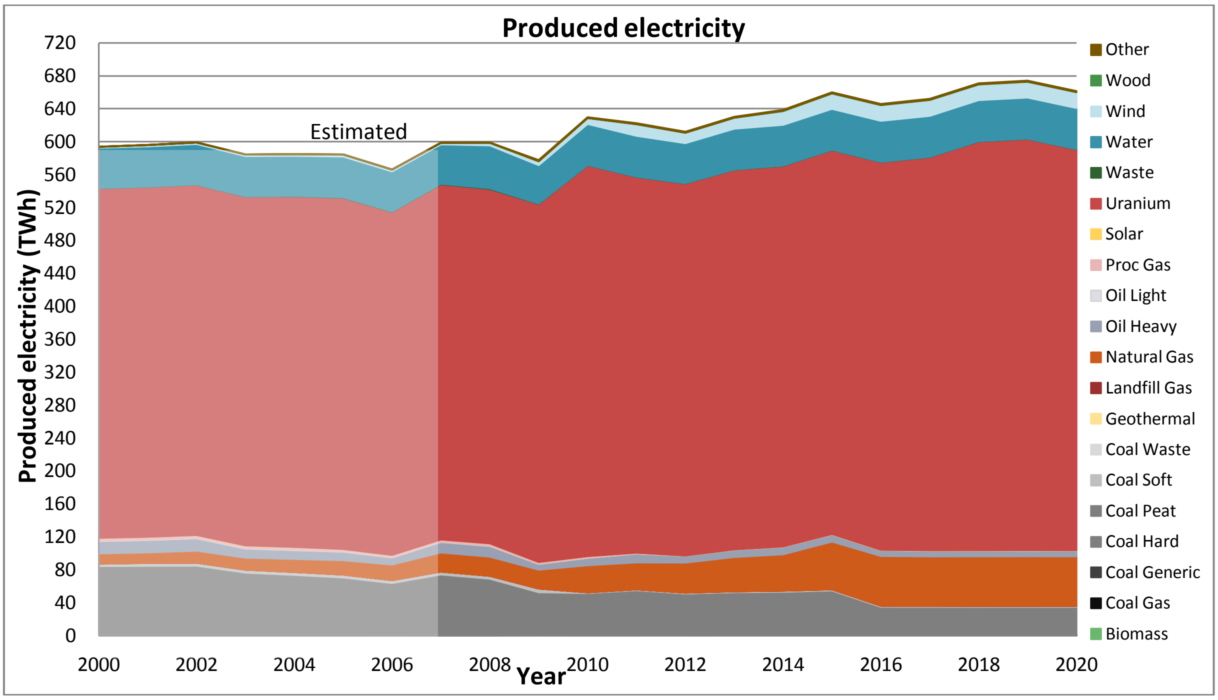


Figure 29: Development of the electricity generation mix of EDF, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1) and annual reports of EDF

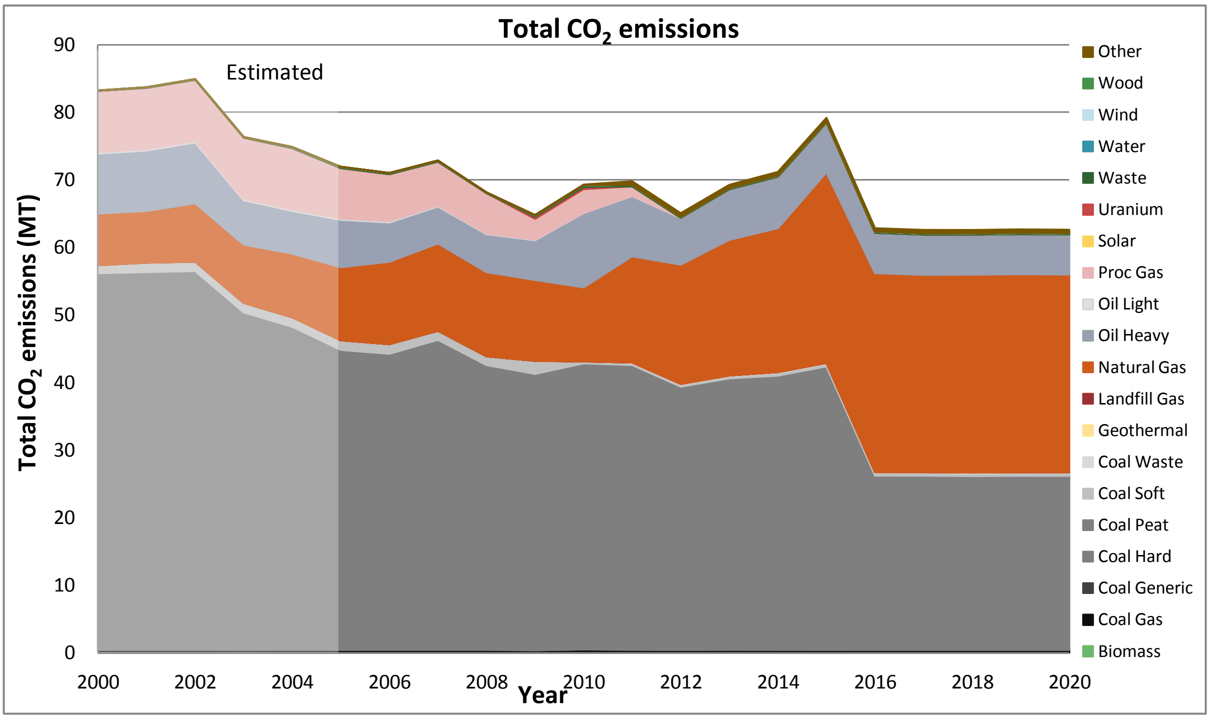
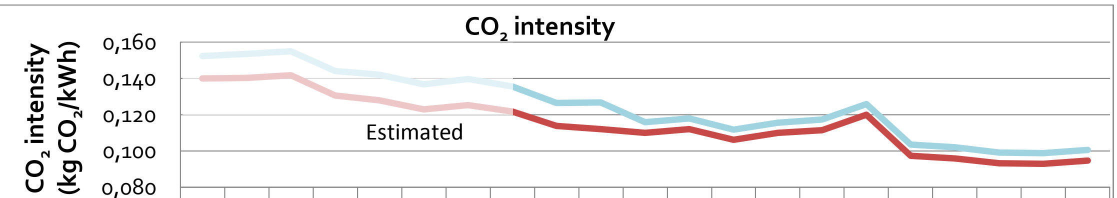


Figure 30: Development of the total CO_2 emissions of EDF, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1), (European Commission, 2010a) and annual reports of EDF

In both graphs, it can be seen that EDF is expected to increase the amount of electricity produced from natural gas, and will decrease the production of electricity from hard coal. The results of this change in the generation mix can be more clearly seen in the total CO_2 emissions of electricity production by EDF, as depicted in figure 30. Especially in the years 2014 – 2016 the changes in the installed capacity will have a large impact on CO_2 emissions. About 4 GW installed capacity of hard coal is replaced by 4 GW installed capacity of natural gas power plants. The years 2005 – 2010 show smaller variations in the total CO_2 emissions than other years, which cannot be led back to changes in the installed capacity. These variations are caused by the use of CO_2 emission data from the EU-ETS, which covers about 95% of the total emissions of EDF. The general trend is that the total CO_2 emissions are reducing over time.

The changes in the total emissions and the generated electricity result in changes in the CO_2 intensity, which are shown in figure 31. This figure shows that the CO_2 intensity is expected to become slightly lower over the years. The reduction of the CO_2 emissions allocated to electricity production because of the use of combined heat and power plants can be seen in the figure. EDF does not have much heat production and therefore the impact on the CO_2 intensity is relatively small.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
With allocation to heat	0,140	0,140	0,142	0,131	0,128	0,123	0,125	0,122	0,114	0,112	0,110	0,112	0,106	0,110	0,111	0,120	0,097	0,096	0,093	0,093	0,095
Without allocation to heat	0,152	0,153	0,155	0,144	0,142	0,137	0,140	0,135	0,127	0,127	0,116	0,118	0,112	0,116	0,117	0,126	0,103	0,102	0,099	0,099	0,101

Figure 31: Development of the CO_2 intensity of EDF, where the hazed section and data after 2010 are estimated. Own calculations based on calculated electricity production and CO_2 emissions

3.2 E.ON

Figure 33 shows the development in the electricity production of E.ON, mainly as a result of changes in the installed capacity shown in figure 32. The electricity mix shows a large growth in the share of natural gas and wind power. The impacts of the financial crisis can be seen in the years 2008 and 2009. While there is an increase in the capacity of natural gas and coal, the increase of the total electricity production is very small, and the electricity production from coal is decreasing.

The electricity mix results in the total CO_2 emissions which are shown in figure 34. The increase in the total electricity production by the increase of in electricity produced by natural gas also increases the total emissions of E.ON.

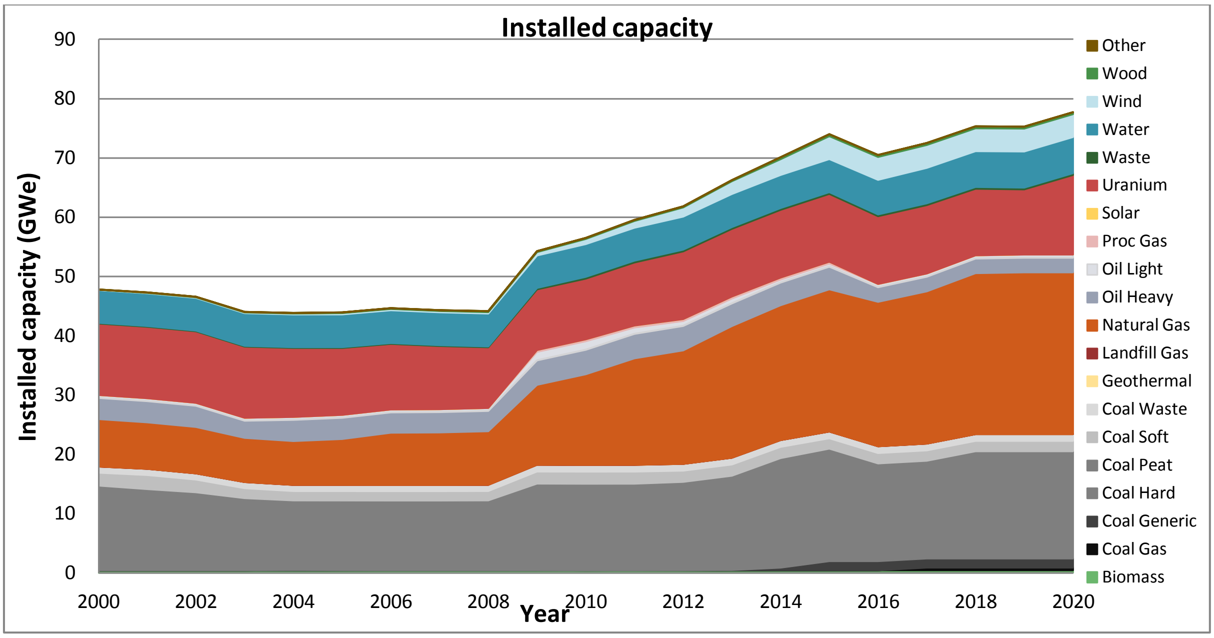


Figure 32: Development of the installed capacity of E.ON (Platts, 2010 Q1)

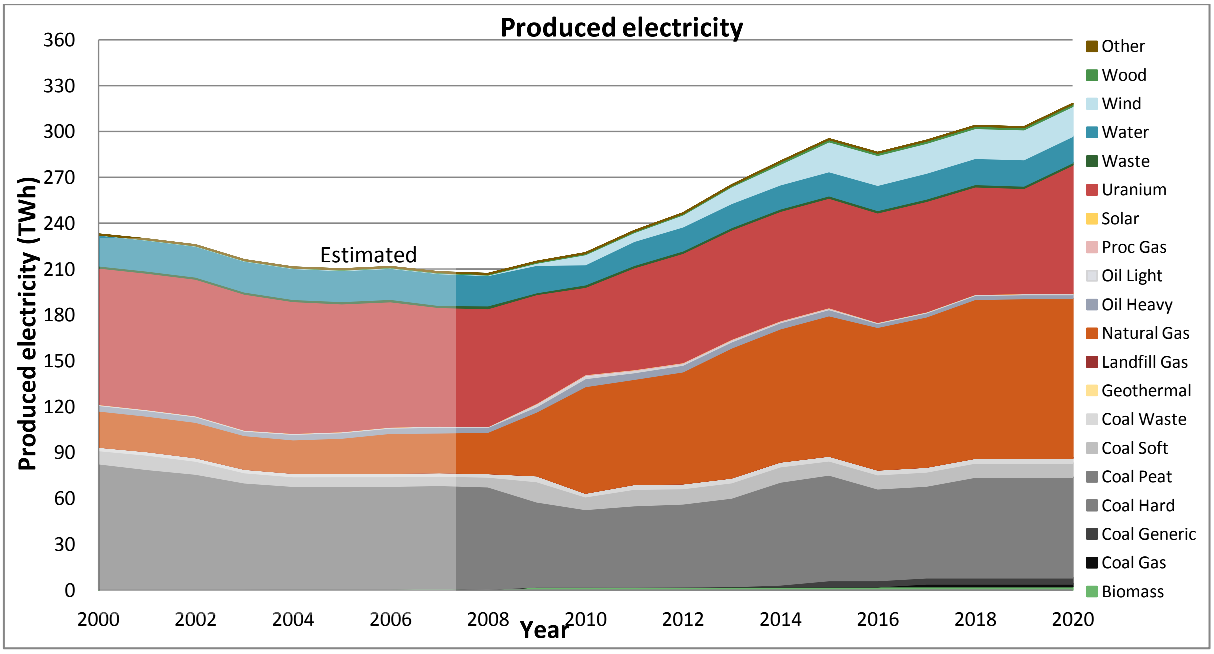


Figure 33: Development of the generated electricity of E.ON, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1) and annual reports of E.ON

The strategy of E.ON is to reduce their CO_2 intensity by changing their electricity mix to 7% hydro, 13% nuclear and 30% renewable in 2030. In 2010, the mix was 6% hydro, 25,9% nuclear and 4,3% renewable, and with their current investments plans, electricity mix is expected to be 5,4% hydro, 26,4% nuclear and 7,4% renewable in 2020. This development shows an increase of the share of renewable electricity production, but a large growth is needed between 2020 and 2030 to reach their own ambitions. Furthermore, the use of nuclear electricity is not decreasing, and will need to be more than halved from 2020 to 2030.

The changes in the generation mix lead to an increase in the CO_2 intensity, as shown in figure 35. The total emissions of E.ON are expected to increase, and the CO_2 intensity remains relatively stable. This is because the fuel mix remains almost the same. The CO_2 intensity has increased in the past five years, which is caused by the decrease of the share of nuclear energy. E.ON has the ambition to reduce the CO_2 intensity from 660 gram/kWh in 1990 by 50% to 330 gram/kWh in 2020 (E.ON, 2010b, p.74). This ambition includes markets outside Europe such as Russia. The calculated CO_2 intensity of this report is about 360 gram/kWh in 2010, while the CO_2 intensity reported CO_2 intensity in 2010 by E.ON is 420 gram/kWh, which also includes Russia. The CO_2 intensity is expected to be about 380 in 2020, which is already higher than the ambition of E.ON. Since the calculated CO_2 intensity is lower than the reported CO_2 intensity, it is expected that this difference will also occur in 2020. Because of this, it is not likely that E.ON will meet their CO_2 reduction ambitions in 2020 with their current investment plans.

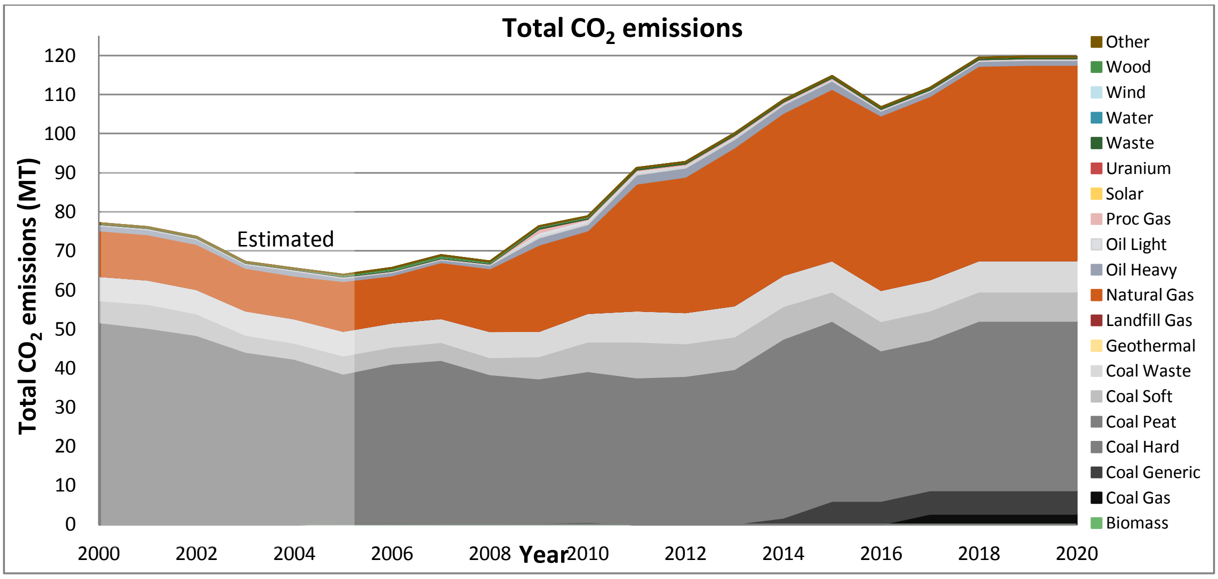
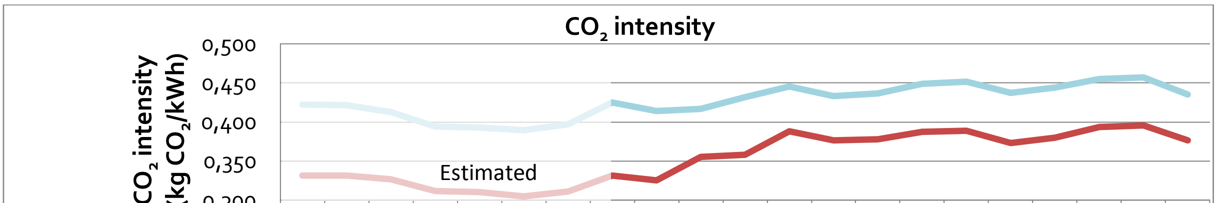


Figure 34: Development of the total CO_2 emissions of E.ON, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1), (European Commission, 2010a) and annual reports of E.ON



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
With allocation to heat	0,331	0,332	0,326	0,311	0,310	0,304	0,311	0,331	0,325	0,355	0,358	0,388	0,376	0,378	0,388	0,389	0,373	0,380	0,393	0,395	0,376
Without allocation to heat	0,422	0,422	0,413	0,394	0,393	0,390	0,397	0,425	0,414	0,417	0,432	0,445	0,433	0,437	0,449	0,452	0,438	0,444	0,455	0,457	0,435

Figure 35: Development of the CO_2 intensity of E.ON, where the hazed section and data after 2010 are estimated. Own calculations based on calculated electricity production and CO_2 emissions

3.3 RWE

Figure 36 shows the installed capacity of RWE, which results in the total produced electricity shown in figure 37. Historically RWE has a large share of coal-fired power plants in their production mix. The total production of electricity by soft coal-fired power plants is expected to reduce, but these will be replaced by hard coal-fired power plants and therefore the total amount of electricity produced by coal will slightly increase. RWE is replacing soft coal by hard coal because hard coal has a lower CO_2 intensity than soft coal. RWE has acquired Essent in 2009 which can be seen by the increase in installed capacity of hard coal and natural gas. In this year, the electricity production did not increase as a result of the financial crisis.

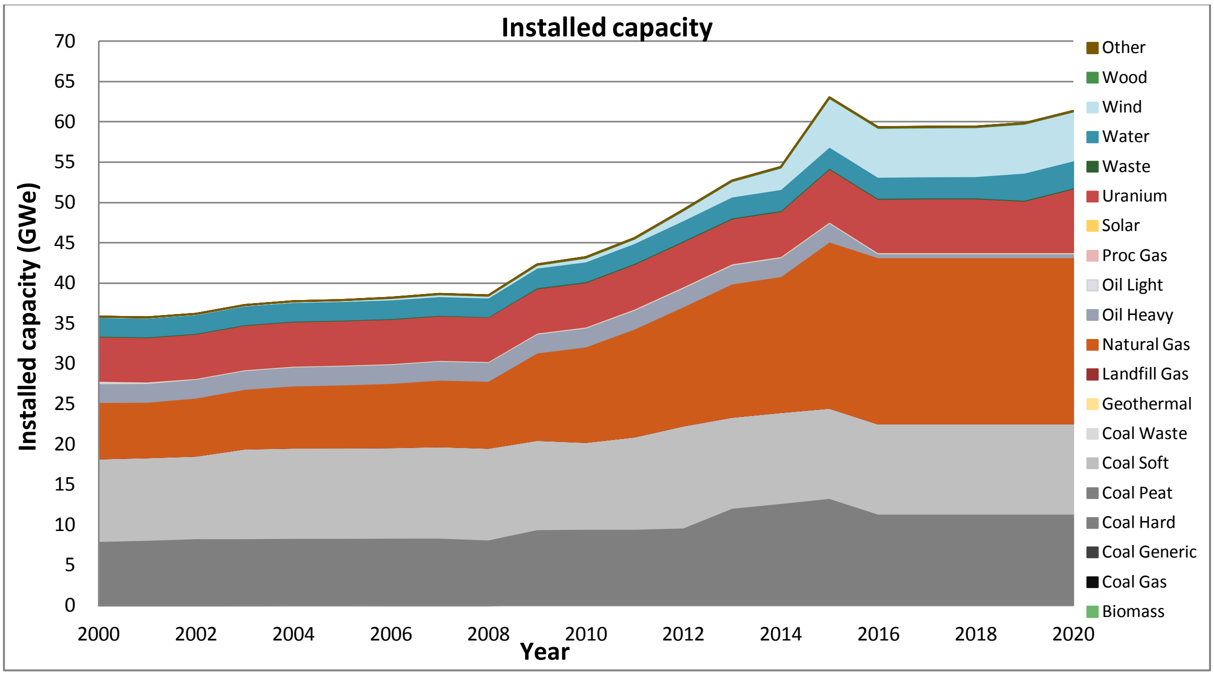


Figure 36: Development of the installed capacity of RWE (Platts, 2010 Q1)

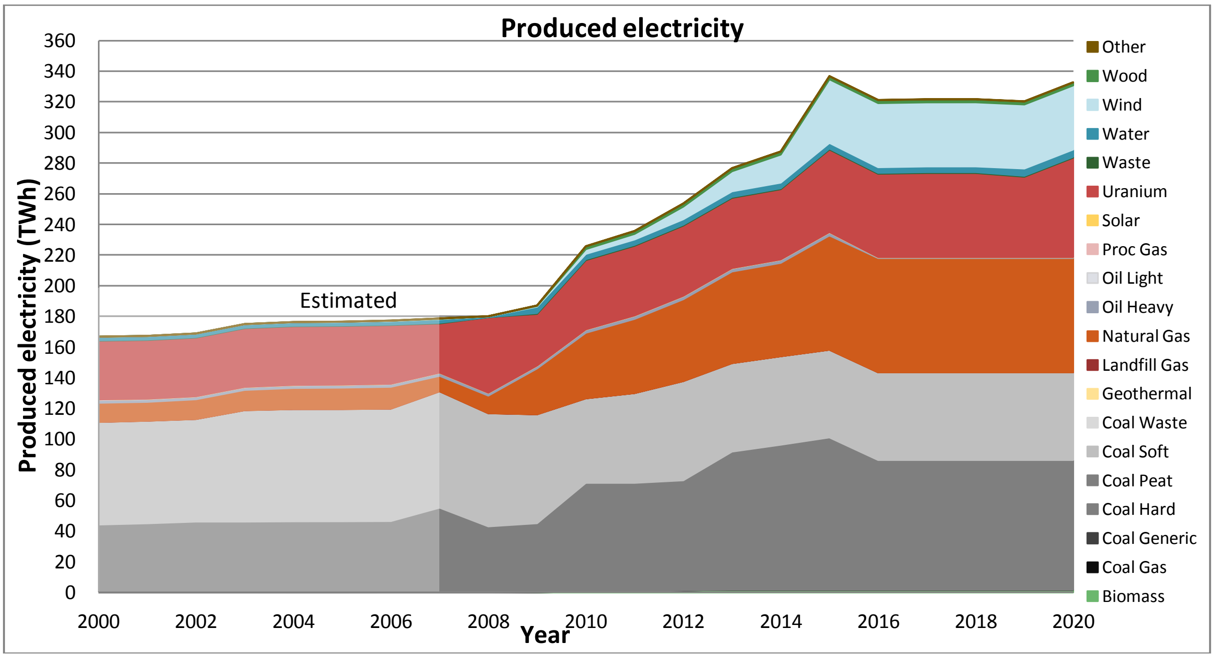


Figure 37: Development of the electricity production of RWE, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1) and annual reports of RWE

Figure 38 shows the total CO_2 emissions of RWE. The total emissions of coal are expected to increase slightly, while the electricity produced from coal is shows a relatively higher increase. This is caused by the replacement of old power plants with new power plants which are more efficient. Another reason is that soft coal is replaced by hard coal, which decreases the CO_2 intensity. The high expected increase of the CO_2 emissions in the years 2011 to 2015 is caused by an increase of the installed capacity of hard coal and natural gas power plants.

Figure 39 shows the development of the CO_2 intensity of RWE, which shows a decrease because of an increase of gas and wind power. In the years 2008 to 2010 the CO_2 emissions are declining, while the installed capacity and the electricity production from coal and gas are increasing. The reason for this is because the assumptions of the CO_2 intensity of these fuels are decreasing in these years. This decrease of the CO_2 emissions is also represented as a reduction of the CO_2 intensity.

The ambition of RWE is to decrease their CO_2 emissions from 796 gram CO_2/kWh in 2009 to 450 gram CO_2/kWh in 2020(RWE, 2009). In this benchmark the calculated CO_2 emissions are lower than reported by RWE, but the expected CO_2 intensity in 2020 is about 533 gram CO_2/kWh, which is higher than the ambition of 450 gram CO_2/kWh in 2020 of RWE. This implies that the current investment plans are not sufficient to reach the CO_2 reduction ambitions of RWE.

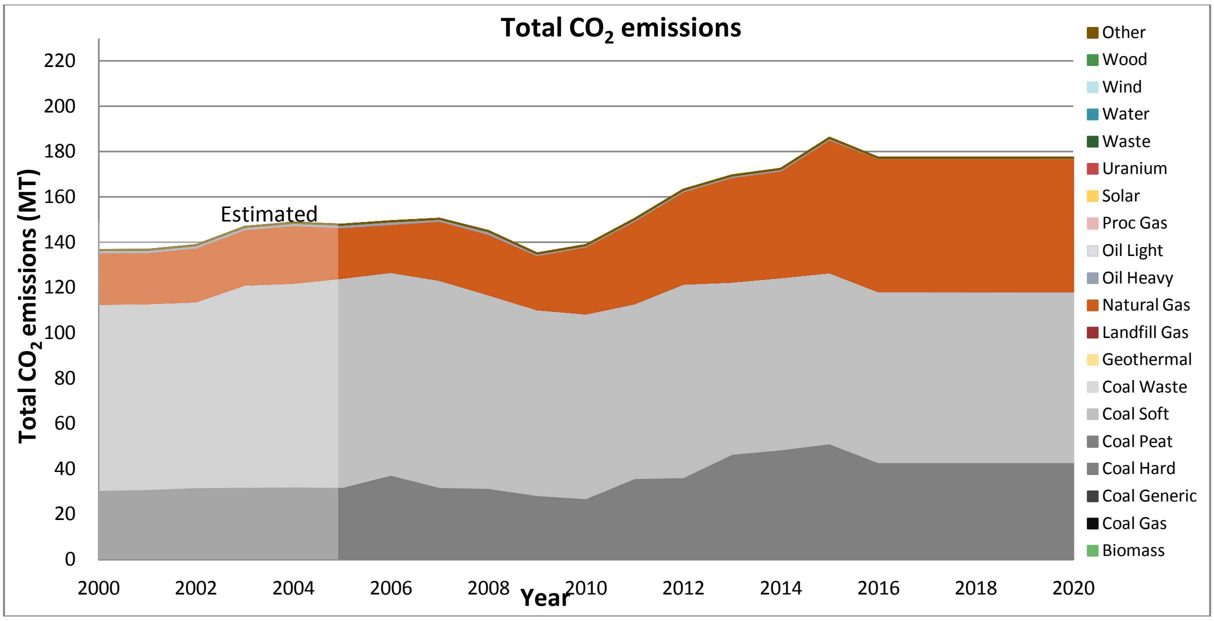
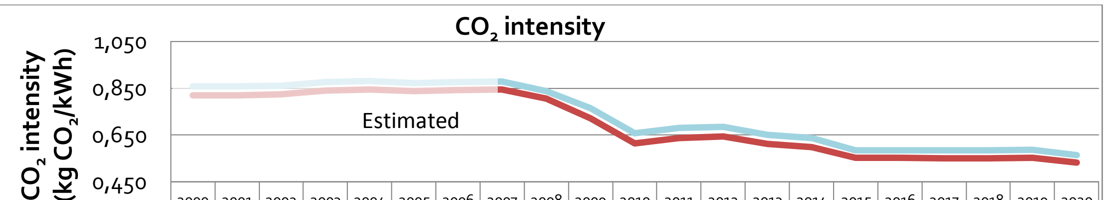


Figure 38: Development of the total CO_2 emissions of RWE, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1), (European Commission, 2010a) and annual reports of RWE



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
With allocation to heat	0,820	0,818	0,823	0,840	0,844	0,837	0,842	0,844	0,805	0,721	0,614	0,637	0,643	0,612	0,599	0,552	0,552	0,551	0,551	0,553	0,533
Without allocation to heat	0,858	0,857	0,861	0,876	0,880	0,871	0,876	0,878	0,837	0,764	0,658	0,681	0,684	0,650	0,637	0,585	0,586	0,585	0,585	0,587	0,565

Figure 39: Development of the CO_2 intensity of RWE, where the hazed section and data after 2010 are estimated. Own calculations based on calculated electricity production and CO_2 emissions

3.4 GDF Suez

Figure 40 shows the installed capacity of GDF Suez, which results in the electricity production, shown in figure 41. The electricity production of GDF Suez shows a reduction in the electricity production in 2009 due to the economic crisis. GDF is increasing coal, gas and wind power, which results in an increase in the total emissions, as shown in figure 42.

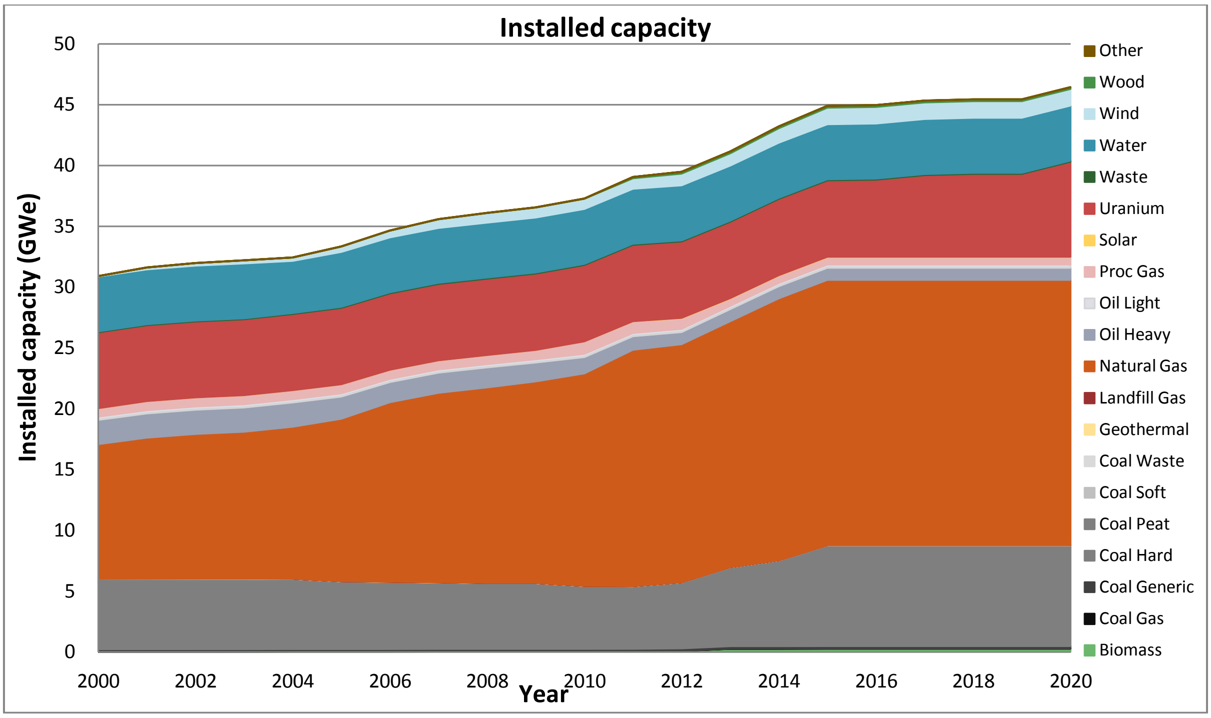


Figure 40: Development of the installed capacity of GDF Suez (Platts, 2010 Q1)

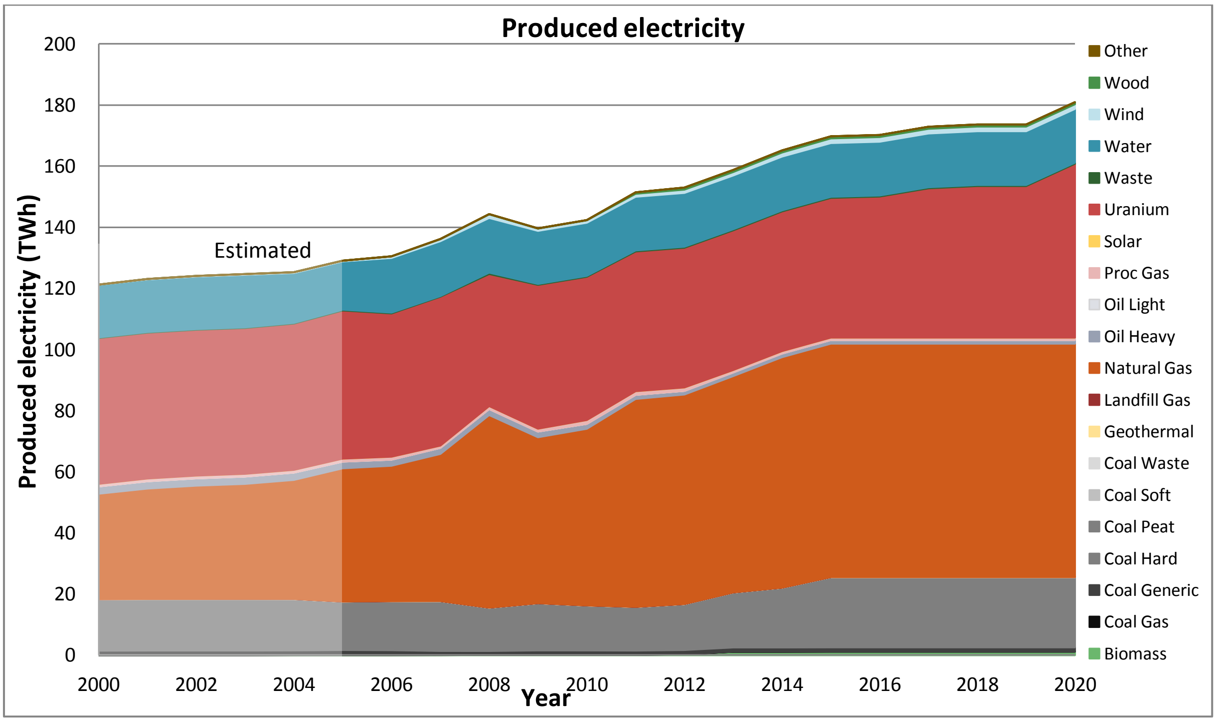


Figure 41: Development of the electricity production of GDF Suez, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1) and annual reports of GDF Suez

Figure 43 shows the development of the CO_2 intensity of GDF Suez. The CO_2 intensity was declining in the previous years, but with the current installation plans the CO_2 intensity is expected to increase. Some utilities use gas-fired power plants to reduce their CO_2 intensity. GDF increases the share of gas-fired power plants, but does not decrease the share of coal-fired power plants. GDF is building new coal-fired power plants and therefore the share of coal-fired power plants remains stable. The increase of the share of natural gas decreases the share of nuclear and hydro power, because no new hydro or nuclear power plants are built. As a result of these changes in the generation mix the CO_2 intensity is expected to increase in the upcoming years. The expected decrease of the CO_2 intensity after the year 2015 is mainly caused by an increase in the share of nuclear energy.

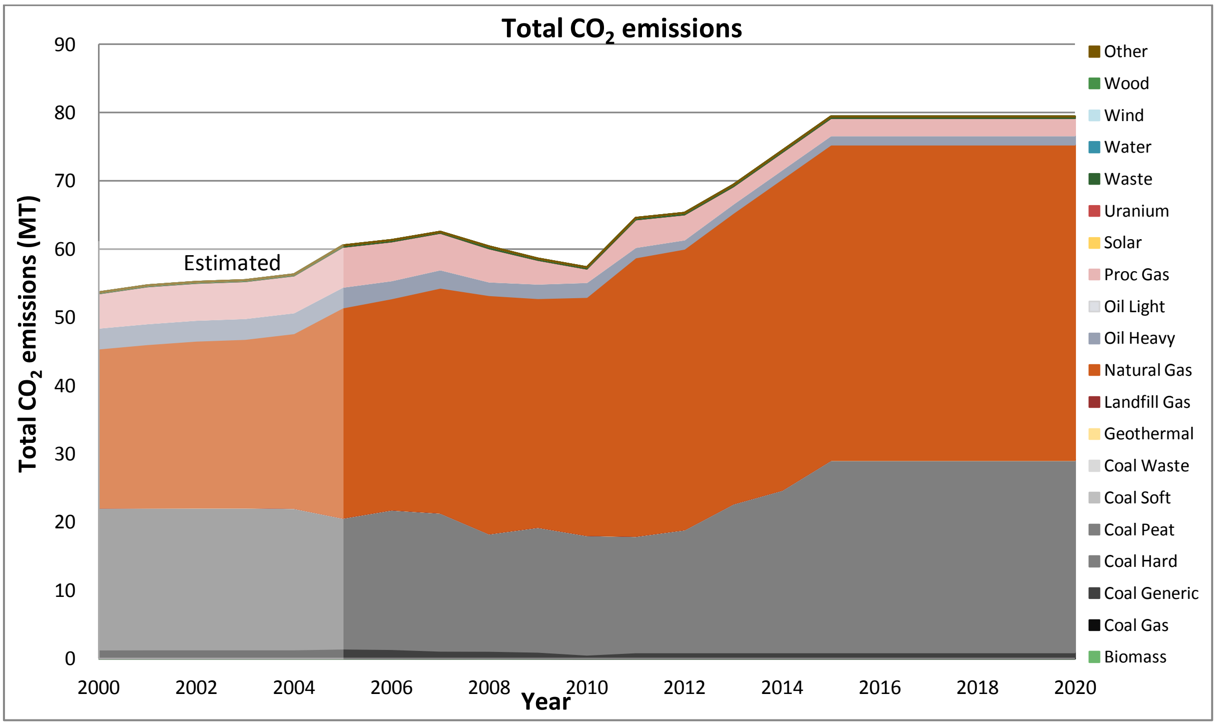
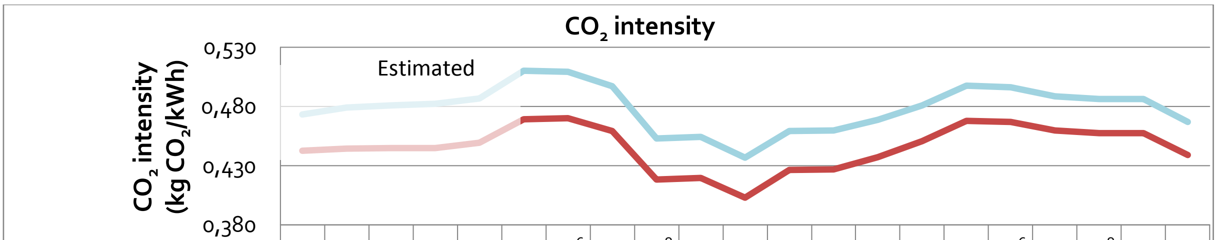


Figure 42: Development of the total CO_2 emissions of GDF Suez, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1), (European Commission, 2010a) and annual reports of GDF Suez



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
With allocation to heat	0,443	0,444	0,445	0,445	0,449	0,469	0,470	0,459	0,418	0,420	0,403	0,426	0,427	0,437	0,451	0,468	0,467	0,459	0,458	0,458	0,439
Without allocation to heat	0,473	0,479	0,481	0,482	0,487	0,510	0,509	0,497	0,453	0,454	0,437	0,459	0,459	0,469	0,481	0,497	0,496	0,488	0,486	0,486	0,467

Figure 43: Development of the CO_2 intensity of GDF Suez, where the hazed section and data after 2010 are estimated. Own calculations based on calculated electricity production and CO_2 emissions

3.5 Enel

Figure 44 shows the development of the installed capacity of Enel, which results in the electricity generation, shown in figure 45. The installed capacity shows a large increase in 2008 due to the acquisition of Endesa. In 2009, the electricity production was reduced because of the economic crisis. Enel is increasing the generation of wind, natural gas, and coal power, while decreasing the generation of electricity produced from fuel oil.

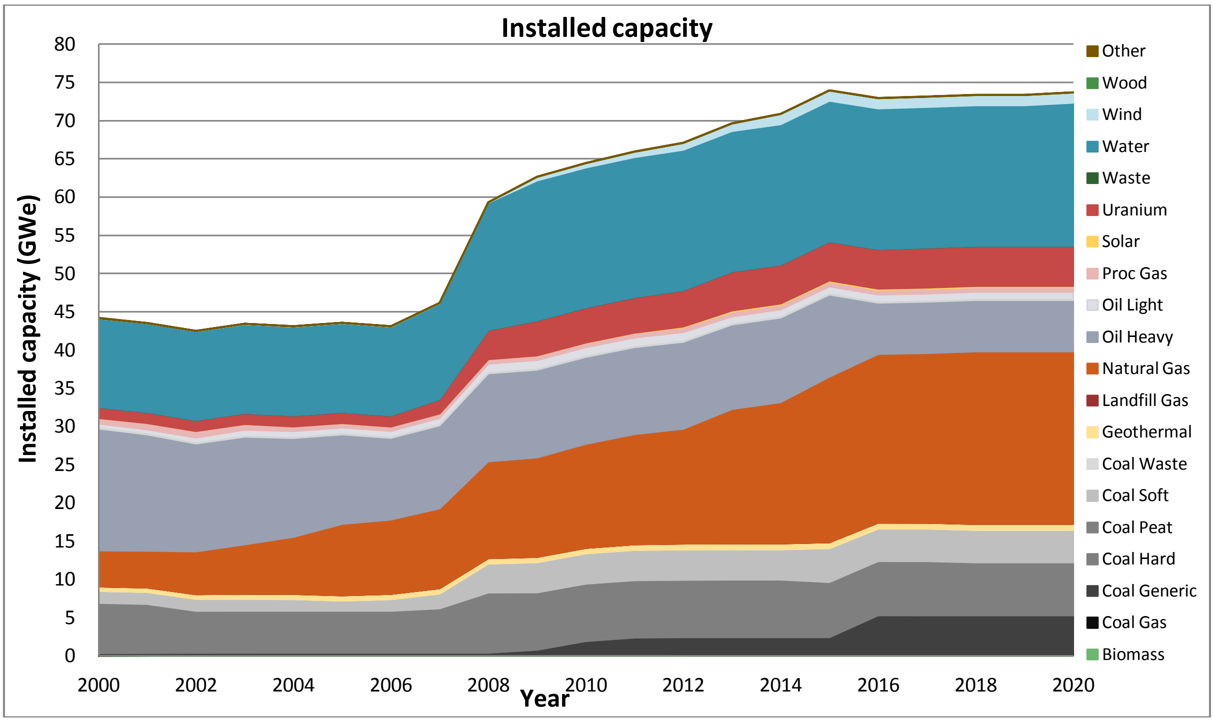


Figure 44: Development of the installed capacity of Enel (Platts, 2010 Q1)

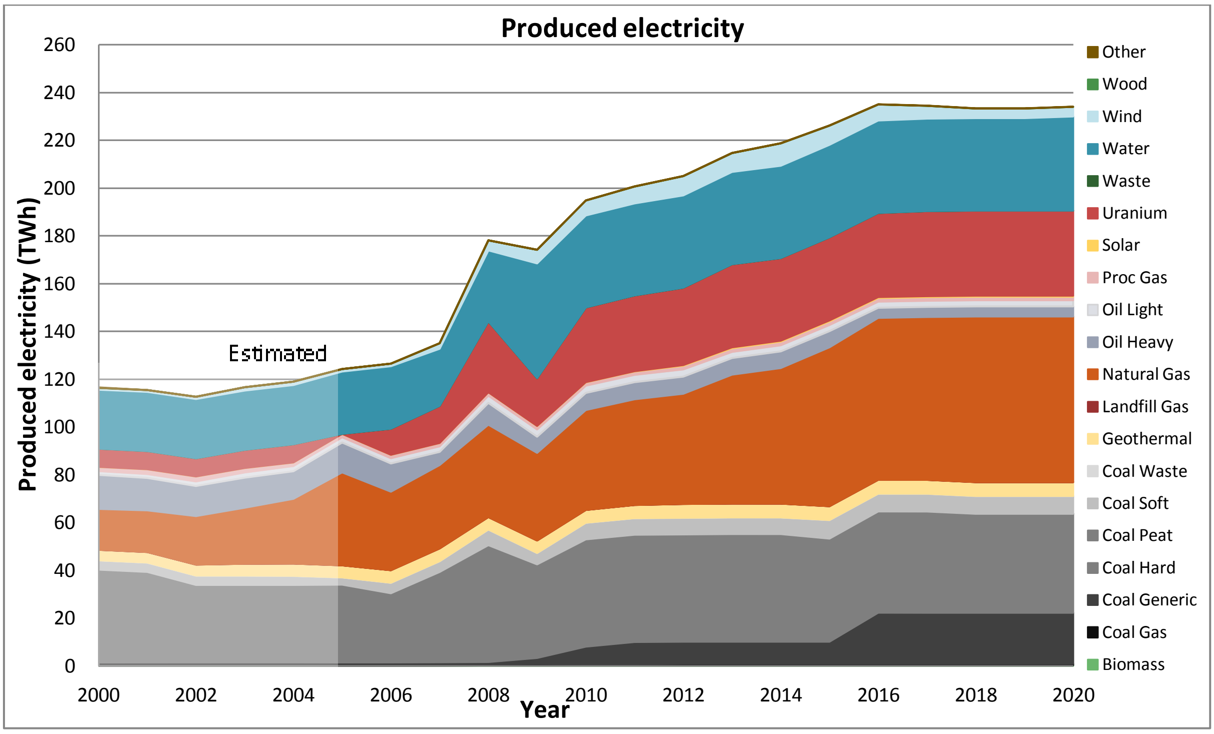


Figure 45: Development of the electricity production of Enel, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1) and annual reports of Enel

Figure 46 shows an expected increase in the total emissions of Enel, while the CO_2 intensity shows a decrease from 2000 to 2020. This decrease is caused by the increasing share of natural gas and wind power, while the share of coal power decreases. Figure 47 shows the CO_2 intensity increases in the years 2009 and 2016, which are caused by an expected increase of the use of hard coal and natural gas and a reduction of the share of hydro and nuclear energy.

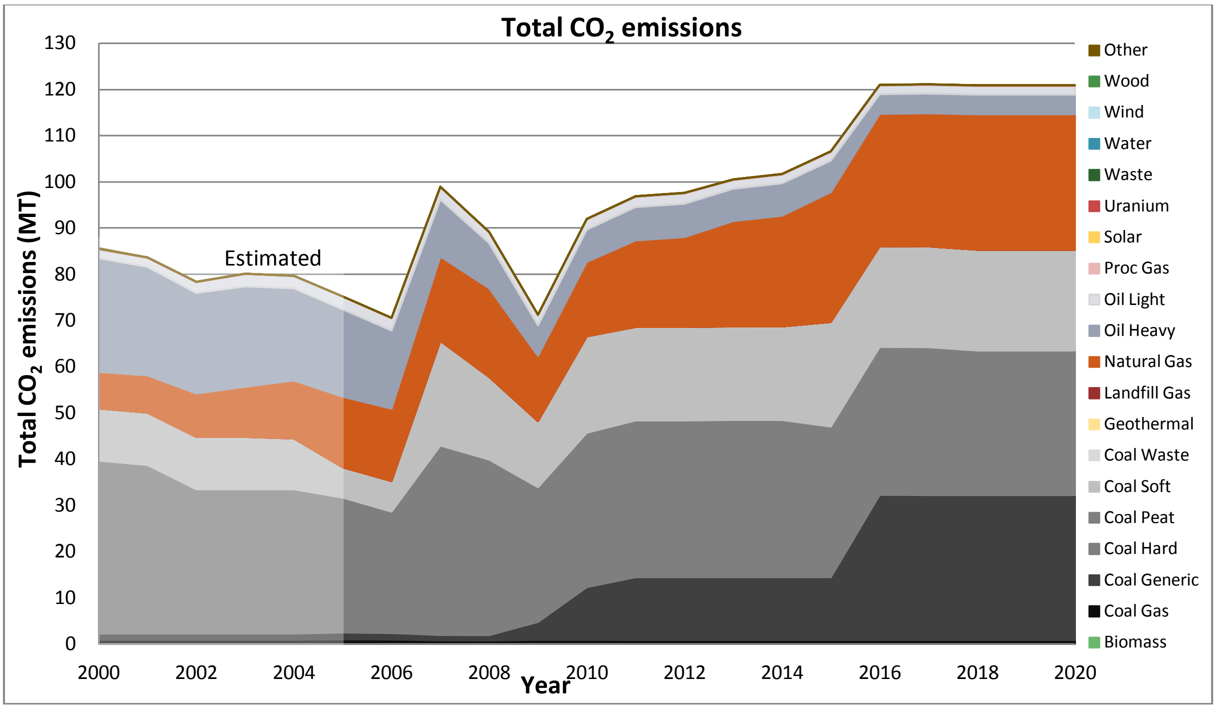
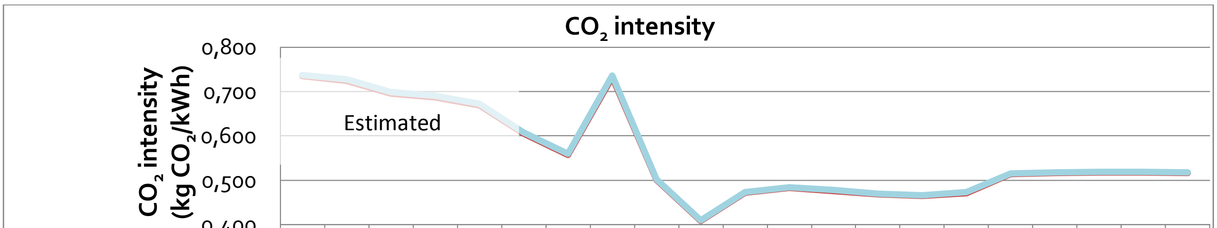


Figure 46: Development of the total CO_2 emissions of Enel, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1), (European Commission, 2010a) and annual reports of Enel



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
kg CO2/ kWh	0,734	0,724	0,695	0,687	0,669	0,605	0,557	0,732	0,500	0,409	0,472	0,483	0,476	0,468	0,465	0,471	0,515	0,516	0,518	0,518	0,516
Without allocation to heat	0,737	0,727	0,699	0,690	0,673	0,607	0,560	0,736	0,502	0,410	0,473	0,484	0,478	0,470	0,466	0,473	0,516	0,518	0,519	0,519	0,518

Figure 47: Development of the CO_2 intensity of Enel, where the hazed section and data after 2010 are estimated. Own calculations based on calculated electricity production and CO_2 emissions

3.6 Vattenfall

Figure 48 shows the development of the installed capacity of Vattenfall, which results in the electricity production mix shown in figure 49. Vattenfall has taken over Nuon in 2009, which has resulted in a small increase in electricity produced by coal-fired power plants and a large increase in the use of natural gas and process gas. In the upcoming years the use of natural gas, coal and wind is expected to increase while the used of other fuels remains relatively stable.

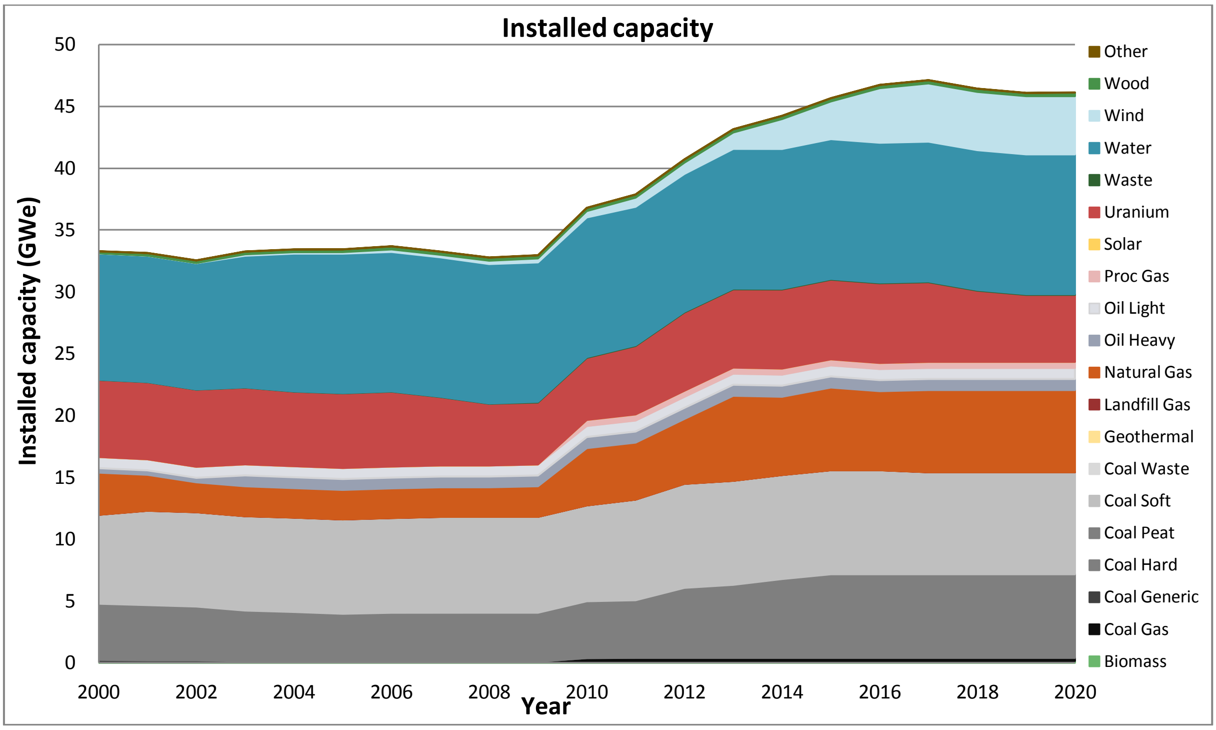


Figure 48: Development of the installed capacity of Vattenfall (Platts, 2010 Q1)

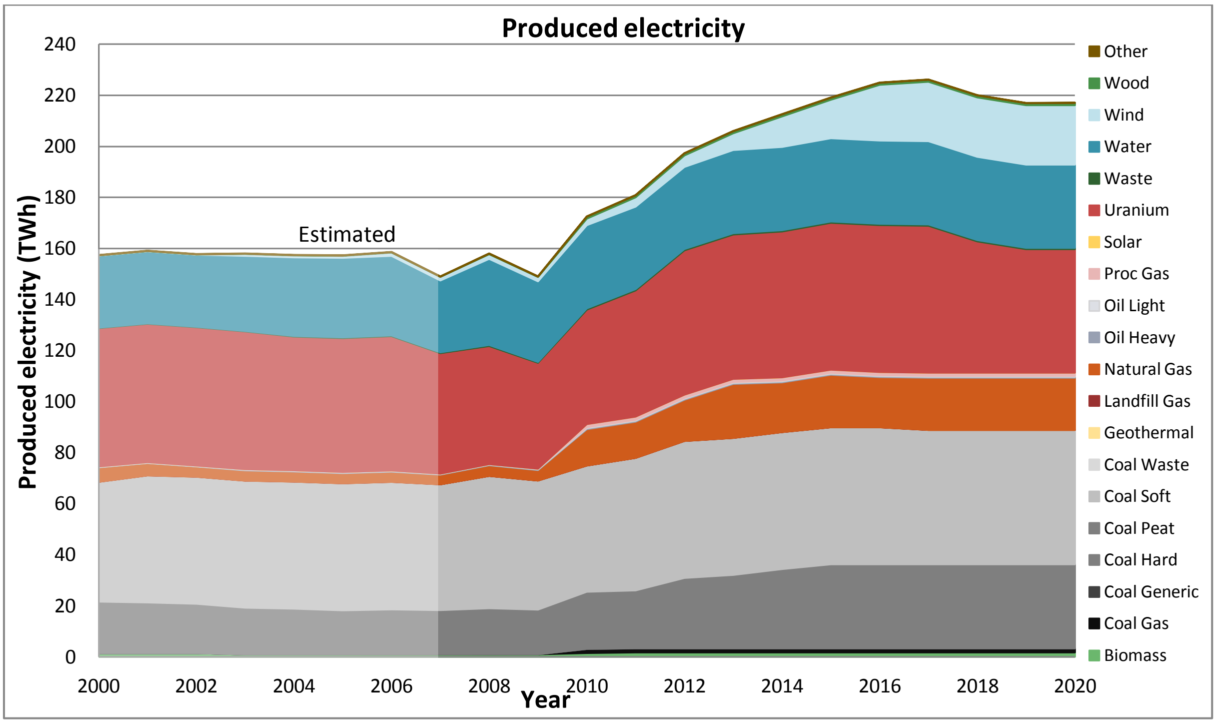


Figure 49: Development of the electricity generation mix of Vattenfall, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1) and annual reports of Vattenfall

The total CO_2 emissions, shown in figure 50, show a large increase in the year 2009 to 2010, which is caused by the acquisition of Nuon. Some of the biomass-fired power plants have some CO_2 emissions. These CO_2 emissions are registered at the EU-ETS and are caused by the use of fossil fuels as a secondary fuel.

Figure 51 shows the development of the CO_2 intensity of Vattenfall. The CO_2 intensity has decreased up to 2008, but because of the acquisition of Nuon the CO_2 intensity has increased again. The CO_2 intensity shows a peak in 2007 because of the reduced output of hydro and nuclear power stations. The CO_2 intensity has increased from 2008 to 2010 because of the installation of new coal-fired power plants. The CO_2 intensity is expected to decrease in the upcoming years mainly because of the increasing share of wind power in the generation mix. The expected increase of the CO_2 intensity after 2017 is due to a decrease of the nuclear power production.

The ambition of Vattenfall is to reduce the CO_2 intensity from 434 gram CO_2/kWh in 2009 to 350 gram CO_2/kWh in 2020(Vattenfall, 2010). The calculated CO_2 intensity in 2009 was 411 gram CO_2/kWh and is expected increase to 416 gram CO_2/kWh. This CO_2 intensity is higher than the reduction ambition of Vattenfall and therefore it is expected that Vattenfall will not reach their CO_2 reduction ambition with their current investment plans.

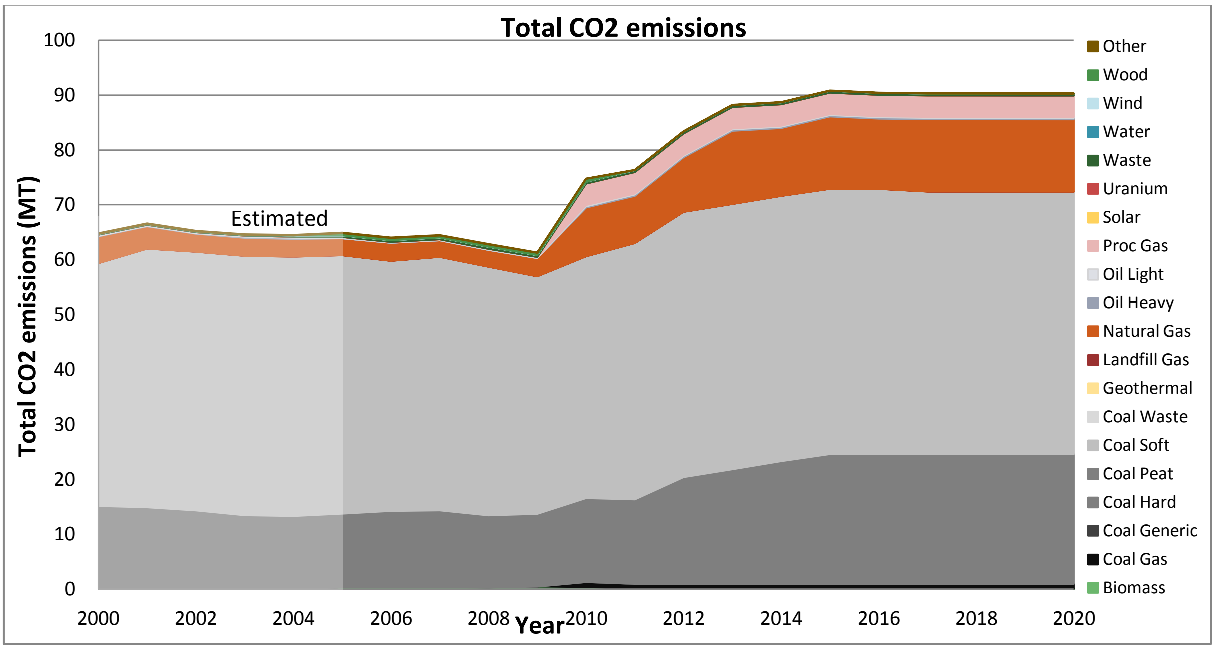
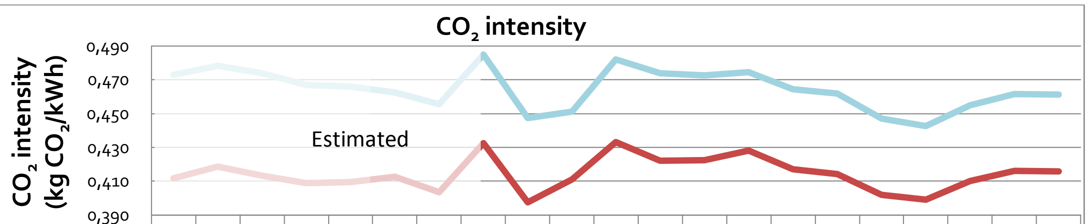


Figure 50: Development of the total CO_2 emissions of Vattenfall, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1), (European Commission, 2010a) and annual reports of Vattenfall



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
With allocation to heat	0,412	0,419	0,413	0,409	0,410	0,413	0,404	0,433	0,398	0,411	0,433	0,422	0,423	0,428	0,417	0,414	0,402	0,399	0,410	0,416	0,416
Without allocation to heat	0,473	0,478	0,474	0,467	0,466	0,462	0,456	0,485	0,447	0,451	0,482	0,474	0,473	0,475	0,464	0,462	0,447	0,443	0,455	0,461	0,461

Figure 51: Development of the CO_2 intensity of Vattenfall, where the hazed section and data after 2010 are estimated. Own calculations based on calculated electricity production and CO_2 emissions

3.7 Iberdrola

Figure 52 shows the development of the installed capacity of Iberdrola, which results in the electricity generation mix shown in figure 53. Iberdrola is increasing the use of natural gas, water and wind power, while decreasing the use of coal and fuel oil. The effects of the financial crisis are also visible in 2009 for Iberdrola.

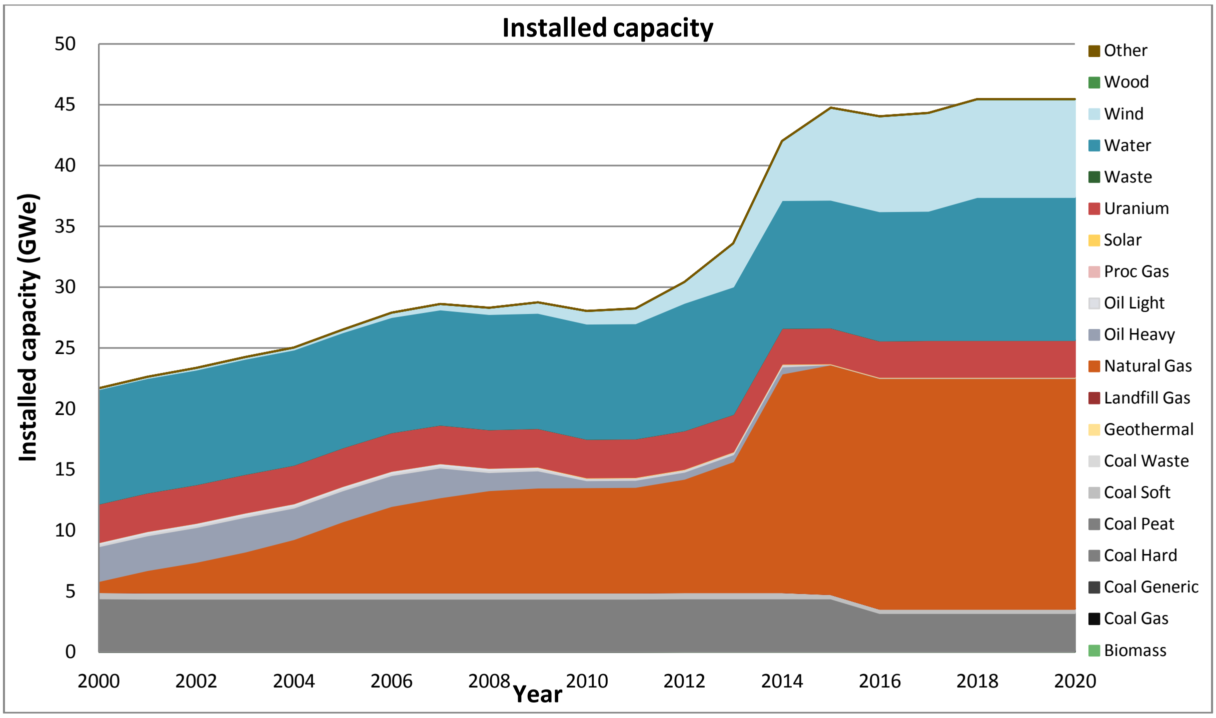


Figure 52: Development of the installed capacity of Iberdrola (Platts, 2010 Q1)

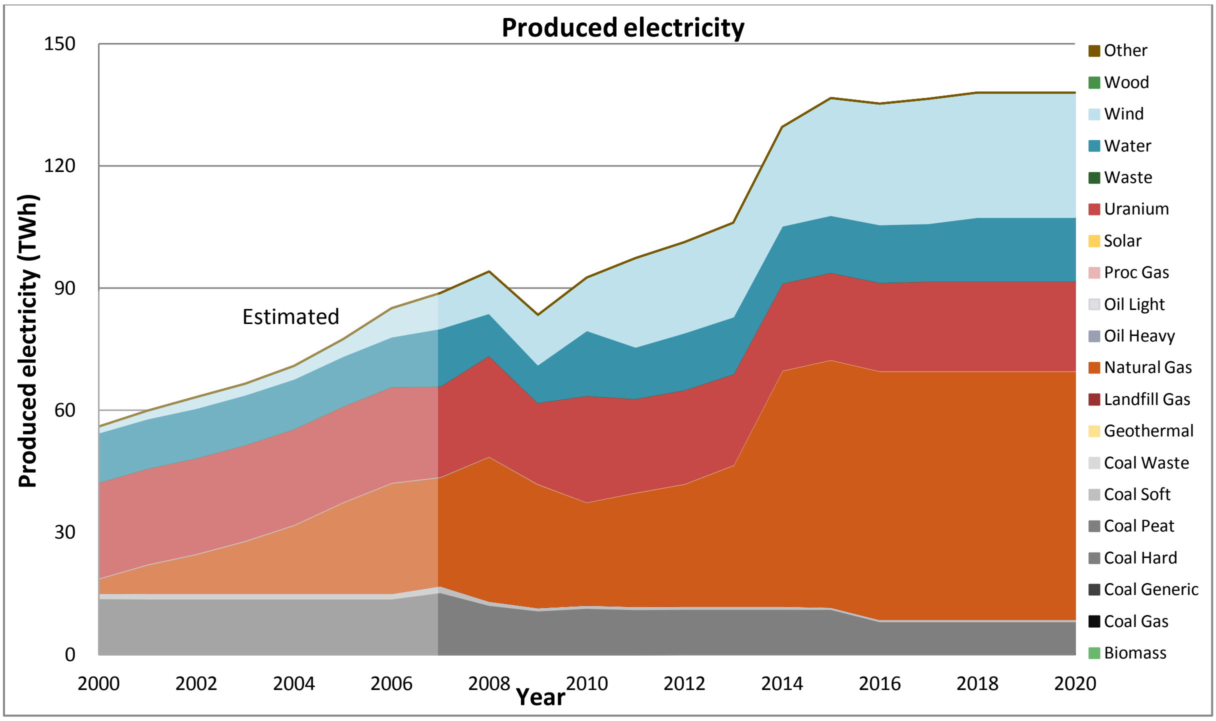


Figure 53: Development of the electricity generation mix of Iberdrola, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1) and annual reports of Iberdrola

Figure 54 shows the development of the total CO_2 emissions of Iberdrola. The total emissions are expected to increase over time, with a steep increase between the years 2013 and 2014, due to ten new natural gas-fired power plants. Seven natural gas power plants will be constructed in Spain, one in England and two in Germany.

Figure 55 shows the development of the CO_2 intensity of Iberdrola. While the total emissions are expected to rise, the CO_2 intensity is expected to decrease. This decrease is cause by the increasing share of natural gas with low emission intensity and the increase of the share of wind power in the generation mix. The ambition of Iberdrola is to reduce their CO_2 intensity to 20% below the recommended European average in 2020(Iberdrola, 2009). The 20-20-20 targets of the European Commission state that the total CO_2 emissions should be cut by 20% of 1990 levels by 2020 (European Commission, 2010b). The CO_2 intensity was 435 gram CO_2/kWh in 1990. If this should be reduced by 20% the EU target will be 348 gram CO_2/kWh, and 20% below this target is 278 gram CO_2/kWh. The given CO_2 intensity by Iberdrola was 279 gram CO_2/kWh in 2009, and the calculated CO_2 intensity is 315 gram CO_2/kWh. This shows that Iberdrola does not have to make an effort to reach their ambitions because they are already at the level they want to be.

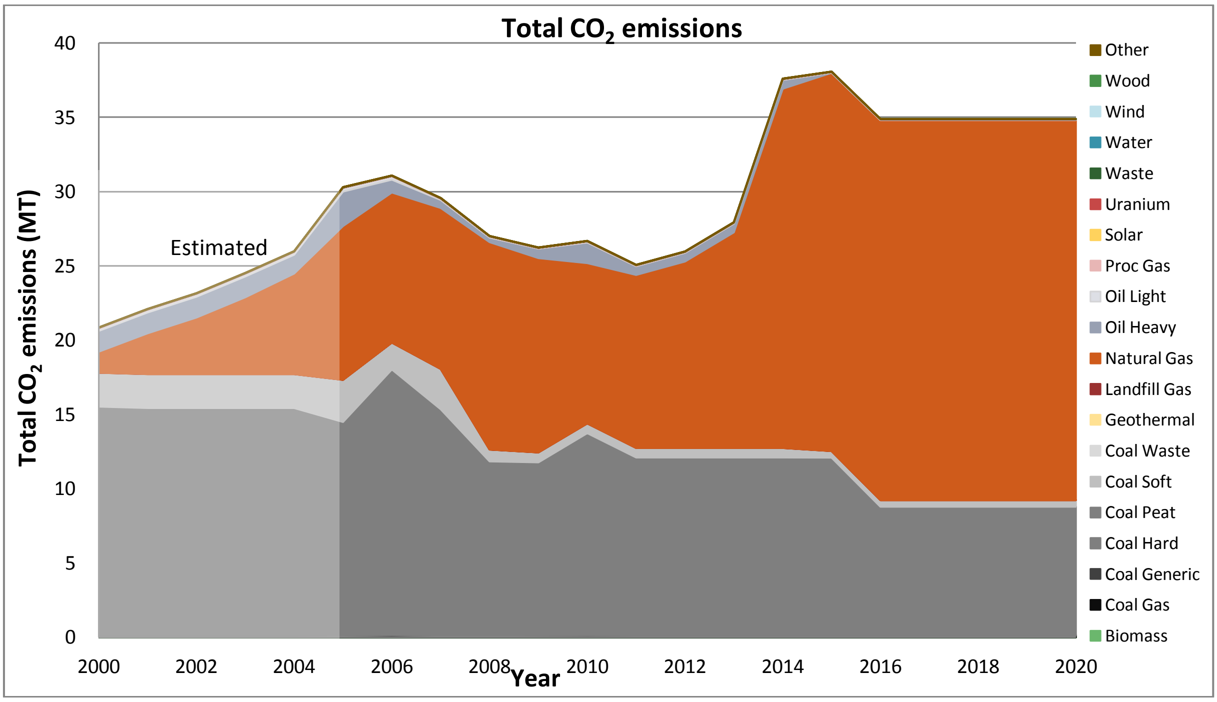
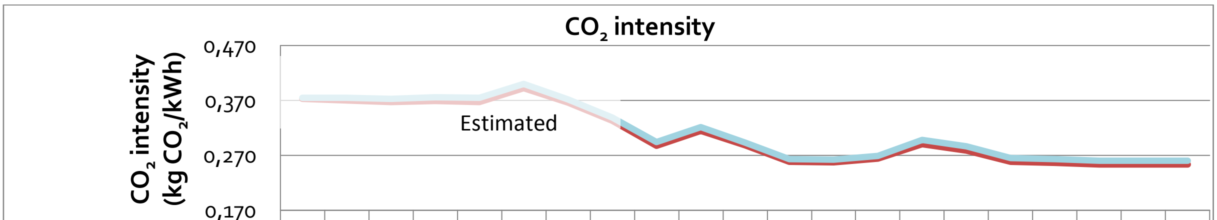


Figure 54: Development of the total CO_2 emissions of Iberdrola, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1), (European Commission, 2010a) and annual reports of Iberdrola



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
With allocation to heat	0,373	0,369	0,367	0,369	0,367	0,392	0,366	0,333	0,287	0,315	0,288	0,258	0,257	0,264	0,290	0,279	0,258	0,256	0,253	0,253	0,253
Without allocation to heat	0,375	0,375	0,372	0,375	0,374	0,399	0,372	0,339	0,294	0,321	0,293	0,263	0,262	0,269	0,298	0,286	0,265	0,263	0,260	0,260	0,260

Figure 55: Development of the CO_2 intensity of Iberdrola, where the hazed section and data after 2010 are estimated. Own calculations based on calculated electricity production and CO_2 emissions

3.8 Energias de Portugal (EDP)

Figure 56 shows the development of the installed capacity of EDP, which results in the electricity generation mix, shown in figure 57. EDP is expected to increase the installed capacity of almost all fuel types, except of fuel oil. While the installed capacity of coal- and oil-fired power plants did not change in the years 2007 to 2010, the electricity production of these power plants dropped. In these years, the total electricity production dropped as a result of the financial crisis. The decrease of the output of coal-fired power plants could indicate that EDP wants to reduce their total CO_2 emissions by abandoning coal-fired power plant. EDP is planning to increase the capacity of coal-fired power plants and therefore this assumption is not likely. Another explanation could be that the demand for electricity dropped, and that coal fired power plants had the highest operational costs. With this assumption, it was economically the best option to reduce the output of the coal-fired power plants. Another possibility is that some power plants were down for maintenance.

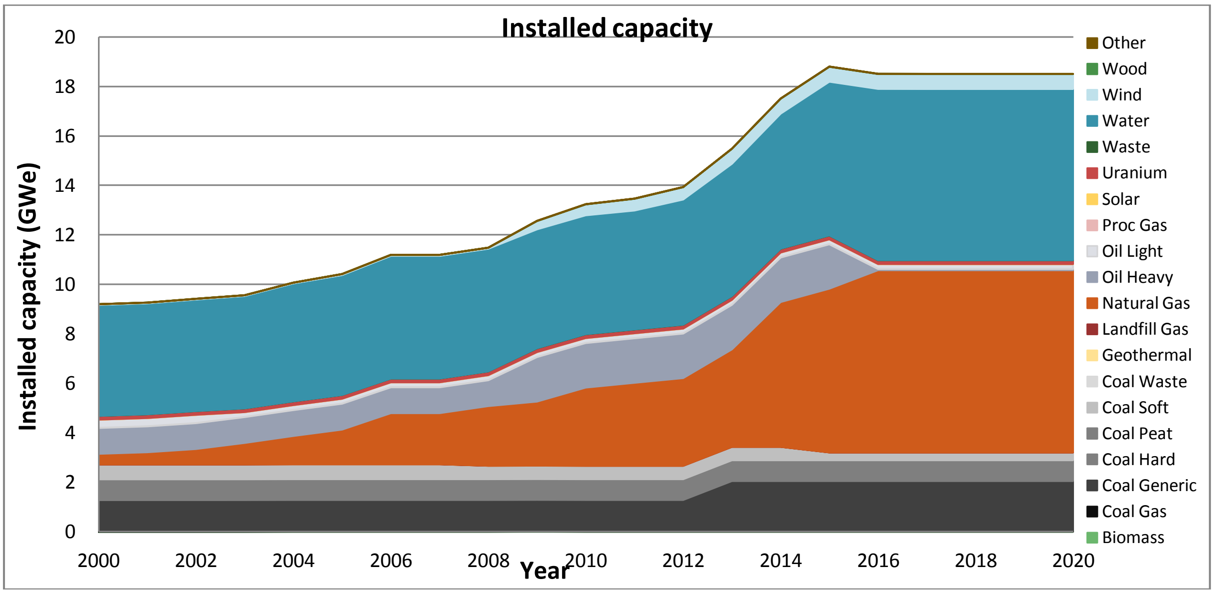


Figure 56: Development of the installed capacity of EDP (Platts, 2010 Q1)

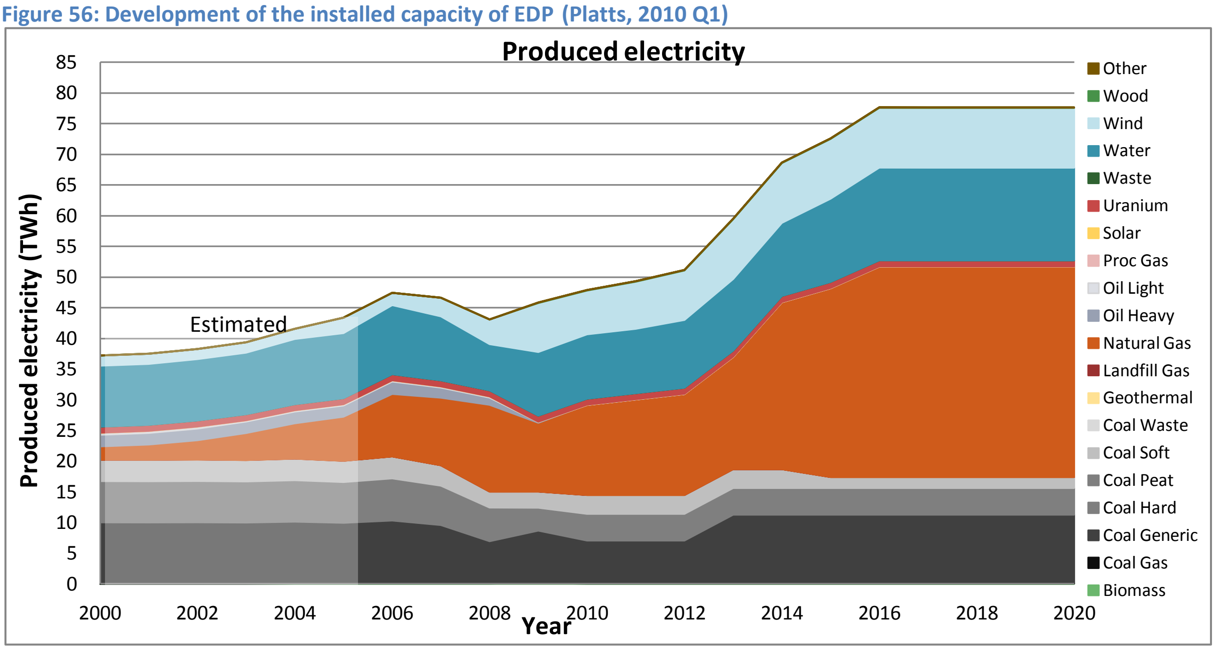


Figure 57: Development of the electricity generation mix of EDP, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1) and annual reports of EDP

Figure 58 shows the development of the total CO_2 emissions of EDP. The total CO_2 emissions show a drop between 2007 and 2010 because of the drop in the electricity production. Figure 59 shows the development of the CO_2 intensity. The overall trend is an expected reduction of the CO_2 intensity, with a small drop in 2010. This drop was caused by the combination of a drop in the electricity produced from coal and a drop in the assumption of the CO_2 intensity of coal. The CO_2 intensity decreases between 2000 and 2010 because of higher shares of renewables and because EDP replaced coal by gas. In the upcoming decade the CO_2 intensity is expected to remain relatively stable. This is because the use of coal is not expected to decrease and there are no large increases of the share of renewables. Only the use of natural gas is expected to increase, but this will not change the CO_2 intensity of EDP because the CO_2 intensity of EDP is almost similar to the CO_2 intensity of a natural gas-fired power plant.

EDP has the ambition to reduce the CO_2 intensity from 362 gram CO_2/kWh in 2009 to 120 gram CO_2/kWh in 2020(EDP, 2009). Figure 59 shows an expected decrease of the CO_2 intensity from 438 gram CO_2/kWh in 2009 to 345 gram CO_2/kWh in 2020, which is a decrease of about 27%. With the given CO_2 intensity of 362 gram CO_2/kWh a decrease of 27% would give a CO_2 intensity of 285 gram CO_2/kWh in 2020. This shows that the current investment plans of EDP are not sufficient to meet their CO_2 reduction ambitions.

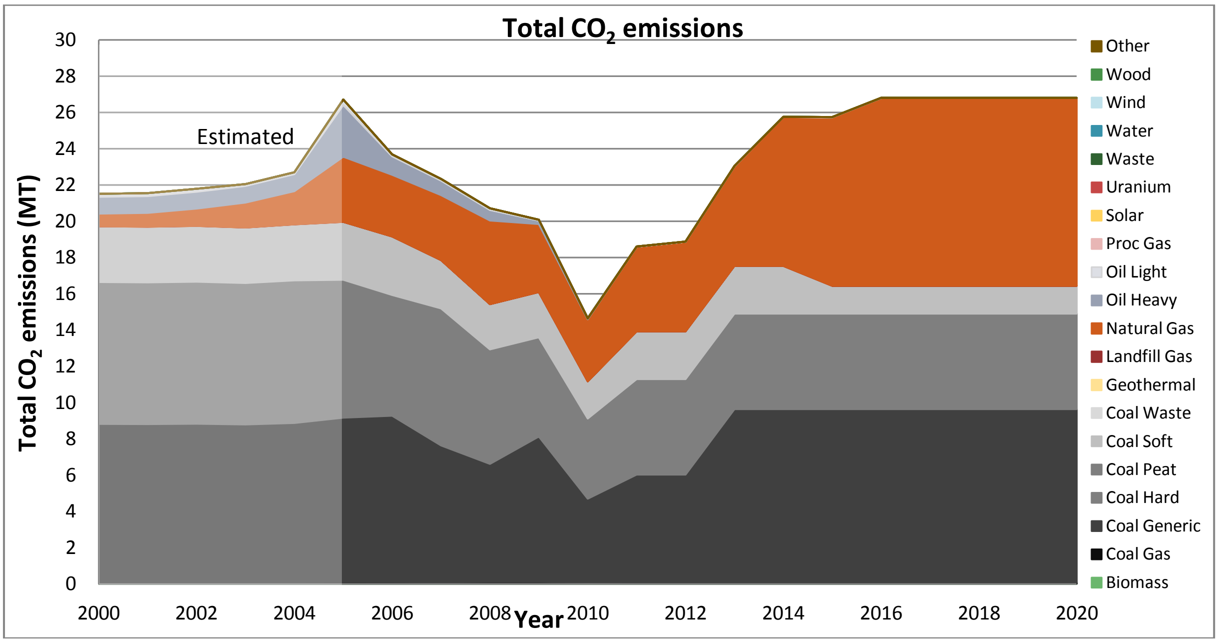
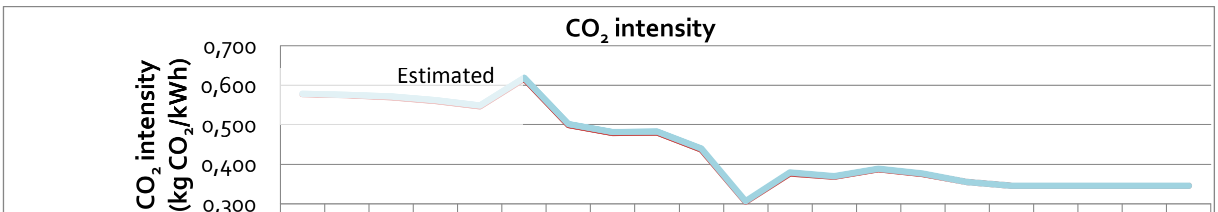


Figure 58: Development of the total CO_2 emissions of EDP, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1), (European Commission, 2010a) and annual reports of EDP



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
With allocation to heat	0,578	0,574	0,569	0,560	0,546	0,616	0,499	0,479	0,481	0,438	0,306	0,377	0,369	0,387	0,375	0,355	0,345	0,345	0,345	0,345	0,345
Without allocation to heat	0,579	0,576	0,572	0,563	0,548	0,619	0,501	0,481	0,483	0,440	0,307	0,379	0,371	0,389	0,376	0,356	0,346	0,346	0,346	0,346	0,346

Figure 59: Development of the CO_2 intensity of EDP, where the hazed section and data after 2010 are estimated. Own calculations based on calculated electricity production and CO_2 emissions

3.9 Public Power Corporation (PPC)

Figure 60 shows the development of the installed capacity of PPC, which results in the electricity generation mix, shown in figure 61. The generation mix is mainly changed by the addition of new natural gas power plants. Some coal-fired power plants are expected to retire in the upcoming years, but these power plants are replaced by new coal-fired power plants. The effects of the credit crisis are not visible in the graph because there was no data available for the years before 2009.

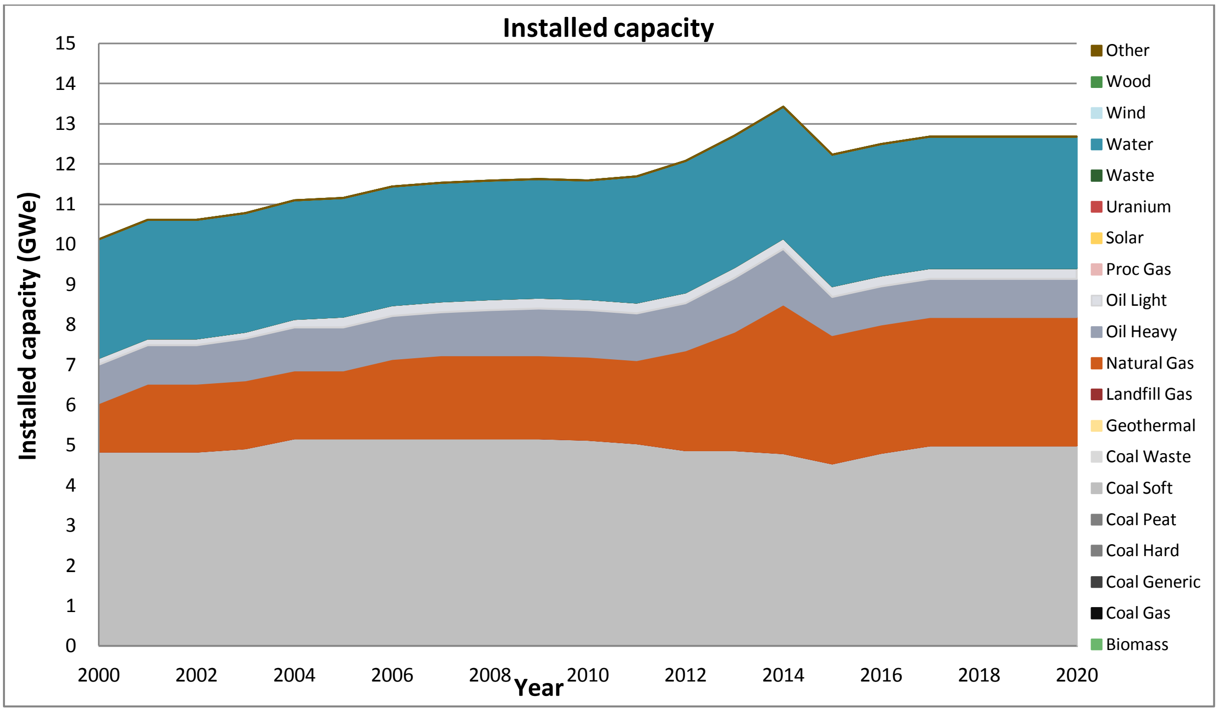


Figure 60: Development of the installed capacity of PPC (Platts, 2010 Q1)

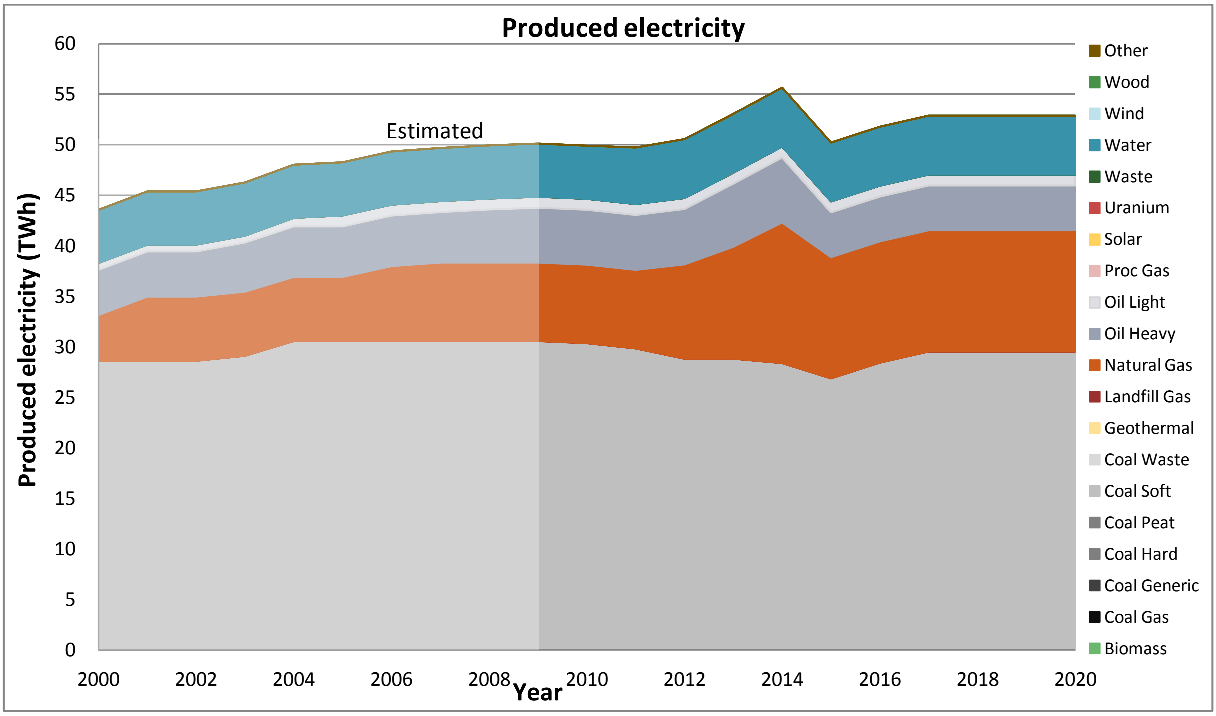


Figure 61: Development of the electricity generation mix of PPC, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1) and annual reports of PPC

Figure 62 shows the total CO_2 emissions of PPC. The total CO_2 emissions show a small increase and small fluctuations due to the changes in the installed capacity. Figure 63 shows the development of the CO_2 intensity of PPC. The ambition of PPC is to reduce their CO_2 intensity from 1000 gram CO_2/kWh in 2008 to 900 gram CO_2/kWh in 2015(PPC, 2009). Figure 63 shows that the CO_2 intensity is expected to reduce from 998 gram CO_2/kWh in 2008 to 914 gram CO_2/kWh in 2015. This shows that the ambition of PPC could be achieved. Figure 63 also shows that the CO_2 intensity will increase after 2015 to 945 gram CO_2/kWh in 2020. As a result, PPC needs to make changes in their investments plants if they want to continue the reduction of their CO_2 intensity after 2015.

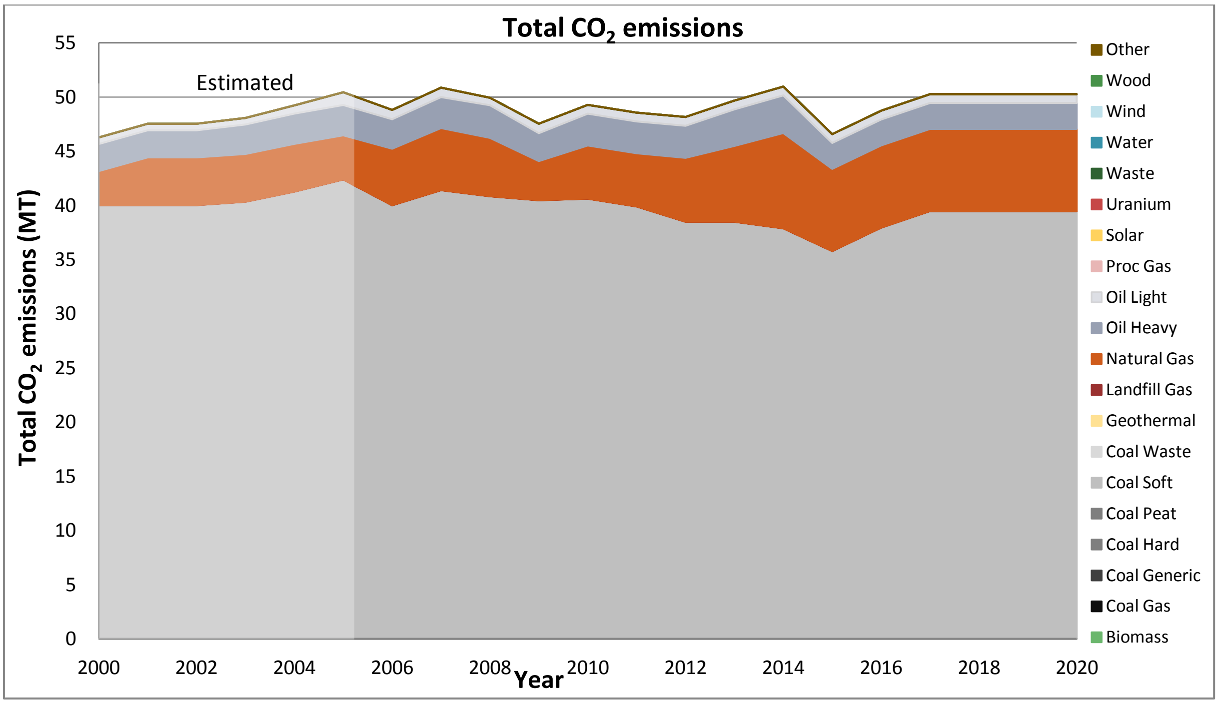
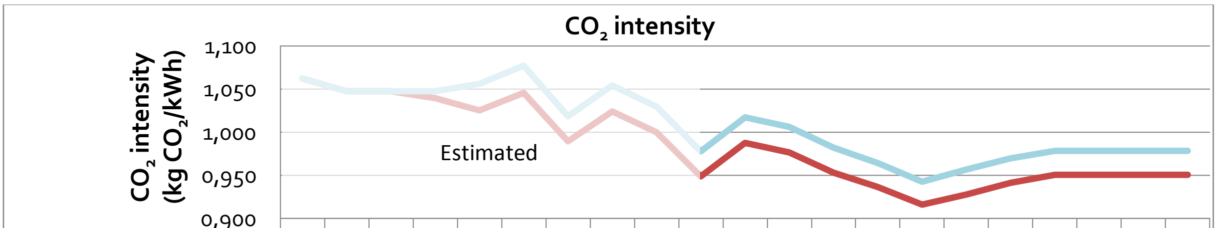


Figure 62: Development of the total CO_2 emissions of PPC, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1), (European Commission, 2010a) and annual reports of PPC



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
With allocation to heat	1,063	1,048	1,048	1,039	1,025	1,045	0,990	1,024	1,000	0,949	0,988	0,977	0,953	0,936	0,916	0,928	0,942	0,951	0,951	0,951	0,951
Without allocation to heat	1,063	1,048	1,048	1,047	1,056	1,077	1,019	1,054	1,030	0,978	1,017	1,006	0,982	0,964	0,942	0,957	0,970	0,979	0,979	0,979	0,979

Figure 63: Development of the CO_2 intensity of PPC, where the hazed section and data after 2010 are estimated. Own calculations based on calculated electricity production and CO_2 emissions

3.10 Scottish & Southern Energy (SSE)

Figure 64 shows the development of the installed capacity of SSE, which results in the electricity generation mix shown in figure 65. SSE is expected to increase the installed capacity of natural gas power plants, and is planning to build a biomass-fired power plant. The largest expected change in the electricity generation mix is the large increase in the production of wind power in the upcoming years. The drop of the electricity production in 2009 is an effect of the financial crisis.

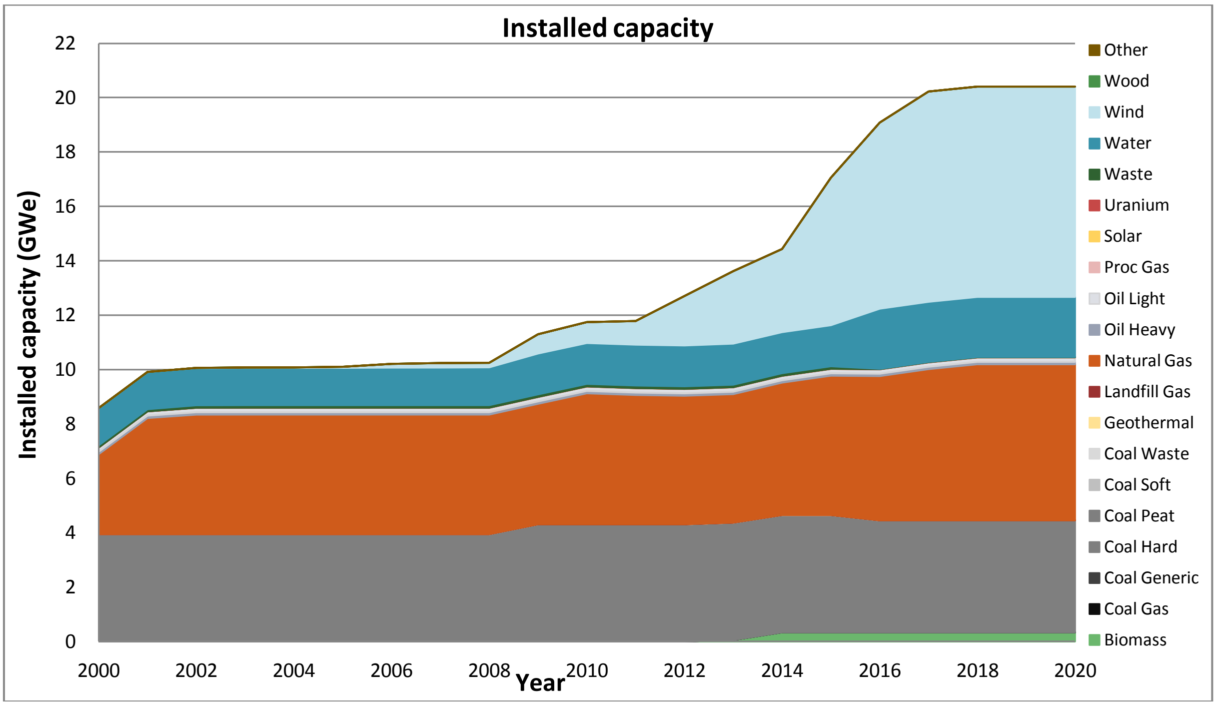


Figure 64: Development of the installed capacity of SSE (Platts, 2010 Q1)

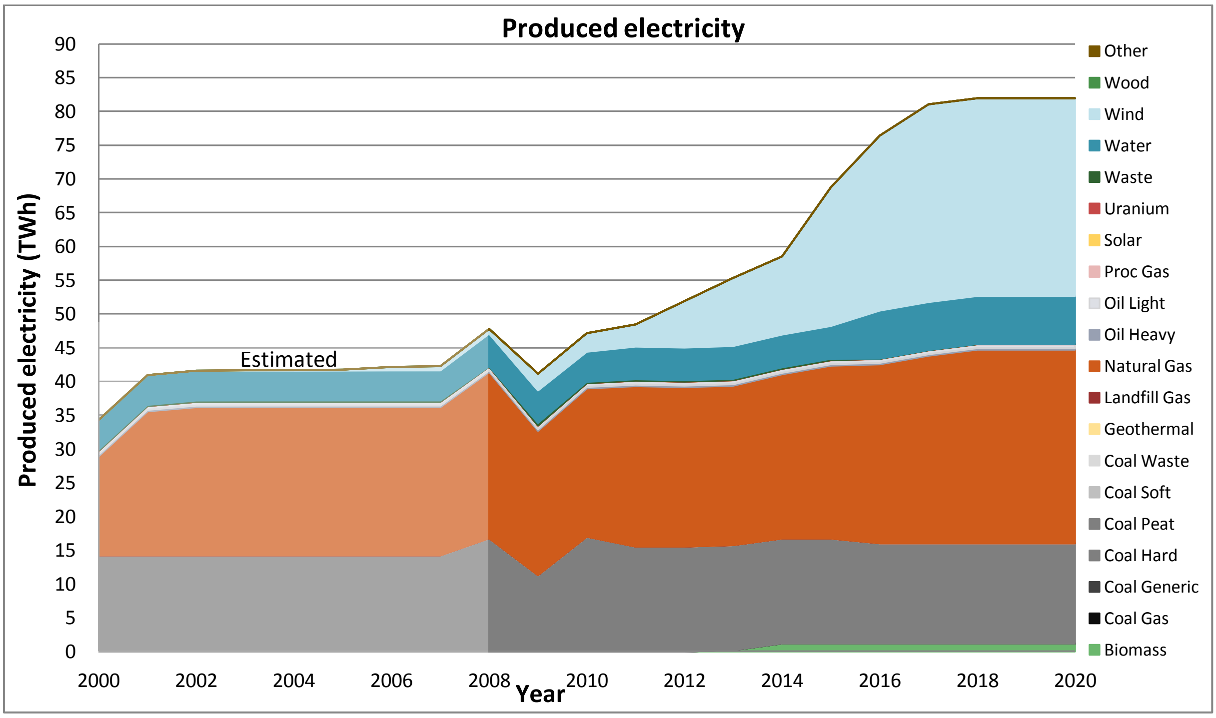


Figure 65: Development of the electricity generation mix of SSE, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1) and annual reports of SSE

Figure 66 shows the total CO_2 emissions of SSE. The largest changes in the total CO_2 emissions are in the years 2008-2010. These changes are caused by a drop of the total generated electricity in 2009, as a result of the financial crisis. This drop in the electricity production was achieved by reducing the electricity output of coal-fired power plants.

The ambition of SSE is to reduce their CO_2 emission intensity from 491 gram CO_2/kWh in 2009 to 308 gram CO_2/kWh in 2020(SSE, 2009b). Figure 67 shows that CO_2 intensity is expected to decrease from 447 gram CO_2/kWh in 2009 to 260 gram CO_2/kWh in 2020. The calculated CO_2 intensity is lower than the CO_2 intensity given by SSE, but with the same reduction percentage the CO_2 intensity will reach about 286 gram CO_2/kWh, which is very close to the reduction ambition of SSE.

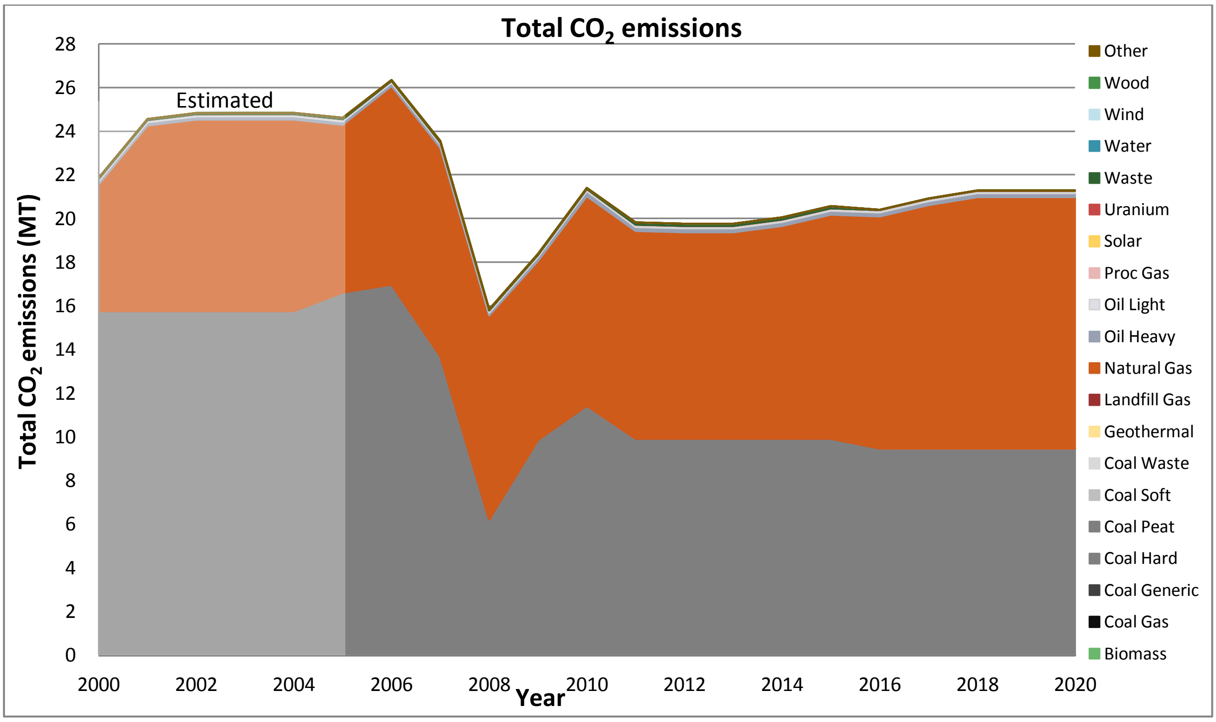
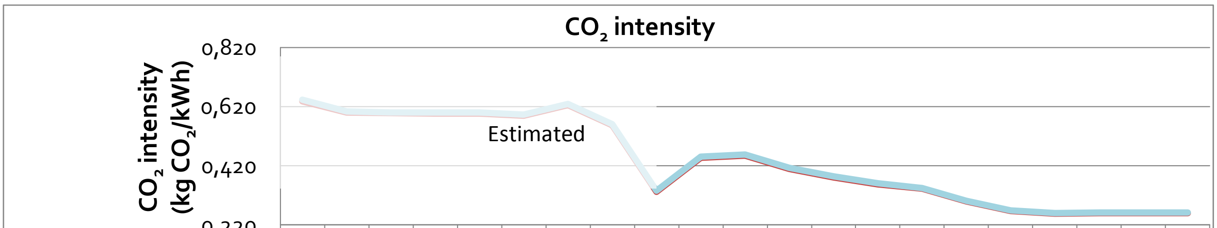


Figure 66: Development of the total CO_2 emissions of SSE, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1), (European Commission, 2010a) and annual reports of SSE



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
With allocation to heat	0,638	0,600	0,597	0,596	0,596	0,590	0,625	0,557	0,332	0,447	0,454	0,409	0,381	0,357	0,343	0,299	0,267	0,258	0,260	0,260	0,260
Without allocation to heat	0,642	0,604	0,601	0,600	0,600	0,593	0,629	0,561	0,335	0,450	0,457	0,412	0,384	0,360	0,345	0,301	0,269	0,260	0,261	0,261	0,261

Figure 67: Development of the CO_2 intensity of SSE, own calculations based on calculated electricity production and CO_2 emissions

3.11 Eneco

Figure 68 shows the development of the installed capacity of Eneco. This shows that Eneco only has natural gas and wind power. Eneco is building a large natural gas-fired power plant, which will be operating in 2012. Eneco is planning to make large investments to increase their installed capacity of wind energy, and will build a small biomass-fired power plant. This results in the generation mix as shown in figure 69.

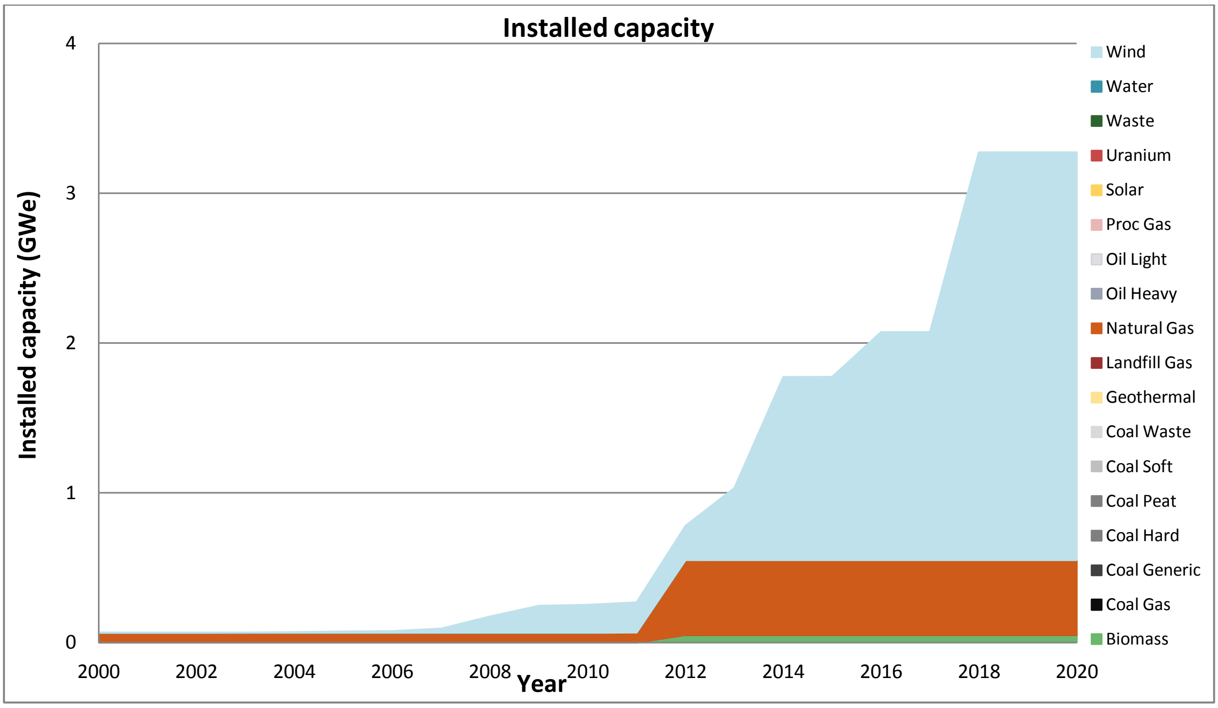


Figure 68: Development of the installed capacity of Eneco (Platts, 2010 Q1)

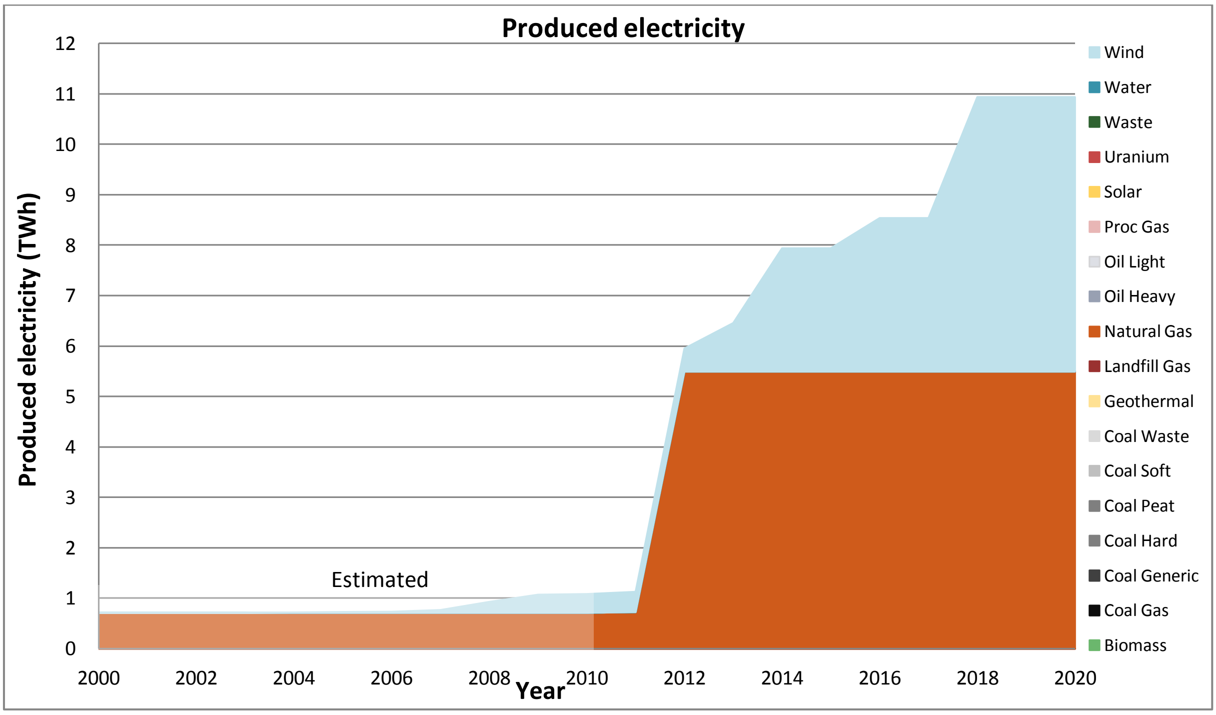


Figure 69: Development of the electricity generation mix of Eneco, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1) and annual reports of Eneco

Figure 70 shows the total CO_2 emissions of Eneco. The CO_2 emissions are caused by the natural gas-fired power plants and the installation of the new gas-fired power plant will increase the CO_2 emissions drastically. This power plant will also increase the CO_2 intensity, which is shown in figure 71. The CO_2 intensity is decrease again by the increased share of wind power in the generation mix. The ambition of Eneco is to generate 70% of their electricity sustainably by 2020(Eneco Holding, 2009). With their current investment plans Eneco will reach about 70% sustainable in 2020 and will therefore Eneco is expected to be able to meet their ambitions.

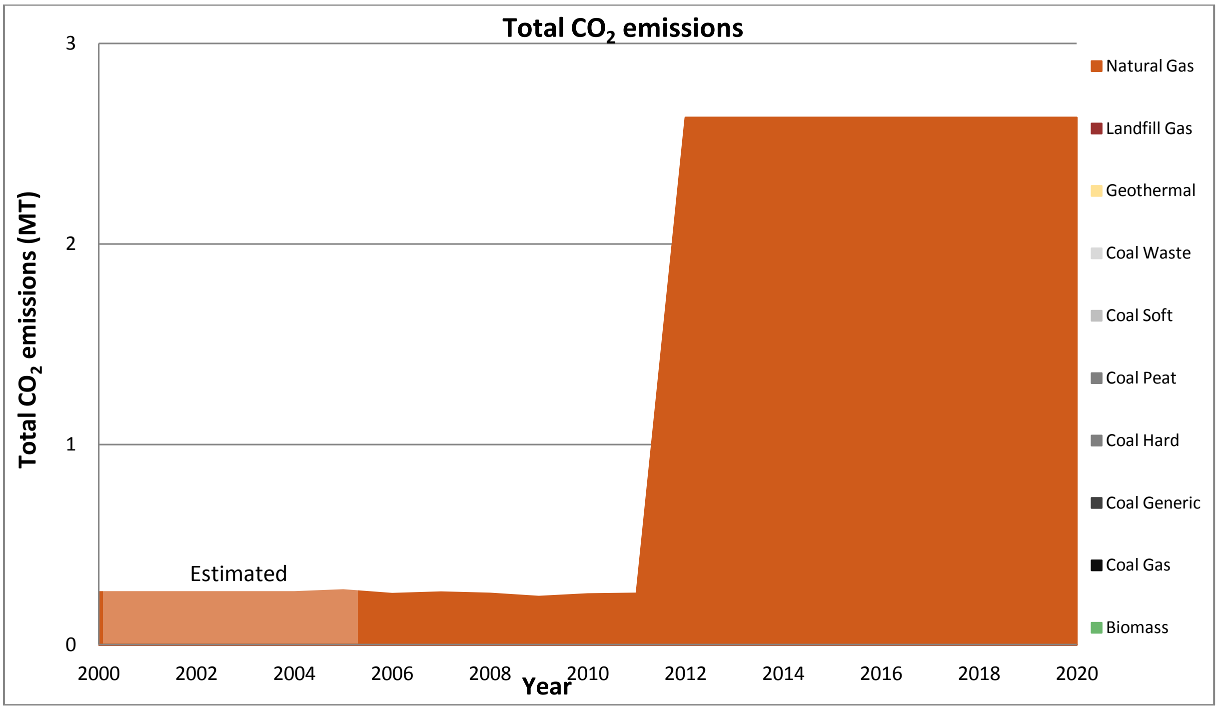
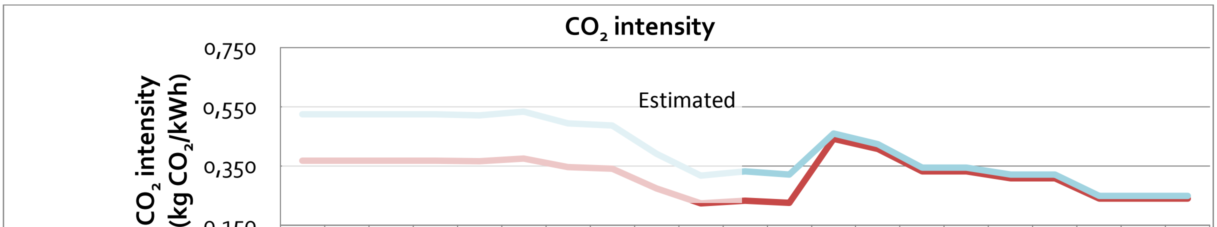


Figure 70: Development of the total CO_2 emissions of Eneco, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1), (European Commission, 2010a) and annual reports of Eneco



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
With allocation to heat	0,368	0,368	0,368	0,368	0,365	0,374	0,346	0,341	0,275	0,223	0,233	0,226	0,442	0,407	0,331	0,331	0,308	0,308	0,240	0,240	0,240
Without allocation to heat	0,525	0,525	0,525	0,525	0,521	0,533	0,494	0,486	0,392	0,318	0,331	0,320	0,460	0,424	0,344	0,344	0,320	0,320	0,250	0,250	0,250

Figure 71: Development of the CO_2 intensity of Eneco, where the hazed section and data after 2010 are estimated. Own calculations based on calculated electricity production and CO_2 emissions

3.12 Drax

Figure 72 shows the development of the installed capacity of Drax. Drax is the owner of a large coal-fired power plant in England. Since 2003 Drax has started co-firing biomass in this power plant. Drax is planning to build three biomass-fired power plants of about 180 MW, which should be operational in 2014. Figure 73 shows the changes in the electricity generation mix caused by the use of biomass.

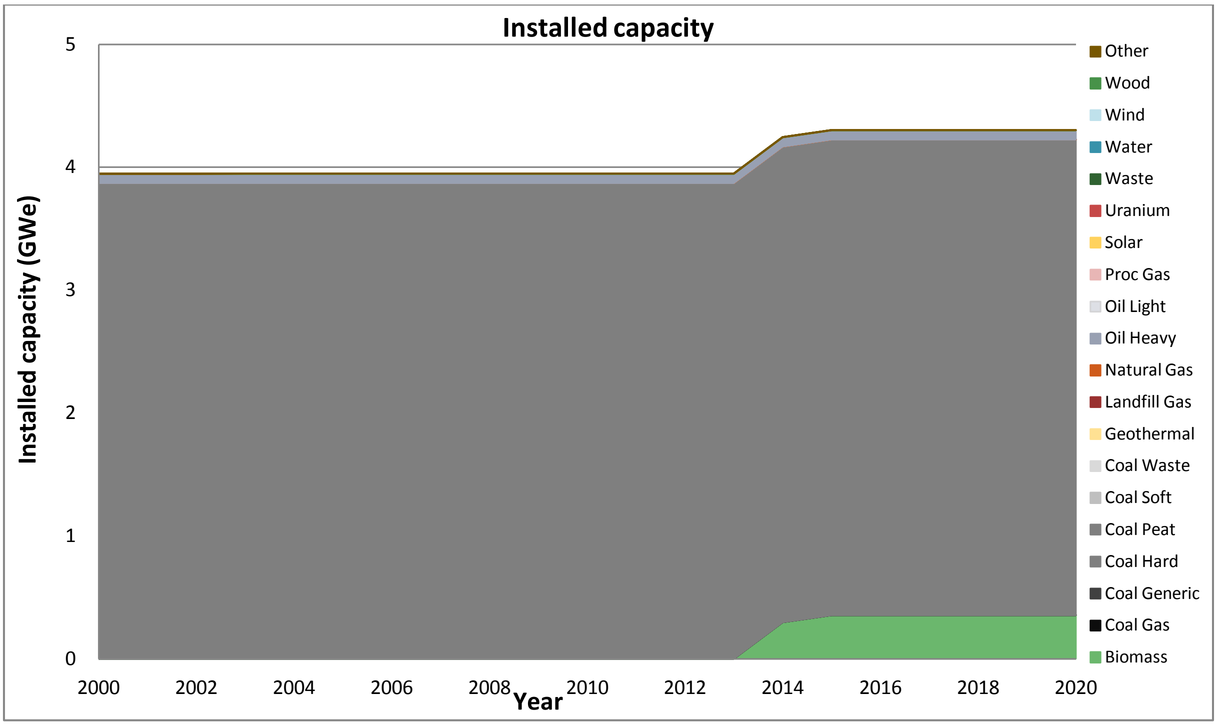


Figure 72: Development of the installed capacity of Drax (Platts, 2010 Q1)

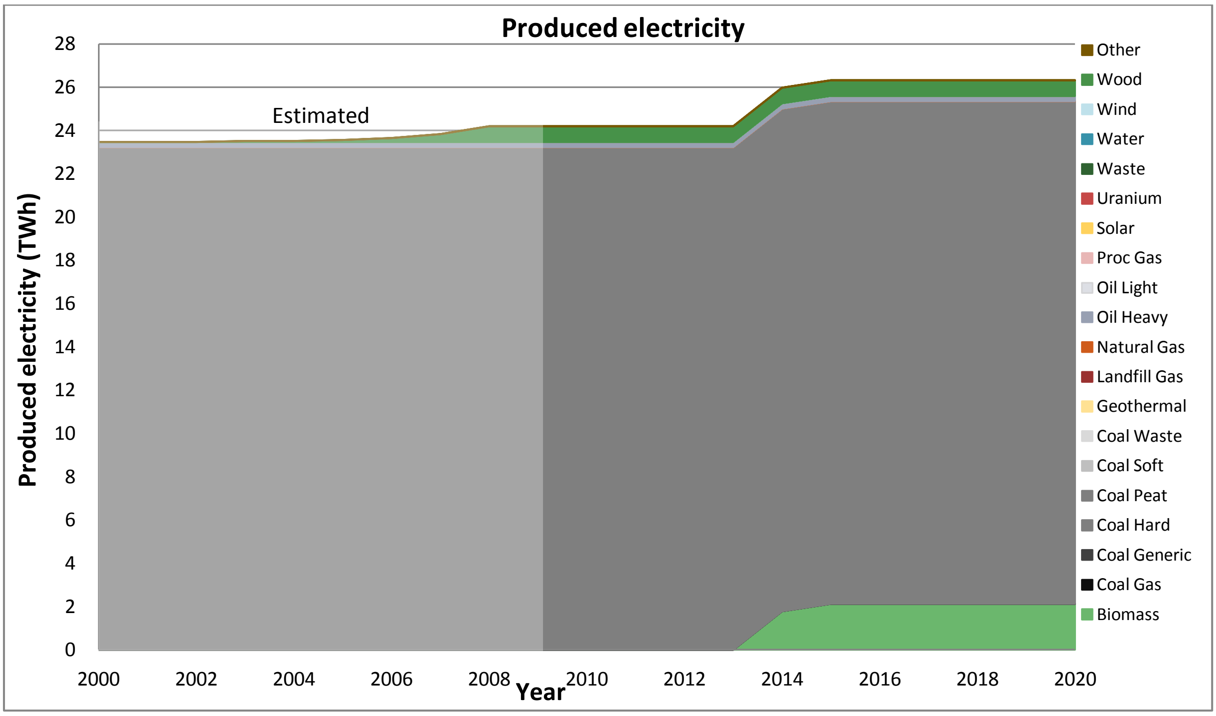


Figure 73: Development of the electricity generation mix of Drax, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1) and annual reports of Drax

Figure 74 shows the development of the total CO_2 emissions of Drax. The decrease of the CO_2 emissions in 2009 is a result of the financial crisis. It is possible that the total emissions will be reduced even more in the upcoming years, but this depends on the percentage of biomass which is co-fired in the coal-fired power plant.

Figure 75 shows the development of the CO_2 intensity of Drax. The CO_2 intensity is declining because of the growing percentage of biomass in the generation mix. The CO_2 intensity of 2009 reported by Drax was 815 gram CO_2/kWh, which is very close to the calculated CO_2 intensity of 821 gram CO_2/kWh.

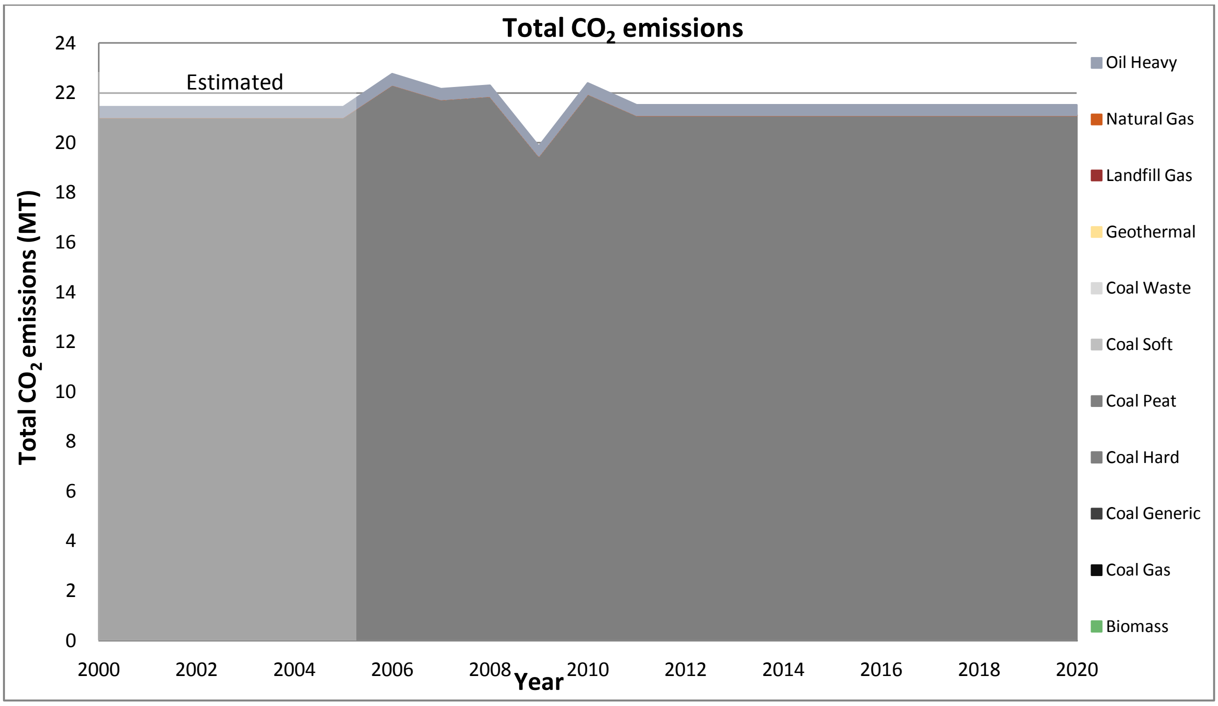
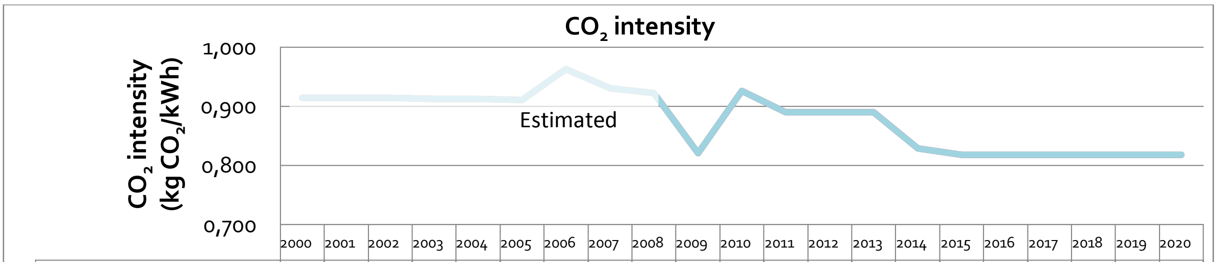


Figure 74: Development of the total CO_2 emissions of Drax, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1), (European Commission, 2010a) and annual reports of Drax



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
With allocation to heat	0,914	0,914	0,914	0,912	0,912	0,910	0,963	0,930	0,922	0,821	0,926	0,889	0,889	0,889	0,829	0,818	0,818	0,818	0,818	0,818	0,818
Without allocation to heat	0,914	0,914	0,914	0,912	0,912	0,910	0,963	0,930	0,922	0,821	0,926	0,889	0,889	0,889	0,829	0,818	0,818	0,818	0,818	0,818	0,818

Figure 75: Development of the CO_2 intensity of Drax, where the hazed section and data after 2010 are estimated. Own calculations based on calculated electricity production and CO_2 emissions

3.13 Benchmark of the utilities and trends in the electricity sector

In the previous sections the utilities have been analysed individually. This section gives a benchmark of the utilities and shows trends in the electricity sector. In the first part of this section the twelve utilities are compared to show differences in their CO_2 performance. The second part of this section analyses trends which can be seen from the benchmark results. Because the twelve utilities account for about half of the electricity generation in Europe, the results can be used to analyse developments in the electricity sector.

3.13.1 Benchmark of the utilities

Figure 76 shows the generation mix of the twelve selected utilities, sorted on the basis of the CO_2 intensity of the utilities, with the utility with the lowest emission factor on the left. In general, utilities with large shares of renewable, hydro and nuclear energy have a low CO_2 intensity and utilities with large shares of coal- and oil-fired power plants have a high CO_2 intensity. There are some exceptions, which are discussed below.

Most utilities with a high CO_2 intensity have relatively high shares of coal in their generation mix. Vattenfall and E.ON are exceptions because they have high shares of coal in their generation portfolio, but their CO_2 intensity is relatively low. This is caused by the high use of combined heat and power of these utilities. Because of this heat production, a large part of the total CO_2 emissions is allocated to the heat production which reduces the total CO_2 emissions allocated to the electricity production.

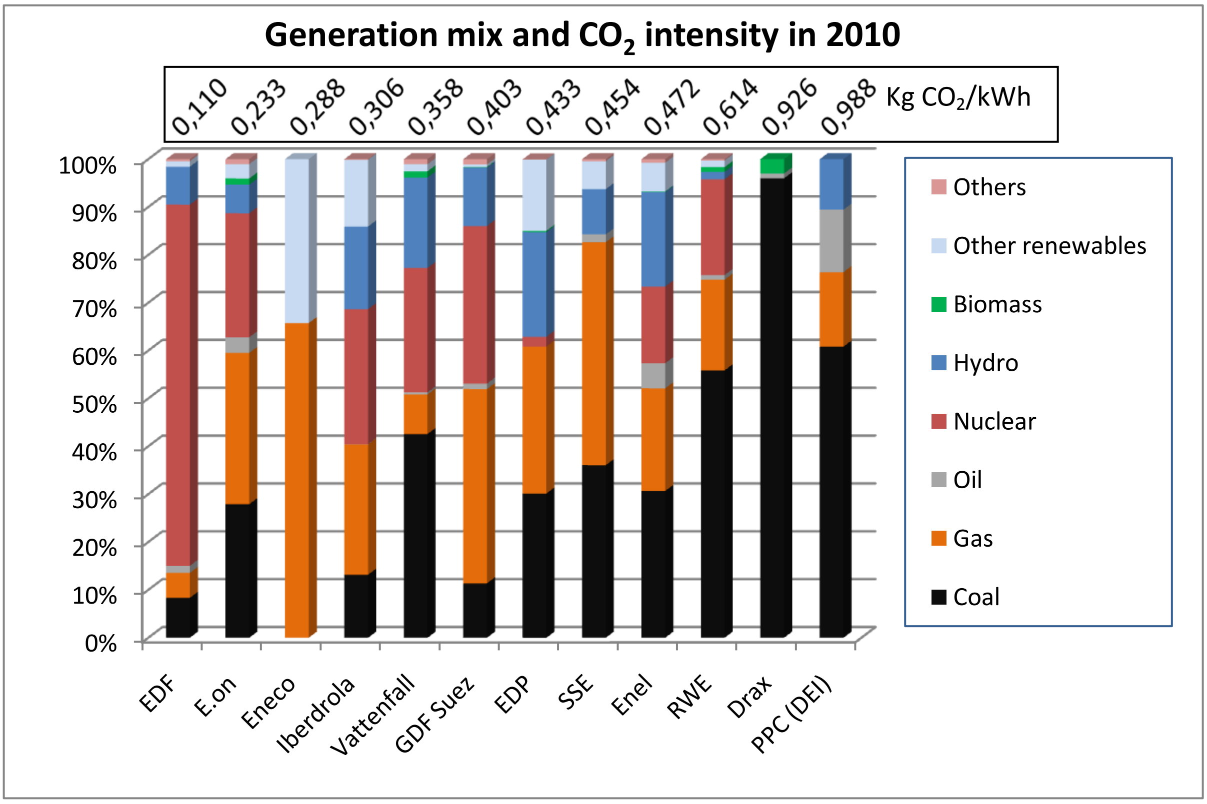


Figure 76: Generation mix and CO_2 intensities of the twelve selected utilities 2010, based on (Platts, 2010 Q1) and annual reports of the utilities

Another exception is PPC, which has the highest CO_2 intensity, while Drax has a far larger share of coal in the generation mix. Drax's coal-fired power plant has a lower CO_2 intensity than the coal-fired power plants of PPC, which indicates that the coal-fired power plant of Drax is more efficient than the coal-fired power plants of PPC. Another reason why PPC has a higher CO_2 intensity is because of the use of soft coal. Soft coal has a higher CO_2 intensity than hard coal and therefore the CO_2 intensity of PPC is higher.

EDP is the utility with the largest share of renewable electricity in the generation mix (hydro included), but does not have a low emission factor compared to other utilities. EDP has a high emission factor because the coal and natural gas-fired power plants have a relatively high emission factor, which indicates that EDP could have power plants with a relatively low efficiency.

Figure 77, 78 and 79 show the development of the CO_2 intensity of the twelve selected utilities. Almost all utilities are expected to decrease their CO_2 intensity, except for Vattenfall and E.ON, both of which show a small increase. The increase by Vattenfall is mainly caused by the acquisition of Nuon in 2009. The CO_2 intensity of electricity generated by E.ON is increasing because of the decreasing share of nuclear energy. The CO_2 intensity of GDF Suez is stable while all other utilities are decreasing their CO_2 intensities as a result of increasing shares in renewable and natural gas use.

What can be seen in figure 79 is that the CO_2 intensity of most utilities remains relatively stable, with a few exceptions. Table 2 shows the increase or decrease of the CO_2 intensity of each of the utilities. Data from the past five years is shown because these figures are mainly based on input data and not on assumptions. This table allows comparison of the efforts of each utility to reduce their CO_2 intensity. For example, EDF is decreasing its CO_2 intensity by 50 gram/kWh between 2000 and 2020, which is a decrease of 32%. PPC is decreasing its CO_2 intensity by 110 gram/kWh in the same period, which is a higher absolute reduction than EDF, but the relative reduction is only 11%. This shows that the EDF's effort to reduce the CO_2 intensity is higher than the PPC's effort. From this analysis, EDP and SSE are the utilities which relatively have the highest decrease in CO_2 intensity. There is a large difference between these companies because EDP has realised the reduction mainly in the past five years, but is expected to increase the CO_2 intensity in the upcoming decade. SSE has made some effort to reduce their CO_2 intensity in the past decade, but compared to other utilities this decrease was not extraordinary. What makes SSE different from the other eleven utilities is that SSE is expected to reduce their CO_2 intensity significantly in the upcoming decade.

Table 2: expected percentage of increase of decrease of the CO_2 intensity of the twelve utilities over five time periods

	2000-2020	2000-2010	2005-2010	2010-2015	2010-2020
EDF	-32%	-21%	-10%	9%	-14%
E.ON	14%	8%	17%	9%	5%
Eneco	-35%	-37%	-41%	44%	3%
Iberdrola	-32%	-23%	-28%	-3%	-12%
Vattenfall	1%	5%	5%	-5%	-4%
GDF Suez	-1%	-9%	-14%	16%	9%
EDP	-40%	-47%	-62%	11%	13%
SSE	-59%	-29%	-22%	-35%	-43%
Enel	-30%	-36%	-24%	0%	9%
RWE	-35%	-25%	-26%	-9%	-13%
Drax	-11%	1%	2%	-13%	-12%
PPC (DEI)	-11%	-7%	-6%	-6%	-4%

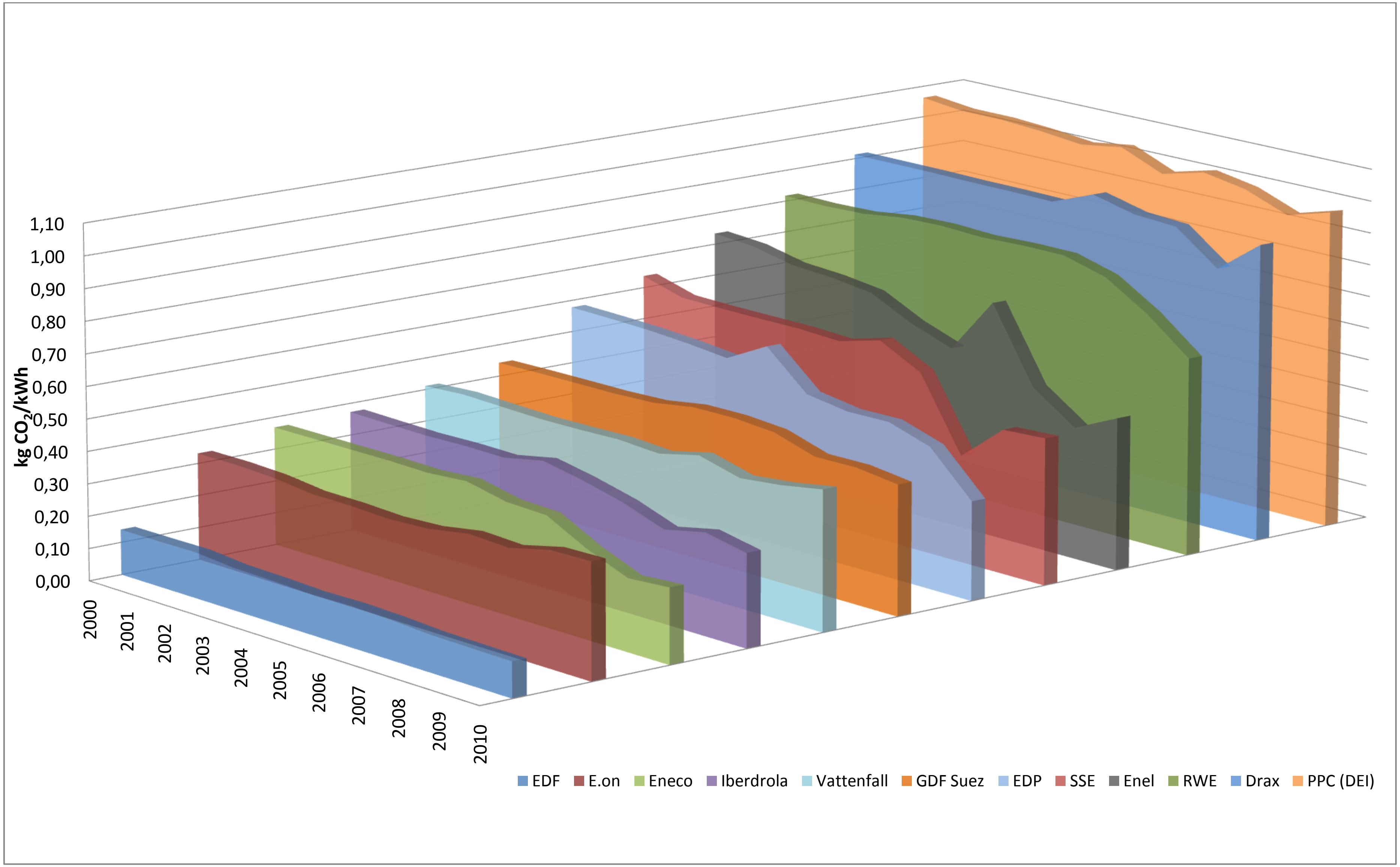


Figure 77: Benchmark of the CO_2 intensity of the twelve selected utilities over the years 2000 - 2010

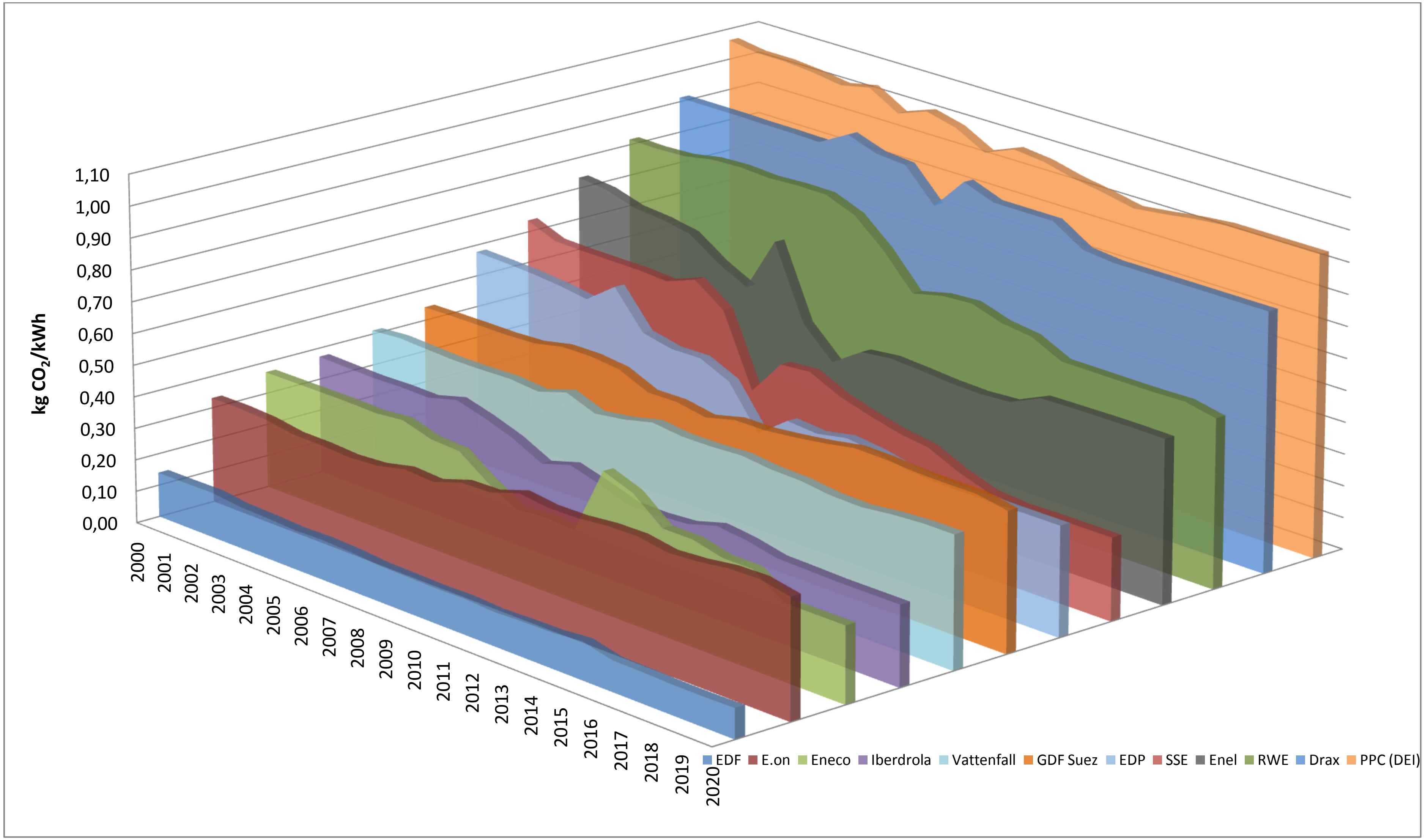


Figure 78: Benchmark of the CO_2 intensity of the twelve selected utilities over the years 2010-2020

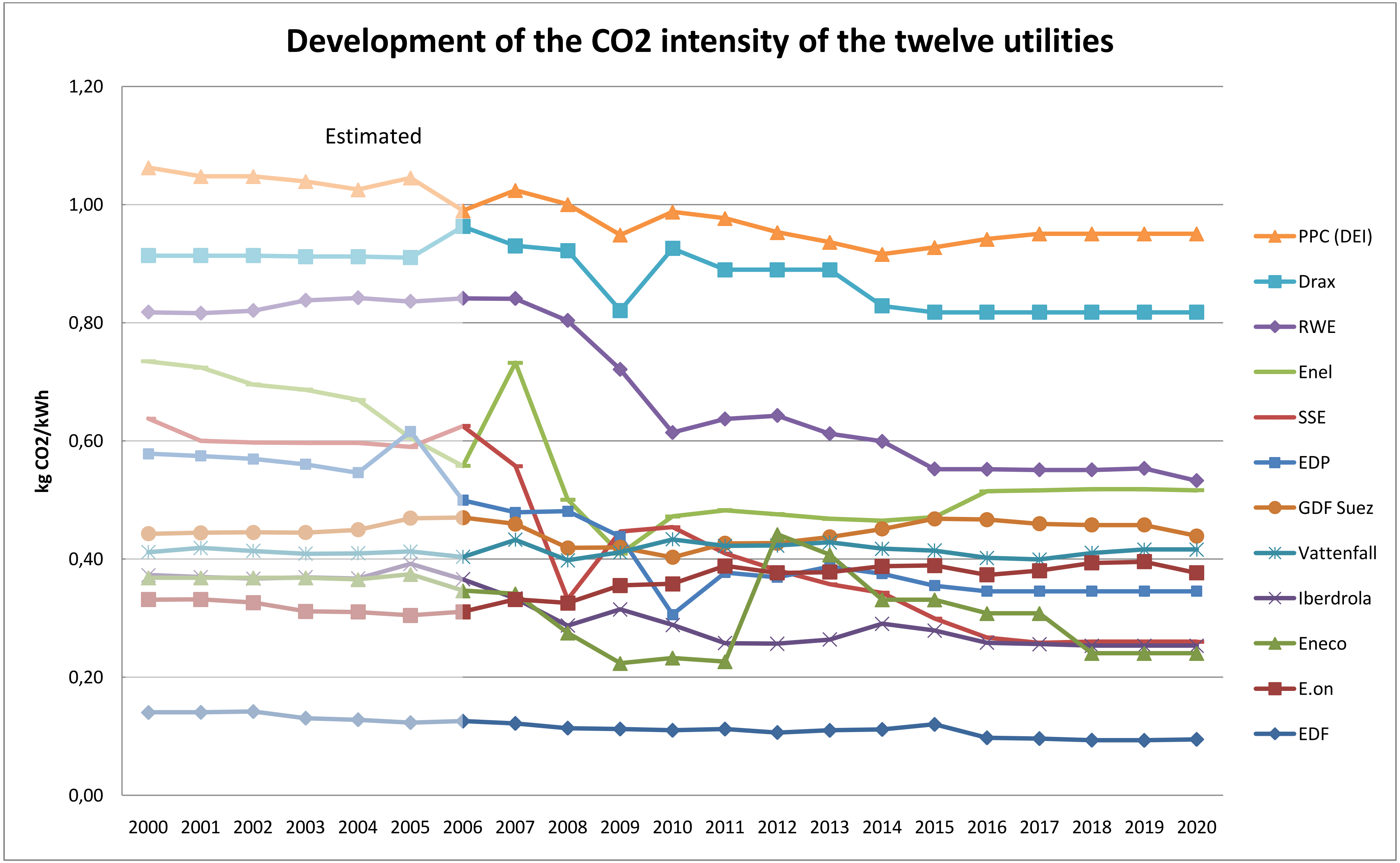


Figure 79: Benchmark of the CO2 intensity of the twelve selected utilities over the years 2010-2020, where the hazed section and data after 2010 are estimated

3.13.1 Trend analysis of the electricity sector

Figure 80 shows the development of the expected electricity generation of the twelve utilities. The use of all fuel types is expected to increase between 2010 and 2020, except for oil and process gas. For the use of coal, nuclear and hydro energy a small increase is expected. The growth of the total electricity production is mainly caused by the increase in use of natural gas and renewables. The growth of the electricity generation is very large compared to the growth of the last decade. This analysis shows that it is likely that the expected growth in the electricity generation is too high. Furthermore, efforts in energy efficiency could decrease the demand for electricity in the next decade. Opposite to this the development of plug-in electric vehicles can increase the demand for electricity. As a result the electricity demand is expected to grow, but not with the high rate as shown in figure 80(GlobalData, 2011a).

The use of natural gas for generation of electricity is expected to increase by about 65% from 2010 to 2020. This increase in the demand for gas can put pressure on the gas price and therefore the gas price is expected to increase because of this development. Furthermore, the natural gas reserves of Europe are limited, and therefore Europe will be dependent on the supply of natural gas from outside of Europe.

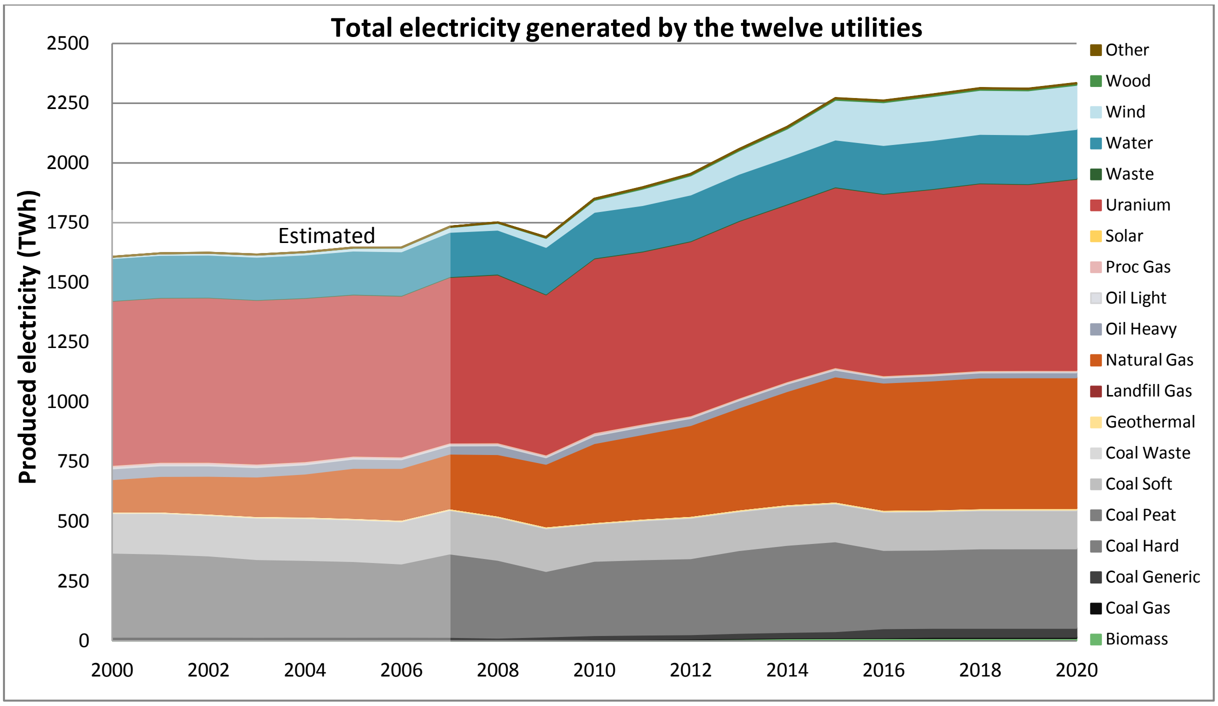


Figure 80: Development of the total produced electricity of the twelve utilities, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1) and annual reports of the utilities

Most utilities are expected to increase the total CO_2 emissions between 2010 and 2020, except for GDF, SSE and Drax. The expected developments of the total CO_2 emissions of the analysed utilities are shown in figure 81. In 2010, the total CO_2 emissions of the twelve utilities were about 645 MT. These twelve utilities account for about 50% of the total emissions from electricity production in Europe, compared to the total verified emissions in Europe in the ETS database. Because the total emissions of electricity generation are expected to increase, this can increase the price of emission allowances. In 2009, the cap of the total emissions under the ETS, including other sectors, was set at about 1900 MT (European Commission, 2011a). The total amount of emission allowances used by the electricity sector was about 1200 MT in this year, which shows that the electricity sector is responsible for a significant amount of emissions under the ETS. The emissions of the twelve utilities are expected to rise by about 25% from 2010 to 2020. If the assumption is made that the emissions of the electricity sector will increase with the same rate, the total emissions of the electricity sector are expected to increase to 1500 MT in 2020. The cap of the ETS will decrease by 1,74% to about 1800 MT in 2020 (European Commission, 2011a). Other industrial sectors emitted about 900 MT of CO_2 in 2010. This analysis shows that there is an expected shortage of emission allowances which will increase the price of these emission allowances. It also shows that the CO_2 emissions of the electricity sector are expected to become too high to comply with the CO_2 emission cap set by the ETS.

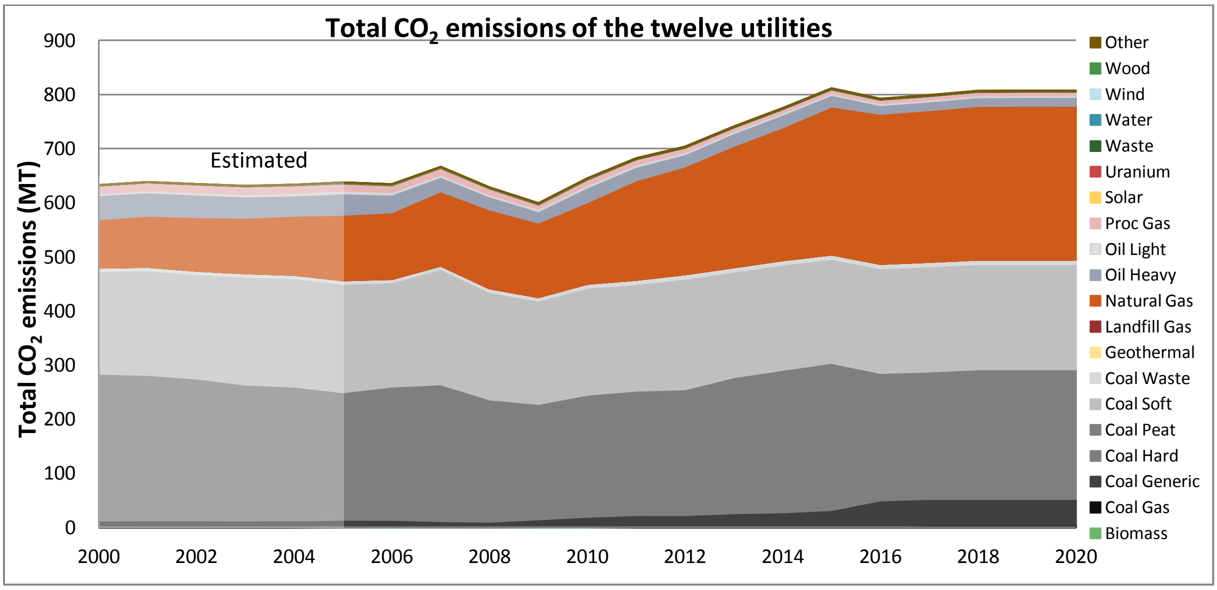
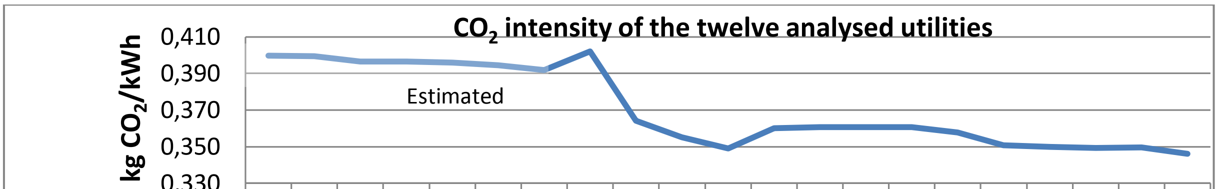


Figure 81: development of the total CO_2 emissions of the twelve utilities, where the hazed section and data after 2010 are estimated. Own calculations based on (Platts, 2010 Q1), (European Commission, 2010a) and annual reports of the utilities

Figure 82 shows the development of the CO_2 intensity of the twelve utilities combined. The peak of the CO_2 intensity in 2007 was caused by a peak in the electricity produced by coal-fired power plants. Figure 82 shows a decrease of the CO_2 intensity between 2007 and 2010. This decrease is caused by a combination of several developments. The most important development is the decrease in CO_2 emissions from coal-fired between 2007 and 2009. Next to this, there is an increase in the use of natural gas and renewable energy for the production of electricity, which decreases the CO_2 intensity. Another reason why the CO_2 intensity is decreasing is because the CO_2 intensities per fuel, calculated by using ETS data, are decreasing. An explanation for this decrease can be that in the years 2007 and 2008 old power plants with a lower efficiency were used, but because of the increasing new capacity and the decrease of the electricity demand in 2009 and 2010 these old plants were less frequently used. The increase of the CO_2 intensity in 2011 is caused by the increase of the electricity output of coal-fired power plants. A further reason why there is an increase this year is because of the assumption that the CO_2 intensity per fuel is based on the average CO_2 intensity of the years 2007-2010. This CO_2 intensity was decreasing and therefore the average is higher than the year 2010.

The expected CO_2 intensity remains relatively stable in the next decade. A large increase is expected for the use of natural gas, but because the CO_2 intensity of natural gas power plants is almost similar to the CO_2 intensity of electricity generated in Europe this will have no effect on this CO_2 intensity. The share of renewables is expected to increase in this period, but because of a small increase in the CO_2 emissions of coal-fired power plants the CO_2 intensity will not decrease.



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
CO2 intensity Europe	0,400	0,400	0,397	0,396	0,396	0,395	0,392	0,402	0,364	0,355	0,349	0,360	0,361	0,361	0,361	0,358	0,351	0,350	0,349	0,350	0,346

Figure 82: development of the CO_2 intensity of the twelve utilities combined, where the hazed section and data after 2010 are estimated. Own calculations based on calculated electricity production and CO_2 emissions

4 Discussion benchmark

In the methodology of the benchmark some important decisions have been made which can have a large impact on the results. This chapter will give an overview which factors have a large impact on the results of the benchmark and how changes in the methodology can have an impact on the results. Some of these factors are applicable to all the utilities analysed in the benchmark, but some are specified per utility.

4.1 Discussion of general assumptions and methodologies

4.1.1 Installed capacity

The installed capacity is based on the data in the Powervision database. For the upcoming years the investments and divestment plants in the Powervision database are used to estimate the development of the installed capacity of the utilities. Because the investment and divestment plans in the Powervision database can be incomplete, an analysis is made of changes in installed capacity in the last decade and the upcoming decade. For most utilities the divestments in installed capacity of the last decade is similar to the expected divestments in the upcoming decade. For this reason the divestment plans of the utilities seem to be complete. The amount of MW installed capacity in the investment plans of most utilities is higher than the newly installed capacity of the last decade. Next to this the expected growth of the generated electricity in the next decade is very high compared to the growth of the last decade. From 1999 to 2009 the electricity generation has grown by about 10% in the EU-27(Eurostat, 2010a). The expected growth in this report is about 26% from 2010 to 2020. This analysis shows that it is likely that some of the investments plans will not be realised. This will make the expected total electricity generation higher than the actual electricity generation in the next decade.

4.1.2 Load factors

An assumption of the load factors is made for the years where no generation data is available. This assumption is based on the years where data is available. Because the load factor is not consistent over time the average of the load factor is used where data is available. For the years of the past decade where no data is available the average of the first few years is used. For the upcoming decade the average load factor of the last few years where data is available is used. This methodology is used because these years are more representative for the years over which the assumptions are made. If another methodology is chosen, this can change the expected electricity generation of the years where no data is available.

4.1.3 CO_2 emission intensities based on EU-ETS data

Analysis of the results of the inclusion of the EU-ETS data showed that, for all utilities, more than 80% of the total emissions were registered in the EU-ETS database, and for most utilities this was more than 90%. The inclusion of the EU-ETS data showed that, for some utilities, there was a large difference between the total emissions calculated with estimations and the total emissions given by the EU-ETS system. With a comparison to the total emissions given by utilities in annual reports it was concluded that the data given by the EU-ETS was more accurate.

For the years where no ETS data is available, assumptions are made to calculate the CO_2 emissions. These assumptions are based on the years where the data is available. For compiling the assumptions several methodologies can be used.

The methodology which is used for this report is to base the CO_2 emission intensities on the average of the years where data is available. The methodology which is used is to base the CO_2 intensities of the years 2000-2004 on the average of the years 2005-2007, and the CO_2 intensities of the years 2011-2020 on the years 2008-2010. This methodology is used because the CO_2 intensity of utilities can change over time. With this methodology the development of the CO_2 intensity is taken into account more accurately than compared to taking the average of the CO_2 intensity of the years 2005-2010 as an assumption for all the years.

An even better methodology to take the development of the CO_2 intensity into account would be to find a trend in the development of the CO_2 intensity and use this trend to extrapolate the development of the CO_2 intensity. This methodology is not possible because the development of the CO_2 intensities does not show a trend.

4.1.4 EU-ETS data availability

In the years 2005 to 2010 the total emissions are mainly based on data from the EU-ETS. For these years more than 95% of the total emissions are in the EU-ETS database, except for 2010. The EU-ETS database does not cover 100% of the emissions for several reasons. The first reason is that some of the CO_2 emissions are emitted by power plants located in Switzerland, which does not participate in the EU-ETS. Another explanation is that the CO_2 emissions from very small power plants are not in the database. These two explanations cover a large part of the power plants which are not in the EU-ETS database, but for other power plants the reason why they are not in the database is not known. For the year 2010 not all data was available at the time of writing.

4.2 Methodology and assumptions per utility

4.2.1 EDF

Some of the input data of the total produced electricity is based on worldwide electricity generation data of EDF. Although for EDF this is not a large part, about 3% of the total generated electricity, it can make a difference. For EDF the share of nuclear will probably rise because most nuclear energy of EDF is located in Europe, and some other shares will be lower. The assumptions for the CO_2 intensity per fuel are influenced by this input data. The power plants produce more electricity because the global electricity production is used as input data. Therefore the CO_2 intensity is reduced. This effect can be especially seen in the year 2010, where the total electricity production of Europe is not known and the share of electricity produced outside Europe by EDF becomes higher.

The methodology which is now used to make assumptions of the load factor for the years 2000-2005 and 2011-2020 is to use the average of the years 2006-2010, because input data is available for these years. Another method could be to use the year 2010 for the upcoming years and the year 2006 for the past years. This can make a large difference for EDF because the assumptions for the CO_2 intensity are decreasing from 2006 to 2010. Another method can be to calculate a growth rate and to reduce the CO_2 intensity for the upcoming years. The problem with all these methodologies is that only 4 years of more accurate data is available, and therefore it is difficult to make projections from this data. This is the reason why the average of this four year is not taken for the years where the electricity generation is not known.

4.2.2 RWE

For RWE the estimated CO_2 intensities per fuel are based on the average of the years 2009 and 2010 instead of an average of the years 2008-2010. This methodology is used because RWE has acquired Essent in 2009.

4.2.3 GDF Suez

GDF Suez is a combination of GDF, Electrabel and Suez. These utilities merged in July 2008 and therefore the data before this data are a combination of several companies (GDF Suez, 2009).

4.2.4 Vattenfall

For Vattenfall another methodology is used for the estimations of the CO_2 intensities per fuel. For the other utilities the average CO_2 intensity per fuel of the years 2008-2010 is used as an estimation for the years 2010-2020. For Vattenfall the year 2010 is used as the reference year because this year is a better representation for the future because Vattenfall acquired Nuon in 2009. This acquisition caused changes for the assumptions of the CO_2 intensities per fuel between the years 2009 and 2010 and therefore the year 2010 is used as a reference year.

4.2.5 Iberdrola

The assumption for the load factor for wind power is adjusted for the upcoming years. The load factor of wind energy was very high because not all the installed capacity is in the Powervision database. To compensate for the missing data in the database the load factor is increased. For the upcoming years Iberdrola is planning to make investments in large wind farms. These large projects are in the Powervision database and therefore the share of the capacity which is in the database is expected to increase. Because the data availability increases the assumption for the load factor has to decrease. The load factor is therefore adjusted for the upcoming years so that the estimated electricity generated by wind power is more realistic.

4.2.6 EDP

The data of the electricity mix and the total electricity production show a large decrease in the years 2007 to 2010. It is not known why this decrease is there and if this decrease will continue, or if a fast recovery to the level of the previous years will take place.

4.2.7 SSE

Like EDP, the total electricity production of SSE has dropped. Both utilities showed a reduction of the output of their coal-fired power plants. The most logic explanation is that one or two of these coal-fired power plants were down for maintenance. Because these utilities are relatively small compared to the other utilities, the effects of a single power plant not producing electricity can be more clearly seen in the total electricity production of the utility compared to larger utilities. Another possibility is that the electricity demand has dropped because of the economic recession. Because the output of the coal-fired power plants is reduced this could mean that the coal-fired power plants have the higher operation costs. This would be strange because historically natural gas was higher in the merit order that coal-fired power plants, which means that the operation costs of gas-fired power plants is higher than that of coal. The reason for this change could be the increase in the fuel costs of coal and the reduction of the natural gas price. If this is true it would not explain why many utilities have plans to invest in new coal-fired power plants. One explanation could be that utilities have based these plans on older data, or that they expect that the coal price will drop and the gas price will rise again to the usual levels.

4.2.8 Eneco

Because the total produced electricity and the electricity mix is not known the load hours are based on the total emissions from the ETS database. The standard emission factor was used to estimate the electricity generation.

4.2.9 Drax

Because no installed capacity of biomass was in the Powervision database this is added, because Drax is using co-firing. Next to this the share of co-firing is not known for the upcoming years. An increase of the use of biomass in the coal-fired power plant can reduce the CO_2 emissions of Drax. For the previous years the CO_2 emissions of Drax are reliable because they are based on ETS data.

4.3 Benchmark results

Because of the methodology used to estimate the load factors of the power plants, the electricity generation data of the individual power plants is estimated. Data of the individual power plants cannot be used for further analysis for this reason.

The methodology which is used to calculate the CO_2 emissions of the utilities for the upcoming years is to take the average CO_2 intensity per fuel calculated with the ETS data. As shown in figure 82, the CO_2 intensity drops in the years 2007 to 2010 and increases again in 2010. One of the explanations of this development is that the assumption of the CO_2 intensities per fuel are based on the average CO_2 intensities of the years 2008 to 2010. These CO_2 intensities per fuel are variable and the general trend is a decrease from 2008 to 2010. If another methodology is chosen, this can have an impact on the expected CO_2 intensity of the next decade. For example, if the average of the years 2009 and 2010 are used to base the assumption of the CO_2 intensities on for the upcoming years instead of the average of the years 2008 to 2010, the CO_2 intensity is expected to develop as shown in figure 83. When these results are compared to the results of the other method shown in figure 82, the expected CO_2 intensity of the upcoming years in figure 83 is lower, with a difference of 5 gram per kWh in 2020.

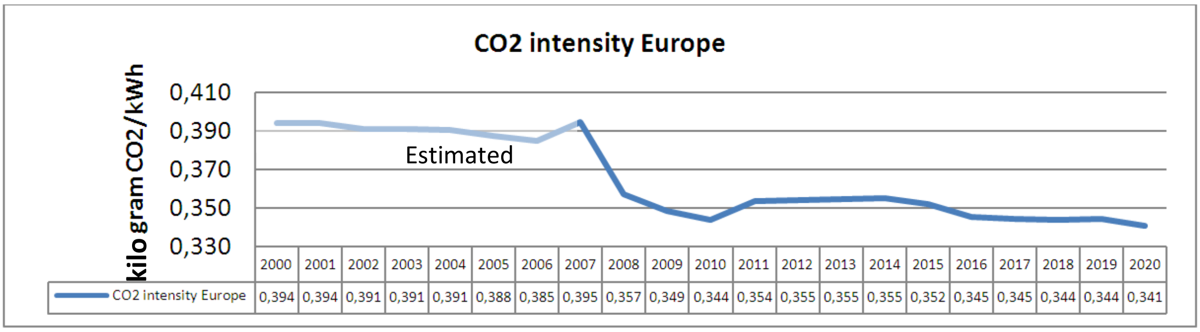


Figure 83: development of the CO_2 intensity of the twelve utilities combined when using another methodology for the assumptions of the emission intensities, where the hazed section and data after 2010 are estimated

Because of the selection methodology for utilities, the conclusions based on the data of the twelve utilities combined can deviate from the average total electricity production in Europe. Some utilities were not selected because of their low CO_2 emissions. These utilities were not selected because it was expected that these utilities do not have interesting CO_2 reduction strategies because their emissions are already low. Another criterion was that most of the largest utilities were selected, and therefore it is possible that larger utilities can have a different CO_2 reduction strategy than smaller utilities. Because the utilities were not selected randomly, it could be that the conclusions drawn from the twelve utilities show different trends than can be expected for the whole of Europe. For example, the CO_2 intensity is expected to decrease from 2000 till 2020, but it is uncertain if this holds true for all utilities in Europe. Another conclusion which is drawn is the increase of the total emissions from electricity production in Europe. This expected increase can be slightly different from reality because of the selection methodology, but the main conclusion of an increase of CO_2 emissions is still expected to be valid because the twelve utilities account for about 50% of the total emissions of electricity production in Europe.

Table 3: Overview of the CO_2 intensities calculated in this report and the CO_2 intensities reported by the utilities of 2009

	Calculated (gram CO_2/kWh)	Reported by utility (gram CO_2/kWh)	Difference
EDF	112	108,8	3%
E.ON	355	386	-9%
RWE	721	796	-10%
GDF Suez	420	366	13%
Enel	409	746	-83%
Vattenfall	411	434	-6%
Iberdrola	315	279	11%
EDP	438	362	17%
PPC	949	1000	-5%
SSE	447	491	-10%
Eneco	223	340	-52%
Drax	821	815	1%

Table 3 shows the CO_2 intensities calculated in this report, the CO_2 intensity reported by the utility and the difference between these two. The largest difference is the reported and the calculated CO_2 intensity of Enel. The most important reason why the reported intensity is higher is because this CO_2 intensity is only for the power plants of Enel in Italy. Enel does not own any nuclear power plants in Italy, but does own nuclear power plants in other countries and therefore the CO_2 intensity will be higher.

The reported CO_2 intensity of Eneco is higher than the CO_2 intensity calculated in this report. The CO_2 intensity of Eneco is the CO_2 intensity of their sold electricity and not of their own generated electricity. Eneco had sold some electricity produced from coal in 2009 which increases the CO_2 intensity.

EDP has a relatively high difference between the reported and calculated CO_2 intensity. This difference can be because the reported CO_2 intensity is the CO_2 intensity which includes the electricity produced outside Europe by EDP. EDP is investing in large renewable energy projects, especially wind farms, outside Europe. For this reason the CO_2 intensity reported by EDP is lower than the calculated CO_2 intensity.

All other differences between the reported CO_2 intensity and the calculated CO_2 intensity can be explained by the assumptions made for the calculations and the methodology used to allocate the CO_2 emissions to heat and electricity production. It is not known how utilities allocate the CO_2 emissions to heat and electricity for their reported CO_2 intensities.

5 Strategy analysis of utilities

In this chapter, the strategies of utilities are analysed. The next two chapters give an analysis of the strategies of E.ON and Vattenfall. These case studies show what the strategy of E.ON and Vattenfall is for building new power plants and why these two utilities are building a coal- or gas-fired power plant in the Netherlands. A general overview of what factors are important for the development of a strategy is needed for a successful case study. This general overview of strategies is provided in this chapter by using two methods: a PESTEL analysis and an analysis of the five forces of Porter. These two methods give a general overview of the strategies which is not specific for E.ON or Vattenfall. For the more specific analysis the case study is be used. The case study will combine the results of the benchmark with the methodologies of the strategy analysis. This methodology will give an insight into the CO_2 reduction strategies of both utilities, which is used to draw generic conclusions on the strategies of utilities.

5.1 PESTEL analyses

A PESTEL analysis is used to show how factors of the business environment impact the industry environment of the utilities (Grant, 2010, pp.64-65). Figure 26 shows the factors which can have an impact on the industry environment. The PESTEL analysis gives insights in which factors of the macro environment are important for utilities and how they can impact utilities. This knowledge is important for the strategies of the utilities because changes in these external factors can have a large impact on the utilities. Therefore these factors have to be analysed to create a robust strategy for the utilities. The PESTEL analysis is also useful for the case study, because it shows which factors are important for utilities. The impacts of these factors are more thoroughly analysed for the decisions of E.ON and Vattenfall to build new coal- or gas-fired power plants. The PESTEL analysis below shows how external factors have an impact on utilities in Europe.

5.1.1 Policies

Before the utilities were privatised they were state owned. The government could make the decision which power plants should be built and find a balance between electricity security, low electricity prices and a good environmental performance. When the utilities were privatised, market forces should have lowered the price of electricity and taken care of the security of supply. These are analysed in the economic factor analysis. Due to the privatisation of the electricity sector, environmental factors are no longer included in the decisions for making new investments in generation capacity. This is because environmental factors are not important for utilities because they do not have a large economic value for utilities. For society, the costs of environmental pollution can be high which causes a problem called the tragedy of the commons, where the polluter does not pay for the damage of the pollution (Hardin, 1968). Policies can be used to take care of the environmental problems related to electricity generation.

One of the largest problems related to the generation of electricity from fossil fuels is global warming. To tackle this problem the European Commission set the 20-20-20 targets. One of these targets is the 20% CO_2 reduction, which aims to reduce the greenhouse gas emissions of Europe (European Commission, 2010b). As a method to reduce the CO_2 emissions, the European commission has introduced the Emission Trading Scheme (ETS). During the first two phases of the ETS the greenhouse gas emission allowances were freely allocated to the utilities. The utilities had to take care to cover their CO_2 emissions with sufficient allowances. This could be done by buying or selling allowances on the market or reduce their CO_2 emissions. Because the total cap on the CO_2 emissions is lowered over time this should reduce the CO_2 emissions of electricity generation (European Commission, 2011a).

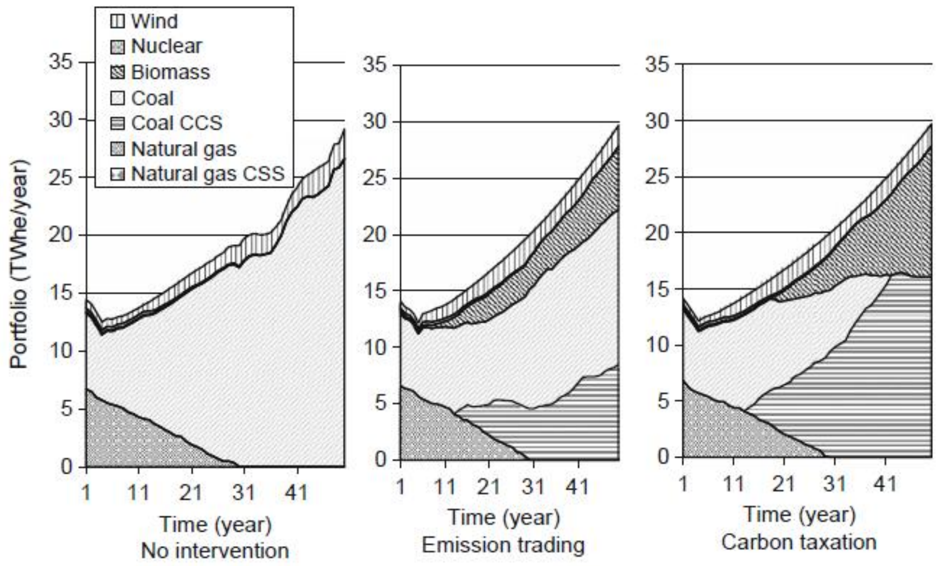


Figure 84: Average generation portfolio evolution for the three scenarios of Chappin et al. (Chappin et al., 2010)

One way of trying to see how effective the ETS will be and how utilities will react to the ETS is to model how utilities will react based on economic considerations. Chappin et al. have made a model for this purpose (Chappin et al., 2010). In this paper, a simulation is made of what the electricity price and generation portfolio will be, based on assumptions of rising energy prices, risk aversion and a small preference for CO_2 reduction if price differences between two types of technologies are small. The model is an agent-based model where the agents decide whether power plants should be dismantled or new generation capacity is needed. Simulations are made of electricity and CO_2 rights trade.

Figure 84 shows the generation portfolio evolution of the three scenarios made by Chappin et al. which shows that emission trading can lead to a reduction in CO_2 emissions. Coal-fired power plants will still be used under the ETS, which shows that it still is economically attractive to make investments in coal-fired power plants. The figure shows the impacts of a carbon tax system compared to the ETS. The outcomes of the model of Chappin et al. showed that a larger CO_2 reduction can be achieved with a carbon tax, which also results in a lower electricity price. The reason for this difference is the higher investment risk because of the price volatility of CO_2 costs by the ETS. The high predictability of the CO_2 price with a carbon tax allows utilities to minimize costs over a long time horizon. Under the ETS this is not possible because of the volatile CO_2 price, which leads to an investment cycle which is not always optimal for a long time horizon (Chappin et al., 2010).

Doherty et al. came to different findings by using a least-cost generation portfolio optimization for the electricity supply in Ireland (Doherty et al., 2008). The paper analysed the effects of fuel and CO_2 prices on the optimal generation portfolio. The results are shown in Table 4. The largest difference with the research of Chappin et al. is the use of gas instead of coal. This difference can be explained by the assumptions of the increase in gas prices. Chappin et al. assumes a high increase in gas prices and therefore coal-fired power plants are built instead of gas-fired power plants with a higher carbon tax.

Table 4: Portfolios with increasing carbon tax for high fuel prices (Doherty et al., 2008).

Plant type	Installed capacity (MW)					
	0 €/t CO_2	10 €/t CO_2	20 €/t CO_2	30 €/t CO_2	40 €/t CO_2	50 €/t CO_2
Coal PF	7,060	6,560	5,229	0	0	0
Coal IGCC	0	0	0	0	0	0
Peat FB	0	0	0	0	0	0
OCGT	1,732	1,838	2,469	2,381	2,374	2,374
CCGT	0	0	576	5,765	5,700	5,630
Wind 1 and 2	0	1,200	1,800	2,800	3,800	3,800
Biomass 1, 2 and 3	0	0	0	0	0	70
Interconnection	800	800	800	800	800	800
Hydro	509	509	509	509	509	509
Total	10,101	10,907	11,383	12,255	13,183	13,183

CO_2: carbon dioxide; PF: pulverized fuel; IGCC: integrated gasification combined cycle; FB: fluidized bed; OCGT: open cycle gas turbine; CCGT: combined cycle gas turbine.

In the first and second phase of the ETS the greenhouse gas emission allowances are freely allocated to the utilities. Because the allowances were allocated freely and because of the high levels of allocated allowances, utilities were able to make profit from emission allowance trading (BBC, 2008). It is also likely that the utilities have passed on the costs of the allowances to the customers, even if the utilities did not have to pay for these allowances. The reasoning behind this is that the emission allowances have opportunity costs. The allowances have a market value and the utilities could have sold the allowances when they would not have used them. Because the utility has used the allowance for the generation of electricity this profit could not have been made and therefore this lack of profit from the emission allowances is passed on to the customer (Sijm et al., 2006). For this reason, it is expected that the profits of the utilities will decrease.

If the generation costs of electricity produced from fossil fuels will rise, this would give a competitive disadvantage to electricity produced with fossil fuels. This would have a negative economic effect on the investments of fossil fuel plants which are already made. Because the price of emission allowances is not known this brings along extra risks.

Another source of uncertainty of the ETS is the cap the European Commission will set. If the cap will be set at a lower level, this would result in higher prices for the emission allowances. The cap is now set until the year 2020, but after this year the reduction rate of the cap is still uncertain (European Commission, 2011a). One important strategy of utilities is to actively lobby for a higher emission cap.

The utilities can bring arguments that a lower cap will not be beneficial because of higher electricity prices which can have a negative impact on the economy.

The 20-20-20 target of the European commission has set the target to increase the use of renewable energy to 20% in 2020. This target is not only to reduce climate change but also to increase the energy security of Europe and the dependency on other countries for the energy supply. The ETS system is mainly focused on the 20% CO_2 reduction, but this can be achieved without increasing the renewable energy to 20% in 2020. All the European countries have different targets because their share of renewable energy is different. For the Netherlands, the target is 14% renewable energy in 2020 (ECN, 2010). The share of renewable energy is tracked by the use of guarantees of origin. A guarantee of origin gives a label to electricity which is produced from renewable energy sources. With guarantees of origin it is possible to shows how much renewable energy is produced at which location. Some European member states have introduced a quota system for renewable energy. This system sets a minimum percentage of renewable energy which has to be consumed or produced by companies. If this system is applied to utilities they have to generate a certain share of renewable energy. Utilities can buy or sell guarantees of origin to meet this share of renewable energy, or increase their share of renewable energy in their generation portfolio(ECN, 2005).

The renewable energy target can be both beneficial and a risk for utilities. Most of the utilities are investing in renewable energy. Because of the renewable energy target, governments are granting subsidies for investments in renewable energy. Utilities can make use of these subsidies to make investments in renewable energy which would not have been profitable without these subsidies. As a result, utilities can profit from renewable energy which opens new business opportunities for utilities. Additionally, the development of renewable helps utilities to improve their brand imago.

A risk of the renewable energy target for utilities can be that it becomes more difficult to make investments in fossil energy. Governments are introducing emission standards for fossil-fired power plants. To comply with these standards utilities have to make higher investments for fossil-fired power plants. Another risk can be that utilities do not get permission to fossil-fired build a power plant because the government cannot reach the renewable energy target if this power plant would be build.

The last part of the 20-20-20 target is the reduction of the primary energy use by 20% in 2020. One policy measure which came forth from this target is the combined heat and power (CHP) directive (European Commission, 2004). CHP is promoted because the energy efficiency of CHP plants is higher than power plants which do not use waste heat. The development of CHP plants is stimulated with several economic incentives such as: feed-in tariffs, premiums, tax support and capital grants, depending on the national policies. Whether this policy is beneficial for a utility depends on the utility. If a utility is already investing in CHP plants, this policy will make these investments economically more attractive. If a utility has no CHP plants and no experience with this type of plant, it is more difficult for this utility to start investing in CHP than a utility which has experience with CHP plants. The utility which has experience can create a competitive advantage with a policy which promotes CHP, and therefore this policy can be a risk for utilities which do not have experience with CHP plants

An important aspect of policies for utilities is that some policies can be unreliable for utilities. Utilities make long term investments in power plants and for some of these power plants the stability of policies is very important. For example, if a feed-in tariff is used by the government to promote wind energy, a utility will take this feed-in tariff into account when looking at the profitability of a project in wind energy. If the feed-in tariff is abandoned after the investment is made by the utility this has negative consequences for the profitability of the investment. For this reason more risk is involved with projects which make use of government support.

The introduction of new policies can also form a risk for utilities. An example of a policy which could be introduced in the upcoming years is the emission performance standard (EPS) for the European power sector (Wartmann et al., 2009). Because the total emissions of coal-fired power plants are expected to rise even under the ETS, there could be a need for an additional policy instrument to reach mid- and long-term targets. The EPS sets a threshold for the emission intensity of electricity generation and therefore it can be more effective to reduce CO_2 emissions. For example, if a threshold is used of 500 gramCO_2/kWh, as was introduced in California, it will become impossible to build a coal-fired power plant without co-firing biomass or using CCS (Wartmann et al., 2009). The introduction of the EPS is a risk for utilities because the costs of coal-fired power plants will increase, since new technologies have to be used to reduce the CO_2 emissions. The investment plans which the utilities have made for the upcoming years have to be revised if this policy is introduced.

5.1.2 Economics

Since the utilities are privatised, market forces should guarantee low electricity prices and security of supply. Electricity is sold to customers on the basis of contracts or on the electricity spot market. Because there are several electricity suppliers, the customer can choose for the supplier with the lowest price, which enhances competition between utilities.

The security of supply is also taken care of by market forces. Utilities have to forecast how much electricity they will produce at each time of the day. Via contracts and the spot market this electricity is sold and the contracts of supply and demand have to be in balance before the electricity is produced. If the utility fails to deliver or if the customer fails to consume the amount of electricity under the contract, a fine will be charged. Because of these high fines the utilities will not take the risk of not being able to supply enough electricity (den Ouden, 2009). Another factor which secures the supply of electricity is the high electricity price when electricity supply is low compared to the demand. If the electricity price becomes high because of a high demand utilities will act by installing new generation facilities. Because utilities use models to forecast the electricity demand they will anticipate a high demand in the future which will guaranty the security of electricity supply (Gross et al., 2010).

Models are used to make investment decisions for new generation capacity. In these models the economic factors are very important. Simulations are made to see how the external economic factors will develop and come up with the best option for new investments. These simulations are very important for the strategy of utilities for investing in new generation facilities. The quality of the inputs is important, and these are dependent on the expectations and beliefs of the utility. Important factors are fuel prices, investment costs, CO_2 prices, O&M costs, lifetime, capacity factors and electricity price (Huang & Wu, 2008). With all these factors an expected generation price per kWh electricity can be calculated. The generation costs can show the economic preference of a technology.

The fuel price is an economic factor which can be influenced by many factors. Oil, gas, biomass and coal power plants are most sensitive for changes in fuel prices. In the past decade the fuel prices have become significantly higher and volatile than the decades before. For example, when the economy grows, the demand for fuels grows which increases the fuel price. Political unrest in fuel supplying countries also increases the fuel price. Policy instruments can lead investments away from coal-fired power plants. If fewer coal-fired power plants are built the demand for coal will be reduced, which will reduce the price of coal. Because of the price reduction it could become interesting again for utilities to invest in coal power plants. An advantage for renewable electricity is that most of these technologies are not dependent on fuel price, except for biomass. This reduces the risk of high fuel prices for renewable electricity.

5.1.3 Social structures

Utilities have to adapt to the values and the expectations of the society. This is important for the acceptability among customers, the motivation of employees, the willingness of investors and financiers to provide funding and for government support (Grant, 2010, p.458), (Boiral, 2006). Global warming is an important factor of societal pressures on utilities. Because utilities are large CO_2 emitters they are seen as responsible for reducing these emissions. Nongovernmental organisations (NGOs) can have a large impact on the attention paid to environmental problems. If NGOs give a lot of attention to certain environmental problems, this could put large pressure on utilities. NGOs can also change the behaviour and the public perception of the customer, which can be of high importance for utilities.

Utilities have to react to these societal pressures because it can impact the corporate image and reputation. Utilities can have a proactive or a reactive attitude towards these issues, which depends on the perception of the importance of the topic by the utility and the strategy of the utility. Other possibilities are to show that the utility is working on the social responsibility of the company, or by investing in green projects to boost the image of the company (Boiral, 2006).

5.1.4 Technology

Utilities have to keep up with technology developments in the energy sector. Changes in technologies in this sector are mainly incremental and slow compared to other sectors e.g. the ICT sector. Because of this, the development of technology is not a threat for the existing capital of utilities. The development of sustainable electricity technologies is important for utilities. The share of renewables is small for most utilities, but this share is expected to become more important in the future. Utilities need a strategy for the development of renewable electricity. Some utilities use the development of renewable electricity technologies as a competitive advantage. Other utilities invest in renewable electricity technologies to keep their options open and because they do not want to face the risk of missing a possible opportunity when it becomes important.

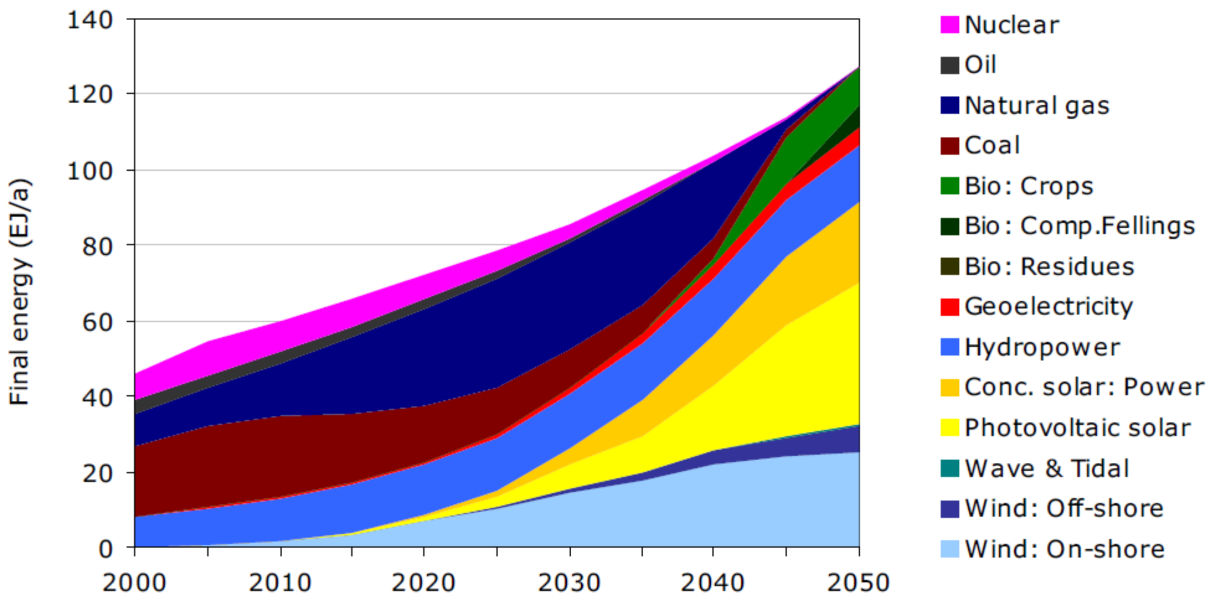


Figure 85: Global power supply in the energy scenario of Ecofys (Deng et al., 2011)

Figure 85 shows the outcome of the model used for the energy report of Ecofys. According to this model the electricity demand increase, which is mainly caused by the electrification of road transportation. In this report a high penetration of renewable electricity generation is used to provide the demanded electricity. More demand for renewable energy will lead to a decline in demand for electricity produced from fossil fuels. Together with the increasing costs of fossil fuels because of the ETS, the fossil-fired power plants have to be phased out. For fossil oriented utilities this forms a risk because their investments made in fossil-fired power plants can become less profitable. If the fossil-fired power plants have to be amortised before their planned economic lifetime because of higher operational costs this can be a large financial risk for a utility. Next to this the knowledge and expertise of these utilities will be less valuable and large costs have to be made to make a transition towards renewable technologies.

5.1.5 Natural Environment and geography

The generation of electricity can be dependent on the natural environment of the generation facility. For wind, water, solar and wave electricity these effects are very important and direct. A reduction of these natural factors will directly lead to a reduction in electricity production. For long term electricity generation these effects are difficult to predict. This makes the investment in these technologies riskier.

Electricity generation from fossil fuels can also be impacted by the natural environment. These power plants need to be cooled, which could be a problem on hot summer days. If not enough cooling is available, the power plants have to reduce their electricity output which can lead to a shortage of electricity supply. The demand of electricity depends on the weather conditions. On very hot days more electricity is needed for cooling appliances and on cold days electricity is needed for electrical heating.

For the location of a power plant, the infrastructure to supply the fuels is important. Many power plants are built near water ways because this decreases the costs of fuel supplies. Because it is beneficial to reduce transportation costs, power plants are built near the fuel’s source, e.g. lignite power plants are built close to lignite mines and gas power plants are built close to gas fields.

5.1.6 Legal issues

Utilities have to comply with air quality standards set by the government. The EU has set limits for the emissions of fine dust, SO_2 and NO_x for electricity generation. The implication for most of the generation facilities is that filters have to be installed to reduce the air emissions of these pollutants (European Commission, 2011d).

The use of some new technologies is restricted by patents. These technologies cannot be used without the permission of the owner of the patent, which can make the use of these technologies more expensive. Examples of these technologies can be new innovations in wind mills, solar panels or carbon capture and storage technology.

Most utilities sell their renewable electricity for a higher price because it is a selling point for customers. To guarantee that the electricity which is delivered to the customer is generated from renewable energy sources, green electricity certificates are used. These certificates are issued by governmental organisations which check if the electricity is produced is actually renewable and how much renewable electricity is produced. The producers of renewable electricity can use these certificates to sell electricity as renewable electricity to their customers. The green electricity certificates can be traded and therefore the supplier does not have to generate the renewable energy (CBS, 2011).

5.2 Analysis of Porter's five forces

To analyse the competition in the utility sector the five forces of Porter are used (Grant, 2010, p.69). The framework of the Porter's five forces of competition is shown in Figure 86. With this analysis the level of profitability and the intensity of competition can be shown. For a strategy analysis these five forces are important because profitability and competition are important factors for a strategy. By analysing how these five forces have an impact on a utility, a strategy can be developed to make use of the possible opportunities and deal with the weaknesses of the electricity sector.

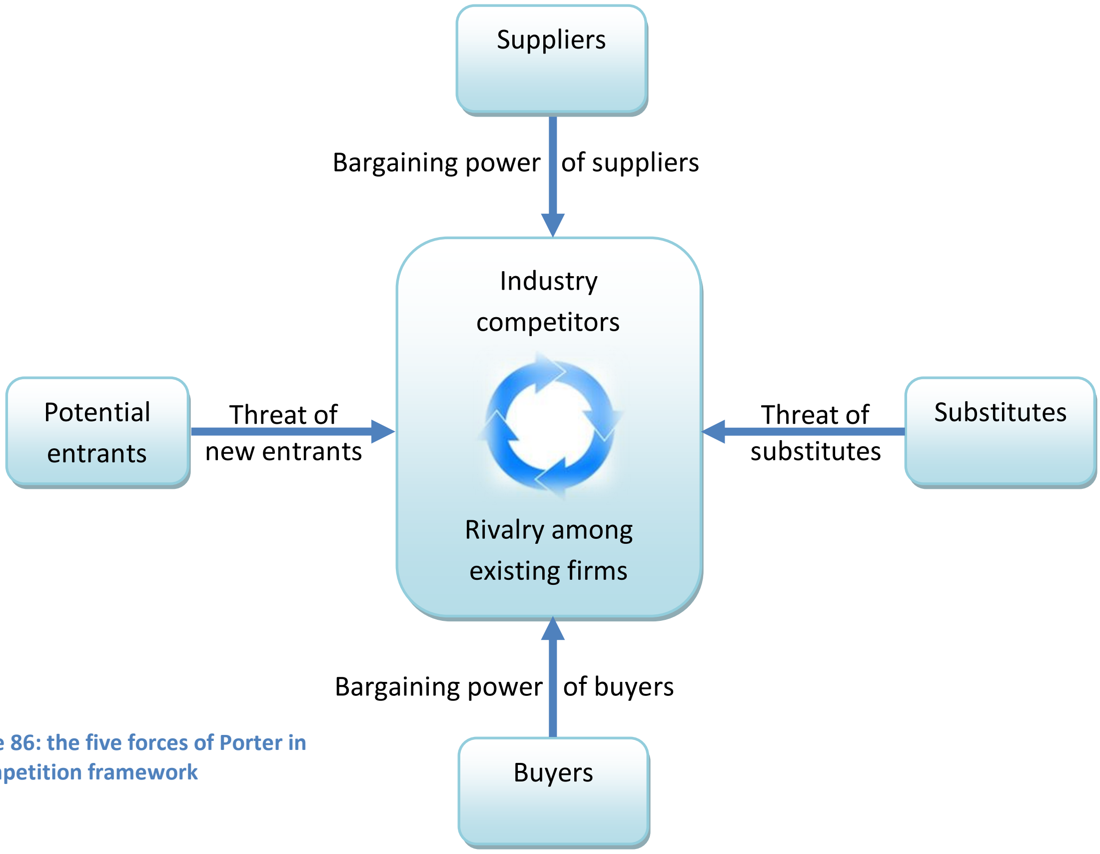


Figure 86: the five forces of Porter in a competition framework

5.2.1 The bargaining power of suppliers

The suppliers of the utilities are the fuel suppliers and the suppliers of electricity generation technology. The fuel suppliers are the most important suppliers for utilities because they are highly dependent on these suppliers. For each type of fuel the bargaining power is different. For coal the bargaining power of suppliers is low. Coal is a commodity which is supplied by many companies. Because utilities can relatively easily switch to another supplier, the price competition of coal market is high. Natural gas is also a commodity, but it is more difficult to switch to another supplier, because the transportation of gas is more difficult. It is possible to switch to another natural gas supplier and therefore there is price competition on the natural gas market. For the supply of oil the bargaining power of the suppliers is higher. This is because oil is produced by large companies which can influence the total supply of oil. By reducing the supply of oil they can increase the oil price. This mechanism gives the oil suppliers more bargaining power. Uranium is a specialised product where the suppliers and buyer are very dependent on each other. The fuel costs of a nuclear power plant are very low and therefore the fuel price of a nuclear power plant is not very important. Long term contracts are used for the supply (and removal) of uranium to reduce the risk of opportunistic behaviour by one of the parties.

Most utilities do not design and build their own power plants, but hire specialised companies. The competition among these specialised companies is high because building a power plant is a large project. These companies will have competition for each project because not many power plants are built each year.

5.2.2 The threat of substitutes

The threat of substitutes depends on the point of view of what can be substituted. For electricity itself the threat of substitutes is very low. Many appliances and processes depend on the supply of electricity, which cannot be changed. Another point of view is that the central electricity supply can be substituted by distributed generation of electricity. Both the industry and households can use for example solar energy, wind energy and combined heat and power for their own electricity supply. The threat of this type of substitution can be high. The European commission and national governments are supporting distributed generation (Cossent et al., 2009). Partly because of this support of the use of distributed generation is expected to grow. Although a large part of the electricity supply can be replaced by local electricity production, a grid connection is still needed. The grid connection is used to cover the peaks of supply and demand. Because it is very difficult for a small energy producer to become self-sufficient a utility can take care of back-up capacity. For this reason it is not likely that distributed generation is a complete substitute for utilities, but it can be a large threat for utilities.

5.2.3 The bargaining power of buyers

The customers of utilities can easily switch to other utilities. Because of the liberalisation of the electricity market customers can choose their electricity supplier. This makes the bargaining power of buyers very high. Customers can choose for the utility with the lowest electricity price. The transaction costs are very low and therefore this does not create a barrier for switching to another utility. The customers of utilities demand a low electricity price, flexibility of supply and security of electricity supply. This can have an impact on the bargaining power of the buyer. Wind and solar electricity do not have a guaranteed supply and are not flexible and therefore their value can drop. Nuclear and coal power plants have a high supply security but the electricity output of these power plants is not very flexible. Utilities can solve this problem by having a diverse generation portfolio. Gas-fired power plants can be used to improve the electricity generation portfolio, because these power plants have a flexible electricity output.

Some industries are highly sensitive to price changes of electricity because it accounts for a large part of their production costs. These companies will actively try to reduce the electricity price (Grant, 2010, p.76). These companies are usually large customers of utilities (e.g. electricity retailers, steel producers) and are important customers for utilities. These customers have a high bargaining power because utilities do not want to lose these customers.

5.2.4 The threat of new entrants

The threat of new entrants is high for the power generation sector. Small generation plants can be built easily. For example wind mills, small CHP plants and PV panels can be installed without the need for very large investments. The growth in these markets is very high and therefore it is possible for companies in this market to develop rapidly.

5.2.5 The rivalry among existing firms

The liberalisation of the electricity market has made the rivalry of the existing firms higher. The main competitive element in electricity sales is the price of electricity. This competition should have reduced the prices of electricity. Aggressive commercials of the utilities and the price competition between the utilities can be seen as a result of rivalry among utilities. Electricity retailers are advertising with low electricity prices, and therefore they will also demand a low electricity price of the utilities. Because there are many utilities this gives a higher chance of a price cut by one of the utilities (Grant, 2010, pp.73-74). Another way of rivalry between utilities is the environmental performance of the utility. Utilities can charge a premium price for green electricity because there is an increasing demand for green electricity. Utilities use the production of green electricity to improve the image.

5.3 Strategic actions

The external factors which have an impact on utilities were analysed in the previous paragraphs. These factors have an impact on the utilities and utilities have to deal with these factors. To do this utilities develop a strategy which encompasses all the external factors. In this paragraph, the information given in the previous chapters will be used to make a general analysis of a strategy for a utility. This analysis will show how the resources and capabilities of the utility can be used to deal with threats and opportunities. The external factors and the company profile can be used to develop competitive advantages over other utilities, which will be analysed as a strategy.

5.3.1 Resources and capabilities of the utility

To develop a business strategy an objective appraisal of the resources and capabilities of utilities is needed. This can give an insight of what the strategic possibilities for a utility are. Utilities have a large capital stock in generation capacity. This generation capacity has to be replaced at a point in time when the power plants are too old. If the current capital stock of a utility is new, there is little space for changes in the generation portfolio. If the capital stock is old, a strategy is needed for how the old power plants should be replaced. If investments are made in a new power plant, the existing generation capacity is an important factor for the decision what kind of power plant should be built.

The current capabilities of a utility are important for the investment decision of a utility. It is easier and less risky to invest in technologies which are already used by the utility, because it has knowledge and experience with these technologies. This can also have an effect on the strategy of a utility and the way a utility reacts on the industry environment. A good example is the how utilities in the UK, Germany and Spain reacted on the introduction of policies to promote wind energy (Stenzel & Frenzel, 2008). Germany and Spain introduced similar policies, but the reactions of the utilities were very different. In Germany the utilities used large centralised generation plants to produce electricity. Wind energy was promoted by the German government via a feed-in tariff and utilities were obliged to buy the electricity produced by wind mills. Because wind energy was still a business with small generation capacities this did not fit into the business model of the German utilities with large centralised power plants. These utilities did not have the capabilities to set up small wind mills dispersed over numerous small sites. Smaller German companies took wind energy up in and developed it to a large market. Utilities reacted on this growing market by investing in wind parks, especially large parks which fitted into their business model. The late entrance of utilities in the wind energy market results in a very small market share of utilities in the total amount of wind energy in Germany.

The reaction of Spanish utilities of the introduction of a similar policy scheme was very different. These utilities invested in wind energy immediately after the feed-in tariffs were introduced. This difference compared to the German utilities can be explained by the differences in capabilities of the Spanish utilities. The Spanish utilities had many small hydro power plants and local knowledge and relations. With these capabilities they developed local projects for investments in wind energy. By acquiring local companies they developed capabilities along the entire value chain of wind energy. Because of their early stage involvement, the market share of utilities in the wind energy sector is large.

The UK government introduced a different policy, which set a lower limit to the implementation of wind energy. Utilities complied with this lower limit and developed wind energy to that level. Utilities did not see wind energy as a core business and it did not fit into their business strategy. The policy scheme did not provide an incentive to develop wind energy beyond the lower limit and therefore the development of wind energy in the UK did not grow rapidly (Stenzel & Frenzel, 2008).

The previous example shows the importance of the capabilities and the resources for the strategy of a utility. Utilities can react differently on an external factor because of their resources and capabilities. Therefore the external factors do not have the same impact on every utility. The ETS can be used as another example. Utilities with high CO_2 emissions because of a large share of coal-fired power plants in their generation portfolio will not react positively to a stricter cap, because the emission rights they have to buy will become more expensive. Utilities with large shares of hydro or nuclear power plants will react positively to this change because their competitive position will improve by this policy adjustment. A typical reaction of utilities to possible changes in policies is to lobby and steer the policy more to their advantage. In the example of the development of wind energy in Germany, the utilities lobbied actively against the policy and announced they would do everything possible to stop the policy. When the policy was introduced the utility went to court to clarify the legality of the policy (Stenzel & Frenzel, 2008). Only after the utilities did not have another option they decided that the best strategy was to comply with the policy and try to adjust their strategy to profit from the policy change (Stenzel & Frenzel, 2008).

5.3.2 Competitive advantage

The Porter analysis showed that the rivalry among utilities is high. Because of the high competition in electricity prices the utilities try to develop a strategy to have an advantage over the competition. Because all utilities try to minimize costs it is very difficult to create a price advantage, and therefore the utilities have to find other ways to differentiate. An important element of the PESTEL analysis is the impact of global warming on the utilities. The developments in policies, social structures, technologies and the natural environment are directed to the global warming problem. Utilities can create a competitive advantage by adopting a proactive strategy towards the implementation of CO_2 reducing actions (Boiral, 2006). The advantage of this strategy for the impacts of new policies is that the utility is prepared for policy changes. Changes in policies are expected to be mainly directed towards CO_2 emission reduction. With a proactive strategy to reduce CO_2 emissions, these policies will have a smaller impact on utility with a proactive strategy than on utilities without a proactive strategy. This reduces the risks of new policies which can be a competitive advantage over other utilities.

The reduction of CO_2 emissions can create a better image for a utility. Most customers prefer environmentally friendly products, which for utilities comes down to renewable electricity (Aragon-Correa & Rubio-Lopez, 2007). Because customers can choose between electricity suppliers they can chose for a supplier with a greener image. An example of a utility which has chosen this strategy is Eneco. By working together with WWF they were able to get the climate savers label (WWF Climate Savers, 2010). This label is used to show customers that they care about the environment, which can give a boost to their image. Another example is EDP, which was adjudged as sustainability leader for the Dow Jones sustainability indexes (SAM Indexes GmbH, 2010). Both these companies improved their environmental performance and set goals for further improvement. With the acknowledgement of a label supporting their progress in the development in renewable electricity they gain legitimacy and can build on a greener image.

Fossil fuels are becoming scarcer and therefore the prices of these resources are expected to rise. Utilities decrease the risks of negative impacts because of high fossil fuel prices by reducing the dependency on these fuels. A proactive strategy of utilities can create a competitive advantage by early investments of renewable energy technology. The introduction of wind energy in Germany and Spain is a good example. In Germany, the utilities did not get involved in the development of wind energy until a late stage, and therefore their market share in wind energy is very small. As a result, the German utilities are now more dependent on fossil fuels. In Spain the utilities started early to invest in wind energy and for this reason they now have a large share of the wind energy market (Stenzel & Frenzel, 2008). The largest challenge for utilities is to create a competitive advantage without losing the price competition in the electricity market. The competition of the electricity price is still one of the most important competition advantages and if the production of green electricity causes a price increase this could price a utility out of the market.

The Porter analysis showed the barrier of new entrants is reduced because of the developments in renewable energy. Renewable electricity has a lower entrance barrier because of smaller investment costs and economies of scale. Therefore renewable energy made it easier for new companies to enter the electricity market which increased the competition. A strategic reaction to this increased competition can be building overcapacity. Overcapacity can be useful to create an entry barrier for other utilities. Small companies can now enter the market because of lower investment costs of renewable energy, but overcapacity will lower the demand for new capacity and therefore companies will hesitate to make new investments. Overcapacity should be created by using technologies with low marginal production costs because they must be able to price other utilities out of the market (Cansino et al., 2010). Creating overcapacity can be a strategy to show commitment to encourage other utilities to exit. Other ways of encouraging other utilities to exit the market can be to lower their exit costs, releasing pessimistic forecasts of the industry's future and supporting more stringent environmental controls that make it more costly for competitors to stay in business. With these measures leadership can be obtained by acquiring plants of other utilities (Grant, 2010, p.341).

A competitive advantage can be created by diversification. The diversification option of green electricity is already discussed, but more options are available. Utilities can look at the demands of the customers and try to find out if these can be fulfilled by using other methods. Customers of electricity do not want the electricity itself, but the service which can be provided by the electricity. An example is investments in Energy Service Companies (ESCOs) by utilities. These companies provide the services which are required by the customer, for example heating, cooling and lighting, by providing these appliances or installations. These companies can make money by saving energy costs by installing energy efficient alliances and installations or investing in energy saving measures for the building. With these energy savings they can cover the costs of the investments, reduce the costs for the customer and make profit (Bertoldi, 2006).

6 Strategy analysis of E.ON

In this chapter the strategy of E.ON is analysed, based on the strategy analysis methodologies discussed in the previous sections and the results of the benchmark. The annual reports of E.ON are used as a source of information for the inputs of the strategy analysis and to explain why E.ON has chosen to adopt this strategy. Special attention is paid to the construction of the new coal-fired power plant of E.ON on the Maasvlakte (Maasvlakte Power Plant 3, MPP3) and how this new plant fits into the strategy of E.ON.

6.1 PESTEL analysis

6.1.1 Policies

The EU-ETS is a policy which is based on creating a value for CO_2 emissions based on market forces. Because CO_2 emissions have a value, utilities will be inclined to reduce their CO_2 emissions. The ETS will only have an impact if the costs effect of the CO_2 emissions are large enough. To see if the effects are large enough for the new coal-fired power plant of E.ON, the costs of the ETS will be calculated and compared to the expected costs and revenues of this power plant.

Table 5: Estimated average yearly costs and profits of the Maasvlakte power plant 3 of E.on, , based on input data from table 6 and table 7 (average of analysis)

Revenues electricity sales	450 million euro
Fuel costs	125 Million euro
CO_2 emission costs	110 million euro
Operation and maintenance costs	70 million euro

The new power plant of E.ON will go online in 2013, and from this year on utilities have to buy all the greenhouse gas emission allowances to cover their CO_2 emissions (European Commission, 2011a). The results of the costs and benefits are shown in table 5. This table shows that the CO_2 emission costs are about 37% of the expected variable costs of electricity production. The analysis of the costs and profits show that the CO_2 emission costs are important for utilities and that it has a large impact on the profits of a coal-fired power plant.

For the calculation of the costs and benefits of the coal-fired power plant at the Maasvlakte, as shown in table 5, the information given in table 6 is used. The CO_2 emissions are expected to be 5.621.700 tonne CO_2 per year (Greenpeace, 2010b). The price of an ETS allowance is estimated at 20 euro/tonne CO_2 (ECN, 2010). To put these costs into perspective some other data is needed. For the revenues of electricity production an average

Table 6: information about the Maasvlakte power plant 3 of E.on, (Greenpeace, 2010b), (E.ON, 2011d)

Start data construction	April 2008
Online year	2013
Building costs	1.200 million euro
Installed capacity	1.070 MW
Efficiency	46% (45% by PwC)
Estimated load factor	6800 h/year (7500 h/year by PwC)
Estimated electricity production	7.300 GWh/year (8.000 GWh/year by PwC)
Estimated CO_2 emissions	5.621.700 tonne per year (6.000.000 tonne per year by PwC)

wholesale price of 62 euro/MWh is used. The coal price is estimated at 2,2 euro/GJ (ECN, 2010). For the operation and maintenance costs, the fixed costs are estimated at 39,3 euro/kWh/year and the variable costs at 3,5 euro/MWh (PricewaterhouseCoopers, 2008).

As a strategy to reduce the costs of CO_2 emissions of the Maasvlakte power plant 3 (MPP3), E.ON has lobbied at the Dutch government. The EU directive of the ETS has made it possible that national governments can give aid to companies for up to 80% of the CO_2 emission costs (Eenvandaag, 2010). E.ON has made a deal together with the Dutch government and 9 large electricity demanding companies that the Dutch government will compensate a large part of the CO_2 emission costs (Greenpeace, 2010a). The government is not allowed to give direct compensation to E.ON for the CO_2 emissions costs by the European Commission. Instead E.ON will charge a higher electricity price to the 9 large companies and these companies agreed to purchase the electricity from the MPP3. These companies will be compensated by the government for this price increase because of the ETS (Wijn, 2007). These companies are compensated because they operate on international markets and have to compete with companies based in countries, which have no CO_2 costs.

The compensation of CO_2 costs is supported by a research on the interference of the Dutch government in the energy market. This report showed that in 2010 the Dutch government has spent 1000 million euro on free emission rights for large energy users (de Visser et al., 2011). The deal reduced the investment risk of the power plant and has increased the profit to a level which was acceptable for E.ON. Without this deal, the investment for the coal-fired power plant would have lower returns and because of the involved risks in the costs and revenues, it is likely that the power plant would not have been built.

The EU directive on renewable energy states that the share of renewable energy in Europe should be 20% in 2020 (European Commission, 2008). The Netherlands has to increase the share of renewable energy to 14% in 2020 (ECN, 2010). In the Netherlands the “schoon en zuinig” policy program was implemented to reach these goals. Government actions which are used to reach the renewable energy goal are for example subsidies for renewable energy and making money available for research for innovations in renewable energy. E.ON can make use of these subsidy schemes to get a better return on investments in renewable energy.

For the investment of the coal-fired power plant other policy actions of the “schoon en zuinig” program are important. Limits have been set to the total allowed SO_2, NO_x and fine dust emissions of a power plant. The effects of these emission limits will be discussed under the legal issues. The government had to give permission to E.ON to build the power plant. The Dutch government has analysed if the new coal-fired power plant fits into the climate targets of the Netherlands and concluded that a building permission could be given to E.ON (NRC, 2007).

The last target of the Dutch government which can be important the development of the generation portfolio of E.ON is the energy efficiency program. The energy efficiency should increase on average by 2% each year in the years 2011 to 2020 (European Commission, 2010b). The new power plant of E.ON should replace older coal-fired power plants with a lower energy efficiency. Because the new power plant of E.ON has a high energy efficiency this policy should not have any consequences for E.ON.

6.1.2 Economics

In the previous section, some of the costs and benefits of the new coal-fired power plants of E.ON at the Maasvlakte were calculated. The effects of the costs caused by the ETS were calculated and this showed that the ETS has a significant impact on the costs of a coal-fired power plant. In this section the other economic factors are discussed to see what the economic risk factors of a coal-fired power plant are. The factors which are important for the profitability of the power plant are the used discount rate, fuel costs, investment costs, operation and maintenance costs and electricity revenues. Table 7 gives an overview of the assumptions used to calculate the profitability of the power plant.

Greenpeace has given an assignment to PricewaterhouseCoopers (PwC) to make an economic assessment of different electricity generation options in the Netherlands in 2008 (PricewaterhouseCoopers, 2008). This analysis is used as a basis for a net present value (NPV) calculation of the coal-fired power plants of E.ON on the Maasvlakte. The results of the analysis of PricewaterhouseCoopers are presented, but are not directly used because of changes in the economic situation in the last three years, and because the properties of the power plant of E.ON are taken into account.

Table 7: Overview if the inputs and the NPV of PwC and of an own analysis of the MPP3, with an economic lifetime of 30 years (ECN, 2010), (PricewaterhouseCoopers, 2008), (E.ON, 2011d), (ICE Futures Europe, 2011), (APX Endex, 2011)

	Data PwC	**Input data based on ECN projections and PwC data**			**Situation April 2011**
	average	Low	Average	high	average
Electricity revenues	56 Euro/MWh	54 Euro/MWh	62 Euro/MWh	70 Euro/MWh	55 Euro/MWh
Fuel costs	2,4 euro/GJ	1,8 euro/GJ	2,2 euro/GJ	2,7 euro/GJ	3,3 euro/GJ
Investment costs	1.356 Million euro	1.200 Million euro	1.200 Million euro	1.200 Million euro	806 Million euro
CO_2 costs	27 euro/ton CO_2	10 euro/ton CO_2	20 euro/ton CO_2	40 euro/ton CO_2	17 euro/ton CO_2
Fixed O&M costs	39,3 euro/kW	35,4 euro/kW	39,3 euro/kW	43,2 euro/kW	25,1 euro/kW
variable O&M costs	3,5 euro/MWh	3,1 euro/MWh	3,5 euro/MWh	3,9 euro/MWh	0,6 euro/MWh
Discount rate	5,28%	4.28%	5,28%	6.28%	5,28%
NPV	**-270 Million euro**	**1860 Million euro**	**1100 Million euro**	**-400 Million euro**	**-340 Million euro**

Table 7 gives an overview of the used values for the NPV of the coal-fired power plant of E.ON. This table shows that the analysis of PwC results in a negative NPV for the coal-fired power plant, which means that E.ON will lose money by investing in this power plant. For the NPV an economic lifetime of 30 years is used.

For the analysis of the NPV of this report, other values for the inputs where used because of changes in the economic situation. The electricity price, fuel costs and CO_2 costs are based on projections made by the energy research centre of the Netherlands(ECN, 2010). The O&M costs and the discount rate are based on the PwC report (PricewaterhouseCoopers, 2008). Table 7 shows a large difference between the NPV of PwC and the NPV calculated with the use of ECN projections. The large difference is mainly caused by the difference in the assumed electricity wholesale price, which is estimated lower by PwC.

At the start of 2011, the electricity price was about 60 euro/MWh, as shown in figure 87. Before 2003, the electricity price was more stable. This is because electricity companies used to be state owned and therefore there was no electricity market but a fixed price. It took some time before trade had a large affect on the electricity price, but the fluctuations of the electricity price between 2004 and 2011 show the effects of trade.

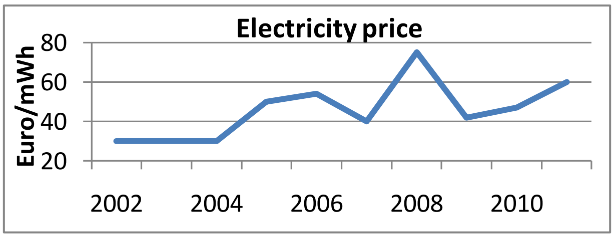


Figure 87: Development of the electricity price (European Commission, 2011c)

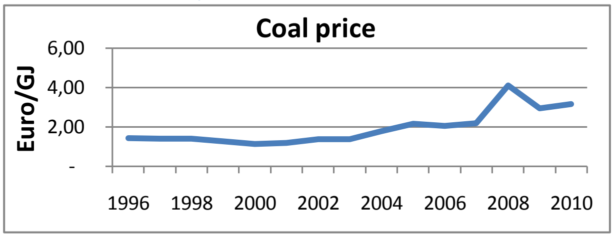


Figure 88: development of the coal price (European Commission, 2011b)

Figure 88 shows that the coal price is more stable than then electricity price, but that in the past few years the coal price has become more volatile. The fluctuations of the electricity price and the coal price make it more difficult for utilities to make investment decisions. The peak of the electricity prices is caused by high oil and coal prices and caused by the high economic growth. The credit crisis has reduced the demand for energy, with dropping energy prices as a consequence. The recovering economic situation of today can increase the electricity price, but the increase in the installed capacity can reduce the electricity price.

With the energy prices of April 2011 the NPV of the MPP3 would be negative, as shown in table 7. The main reason why the NPV has become lower compared to the NPV calculated with the assumptions based on projections of ECN, is because the fuel price was high. In the first half year of 2011, the coal price was in higher than the highest coal price projected by ECN (ICE Futures Europe, 2011). This shows that the coal price projection of ECN could be too low.

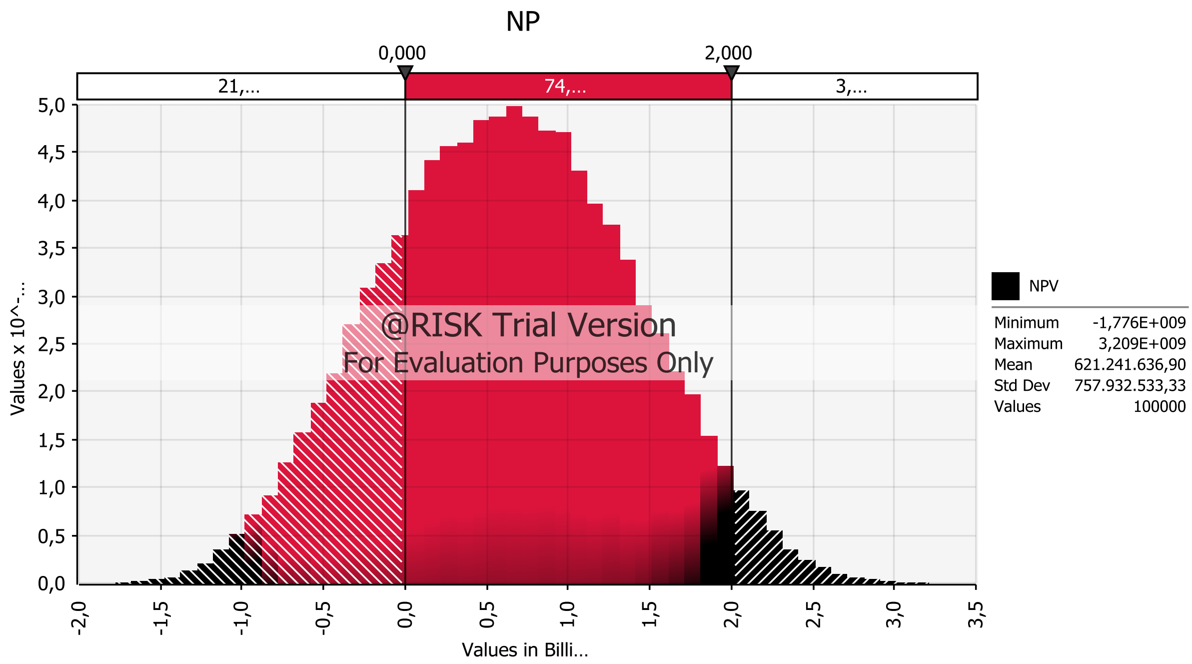


Figure 89: Monte Carlo simulation of the NPV of the coal-fired power plant at the Maasvlakte, using data from table 8

With the data of table 7, a Monte Carlo simulation of the NPV is made, of which the results are shown in figure 89. Figure 90 shows an example of the probability distribution which is used, where the high, average and low values of table 7 are used as maximum, average and minimum values. The result of the Monte Carlo analysis shows that the expected NPV of the coal-fired power plant at the Maasvlakte is about 620 million euro. This NPV is lower than the average NPV of table 7, because the difference between the high CO_2 price and the average CO_2 price is higher than the difference between the low CO_2 price and the average CO_2 price. The expected NPV is positive and therefore the investment in the coal-fired power plant is a good investment from an economic perspective. Utilities have a certain rate of return to evaluate is a project is worthwhile. If this rate of return would be higher than 620 million euro, E.ON would have not invested in this power plant. The chance on a negative NPV is about 22% and therefore there is a risk of making an economic loss with this investment.

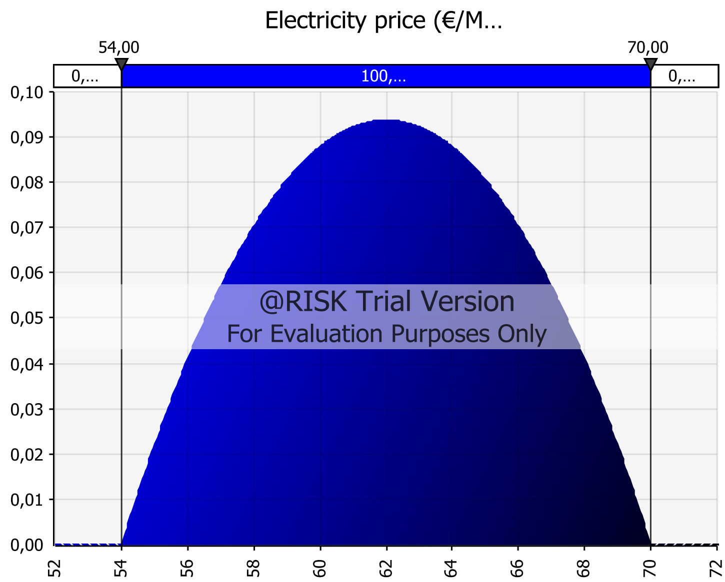


Figure 90: Example of a probability distribution used for the Monte Carlo analysis of the NPV

Although the NPV is expected to be positive, there could be a better option than an investment in coal-fired power plants. There is still a chance that the NPV is negative, and with the energy prices of April 2011 the NPV was negative. The analysis of PwC showed that an investment in a gas-fired power plant or a wind park can be a better option because these investments have a higher NPV.

This conclusion is supported by a comment of the CEO of Essent (RWE). Essent is building a new coal-fired power plant in the Netherlands. In an interview the CEO of Essent indicated that in 2008, which is the year when the investment decision was made, the coal-fired power plant would have been profitable. The Dutch government has requested investment in coal-fired power plants from utilities because the electricity price was too high in the Netherlands. The new power plants should lower the electricity price and make the Netherlands more competitive with other countries. According to the CEO of Essent a coal-fired power plant would not be profitable with the current economic conditions. Compared to 2008 the electricity price is lower and the coal price is becoming higher. Furthermore, the negative image of coal-fired power plants has become stronger, according to the CEO of Essent (Strop, 2011).

6.1.3 Social structures

As stated in the PESTEL analysis of utilities, an important reason to invest in sustainable energy is to create a better corporate image. This is important for investor, customer and employee relations. In this paragraph the methods of E.ON for building a corporate image are analysed. This is done by analysing what news E.ON brings out and what is reported in the annual reports.

One problem for E.ON is that building a new coal-fired power plant is not good for the corporate image. On the information page of the power plant the positive aspects of the power plant are presented. The high efficiency, co-firing possibility of biomass, carbon capture and storage (CCS) possibility and the fact that the coal supply is more stable than the gas supply are pointed out (E.ON, 2011d). E.ON acknowledges the climate problems of coal-fired power plants, but states that coal is needed as a temporarily solution. Coal-fired power plants are needed for the security and affordability of electricity supply and together with CCS it can help to move towards a low-carbon future (E.ON, 2009b).

E.ON is investing more than 100 million euro to develop CCS and aims to make CCS commercially viable by 2020. These investments are not only for the power plant at the Maasvlakte but for the whole company. The investments are relatively low compared to the expected annual CO_2 costs of 110 million euro per year for the Maasvlakte coal power plant. The strategy of E.ON is to develop CCS to keep the option open for when this technology becomes commercially viable. When CCS becomes commercially viable it is expected that E.ON will start investing more in CCS.

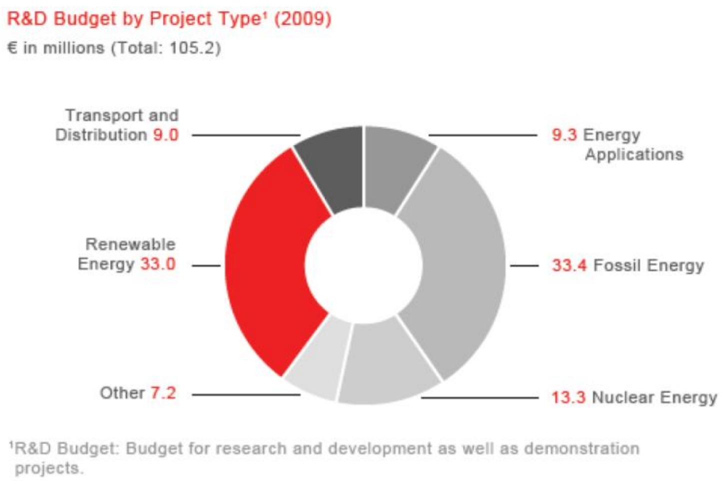


Figure 91: R&D budget per project type of E.on in 2009 (E.ON, 2010b)

E.ON recognises the negative reactions on building a coal-fired power plant and in their corporate responsibility report is explained how E.ON deals with questions and comments. E.ON wants a dialog to share their views with NGOs, investors and local communities. E.ON knows that opponents of coal-fired power plants cannot be convinced that coal can be a clean technology, but does want to share E.ON’s view that it is a necessary step towards a sustainable energy supply. As a reaction to concerns of local communities about pollution of coal and risks of CCS, E.ON has opened a visitor centre to explain how the technology will work and what E.ON does to reduce the environmental effect of the power plant (E.ON, 2009b).

For the development and communication of a good corporate image, the company website and annual reports are important media. When looking at both these sources it is clear that E.ON wants to emphasise their developments in renewable energy. For example, the home page of eon.com shows the topics CCS, bio-energy, solar energy, E.ON's responsibility and wind energy. While these are topics where E.ON is active in, they are not their main business. As can be concluded from the benchmark results in figure 33, the largest energy sources for electricity production used by E.ON are coal, gas and uranium, but these fuel sources are not mentioned at the home page. Figure 91 shows the research and development (R&D) budget of E.ON which shows that E.ON is making large investments in renewable energy, but that it is not their core business (E.ON, 2009c). The strategy of E.ON to improve their corporate image is to try to communicate as much as possible, also about fossil energy, but emphasis their developments in renewable energy.

6.1.4 Technology

In this paragraph the impact of technology on the business environment of E.ON is analysed. For E.ON there is a large risk because of the uncertainty of technology development. Several sustainable energy technologies are developing at this moment. E.ON is investing in renewable energy but their main focus remains fossil fuels. With changes in the demand for renewable energy or of the economic competitiveness because of technology developments in renewable energy, there is a possibility that these technologies could take over the place of fossil fuels. With the large capital stock, investment plans and internal knowledge in fossil fuels of E.ON, such developments in renewable energy could be problematic.

The strategy of E.ON is to keep their options open for many renewable energy technologies. E.ON is making investments in the development and realisation of solar, biomass and geothermal energy. With these investments E.ON is creating the opportunity to develop these technologies heavily if this is beneficial for the company, and thereby reducing the risk of missing a possible opportunity of these renewable energy technologies.

The coal-fired power plant at the Maasvlakte is a good example how E.ON is dealing with changes in technology. The power plant is a very efficient power plant and therefore the fuel costs and the CO_2 emissions costs are reduced. E.ON is developing CCS at this plant. CCS is not cost effective yet but E.ON is developing CCS and tries to make it cost effective. By starting to develop CCS now, E.ON is gaining knowledge and capacity to implement CCS at a larger scale. With this strategy E.ON will not miss the opportunity CCS can have in the future.

6.1.5 Natural environment & geography

E.ON is becoming more dependent on the natural environment because of the increasing share of wind energy in their generation mix. Because the electricity output of wind energy is variable these fluctuations have to be backed up with other power plants. Natural gas-fired power plants are most suitable for this purpose because of the low start-up costs. As can be seen in figure 32, E.ON is increasing the installed capacity of natural gas-fired power plant. The increasing share of wind energy could be one of the motivations to increase the capacity of natural gas-fired power plants to keep the supply of electricity reliable.

The location of the Maasvlakte power plant is chosen because of the favourable natural environment. The power plant is located near the sea and therefore the plant can use sea water for cooling. Without the use of sea water large cooling towers would be needed which increase the investment costs for the power plant. Furthermore, the location next to the sea gives the advantage that coal and biomass can be easily supplies via large transportation ships (E.ON, 2011d).

The development of CCS has made the location of power plants even more important. For underground storage of CO_2 suitable geological formations are needed. At the Maasvlakte these formations are present and CO_2 could be stored nearby the power plant. If these formations are not close by the CO_2 has to be transported to a storage location, which will increase the costs of CCS.

6.1.6 Legal issues

E.ON is a party of various lawsuits and government investigations. These proceedings concern price-fixing agreements, anticompetitive practises and violation of environmental standards. The involvement of E.ON in these lawsuits can decrease the profitability and can have an adverse effect on the brand image.

The European commission has imposed a fine of 553 million euro on E.ON in 2009. This fine was imposed on E.ON because of anti-competition agreements with GDF Suez. In 1975 the MEGAL pipeline was built by GDF Suez and E.ON, which made it possible to import Russian gas. An agreement was made that the two companies would not compete with each other on their national gas markets. This agreement should be abandoned with the liberalisation of the natural gas market. This agreement was not abandoned until 2005, and therefore the fine was imposed (Reuters, 2009). This lawsuit has a decreased the profitability of E.ON and could have an adverse effect on the brand image. E.ON does not rule out the possibility of subsequent lawsuits (E.ON, 2010a, p.44).

In 2011 Greenpeace and some other NGOs disagreed with the environmental permit given to E.ON, which allowed the construction of the coal-fired power plant on the Maasvlakte. The NGOs claimed that that the permits where falsely issued to E.ON, because the power plant will exceed the environmental standards set by the European Commissions. These matters where brought to the court of justice of the European Union, who concluded that the environmental permits were issued under legal conditions. For E.ON this means that the construction of the power plant can continue. The final decision has to be made by the council of states of the Netherlands, which will give the final judgement if the permits where granted on legal grounds before the end of 2011 (BNR Nieuwsradio, 2011). The council of states will use the conclusions of the court of justice and will investigate if the coal-fired power plant fits into the emission cap of the Netherlands. E.ON expects that the power plants will be operational in 2013, which is the scheduled date (E.ON, 2011c). Although the actions of the NGOs to fight the environmental permit of E.ON has no direct consequence for E.ON, the attention to the negative effects of the power plant can have a negative effect on the brand image of E.ON.

6.2 SWOT analysis

This SWOT analysis shows the strengths, weaknesses, opportunities and threats to E.ON. This SWOT analysis is mainly based on a SWOT analysis of GlobalData. The SWOT analysis of GlobalData analysed all the activities of E.ON, while the SWOT analysis as presented below is focused on the electricity generation division of E.ON (GlobalData, 2011a). Nevertheless much of the SWOT analysis of GlobalData is used because of the high relevance to the strategy analysis of E.ON, and some additions are made.

6.2.1 Strengths

6.2.1.1 *Leading market position*

E.ON is the largest utility is Europe based on revenue and the second largest utility based on electricity production. This leading business position will help E.ON achieve profitable growth and a successful expansion of its portfolio. E.ON has leading market positions in Germany, the UK, Sweden and Eastern Europe. The company has an important position in the gas supply of Europe which is beneficial for the natural gas supply security to power plants and risk evaluation of this supply. The leading market position enables E.ON to attract new customers in existing and new markets, and enhances the brand image (GlobalData, 2011a).

6.2.1.2 *Integrated and diversified business operations*

E.ON is active across the energy value chain of electricity production which can give various costs advantages. The business branches in which E.ON is active are production of oil and gas, electricity production, transmissions, distribution, trading and supply to customers. The company focuses on creating value by expanding its asset base in electricity and gas in Europe, while continuing to reduce carbon exposure and invest in renewable energy. E.ON is utilising a diverse generation mix including hard coal, natural gas, oil, nuclear, wind, bio-methane and other sources. E.ON is active in more than 30 countries and has a customer base of about 30 million in Europe. The integrated business model and diversity of the generation mix and geographic location enables E.ON to operate efficiency and capitalize emerging opportunities (GlobalData, 2011a).

6.2.2 Weaknesses

6.2.2.1 *Legal proceedings*

E.ON is subjected to various lawsuits, governmental investigations and other claims, which can affect the brand image and the profitability negatively. E.ON was subject to a proceeding concerning price agreements and anticompetitive practices with GDF Suez. A fine of 533 million euro was imposed. In addition, there are lawsuits pending against E.ON AG and its US subsidiaries connected to the disposal of VEBA Electronics in 2000. Further, the legality of the environmental permits assigned to the coal-fired power plant on the Maasvlakte was put to discussion by Greenpeace (BNR Nieuwsradio, 2011).

6.2.2.2 *Deteriorating profitability ratios*

The deteriorating profitability ratios indicate that the company is not delivering value as expected by its shareholders. E.ON witnessed a decline across its various profitability indicators for the fiscal year ended 2010. The company reported operating margin of 10.63% in 2010, as against 13.66% in 2009. This was below the power generation sector average of 14.61%. A lower than sector average operating margin may indicate inefficient cost management or a weak pricing strategy by the company. The operating margin has decreased in 2009 which may indicate management's low focus on profitability. In addition, the company’s return on equity declined to 14.05% in 2010 from 20.85% in 2009 (GlobalData, 2011a).

6.2.3 Opportunities

6.2.3.1.1 Growing focus on renewable energy

The market for renewable energy is growing rapidly in Europe. The present growth rate is around 15% for wind energy, 12% for bio-natural gas and 20% for solar energy. The share of renewable energy in the final energy consumption is expected to double by 2020 in Germany, which is the most important country for E.ON. E.ON has planned to expand its renewable generating capacity to 10 GW by 2015. During 2010, the company achieved 52% increase in renewable capacity. E.ON has a large focus on the development of wind energy and is expected to make large investments in wind energy, including the development of large off-shore wind farms. Next to wind energy E.ON is increasing the focus on solar energy. Apart from expanding its global renewable energy portfolio, the company is promoting the development of new renewable technologies. The increasing importance of renewable energy coupled with the strong focus of the company on expanding its generation portfolio would promote its growth and boost its revenues (GlobalData, 2011a).

6.2.3.2 *Strategic investments*

E.ON has planned capital investments of €30 billion for the period 2009-2011. Of these investments one third will be spend on the reconstruction or replacement of the current generation facilities. These investments include the construction of high efficiency gas and coal-fired power plants. With these investments E.ON is retaining a dominant position, creates a competitive advantage, guarantee energy security and create growth in the region where the company is already active. The remaining two thirds of the investments will be spent on growth, of which 80% will be spent on organic growth. Furthermore E.ON will invest in renewable energy and adding network and gas transportation capacity. These investments enable the company to continue to operate successfully and to grow even in uncertain market conditions (GlobalData, 2011a).

6.2.3.3 *Growing demand for electricity*

The demand for electricity was growing in Europe in the last decades and is expected to continue to grow (Eurostat, 2011). In the international energy outlook 2010 of the Energy Information Administration the world electricity use is expected to nearly double during 2006-2030 (Energy Information Administration, 2010). This growth is expected to mainly take place in non-OECD countries, but the electricity use of Europe is also expected to grow. E.ON can profit from this growing demand of electricity.

6.2.4 Threats

6.2.4.1 *Destabilization of Middle East and North Africa*

Recent political developments in the Middle East and North Africa have resulted in an increase of the crude oil price. In the first half of 2011 the WTI crude oil price varied between $90 and $110 per barrel. The oil price was driven up because of the reduced supply of Libyan oil. The EU and the US have made the decision to use their strategic reserves to reduce the oil price (TRL-Z, 2011). As a result of the high oil price, the European gas prices are expected to rise. As a consequence the customers of E.ON will request contracts based on the spot price of natural gas rather than long term contracts (GlobalData, 2011a). This increase in the uncertainty is of contracts is not beneficial for the business of E.ON

6.2.4.2 *Reliability Concern of Russian Gas Supplies*

E.ON procured 27% of its natural gas from Russia in 2010, 25% from Norway, 23% from Germany, and 17% from Netherlands. The recent events in some Eastern European countries have increased the concerns of Western European countries about the reliability of gas supply from Russia. The reliance of E.ON on the Russian gas supplies brings along uncertainty in the reliability of the gas supply and could increase the business risk (GlobalData, 2011a).

6.2.4.3 *Volatile Macro Environment*

The financial crisis has an impact on E.ON. Because of the financial crisis the electricity sales went down in the years 2009 and 2010. The execution of the expansion strategy is made more difficult because of the economic slowdown. According to The World Bank, overall global GDP growth is expected to be 3.3% in 2011, before picking up to 3.5% in 2012, well below the 8.1% growth rate in 2007. Although Europe has overcome various crises, economic recovery is still weak. In 2010, fears of a sovereign debt crisis surfaced in various European countries, including Portugal, Ireland, Italy, Greece and Spain (GlobalData, 2011a). The current uncertainties in economic conditions influence international capital market and make it difficult for the E.ON to plan budgets and make scenarios.

6.2.4.4 *Movement against nuclear energy*

The nuclear incident in March 2011 in Japan has increased the concerns about the safety of the nuclear power plants in Europe. Because of these concerns it is becoming more difficult for E.ON make investments in nuclear energy. Especially in Germany there is a large opposition towards nuclear energy. In Germany seven nuclear reactors where shut down in March 2011 as a reaction on the nuclear incident in Japan (BBC, 2011). In May 2011 the chancellor of Germany announced that all nuclear power plants of Germany will be shut down in 2022 (Guardian, 2011). These decisions are a threat to E.ON because E.ON has nuclear power plants in Germany. Two of these plants were temporarily shut down in March 2011 (E.ON, 2011e). This shut down of the nuclear power plants has serious negative consequences for E.ON. Next to this, the negative public opinion towards nuclear energy can have a negative impact on the image on E.ON.

6.3 Strategic actions

The PESTEL analysis gave an overview of how external factors have an impact on the strategy of utilities. The SWOT analysis showed what the strengths, weakness, opportunities and threats are of E.ON. This section will discuss how E.ON uses the resources and capabilities to create a stronger competitive position.

6.3.1 Resources and capabilities

The most important assets for the production of electricity are the installed power plants. The strategy of E.ON is dependent on the current portfolio of installed capacity. In this chapter an analysis will be made how E.ON uses their current installed capacity and why E.ON will make changes in this portfolio.

The developments of the installed capacity are shown in Figure 32, but for convenience it is also shown in Figure 92. Figure 93 shows which type of installed capacity E.ON will add in the years 2011 up to 2015. The most important conclusion when comparing this to the current installed capacity is that the focus shifts to coal, natural gas and wind power. Figure 94 shows how much capacity E.ON has installed in the previous years. When looking at the installed capacity of coal, this graph shows that this capacity increased heavily between 1960 and 1975. Because the lifetime of coal-fired power plants is about 40 years these power plants should be almost replaced. This can be a reason why E.ON is planning to construct new coal fired power plants between 2010 and 2020, under which the power plant at the Maasvlakte. Figure 92 shows that the installed capacity of coal-fired power plants is increasing in the upcoming years. This is because the deconstruction dates of some of the old coal-fired power plants are not in the Powervision database. For this reason it is not known if these old coal-fired power plants will be removed and replaced, or is the new coal-fired power plants are additional to the current installed capacity.

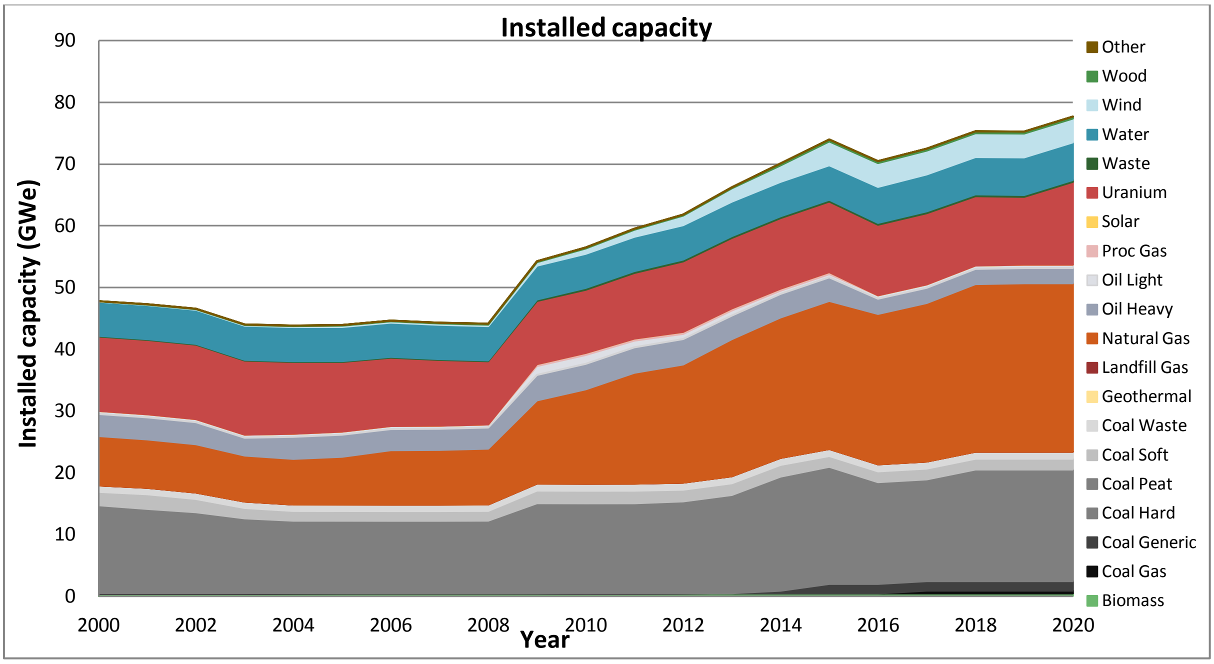


Figure 92: Development of the installed capacity of E.ON (Platts, 2010 Q1)

Figure 94 shows that E.ON is investing heavily in new natural gas-fired power plants. Some of these plants could be used to replace older gas-fired power plants, but the largest part will be new capacity. This shows that the development of natural gas-fired power plants has become more attractive since 2000, or that it is strategically attractive to build these power plants. One conclusion that can be drawn for E.ON is that gas-fired power plants fit into the existing company profile. E.ON has a large natural gas distribution network. These resources can be used by E.ON to make the gas fired power plants more profitable because of combining of several business units. This can give the advantage that transaction costs are lower and knowledge can be used for both business units. Another advantage is that the security of the supply of natural gas to the power plants is increased.

E.ON is making relatively small investments in nuclear energy compared to their installed capacity of nuclear energy. The nuclear power plants of E.ON were built between 1970 and 1990. After the nuclear incident in Chernobyl nuclear energy was not in favour anymore and no plans were made for new nuclear power plants. E.ON is planning to increase the capacity of their existing nuclear power plants in the years 2010-2015, but because some power plants are shut down only a small increase in the installed capacity is expected. E.ON is planning to build three large nuclear power plants in 2020 in Finland and the UK, but because older nuclear power plants are shut down the total installed capacity remains relatively stable.

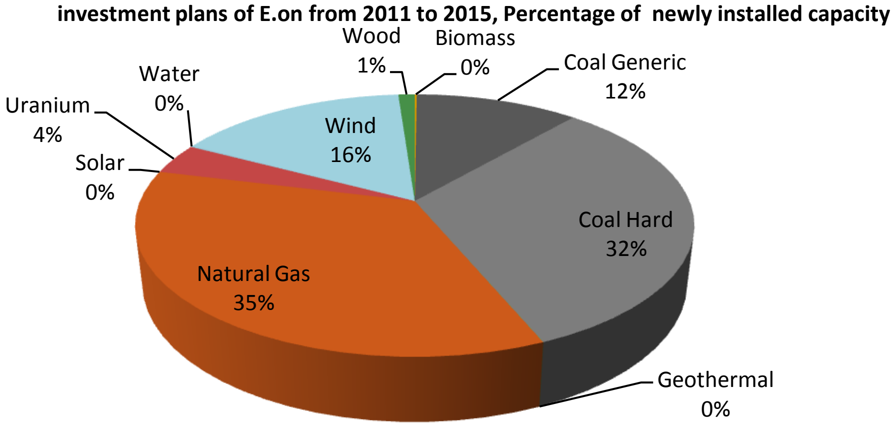


Figure 93: Investments plants of E.on for the years 2011 up to 2015 (Platts, 2010 Q1)

E.ON is expected to increase the total emissions and the CO_2 intensity is expected to remain relatively stable at about 380 gram/kWh. These results do not show that E.ON is trying to reduce the costs of their CO_2 emissions and therefore it is likely that E.ON has another strategy for the ETS. E.ON is investing in climate protection projects which fall under the Clean Development Mechanism and the Joint Implementation of the ETS. These projects are used by E.ON to compensate their CO_2 emissions and therefore E.ON has to buy less ETS allowances on the market. Another strategy can be to lobby at governments to try to reduce the costs of the CO_2 emissions. Although there are no clear indications that E.ON is lobbying it seems to be a good strategy for E.ON. E.ON is investing in new coal and gas-fired power plants and has to pay for the CO_2 emissions from 2013 onwards. National governments are allowed to compensate up to 80% of the total CO_2 emissions of companies. The coal-fired power plant of E.ON at the Maasvlakte will make use of the CO_2 cost compensation and therefore it is likely that similar agreements have been made for other power plants.

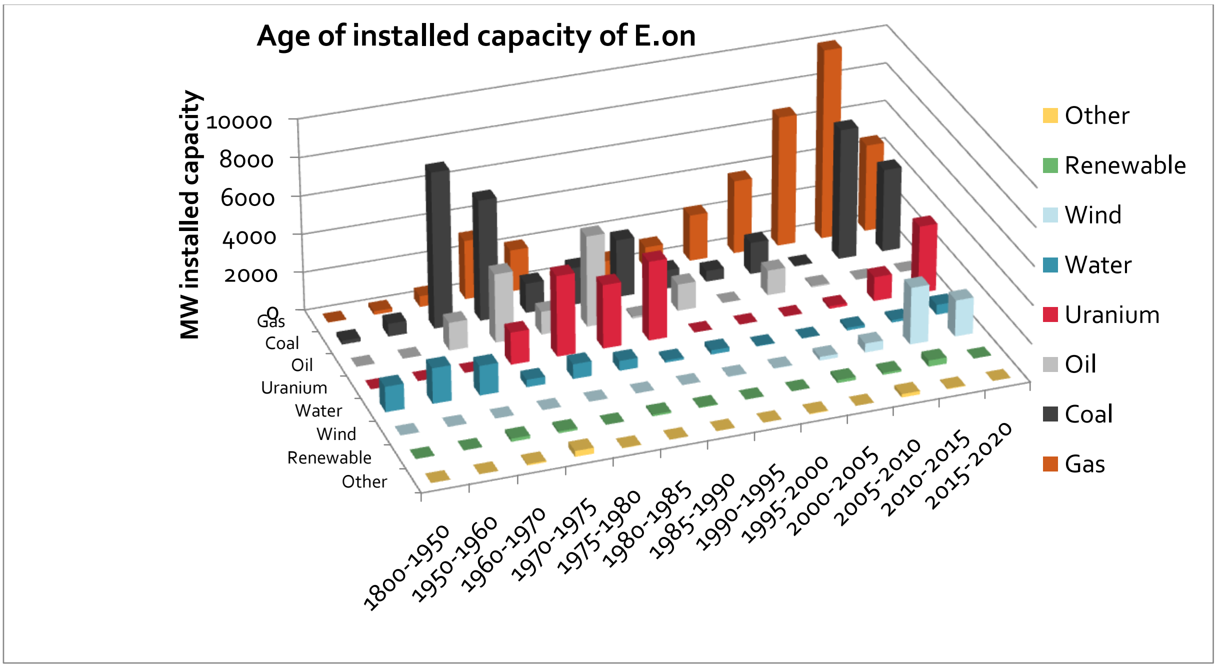


Figure 94: Installation years of the installed capacity of E.ON (Platts, 2010 Q1)

E.ON has the ambition to reduce the CO_2 intensity by 50% from 1990 to 2020. Nuclear energy is stated as an essential condition to achieve this goal (E.ON, 2010b). In their corporate responsibility report about 2010 E.ON reported that it was likely that their ambition would be met because of the life-time extension of German nuclear power plants. This was agreed with the German government in 2010, but in 2011 the sentiment changed and the nuclear power plants have to be shut down earlier. This has a serious impact on the ability of E.ON to meet their CO_2 reduction goals.

6.3.2 Competitive advantage

The coal-fired power plants at the Maasvlakte which is now under construction can be used to replace an old coal-fired power plant, but because this is not certain, another explanation why this power plant is built is possible. If the power plant is built as additional capacity, this can be part of a strategy to create overcapacity to reduce the threat of new entrants. The Netherland is expected to change from an electricity importing to an electricity exporting country over the period between 2000 and 2013(ECN, 2010). By building this coal-fired power plant other utilities are less inclined to increase their installed capacity. An increase of the installed capacity creates more electricity supply which can reduce the electricity price. For this reason the profit of utilities is reduced. This should not be a problem because this effect can be accounted for by E.ON. What is more important for E.ON is that the economic viability of new projects of other utilities is expected to decrease. Especially for renewable energy, which has an electricity generation price which is typically higher than that of a coal-fired power plant, new investments become less attractive. With this strategy the competitive position of E.ON is increased.

The increasing energy efficiency of appliances can be a threat to the energy demand of electricity. As a diversification strategy and a way to make profit from the trend of energy efficiency E.ON is investing in new projects concerning energy applications. Examples of these projects are smart meters, smart homes and micro-CHP. E.ON is also investing in projects with electric cars which use electricity, but can also store electricity.

E.ON is creating a competitive advantage by diversifying their generation portfolio. E.ON is investing in natural gas and wind power and thereby creates a diversified installed capacity. This strategy reduces the risks accompanied by volatile energy prices. Furthermore, natural gas can be used as flexible power generation supply to compensate for the supply changes of wind power and other renewable energy sources. With the investment plans E.ON is creating a good mix between base load and flexible generation facilities.

7 Strategy analysis of Vattenfall

In this chapter the strategy of Vattenfall is analysed. This analysis is made by using a PESTEL analysis and a SWOT analysis. The results of the benchmark are used to analyse the electricity generation profile developments. Special attention is paid to the construction of a gas-fired power plant (the Magnum power plant) at the Eemshaven in the Netherlands.

Vattenfall had planned to construct the Magnum as a multi-fuel power plant, which can use coal, biomass and natural gas as a fuel. The construction consists of two phases; namely the construction of the combined cycle gas turbine and the construction of a coal and biomass gasification plant. The combined cycle gas turbine is now under construction and is expected to start operating in 2012. The coal and biomass gasification plant will not be constructed. Because Vattenfall will not add the gasification plant, the Magnum will not be a multi-fuel power plant but a natural gas-fired power plant. This strategy analysis shows why Vattenfall has made the decision not to use coal and biomass as a fuel for the Magnum, and how the Magnum power plant fits into the strategy of Vattenfall.

7.1 PESTEL analysis

7.1.1 Policies

Vattenfall's activities are affected by policies made by the European commission and policies of national governments. The most important policies are those which come forth from the 20-20-20 targets of the European commission (European Commission, 2008). These policies are the ETS, the renewable energy directive and policies to improve energy efficiency.

Vattenfall has to buy emission allowances for their fossil-fired power plants from 2013 onward. For Vattenfall the costs of buying allowances are estimated at about 1.600 million euro per year, with the expected total emissions of 80 MT and an emission allowance price of 20 euro/tonne. In 2010 the operating profit of Vattenfall was about 4.438 million euro and therefore the ETS can decrease this profit with about 36% (Vattenfall, 2010).

The CO_2 costs of the magnum power plant are estimated to be about 13% of the total variable costs. This estimation is based on the costs shown in table 8, with input data from table 9 and the average ECN projections of table 10. This analysis shows that the CO_2 costs are important for the profits of the Magnum power plant, but compared to a coal-fired power plant, as shown in table 5, the impact of the CO_2 costs are much smaller. This is one of the reasons why Vattenfall has chosen to only use natural gas in the Magnum power plant. One of the statements in the strategy description of Vattenfall is that they will only make investments in low-carbon emitting electricity production (Vattenfall, 2010). The Magnum power plant fits into this strategy.

Table 8: Estimated average yearly costs and profits of the Magnum power plant of Vattenfall, based on input data from table 9 and table 10 (average of analysis)

Revenues electricity sales	446 million euro
Fuel costs	294 Million euro
CO_2 emission costs	51 million euro
Operation and maintenance costs	34 million euro

The target for the share of renewable energy is set on 20% in 2020 for Europe. The share of renewable energy in 2008 was 10,3% of the gross energy consumption of Europe (Eurostat, 2010b). Therefore the share of renewable energy has to increase by 94% from 2008 to 2020 to reach the target. Vattenfall had a share of 22% in 2008 which is expected to grow to 27% in 2020. This is an increase of 24% from 2010 to 2020, while in the same time the share of renewable energy in Europe has to increase by 94%. This is a reason to assume that governments will demand a higher increase of the share of renewable energy of Vattenfall.

Table 9: information about the Magnum power natural gas fired power plant of Vattenfall at the Eemshaven (Nuon, 2011a), (PricewaterhouseCoopers, 2008)

Online year	2012
Building costs	800 million euro
Installed capacity	1.200 MW
Efficiency	58%
Estimated load factor	6000 h/year (7500 h/year by PwC)
Estimated electricity production	7.200 GWh/year (8.900 GWh/year by PwC)
Estimated CO_2 emissions	2.500.000 tonne per year (3.150.000 tonne per year by PwC)

Vattenfall has a high share of hydro power (about 19% in 2010) in their generation mix. Vattenfall did not have to make an effort for this share of renewable energy in their electricity mix. This is because this share is there because of the history and location of the utility. For this reason it is expected that governments will demand a higher increase in the share of renewables from Vattenfall.

Vattenfall is the utility with the highest share of CHP plants of Europe (GlobalData, 2011b). This can be an advantage for Vattenfall, because of the energy efficiency target of the European Commission (European Commission, 2010b). National governments are promoting the use of CHP plants because these types of plants are very energy efficient compared to traditional fossil-fired power plants (CHPA, 2011). Vattenfall can take advantage of these national policies and use their expertise in CHP to create a competitive advantage. Furthermore, the newly built power plants of Vattenfall should have a high efficiency because of the European energy efficiency target. The Magnum power plant has an efficiency of 58%, which is a high efficiency for a gas-fired power plant. Therefore it is expected that energy efficiency policies will have no negative consequences for Vattenfall.

7.1.2 Economics

A net present value (NPV) analysis is used to assess the economic situation of the Magnum power plant. The results of this calculation are shown in table 10. The NPV calculated by PricewaterhouseCoopers (PwC) is slightly positive. Because the economic situation has changed since the publish date of the PwC report other values for the input data were used. The energy prices of the NPV analysis are based on a projection of the energy prices by ECN (ECN, 2010). The use of this data resulted in a slightly negative NPV, and therefore a utility would not make an investment in a gas-fired power plant at this moment, based on the assumptions of the costs and benefits of this report.

Table 10: Overview if the inputs and the NPV of PwC and of an own analysis, with an economic lifetime of 15 years (ECN, 2010), (PricewaterhouseCoopers, 2008), (ICE Futures Europe, 2011), (APX Endex, 2011)

	Data PwC	Input data based on ECN projections and PwC data			Situation April 2011
	average	Low	Average	high	average
Electricity revenues	56 Euro/MWh	54 Euro/MWh	62 Euro/MWh	70 Euro/MWh	55 Euro/MWh
Fuel costs	6 euro/GJ	4,0 euro/GJ	6,5 euro/GJ	9,5 euro/GJ	5 euro/GJ
Investment costs	806 Million euro	806 Million euro	806 Million euro	806 Million euro	806 Million euro
CO_2 costs	27 euro/ton CO_2	10 euro/ton CO_2	20 euro/ton CO_2	40 euro/ton CO_2	17 euro/ton CO_2
Fixed O&M costs	25,1 euro/kW	22,6 euro/kW	25,1 euro/kW	27,6 euro/kW	25,1 euro/kW
variable O&M costs	0,6 euro/MWh	0,54 euro/MWh	0,6 euro/MWh	0,66 euro/MWh	0,6 euro/MWh
Discount rate	5,28%	4.28%	5,28%	6.28%	5,28%
NPV	**7 Million euro**	**1000 Million euro**	**-50 Million euro**	**-1485 Million euro**	**230 Million euro**

The investment decision of the magnum power plant was made in 2006. In this year the natural gas price was about 4 euro/GJ (APX Endex, 2011), the electricity price 50 euro/MWh (European Commission, 2011c) and the CO_2 price 16 euro/tonne (Platts, 2010 Q1). This results in a NPV of about 360 million euro. Next to this the Magnum was designed to be able to use coal as a fuel. When the coal price of 2006 of 2 euro/GJ is used the NPV is about 230 million euro(European Commission, 2011b). With this positive NPV for both fuels the investment in the Magnum power plant can be explained.

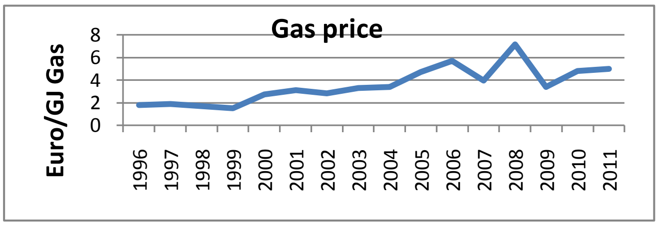


Figure 95: Developments of the european natural gas price (PricewaterhouseCoopers, 2008)

Figure 96 shows the results of a Monte Carlo analysis of the NPV of the Magnum power plant. This figure shows that the expected NPV is about -320 million euro. There is a 66% chance on a negative NPV, and therefore this investment would not be a good investment. The figure shows that the NPV is highly sensitive to the used input values.

Vattenfall has made the decision to cancel the construction of the coal gasification plant for the Magnum power plant. This decision was made in April 2011 and one of the reasons given by Vattenfall was the changed economic situation of a coal-fired power plant (Nuon, 2011a). In table 7 an analysis of the NPV of a coal-fired power plant is made with the energy prices of April 2011. This analysis results in a negative NPV, mainly because of the high coal price.

Table 10 shows that the NPV of the gas-fired power plant is positive when the energy prices of April 2011 are used. Therefore it is economically more attractive for Vattenfall to use the Magnum as a gas-fired power plant and not as a coal-fired power plant. Figure 95 shows the development of the gas price in Europe. This graph shows that the gas price has become more volatile in the last few years.

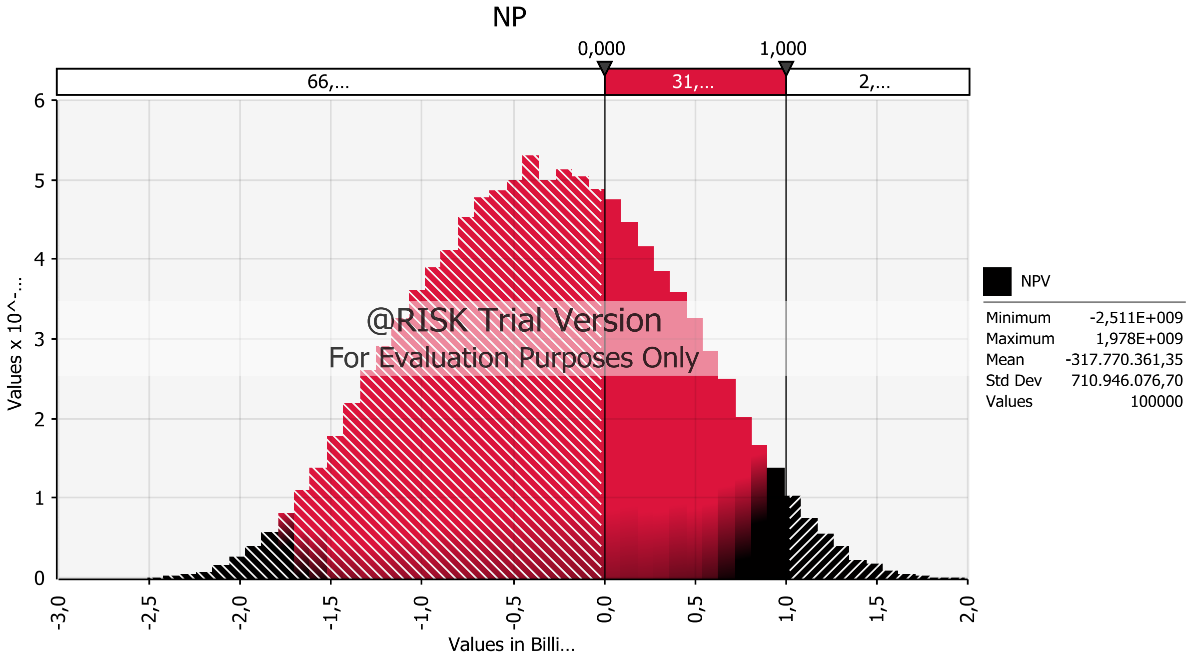


Figure 96: Monte Carlo simulation of the NPV of the coal-fired power plant at the Maasvlakte, using data from table 10

7.1.3 Social structures

An analysis of the annual reports and the website showed that Vattenfall wants to communicate that all their generation facilities are needed to facilitate the energy triangle. The energy triangle of Vattenfall is shown in figure 97 and represents the challenge of combining climate and environment, security of supply and competitiveness. The competitiveness is analysed in the economy section of the PESTEL analysis and the climate in the environment section. The security of supply is a factor which is important for this section. Wind and hydro power have the positive element for the security of supply of being local energy sources. Although coal, nuclear and gas power are not locally available, they are seen as fuels which increase the security of supply because these markets are reliable. These fuels, together with hydro power, can be used as base load because they can deliver high volumes. Gas and hydro plants are of importance because of their flexible output and can therefore keep the supply and demand in balance. Biomass is seen as a negative factor for the

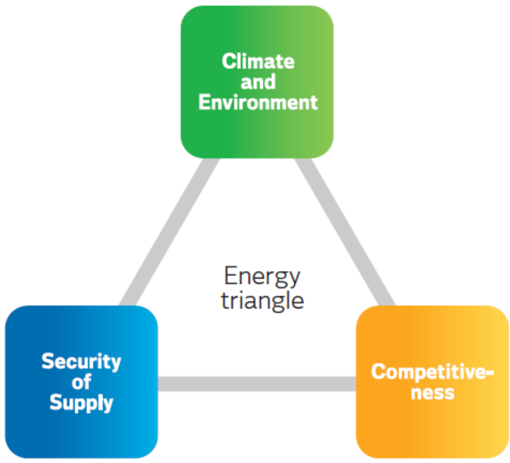


Figure 97: Energy triangle of Vattenfall (Vattenfall, 2010)

security of supply because the supply of biomass it is not as dependable as other fuels. The output of wind power is variable and therefore it cannot be used as base load(Vattenfall, 2010).

The main message of Vattenfall is that they use six main energy sources for their electricity generation and that their ambition is to increase the share of renewable energy. This message is shown on the homepage of the website and in annual reports. Figure 98 shows the main questions customers can have about the electricity mix of Vattenfall. The most important aspects of the answers of Vattenfall to these questions will be discussed below.

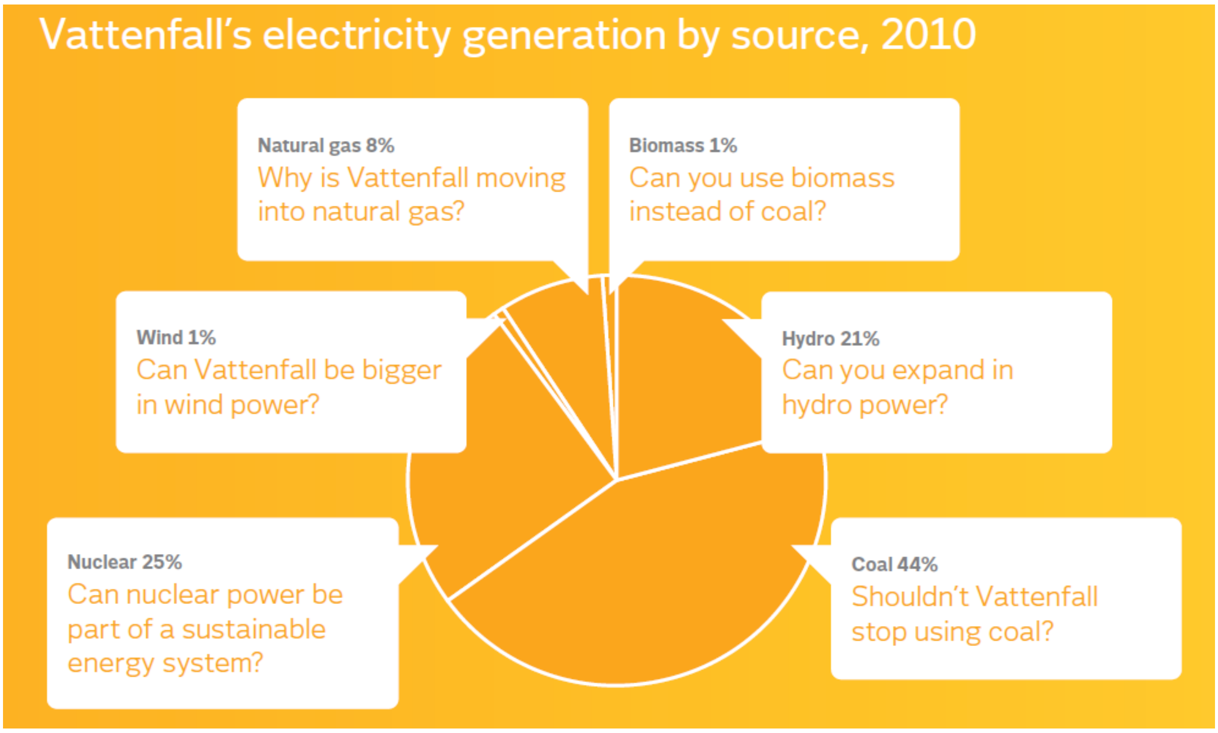


Figure 98: Illustration of how vattenfall communicates their current electricity mix (Vattenfall, 2010)

Vattenfall asks itself the question if the share of biomass, hydro and wind energy can become higher in the electricity mix. Hydro power cannot be expanded on a large scale because there are no suitable locations for many more hydro plants. Vattenfall's strategy is to modernise their existing hydro plants. This is visible in the expected electricity generation mix of Vattenfall, shown in figure 49.

Vattenfall is making large investments in wind energy. Of the investment of the upcoming years 24% will be invested in wind energy(Vattenfall, 2010). This growth is shown in figure 49, where the expected output of wind electricity in 2020 is about ten times higher than that of 2010. Vattenfall is making investments to increase the share of biomass in the electricity generation mix, but these investments are relatively low. One of the issues of biomass which Vattenfall puts foreword is the impact of biomass production on the local environment. Vattenfall is now using biomass from waste streams, but because these sources are not very large the share of biomass from plantations has to be increased. This type of biomass should be produced sustainably, but because there are not yet good certifications of biomass for energy use this is difficult to assess. Furthermore, the supply of biomass is seen as unreliable by Vattenfall, which is another reason why the investments in biomass are relatively low(Vattenfall, 2010).

Vattenfall is expected to make large investments in the production of electricity from natural gas. One of the strategic reasons for this increase is that gas reduces the company's risks. The current share of natural gas in the electricity mix of Vattenfall is relatively low. By increasing this share, the electricity mix of Vattenfall will be more balanced. This reduces the financial risk of increasing fuel prices. Another reason why Vattenfall is investing in natural gas is because this allows an increase in the share of renewable energy. The output of a gas-fired power plant is flexible and therefore more variable solar and wind power can be allowed without threatening reliability. Vattenfall wants to replace coal-fired power plants by gas-fired power plants to reduce the CO_2 emissions(Vattenfall, 2010). This effect is not seen in the expected electricity mix shown in figure 49. The output of coal-fired power plants is expected to increase and therefore the gas-fired power plants do not replace coal-fired power plants.

In figure 98 Vattenfall ask itself the question if the use of coal can be reduced. As shown in figure 49 the electricity production from coal is expected to increase, but the share of coal is expected to decrease from 42% in 2010 to 40% in 2020. Vattenfall will use coal as long as it is essential to secure the energy supply. To reduce the CO_2 emissions from coal, Vattenfall wants to use technologies such as pre-drying and CCS. Vattenfall is building two new coal-fired power plants which will increase the total emissions (Vattenfall, 2010). Vattenfall was planning to use coal for electricity production in the Magnum power plant. Vattenfall has made a deal with NGOs to not use coal in the Magnum power plant if the NGOs will not take legal actions to the gas-fired power plants of Vattenfall, which will be discussed in the legal issues of the PESTEL analysis(Nuon, 2011a).

Vattenfall is investing 16% of the total investment in the next five years in nuclear energy. Vattenfall gives several reasons why nuclear energy is safe and can have environmental benefits(Vattenfall, 2010). Although there is opposition towards the use of nuclear energy, Vattenfall is communicating the benefits and is expected to increase the use of nuclear energy.

The main conclusion which can be drawn from an analysis of the way Vattenfall communicates about the development of the company, is that Vattenfall wants to make clear why they make the decisions they make. For most of the used technologies the positive aspects are emphasized, but information is given about the negative aspects and how Vattenfall deals with these aspects. This shows that the communication strategy of Vattenfall is to be open and try to gain understanding from customers for their business decisions.

7.1.4 Technology

Wind energy is a relative new type of technology for utilities. Vattenfall is making large investments in wind energy and the development of wind energy has become a part of their investment strategy. For other types of renewable energy the investments are much lower. Vattenfall states that the supply of biomass can be unreliable. For this reason their investments in biomass are low, but Vattenfall keeps the option open to use biomass on a larger scale if this becomes more attractive. Vattenfall has little or no activities in the development of solar, geothermal, wave of tidal energy(Vattenfall, 2010). Therefore it can be concluded that Vattenfall does not expect that these types of technology will play an important role for Vattenfall in the next decade.

The magnum power plant is a good example of how the development of technology can be used to reduce risk accompanied with high fuel prices. Vattenfall was planning to construct the Magnum as a multi-fuel power plant. Although the Magnum will not become a multi-fuel power plant, it does show a part of the strategy of Vattenfall to reduce the risks of high fuel prices. According to the original construction plans the Magnum power plants could be fuelled by natural gas, biomass and coal. With this technology the power plant would not be dependent on one type of fuel and could easily switch to the fuel which is most attractive to use(Nuon, 2011a).

Vattenfall was planning to make use of CCS technology to reduce the CO_2 emissions of the Magnum power plant, but because of several reasons this will not be realised. Vattenfall started a CCS pilot at the Buggenum power plant in the Netherlands. This power plant is a coal and biomass gasification plant. The CO_2 emissions are captured before the fuels are combusted. The plan was to apply this technology to the Magnum power plant, if this pilot would be successful. The pre-combustion CCS is not possible anymore for the Magnum power plant, because the coal and biomass gasification plant will not be constructed(Nuon, 2011a). Another reason why Vattenfall has chosen to stop de development is CCS at the magnum power plant is because there is no support for onshore storage of CO_2 in gas fields(Nuon, 2011a). In February 2011 the minister of economic affairs has decided to stop the development of onshore storage of CO_2 in the north of the Netherlands(NOS, 2011).

7.1.5 Natural environment & geography

Vattenfall is planning to increase the share of wind energy in their electricity mix in the next decade. This will make Vattenfall more dependent on the natural environment because the output of wind turbines depends on the wind speed. As a strategy to guarantee the energy security, Vattenfall is increasing the capacity of natural gas power plants with a flexible output. These plants can compensate for the variable output of wind turbines and this combination can guarantee the balance between supply and demand of electricity(Vattenfall, 2010).

The location of the Magnum is chosen because of the favourable geographic conditions. The power plant can make use of sea water for cooling purposes, which makes the construction of an expensive cooling tower unnecessary. For the use of CCS there are nine onshore gas fields which could be used to store CO_2. Although Vattenfall will not make use of these gas fields for CO_2 storage because of the negative sentiment towards CCS, it was a criterion for the location of the power plant(Nuon, 2011a). The last advantage of the Eemshaven is that fuels can be easily supplied.

7.1.6 Legal issues

In May 2008 Vattenfall had to stop with the construction of the Magnum power plant. NGOs objected to the environmental licence. The council of states declared that the licence was not legal because it was issued by the minister of environmental affairs, which is not qualified to issue this licence(FD, 2008). The province of Groningen had to issue the environmental licence, which it did. In December 2008 this environmental licence given by the province of Groningen was made invalid because the province had used to loose emission norms for the environmental licence(Waddenzee.nl, 2008). In September 2009, more than a year after the construction process was stopped, Vattenfall could continue building the Magnum power plant. The province of Groningen issued a new environmental licence which made it possible to continue the construction(NRC, 2009). The delay in the construction process had large negative financial consequences on the construction costs of the power plant.

Vattenfall has made a deal in April 2011 with environmental organisations to stop the construction of the coal gasification plant of the Magnum. With this deal Vattenfall prevented additional law suits to gas-fired power plants Vattenfall is now building in the Netherlands. Vattenfall has made the promise that they will not build a power plant in the Netherlands which will emit more CO_2 than a gas-fired power plant. With this deal it is still possible for Vattenfall to use coal, but only in combination with biomass or CCS(AD, 2011). The pressure of the NGOs was not the only reason to cancel the plans to use coal in the Magnum. The development of the fuel prices was another reason why the Vattenfall has made this decision, as shown in the economic analysis. Additionally, the government has banned onshore CO_2 storage. The strategy of Vattenfall is to stop building coal-fired power plants without the possibility of CCS. The ban of onshore CCS would have made CCS more expensive and therefore this is another reason why the coal gasification plant will not be built in the near future (Nuon, 2011a).

7.2 SWOT analysis

This SWOT analysis shows the strengths, weaknesses, opportunities and threats to Vattenfall. This SWOT analysis is mainly based on a SWOT analysis of GlobalData. The SWOT analysis of GlobalData analysed all the activities of Vattenfall, while the SWOT analysis as presented below is focused on the electricity generation division of Vattenfall (GlobalData, 2011a). Nevertheless much of the SWOT analysis of GlobalData is used because of the high relevance to the strategy analysis of Vattenfall, and some additions are made.

7.2.1 Strengths

7.2.1.1 *Significant market position*

Vattenfall is the fifth largest electricity generator and the largest producer of heat in Europe. The company is the largest electricity generator in Sweden, has the third position in the Netherlands, Germany, Belgium and Finland and is the fifth largest electricity generator of Poland. Because of this strong market position in several countries in Europe, it has an edge over its international and domestic competitors (GlobalData, 2011a).

7.2.1.2 *Diversified business operations*

Vattenfall has a diverse production mix of coal, hydro, nuclear, gas, wind and biomass, as shown in figure 49. The expected generation mix of 2020 is even more diversified because the increase in natural gas and wind power. A diversified generation portfolio has the strategic advantage that it reduces the sensitivity to changes in fuel prices or regulation. These changes can affect the profitability of Vattenfall and therefore the diversification strategy creates more financial stability. Additionally, Vattenfall is located in several countries which reduce the risks accompanied with changes in demand and policies in individual countries (GlobalData, 2011a).

7.2.1.3 *Substantial customer base*

Vattenfall had 7,8 million electricity customers in the fiscal year of 2010. The customer base is growing, which can be explained by a positive performance in the customer satisfaction index. Vattenfall is trying to have a good customer service and has energy efficiency services for customers. Because of this constructive attitude and responsible approach towards customers, Vattenfall is positioning itself as a key player in the electricity market (GlobalData, 2011a).

7.2.2 Weaknesses

7.2.2.1 *Weak liquidity position*

Vattenfall has a weak liquidity position. The current ratio was 1,18 at the end of 2010, while the average current ratio of the power generation sector was 1,43(GlobalData, 2011b). For this reason Vattenfall was unable to meet short term obligations. The current ratio is important for a company because it needs cash to make cash from their operations. Money is needed to finance new investments. The weak liquidity position of Vattenfall can decrease the growth and expansion plans(GlobalData, 2011b). To increase the current ratio Vattenfall is selling parts of their business operations. For example, Vattenfall has sold the exploitation rights of the Dutch gas field at the North Sea in 2011. Vattenfall gave as explanation that the company wants to focus on their main activities and to create financial stability for necessary investments (IEX, 2011). While financial stability is a likely explanation, the focus on their main activities is less likely. This is because the one of the key strategy objectives in 2010 of Vattenfall Benelux was to further increase the stakes in gas fields (GlobalData, 2011b). This change in strategy has likely been caused by the weak liquidity position of Vattenfall.

7.2.3 Opportunities

7.2.3.1 *Growing focus on renewable energy*

The electricity consumption is expected to grow in the upcoming decades (Energy Information Administration, 2010). This increasing demand can for a large part be met with a strong growth in renewable energy. The electricity generation from renewable energy is expected to growth with an average of 3% per year from 2007 to 2035 (GlobalData, 2011b). This growth is mainly driven by environmental policies. For Vattenfall this is an opportunity to increase their investments in renewable energy and increase its market share and revenue. Vattenfall is investing strongly in wind energy. In November 2010 Vattenfall opened the world’s largest offshore wind farm in the south east coast of England. Next to this Vattenfall is planning to construct more wind farms in the upcoming years. These new projects are opportunities to enhance the market value of the company (GlobalData, 2011b).

7.2.3.2 *Strategic Initiatives*

Vattenfall has acquired 30% of Buchanan Renewables Fuel Ltd in 2010(GlobalData, 2011b). Buchanan Renewables is a producer of biomass in Liberia. Vattenfall has plans to expand and secure the supply of biomass with this acquisition. With this strategic investment, Vattenfall can increase the share of biomass in the generation portfolio and reduce the companies CO_2 emissions. Another strategic initiative is the agreement to construct an electrical interconnector between Norway and the UK together with E-CO, Lyse, Scottish, Southern Energy and Agder Energi (GlobalData, 2011b). This interconnector can establish stable energy prices and secure the supply of electricity. This investment gives Vattenfall an opportunity to increase its market shares and sales (GlobalData, 2011b).

7.2.4 Threats

7.2.4.1 *Volatility in Electricity Prices*

The electricity prices have become more volatile in the last decade. The volatility in electricity prices is driven by various factors. The financial crises had decreased the demand of electricity. Because of the liberalisation of the electricity market trade in electricity is possible. The number of participants and the willingness of these participants to trade affect the electricity price. The supply of electricity also has an impact on the electricity price. The availability of reserve margins, stream flows for hydroelectric generation, the scheduled and unscheduled outages of generating facilities and constraints on transmission facilities can make the supply of electricity more volatile. Recent political developments in the Middle East and North Africa have affected the oil price. Furthermore, the gas and coal price have become more volatile (GlobalData, 2011b). All these factors make the electricity price more volatile, which can affect the overall financial performance of Vattenfall.

7.2.4.2 *Changes in Regulatory Environment*

Changes in government regulation can be a risk for Vattenfall, because it may result in significant additional expenses which decrease the business growth. Vattenfall is subject to local, national and EU regulations. Many of the safety and environmental protection norms and regulations are likely to be modified in the near future. Because Vattenfall has projects in various phases of development, these changes may lead to increase in expenses, thereby affecting its profitability (GlobalData, 2011b).

7.2.4.3 *Intensifying Market Competition*

Deregulation has opened the European electricity market for numerous players. New small players can enter the market and large players are expanding and capturing markets. This intensified market competition has led to a price competition as a strategy to gain market share. The higher fuel prices and the lower electricity prices are a threat for the profitability of Vattenfall. Although Vattenfall is active in various markets, the price competition and the heavy competition because of acquisitions and growth of competitors is a threat to Vattenfall. It is a threat to the expansion plans of Vattenfall and creates a barrier for entering other markets, thus limiting its growth potential (GlobalData, 2011b).

7.2.4.4 *Movement against nuclear energy*

Because of the nuclear accident in March 2011 in Japan the discussion about the necessity of nuclear energy in Europe has increased. Vattenfall has nuclear power plants and therefore this discussion has an impact on Vattenfall. The negative attention to nuclear energy can have a negative impact on the brand image of Vattenfall. Next to this, the decision of Germany to close the nuclear power plants earlier than planned has negative financial consequences for Vattenfall, because Vattenfall owns nuclear power plants in Germany (Guardian, 2011).

7.3 Strategic actions

The PESTEL analysis gave an overview of how external factors have an impact on the strategy of Vattenfall. The SWOT analysis showed what the strengths, weakness, opportunities and threats are. This section will discuss how Vattenfall uses the resources and capabilities to create a stronger competitive position.

7.3.1 Resources and capabilities

The resources and capabilities are dependent on the current installed capacity of Vattenfall. The main assets which are used by Vattenfall are their generation facilities. Vattenfall has most knowledge of the type of power plants which they already own. For this reason the capabilities of Vattenfall are in line with their installed capacity.

The developments of the installed capacity are shown in figure 48, but for convenience also shown in figure 99. This figure shows that the main developments are expected in coal, natural gas and wind energy. Figure 100 shows the investment plants of Vattenfall of the next five years. In this figure it is even clearer than coal, natural gas and wind energy are the main energy sources for newly installed capacity for the next five years. Compared to the installed capacity of 2010, the shares of soft coal, hydro and oil are expected to decrease towards 2020. Figure 101 shows the age of the installed capacity of Vattenfall. What can be seen from this figure is that about 30 to 40 years ago the installed capacity of coal-fired power plants has increased significantly. Since the average lifetime of these power plants is about 40 years these, power plants are expected to be shut down in the next decade. Therefore it is possible that the planned investments in coal-fired power plants in the next decade are used to replace old coal-fired power plants. However, there are no deconstruction dates available in the Powervision database for some old coal-fired power plants, and therefore it is not certain if the new coal-fired power plants will be additional capacity or if it is a replacement of old coal-fired capacity.

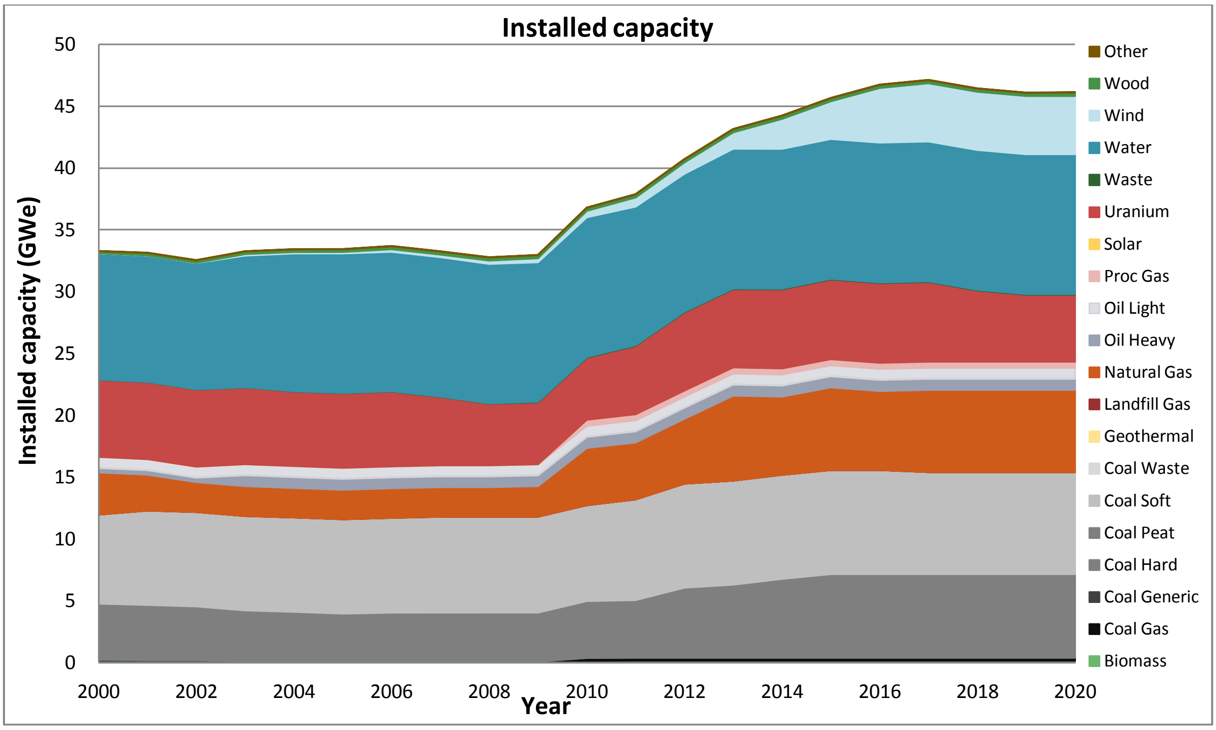


Figure 99: Development of the installed capacity of Vattenfall (Platts, 2010 Q1)

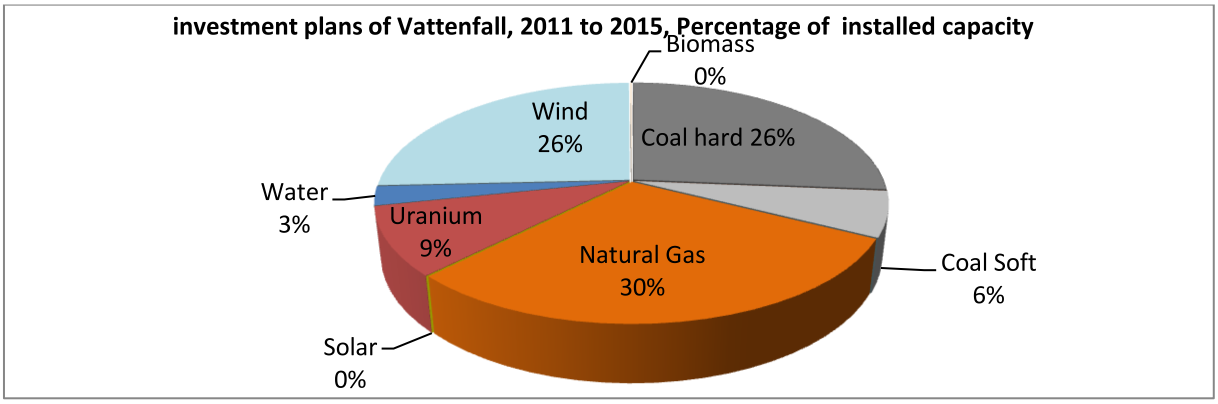


Figure 100: Investment plans of Vattenfall for the years 2011 to 2015 (Platts, 2010 Q1)

About 30 to 40 years ago Vattenfall installed new gas-fired power plants. Some of these plants will be replaced in the upcoming years, but most of the investments in gas-fired power plants will be additional power plants. Because of this development, the share of gas in the generation portfolio of Vattenfall is expected to increase. The increase of the share of gas-fired power plant is strategically a good option. Because of this increase the electricity output of Vattenfall is becoming more flexible. Flexibility is necessary to balance the electricity supply with the electricity demand. As shown in figure 100, Vattenfall is increasing the installed capacity of wind power. The electricity of wind turbines is volatile and the natural gas power plants can be used to balance the total electricity output of Vattenfall and secure the supply of electricity.

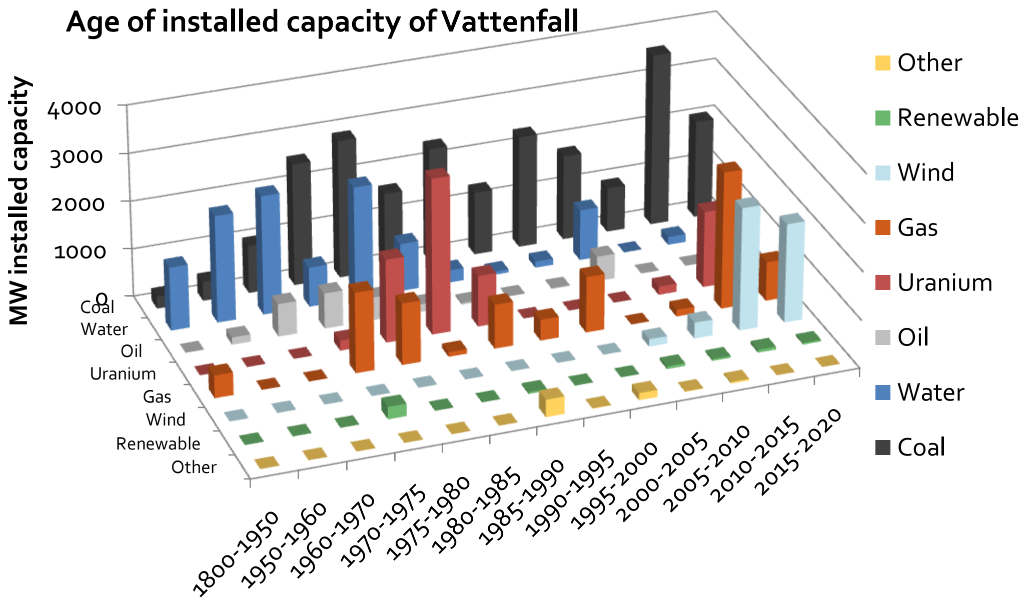


Figure 101: Installation years of the installed capacity of Vattenfall (Platts, 2010 Q1)

Figure 101 shows that Vattenfall is planning to invest in new nuclear power plants in the upcoming years. Because Vattenfall has shut down a nuclear power plant in 2007 and will shut down a nuclear power plant in 2018 this newly built capacity does not increase the total nuclear capacity and therefore it can be seen as replacement.

Vattenfall is investing heavily in wind energy. Historically seen wind energy does not fit into the resources and capabilities of Vattenfall. Vattenfall had little experience with wind energy or a comparable technology. Therefore Vattenfall has to develop these capabilities. Because Vattenfall is investing heavily in wind energy, it is apparent that Vattenfall thinks it is worthwhile to develop capabilities for the development and operation of wind farms. One way to connect wind energy with their current capabilities is to build large wind farms. Vattenfall resources are mainly large power plants and therefore single wind mills are very small compared to their current resources. Large wind farms are more in line with business model of Vattenfall.

A reason why Vattenfall can develop capabilities in wind is because wind energy is a relatively new energy source for utilities. Because of this there are no competitors with large capabilities in wind energy and with a competitive advantage over Vattenfall. As a result, Vattenfall has still time to be competitive and to develop capabilities in wind energy to make wind energy part of their investment strategy.

Vattenfall has the ambition to reduce its CO_2 intensity from 417 gram CO_2/kWh in 2010 to 350 gram CO_2/kWh in 2020 (Vattenfall, 2010). Figure 102 shows the strategy of Vattenfall to achieve this strategy. There are some remarks regarding this figure. The CO_2 intensity of 2010 in this figure is about 538 gram CO_2/kWh (91,5MTonnes/170TWh), which is not similar to the reported CO_2 intensity by Vattenfall of 417 gram CO_2/kWh in 2010. The ambition of Vattenfall is to reduce the CO_2 intensity to 350 gram CO_2/kWh in 2020, while the CO_2 intensity in this figure results in an ambition of 361 gram CO_2/kWh.

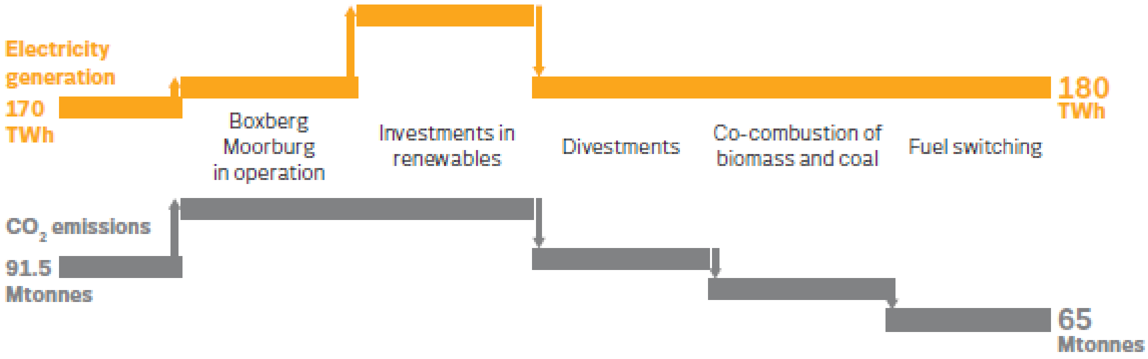


Figure 102: Vattenfall's roadmap for reducing CO_2 exposure 2010-2020 (Vattenfall, 2010)

What figure 102 does show is the steps which Vattenfall is planning to take to reduce their CO_2 emissions. The first step which is shown in the roadmap is that the coal fired power plants Boxberg and Moorburg will come online. These power plants have a combined capacity of about 2200 MW to generate about 10 TWh/year and will increase the CO_2 emissions. The next step shown in figure 102 are the investments in renewable energy. This will increase the total electricity production, but this increase will be balanced by divestments of old power plants. These divestments will reduce the total CO_2 emissions of Vattenfall. The last two steps are co-firing of biomass and fuel switching, which will reduce the total CO_2 emissions.

The impact of the investments in renewable energy shown in figure 102 is probably too high. Figure 103 shows the construction and deconstruction plans from the Powervision database. This figure shows the investments in the Boxberg and Moorburg power plants, but also large investments in natural gas and wind energy. In the road map of figure 102 the impact of the coal-fired power plants on the electricity generation is relatively small compared to impact of the investments in renewables. Figure 103 shows that the expected new installed capacity of renewable energy is higher than the installed capacity of coal, but the difference is much smaller compared to the difference in figure 102. The load factor of coal-fired power plants in higher than that of renewable energy and therefore the difference in the electricity generation will be reduced. For this reason the impact of renewables in figure 102 is probably too high.

Figure 103 shows high investments in natural gas. These investments are expected to increase the total CO_2 emissions of Vattenfall, which is not shown in figure 102. The investments in natural gas could fall under fuel witching of figure 102. Because this reduces the total CO_2 emissions the new natural gas-fired power plants should replace power plants with a higher CO_2 intensity such as oil or coal-fired power plants. Figure 103 show small divestment plans in coal and oil. With these plans it is not possible to reduce the CO_2 emissions with fuel switching and at the same time reduce the CO_2 emissions with divestments as shown in figure 102. A possibility is that the investment plans are too high and the divestment plans are too low in the Powervision database. Although the expected plans from Powervision could be incomplete, the difference is very large and therefore it is likely that the CO_2 reduction as represented in figure 102 will not be possible with the current investment plans of Vattenfall.

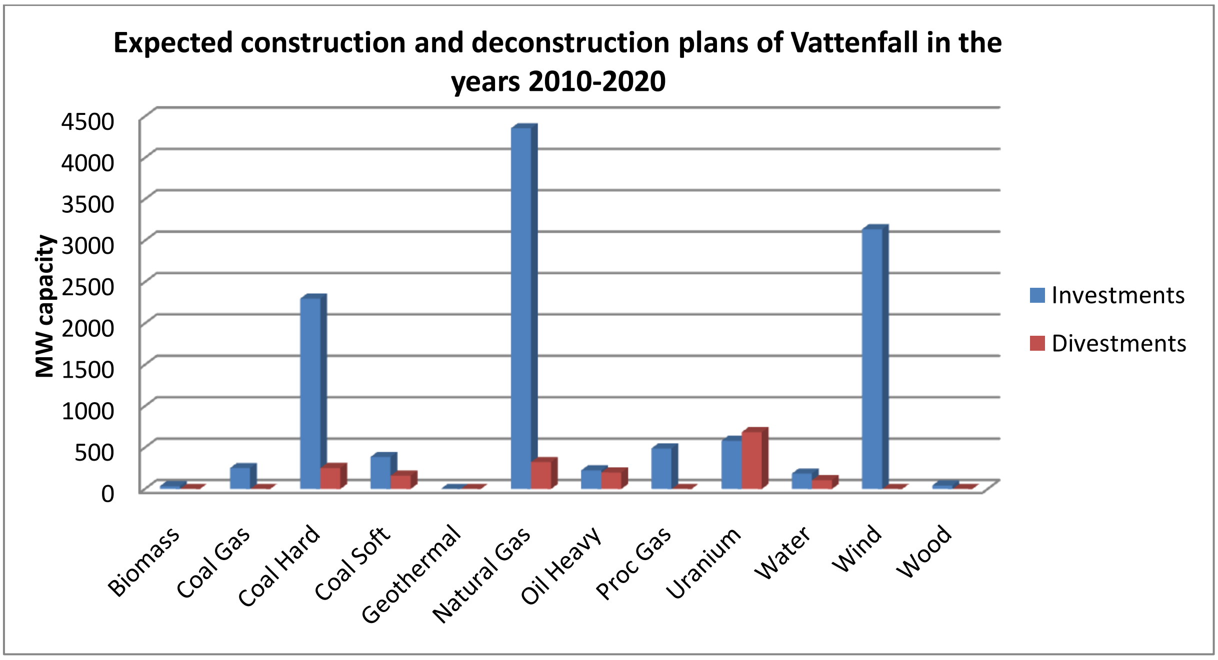


Figure 103: Expected construction and deconstruction plans of Vattenfall for the years 2010-2020(Platts, 2010 Q1)

7.3.2 Competitive advantage

Vattenfall is creating a competitive advantage by diversifying their business activity to markets related to electricity generation. One of these business opportunities is the investment in the development is an electric vehicle of Volvo. Vattenfall sees the introduction of the electric car as an important change in the use of energy (Vattenfall, 2010). For Vattenfall the electric car is an opportunity to increase the sales of electricity. By working together with Volvo, they can develop products which can be used to stimulate the use of electric cars. Vattenfall can use their produces to increase their profit and increase their customer base, because they can provide products and services for electric cars.

Vattenfall is investing in energy efficient houses as another diversification strategy(Vattenfall, 2010). Increasing energy efficiency will decrease the electricity demand for Vattenfall. Since the increase in energy efficiency will happen anyway the strategy of Vattenfall is to try to make money out of this development. An advantage of this strategy is that it has a positive impact on the brand image. Vattenfall can be a good player in the energy Furthermore, efficiency market because they have a good insight in the energy costs of costumers. Next to this Vattenfall can use their electricity grid to support the use of small scale renewable technologies.

The Netherlands is expected to change from a net importer of electricity to a net exporter of electricity in the upcoming years(ECN, 2010). This change is mainly caused by the construction of a few large coal and gas-fired power plants, under which the Magnum. The strategy of the utilities which are constructing these power plants, including Vattenfall, can be to create overcapacity. By creating overcapacity it will become less attractive to make new investments in the Netherlands for other utilities because it will be more difficult to sell their electricity and to get good electricity prices. Another reason why Vattenfall is building the Magnum power plant is to keep up with the competition. Because the competition is building large power plants in the Netherlands, Vattenfall has to build a large power plant to prevent losing market share in the Netherlands.

8 Results of the strategy analysis

In the last two sections, the strategies of E.ON and Vattenfall were analysed. The results of these analyses are specific for these utilities, but some of the results can be generic for the strategy of all utilities. This chapter will show the results of the two case studies which are relevant for other utilities.

8.1.1 Policies

The ETS is an important policy for utilities because it decreases the profitability of fossil fuelled power plants. From 2013 onwards, the utilities have to buy all their emission allowances at auction. Because the utilities have already passed the CO_2 costs on to the customer as opportunity costs, the profit of electricity generation is expected to decrease. The share of CO_2 costs varies from 10% to 40% of the total operation cost of a power plant, depending on the expected allowance price and the power plant type.

In general, policies are a risk for utilities. Long term stability of policies is often not guaranteed and therefore it is difficult to assess the impacts on long term investments and strategies. Subsidies can be used to make investments in renewable energy possible, but an economic risk is involved because subsidies can be cancelled. Greenhouse gas reduction policies can increase the costs for investments in fossil power plants and therefore policies are a risk factor for utilities.

8.1.2 Economic factors

The most important factors for the NPV of a power plant are the fuel prices, CO_2 price and the electricity price. These inputs of the NPV have become more volatile in the last decade and therefore the investment risk has increased. Fuel costs can be passed on to the customer, but because of long term contracts this can be difficult. Changes in fuel prices can change the economic preference for coal- or natural gas-fired power plants. Because fuel switching is very difficult for a power plant, the changes in the fuel prices can lead to a decrease in profits of power plants. Diversification of the installed capacity portfolio is a strategy used by utilities to reduce the risks of volatile fuel prices. A utility is not dependent on one type of fuel with a diverse portfolio. Therefore the impact of a high fuel price of one type of fuel will be lower, because the utility can make profit with power plants based on other fuel types. With this strategy, the risk of losing price competition because of changes in fuel prices is reduced, which is a strength for a utility.

The NPV did not show a clear preference for a coal- or gas-fired power plant. With the fuel prices based on the projections by ECN a coal-fired power plant would be the best investment. The NPV analysis based on the fuel prices of April 2011 and the NPV analysis of PwC showed a preference for a natural gas-fired power plant.

The economic crisis has reduced the electricity demand. The economic situation of most utilities is not good because of macro-economic developments. These financial problems can be seen as a weakness of utilities.

8.1.3 Social structures

Renewable energy and climate change are important topics for utilities. Renewable energy is used to improve the brand image. In annual reports and on websites of utilities much attention is paid to projects in renewable energy and energy saving, although this is not the core business of the utilities. Vattenfall and E.ON use openness as a strategy to explain their investments in fossil-fired power plants. Both utilities state that fossil fuels are necessary to ensure low electricity prices and energy security. Additionally, both utilities present their plans to make their fossil-fired power plants cleaner so that the impact on climate change and the local environment is reduced.

8.1.4 Technology

The investments of utilities in renewable energy are mainly strategic investments. Utilities keep their options open to several renewable energy technologies, and utilities use these investments to enhance their brand image. Exceptions to this strategy are hydro energy and, for some utilities, wind energy, which are technologies which are used to generate electricity on larger scales.

CCS is seen as a technology which will become important for reducing greenhouse gas emissions, and thereby the CO_2 costs of fossil-fired power plants. The investments in CCS are not very large and it is expected that this technology will be economically competitive in 2020. For this reason it is can be seen as a strategy for the future and as a promise to reduce the CO_2 emissions of the fossil-fired power plants. This can have a positive effect on the image of fossil-fired power plants.

8.1.5 Natural environment and geography

The location of power plants depends on the possibility to supply fuel to the power plant and to use cooling water for the power plant. A new criterion for the location of fossil-fired power plants is the possibility to store or transport CO_2 emissions. Renewable energy is dependent on the environmental conditions and therefore the utilities are becoming more dependent on the natural environment and geography.

8.1.6 Legal issues

Legal issues seem to be impossible to avoid with the construction of a fossil-fired power plant. NGOs are opposing new fossil-fired power plants and therefore there is a high chance that the environmental permits will be a legal issue. Legal issues are a financial risk for utilities and are bad for the brand image, which make it a threat for the utility.

8.1.7 Strategic actions

Utilities use their resources and capabilities to develop a strategy and create a competitive advantage. Most utilities have natural gas-fired power plants and can use their capabilities to increase the installed capacity of natural gas power plants. These investments lead to a balanced generation portfolio. Old coal-fired power plants need to be deconstructed and many utilities are expected to replace these with new coal-fired power plants. The strategic reason behind this is that coal-fired power plants can be used as reliable base load with low generation costs. Therefore a share of coal-fired power plants in the portfolio can be good for the competitive position of a utility.

Utilities are entering new markets to get a competitive advantage. The renewable energy market is growing strongly and most utilities are making investments to profit from this growth. Utilities are looking at markets outside their core business to make profit from growing markets. Energy efficiency and electric cars are two typical markets in which utilities are investing. These markets have a strong connection with electricity generation and therefore their capabilities can be used to make profits in these markets.

8.2 Discussion of the strategy analysis

Several strategy analysis methods are used to structure the analysis of the strategies of utilities. Although these methodologies try to cover all aspects of a strategy analysis, it is possible that some aspects are not included in the strategy analysis. Because the real strategy of the utilities is not available, this report gives an analysis of the strategy based on publically available information. Because not all information is available, some aspects of the strategy could have been passed over. Next to this, the strategy analysis is an interpretation by the author and other interpretations are possible.

9 Conclusion

The aim of this study is to show what the CO_2 intensity of various utilities and how this compares with their peers. Also, the CO_2 reduction strategy of utilities is analysed to see how utilities take up the challenge of reducing CO_2 emissions and whether and how external factors influence this strategy.

This research has shown that there are significant differences between the CO_2 intensities of the twelve selected utilities. The lowest CO_2 intensity was reported for EDF, with a CO_2 intensity of 110 gram/kWh in 2010. The main reason for this low CO_2 intensity is the high share of nuclear energy in its electricity mix. PPC is the utility with the highest CO_2 intensity. The CO_2 intensity of 988 gram/kWh is caused by the high share of electricity produced from soft coal.

Vattenfall and E.ON have a large share of combined heat and power plants in their generation portfolio. For this reason, some of the CO_2 emissions of these power plants are allocated to the heat production. As a result the CO_2 emissions of Vattenfall and E.ON are lower than utilities which use a comparable fuel mix.

A projection of the expected developments in the CO_2 intensity of the utilities was made, based on the investments and divestments plans from the Powervision database. EDP and SSE are the utilities with the largest expected decrease of the CO_2 intensity. EDP was awarded sustainability leader of the electricity sector by the Dow Jones sustainability index. In the past decade the CO_2 intensity of EDP decreased by almost 50%, mainly because of increasing use of renewables and decreasing use of coal. In the upcoming decade the only large change is an expected growth in the use of natural gas, which increases the CO_2 intensity by 13%. SSE is expected to achieve a reduction of the CO_2 intensity of about 60% from 2000 to 2020 because of investments in renewables and divestments in coal.

Many utilities report emission reduction ambitions in their annual reports, but most of the utilities are expected to be unable to meet their own CO_2 reduction ambitions. The total electricity supply is expected to grow by 24% in the next decade. The growth of the electricity consumption of the EU-27 of the last decade was about 10%, and therefore the expected growth of 24% is very large. This large growth is a result of an increase of the installed capacity and therefore it is likely that the investment plans are overestimated and the divestment plants are underestimated. As a result of the large growth of the electricity production, the total CO_2 emissions of most utilities are expected to increase. This increase could increase the price of emission allowances of the emission trading system because the demand for these allowances is expected to increase, while the supply will decrease.

An identifiable trend is that the use of natural gas and wind is increasing. The large increase in wind energy shows that wind energy has become economically attractive for utilities. The large increase in the use of natural gas will cause a higher demand for natural gas which can lead to an increase in the gas price. Furthermore, the dependency of Europe other countries will not be decreased by the use of natural gas because the gas reserves of Europe are limited.

The CO_2 intensity of electricity produced in Europe was decreasing in the last few years, but is expected to remain stable in the upcoming decade. The decrease was caused by declining emissions from coal-fired power plants and small increases in renewable energy. The expected growth in the use of renewable energy reduces the CO_2 intensity in the next decade, but the small expected growth in the CO_2 emissions from coal even out this effect. The large expected investment in natural gas-fired power plants have little effect on the European CO_2 intensity, because the CO_2 intensity of gas-fired power plants is almost equal to the CO_2 intensity of electricity produced in Europe.

The strategy analysis of this research has shown that utilities try to develop a strategy to reduce their CO_2 emissions, be competitive and maintain the security of electricity supply. The economic analysis of the CO_2 costs showed that the ETS has a significant impact on the profitability of a utility. Utilities are trying to reduce the CO_2 costs of their power plants. For example, E.ON has made a deal with the Dutch government which indirectly compensates the CO_2 costs of the newly built coal-fired power plant at the Maasvlakte.

Fuel prices and electricity prices are very important for the profitability of power plants. These factors have become more volatile in the last decade and therefore the investment risks have increased. An example of the consequences in the changes of fuel prices is Vattenfall's decided to not use coal in their Magnum power plants. Another reason for this decision is because of pressure from NGOs to stop using coal. Vattenfall has made a deal with the NGOs to not use coal at the Magnum power plants and the NGOs will not start legal procedures against the gas-fired power plants of Vattenfall. This is beneficial for Vattenfall because the strategy analysis has shown that legal issues are a threat to utilities

The environmental performance is an important factor in the strategy of a utility because it is beneficial for the corporate image. In the communication of utilities much attention is paid to their developments in renewable energy. Most utilities make small investments in renewable energy which are used to keep the option open to invest in these technologies when they become economically attractive. The developments are emphasised in their external communication to enhance their corporate image. Next to this utilities are open about their developments in fossil fuelled power plants and point out the positive aspects and the necessity of these power plants.

As a strategy to create a competitive advantage, utilities are creating a diverse generation portfolio. This decreases the financial risks of policies and high fuel prices. Overcapacity is another strategic action, which can decrease the threat of other utilities investing in the same geographic area or in other technologies.

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11 Appendix 1

EDF				
	2007	2008	2009	2010
Total electricity generation	598,8	610,0	577,0	630,4 (Worldwide)
Reference	EDF Group, 2007. *Sustainable Development report*, p.27	EDF Group, 2008. *Sustainable Development report*, p.2	EDF Group, 2009. *Activity and Sustainable Development Report*. pp. 46, 64, 70, 74	EDF Group, 2010, *Activity & Sustainable development*, p.3
Shares of electricity generation				
Fossil Fired	19,5%	14,4%	11,2%	9,8%
Gas	-	4,3%	4,3%	5,5%
Nuclear	72,1%	71,9%	75,4%	75,4%
Hydro	8,0%	8,7%	8,1%	7,9%
Other renewable	0,4%	0,7%	1,1%	1,3%
Remark	Worldwide	Worldwide	Worldwide	Worldwide
Reference	EDF Group, 2007. *Sustainable Development report*, p.26	EDF Group, 2008. *Sustainable Development report*, p.14	EDF Group. *Activity and Sustainable Development Report.* 2009. p.40	E EDF Group, 2010, *Activity & Sustainable development*, p.33

E.ON				
	2007	2008	2009	2010
Total electricity generation	208 (Spain and Italy not included)	207 (Spain and Italy not included)	211	220
Reference	E.ON, 2007. *Strategy & key figures*, pp.30, 87, 103	E.ON, 2008. *Strategy & key figures*, pp.30, 87, 103	E.ON, 2009. *Company Report.* pp. 50, 58, 62, 84, 88	E.ON, 2010. Annual report 2010, p14
Shares of electricity generation				
nuclear	37,2%	37,3%	33,7%	26,0%
Hard coal	32,2%	32,3%	32,7%	23,0%
Lignite	4,2%	4,3%		5,0%
Oil/gas	13,9%	14,2%	22,2%	35,0%
Waste incineration	0,6%	0,9%		
Hydro	9,9%	9,5%	8,5%	6,0%
Other renewable	0,9%	0,6%		
Combines heat and power	0,7%	0,7%		
Others	0,4%	0,3%	2,8%	2%
Wind				3,0%
Reference	E.ON, 2007. *Strategy & key figures*, pp.30, 87, 103	E.ON, 2008. *Strategy & key figures*, pp30, 87, 103	E.ON, 2009. *Company Report.* pp. 50, 58, 62, 84, 88	E.ON, 2010. Annual report 2010, p14

RWE				
	2007	2008	2009	2010
Total electricity generation	179	180	187	225
Reference	RWE, 2008. *Annual report*, XLS file	RWE, 2008. *Annual report*, XLS file	RWE, 2009. *Our Responsibility report,* p. 12	RWE, 2008. *Annual report*, p.76
Shares of electricity generation				
Lignite	42,5%	41,0%	38,0%	31,5%
Hard coal	30,9%	23,9%	24,0%	24,5%
Nuclear	17,9%	27,3%	18,0%	20,1%
Gas	5,6%	6,4%	16,0%	19,0%
Renewable energies	1,8%	0,3%		
Pumped storage, oil, other	1,2%	1,1%		
renewable			3,0%	
other			1,0%	1,0%
Hydro				1,6%
Wind				1,4%
Biomass				1,0%
Reference	RWE, 2008. *Annual report*, XLS file	RWE, 2008. *Annual report*, XLS file	RWE, 2009. *Our Responsibility report,* p. 12	RWE, 2008. *Annual report*, pp.76, 159

GDF Suez						
	2005	2006	2007	2008	2009	2010
Total electricity generation	127,2	128,7	134,5	145,6	139,0	142,8 (assumption base on data 2009 and 2010)
Reference	Carbon disclosure project, 2008.	Carbon disclosure project, 2008.	Carbon disclosure project, 2008.	Carbon disclosure project, 2008.	GDF Suez, 2009. *Reference document*, p.11	GDF Suez, 2010. *Reference document*, p. 11.
Shares of electricity generation						
Coal - hard	13,8%	13,7%	13,1%	10,6%	11,0%	12,0%
Fuel oil	0,2%	0,2%	0,2%	0,2%		
Gas	6,9%	6,9%	6,6%	5,4%	49,0%	47,0%
Combined Cycle (CCGT)	20,7%	23,2%	24,7%	32,3%		
CHP	7,4%	5,1%	5,0%	6,3%		
other	0,0%	0,0%	0,0%	2,1%	2,0%	3,0%
Nuclear	38,1%	36,4%	36,2%	29,7%	18,0%	16,0%
Hydro	12,4%	13,8%	13,4%	12,3%	18,0%	19,0%
Wind	0,2%	0,4%	0,5%	0,8%	1,0%	1,0%
Other renewables	0,2%	0,2%	0,2%	0,4%		
Biomass and biogas					1,0%	2,0%
Reference	Carbon disclosure project, 2008.	Carbon disclosure project, 2008.	Carbon disclosure project, 2008.	Carbon disclosure project, 2008.	GDF Suez, 2009. *Reference document*, p.11	GDF Suez, 2010. *Reference document*, p. 11.

Enel					
	2005	2006	2007	2008	2009
Total electricity generation	124,2	126,5	135,0	180,2	171,0
Reference	Carbon disclosure project, 2008.	Carbon disclosure project, 2008.	Carbon disclosure project, 2008.	Carbon disclosure project, 2008.	Enel, 2009. *Sustainability Report.* pp. 45,46
Shares of electricity generation					
Coal – hard	26,9%	23,6%	28,7%	27,6%	27,6%
Coal – lignite (brown)	2,9%	3,9%	3,8%	4,0%	
Fuel oil	13,0%	12,2%	6,8%	7,5%	
Gas (excluding OCGT,CCGT and CHP)	13,1%	10,3%	7,3%	3,2%	
CCGT	17,9%	15,4%	18,2%	18,1%	12,9%
Wind	0,8%	0,8%	1,7%	2,3%	
Nuclear	0,0%	8,6%	11,5%	16,5%	11,9%
Hydro	21,0%	20,7%	17,7%	17,6%	28,4%
Geothermal	4,0%	4,1%	3,9%	2,9%	
Oil/Gas					15,3%
Other renewable					3,9%
Reference	Carbon disclosure project, 2008.	Carbon disclosure project, 2008.	Carbon disclosure project, 2008.	Carbon disclosure project, 2008.	Enel, 2009. *Sustainability Report.* pp. 45,46

Vattenfall				
	2007	2008	2009	2010
Total electricity generation				
Reference	Vattenfall, 2009. *Corporate social responsibility report*, pp. 52.	Vattenfall, 2009. *Corporate social responsibility report*, pp. 52.	Vattenfall, 2009. *Corporate social responsibility report*, pp. 52.	Vattenfall, 2010. *Annual report*, p1
Shares of electricity generation				
lignite	33,0%	32,6%	33,8%	30,1%
hard coal	11,6%	11,4%	11,7%	13,0%
gas	2,6%	2,7%	2,8%	8,3%
peat	0,1%	0,2%	0,2%	0,2%
waste non-biogenic	0,2%	0,3%	0,2%	0,3%
biomass and biogenic waste	0,7%	0,8%	0,7%	1,3%
hydro power	18,9%	21,4%	21,2%	18,9%
wind and solar power	1,0%	1,2%	1,1%	1,5%
nuclear power	31,7%	29,3%	27,9%	26,0%
others inc oil	0,3%	0,3%	0,4%	0,5%
Reference	Vattenfall, 2009. *Corporate social responsibility report*, pp. 52.	Vattenfall, 2009. *Corporate social responsibility report*, pp. 52.	Vattenfall, 2009. *Corporate social responsibility report*, pp. 52.	Vattenfall, 2010. *Annual report*, p30

Iberdrola				
	2007	2008	2009	2010
Total electricity generation	124 (Worldwide)	141 (Worldwide)	143 (Worldwide)	153 (Worldwide)
Reference	Iberdrola, 2009. *Sustainability Report*, p. 23.	Iberdrola, 2009. *Sustainability Report*, p. 23.	Iberdrola, 2009. *Sustainability Report*, p. 8.	Iberdrola, 2010. *Sustainability Report*, p. 7.
Shares of electricity generation				
hydro	12,8%	8,2%	8,4%	14,5%
renewable	10,7%	12,0%	15,1%	15,9%
Coal	13,6%	9,4%	9,3%	9,8%
Combined cycle	41,1%	48,0%	46,8%	38,5%
Cogeneration	4,0%	4,9%	4,5%	4,3%
Nuclear	17,9%	17,5%	16,0%	17,1%
Reference	Iberdrola, 2009. *Sustainability Report*, p. 23.	Iberdrola, 2009. *Sustainability Report*, p. 23.	Iberdrola, 2009. *Sustainability Report*, p. 23.	Iberdrola, 2010. *Sustainability Report*, p. 29.

EDP					
	2006	2007	2008	2009	2010
Total electricity generation	46,5	45,8	42,2	42,0	47,2
Reference	Carbon disclosure project, 2008.	Carbon disclosure project, 2008.	Carbon disclosure project, 2008.	EDP, 2009, *Annual report*, pp.11-21, 37-42	EDP, 2010, *Annual report*, p.9
		Shares of electricity generation			
CHP	5,6%	6,6%	7,4%	6,0%	5,5%
Coal – hard	44,6%	42,1%	35,6%	35,6%	30,6%
Of which solid biomass	0,1%	0,3%	0,1%	0,3%	0,5%
biomass	0,0%	0,2%	0,0%	0,0%	0,0%
Hydro	24,2%	22,8%	17,9%	24,7%	22,2%
Wind	4,3%	6,6%	9,5%	11,9%	15,1%
Fuel oil	4,8%	4,0%	3,2%	0,4%	0,0%
CCGT	16,3%	17,5%	26,1%	20,7%	25,7%
Gasoil & Biomass	0,1%	0,1%	0,1%	0,3%	0,4%
Reference	Carbon disclosure project, 2008.	Carbon disclosure project, 2008.	Carbon disclosure project, 2008.	Carbon disclosure project, 2008. Projections made by EDP	Carbon disclosure project, 2008. Projections made by EDP

PPC			
	2007	2008	2009
Total electricity generation	53,9	52,4	50,1
Reference	Public Power Corporation, 2009. *Annual Report*. p. 9	Public Power Corporation, 2009. *Annual Report*. p. 9	Public Power Corporation, 2009. *Annual Report*. p. 9
Shares of electricity generation			
Lignite			61,0%
Fuel oil			13,0%
Natural gas			15,5%
Hydro			10,0%
Renewable			0,5%
Reference			Public Power Corporation, 2009. *Annual Report*. p. 10

Eneco – No info

SSE			
	2008	2009	2010
Total electricity generation	47,9	41,2	47,2
Reference	Scottish and Southern Energy, 2009. *Annual Report,* p. 25	Scottish and Southern Energy, 2009. *Annual Report,* p. 25	Scottish and Southern Energy, 2010. *Annual Report,* p. 21
Shares of electricity generation			
Gas and oil	53,1%	53,9%	48,3%
Coal	35,0%	27,5%	36,0%
Biomass	0,1%	0,9%	0,4%
Hydro	10,3%	11,7%	9,5%
Wind	1,5%	6,0%	5,8%
Reference	Scottish and Southern Energy, 2010. *Annual Report,* p. 17	Scottish and Southern Energy, 2010. *Annual Report,* p. 17	Scottish and Southern Energy, 2010. *Annual Report,* p. 17

Drax	
	2009
Total electricity generation	22,6
Reference	Drax Group, 2009. *Annual Report and Accounts,* p. 2
Shares of electricity generation	
coal	88,0%
biomass	3,0%
Pet coke	7,0%
Pond fines	1,0%
Other	1,0%
Reference	Drax Group, 2009. *Annual Report and Accounts,* p. 29

11.1 Appendix 2

The CO_2 emissions are estimated by using three different methods, namely the IEA CO_2 intensity method, the fuel use method and the EU-ETS CO_2 intensity method. This appendix explains what these three methods are, shows what the results are of these three methods and explains why the EU-ETS CO_2 intensity method is used to calculate the CO_2 emissions in this report. Next to these three methods data from the European commission Emission Trading System (EU-ETS) is available for the years 2005 to 2010 (European Commission, 2010a). The verified emissions from EU-ETS database are used to replace the emissions estimated by one of the three methods. The EU-ETS data is considered to be accurate data and therefore this data is used where this data is available. Because almost all CO_2 emissions of the utilities are in the EU-ETS this increases the reliability of the CO_2 emissions per power plant in the benchmark. When no EU-ETS data is available one of the three methods are used to estimate the CO_2 emissions. The three methods are discussed below and an explanation is given why the EU-ETS CO_2 intensity method is selected.

All the figures in this section are presented to illustrate of the differences in the outcomes of the three CO_2 emission calculation methods. These figures are chosen because these figures are good examples to show the differences in the results of the three CO_2 calculation methods. For both CO_2 estimations and the ETS data the CO_2 emissions are allocated to electricity and heat and therefore this could not be an explanation why there are differences in the results.

The best available data on which to base the CO_2 emissions of the utilities on is the data from the EU-ETS database. This data is available for the years 2005-2010 and are indicated with the dashed line in the figures. For the other years, one of the three methodologies is used to calculate the CO_2 emissions. When comparing the outcomes of the three methods there are differences between these results. Because there are differences in the results of the three methods, one method is chosen.

Table 11: CO_2 emission factors, based on IEA 2005

fuel type	Tonne CO_2/TJncv
Biomass	0
Coal Gas	108,2
Coal Generic	101,2
Coal Hard	98,3
Coal Peat	106
Coal Soft	101,2
Coal Waste	108,2
Geothermal	0
Landfill Gas	56,1
Natural Gas	56,1
Oil Heavy	77,4
Oil Light	69,3
Proc Gas	242
Solar	0
Uranium	0
Waste	73,3
Water	0
Wind	0
Wood	0
Other	73,3

11.1.1 Fuel use method

The fuel use method used the electric conversion efficiency to calculate the primary energy use per power plant. With this method the CO_2 emissions are calculated by using the produced electricity, the used resources and the emissions factor of the used fuel per electricity generation facility. The CO_2 emissions are calculated by:

$$CO_2 \text{ emissions (kg)} = \text{Electricity production (TJ)} \times \text{Electric efficiency (\%)} \times CO_2 \text{ emission factor per fuel (kg } CO_2\text{/TJ)}$$

The efficiency is based on the installation year of the power plant, where the assumption is made that older power plants are less efficient than new power plants. The efficiency is based on the reference efficiencies used by the European Commission (European Commission, 2006). This reference efficiency is given for the years

1997 to 2005. For the installation years before 1997, the efficiency is estimated using the growth factor of the efficiencies from the years 1997 to 2005. A minimum efficiency of 20% is used for old power plants, which is indicated to be a minimum efficiency for power plants (Yeh & Rubin, 2007), (Susta & Greth, 2001). The fuel use per power plant is multiplied by the emission factor of the primary fuel of the power plant which gives the total CO_2 emissions of the power plant. The emission factors are based on the emission factors given by the IEA, which are also used by the IPCC as default data, shown in table 11 (IEA, 2005). In addition to the CO_2 emissions estimations by the fuel use method, data from the EU-ETS is used (European Commission, 2010a).

The results of the fuel use method show that the inclusion of the EU-ETS data can be clearly seen in the years 2004 and 2010 in Figure 104. Especially the estimations of the CO_2 emissions from hard coal are higher than the actual CO_2 emissions of the EU-ETS, which can be seen by the steep decrease of the CO_2 emissions between the years 2004 and 2005. The CO_2 intensity of hard coal is about 800 gram/kWh based on EU-ETS data, while the fuel use method uses a CO_2 intensity of 1200 gram/kWh.

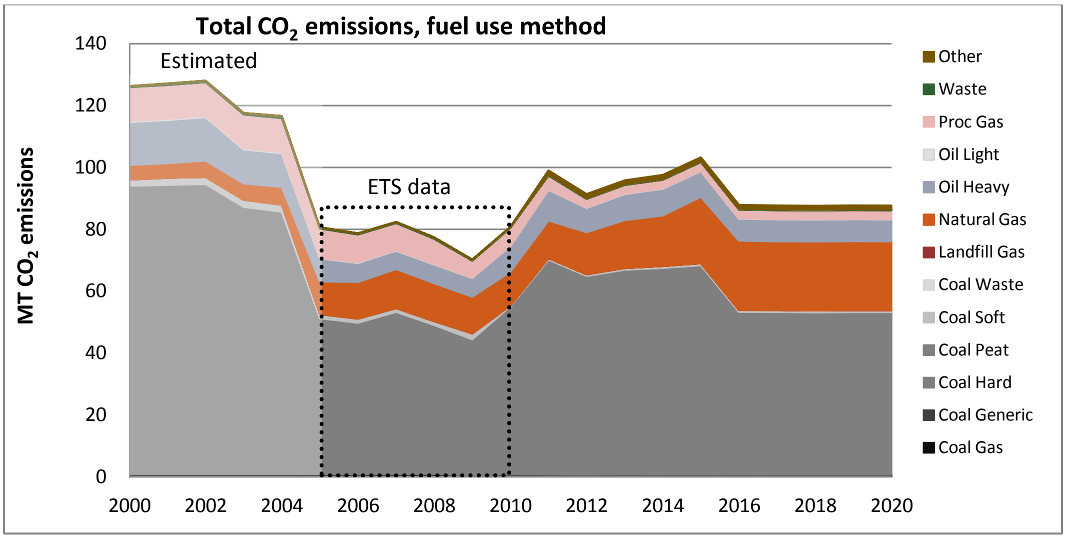

Figure 104: Total CO2 emissions of EDFusing the fuel use method, own calculations based on (Platts, 2010 Q1),

The CO_2 intensity used for the fuel use method is a fuel property, but the estimations of the efficiency of the power plants is a factor which is estimated. This explains why the CO_2 emissions calculated by the fuel use method can differ from the ETS data.

According to the results of Figure 104 the estimated efficiency for hard coal fired power plants is too low for the power plants of EDF. Another example of the differences between the assumptions of the fuel use method and the EU-ETS data is depicted in Figure 105. In this figure the differences are mainly caused by the soft coal emissions, with a CO_2 intensity for the fuel use method of 1200 gram/kWh compared to the CO_2 intensity based on EU-ETS data of 1400 gram/kWh. The results of the fuel use method for GDF Suez, shown in Figure 106, show that the estimated CO_2 emissions for natural gas are too high compared to the ETS data. The fuel uses a CO_2 intensity of 580 gram/kWh compared to a CO_2 intensity of 710 gram/kWh based on ETS data.

The differences between the ETS-data and the assumptions made by the fuel use method can be explained by the lack of good references for the assumptions of the electric efficiency of the power plants. The assumptions for the efficiency are not specified per country or per utility.

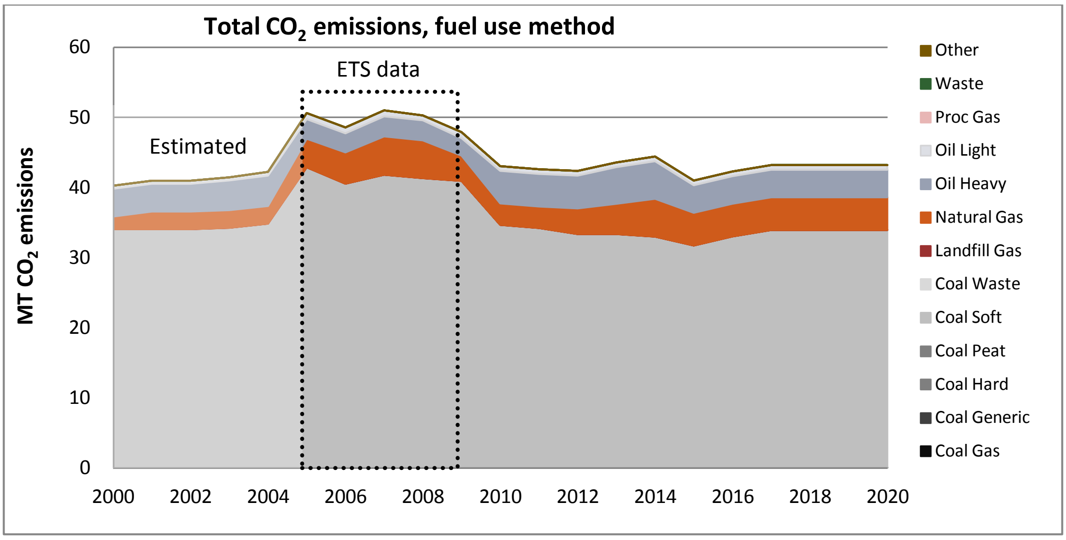

Figure 105: Total emissions of PPC using the fuel use method, own calculations based on (Platts, 2010 Q1), (European

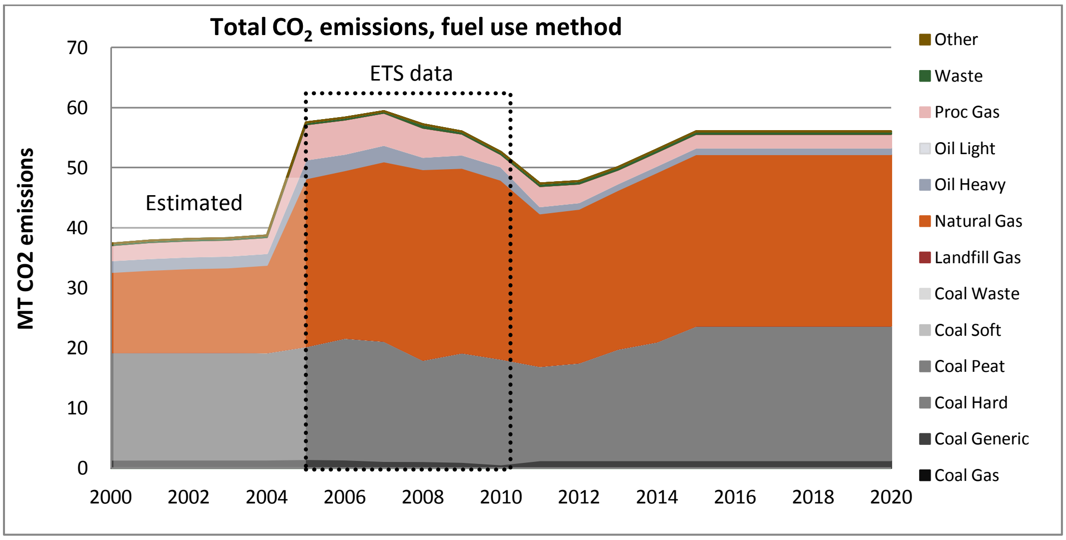

Figure 106: Total emissions of GDF Suez using the fuel use method, own calculations based on (Platts, 2010 Q1), (European Commission, 2010) and (GDF Suez, 2009)

IEA CO_2 intensity method

The IEA CO_2 intensity method uses CO_2 intensity data per country per year from the IEA and is calculated by:

$$CO_2 \text{ emissions (kg)} = CO_2 \text{ intensity per fuel (kg } CO_2\text{/kWh) x electricity production (kWh)}$$

The CO_2 intensity data gives the CO_2 intensity of electricity produced from oil, gas and coal and is used to calculate the CO_2 emissions per power plant. Where no data was available the average CO_2 intensity of Europe was used. For the upcoming years the average of the years 2000-2008 is used per country. Next to these estimations of the CO_2 emissions per power plants the data of the EU-emissions trading system (EU-ETS) is used (European Commission, 2010a).

Figure 107 shows a difference between the CO_2 emissions for the years 2004 and 2005. For this figure the estimations are based on the CO_2 intensities given by the IEA. The actual CO_2 emissions for hard coal are lower than the estimations based on the IEA CO_2 intensities, but for natural gas the CO_2 emissions are higher.

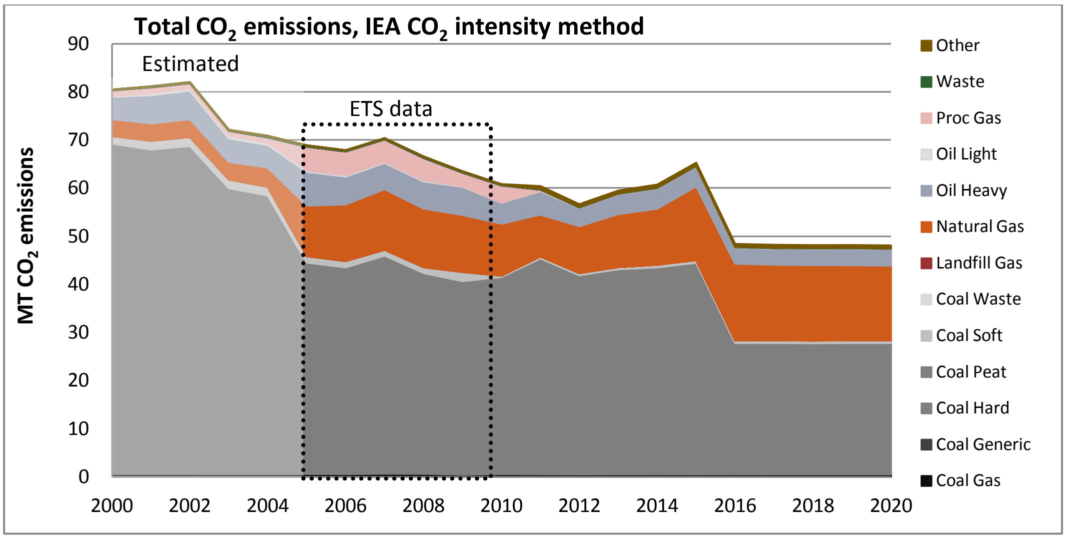

Figure 107: Total CO2 emissions of EDF using the IEA CO_2 intensity method, own calculations based on (Platts, 2010 Q1), (European Commission, 2010) and (EDF Group, 2009)

Figure 108 and show larger differences between the IEA CO_2 intensity method and the EU-ETS data. Figure 108 shows that the soft coal and the natural gas emissions of PPC are estimated too low with the IEA CO_2 intensity method compared to EU-ETS data. In figure 108 the estimated CO_2 emissions of hard coal are too low, opposite to the estimated hard coal emissions of EDF, which are too high. The largest differences are the CO_2 emissions of natural gas, with a CO_2 intensity of about 290 gram/kWh for the IEA method and about 700 gram/kWh for the EU-ETS data.

Because of variations in the results it is difficult to give a single explanation why there are differences between the results of the EU-ETS data and the IEA CO_2 intensities method. Because there is no consistency in the deviation of the estimations from the EU-ETS data, several reasons are given to explain the difference between the EU-ETS data and the estimations.

The first explanation is that the IEA CO_2 intensity method is based on the average CO_2 intensity of electricity produced by gas, coal or oil per country. Because the average per country is used it could be that the CO_2 intensity of the utility is different than the country average. Small difference could be

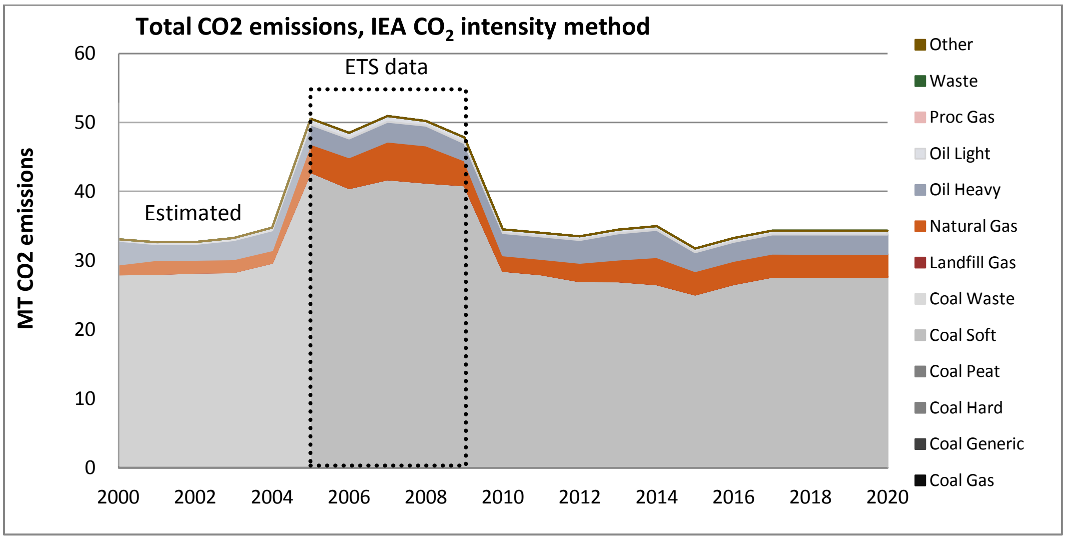

Figure 108: Total emissions of PPC using the IEA CO_2 intensity, own calculations based on (Platts, 2010 Q1), (European Commission, 2010) and (PPC, 2009)

explained by this effect, but the large difference in Figure 109 of GDF Suez is not possible. GDF owns a large share of the natural gas fired power plants in Belgium. The CO_2 intensity of Belgium is about 300 gram/kWh for natural gas according to the IEA data, while the calculated CO_2 intensity using the EU-ETS database is about 700 g/kWh. To come to an average of 300 gram/kWh there should be power plants with a CO_2 intensity below this average. A CO_2 intensity of 300 gram/kWh is already low and therefore it would be impossible to reach the given average CO_2 intensity of Belgium.

Another explanation for GDF Suez is that the estimated load factor for natural gas is too low. The load factor is now estimated around 3200 h/year, based on data from annual reports, and should be about 8000h/year to reach the same CO_2 emission level as given in the EU-ETS database. This load factor is far too high because natural gas fired power plants are not used as base load.

The most likely explanation of the large difference between the EU-ETS data and the assumptions for GDF Suez is a combination of explanations. The CO_2 intensity given by the IEA could be too low, GDF Suez can be above the average CO_2 intensities of the countries and this in combination with a load factor which can be estimated too low can give the large difference in the results

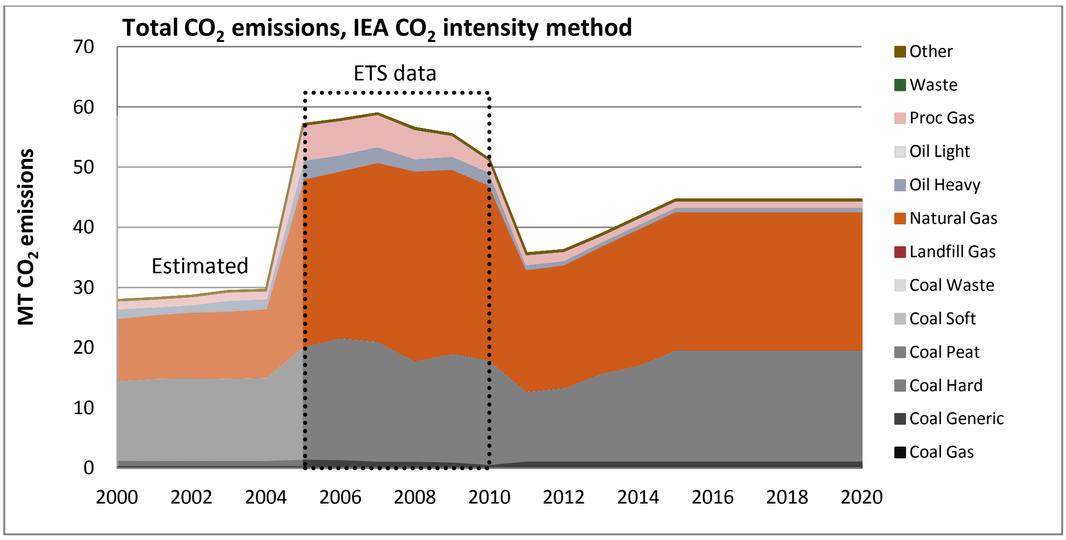

Figure 109: Total emissions of GDF Suez using the IEA CO_2 intensity, own calculations based on (Platts, 2010 Q1), (European Commission, 2010) and (GDF Suez, 2009)

11.1.2 EU-ETS CO_2 intensity method

For the results of this benchmark the ETS data CO_2 intensity method is used, which is described in section 2.4. The reason why this method is used is because the assumptions made for this method are more specific to the utility. While the IEA method uses CO_2 intensities based on average per country and the fuel use methods uses average efficiencies for Europe, the EU-ETS method uses the CO_2 emissions of the utility to make assumptions of the CO_2 intensity. As a result the outcomes of the total CO_2 emissions of the EU-ETS method do not show differences when the EU-ETS data is included for the years 2005 to 2010. This can be seen in Figure 110, Figure 111 and Figure 112, which show the results of the same utilities as discussed in the two other methods, but the differences between the ETS data and the estimations are lower.

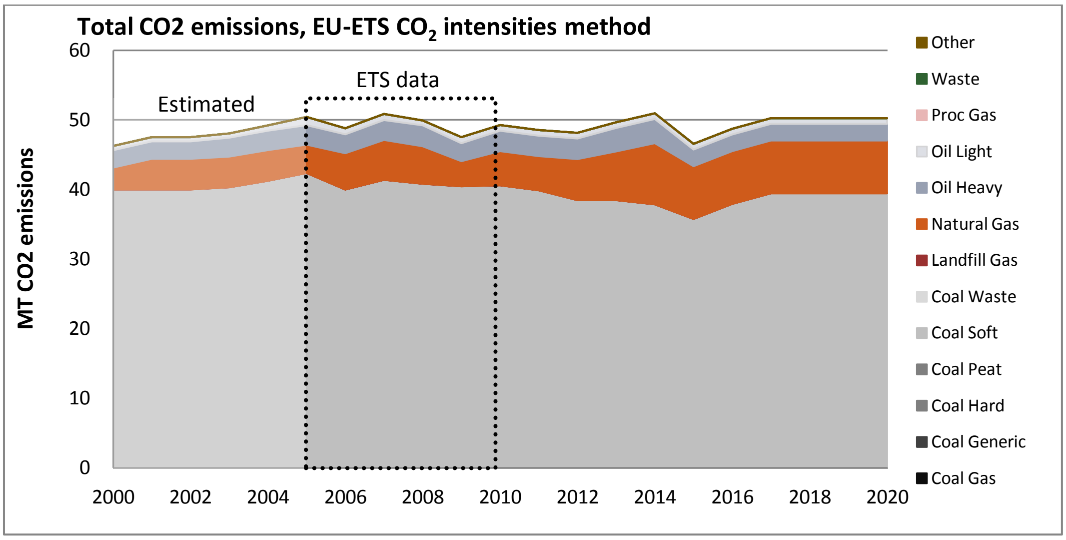

Figure 111: Total emissions of PPC using the EU-ETS intensities method, own calculations based on (Platts, 2010 Q1), (European Commission, 2010) and (PPC, 2009)

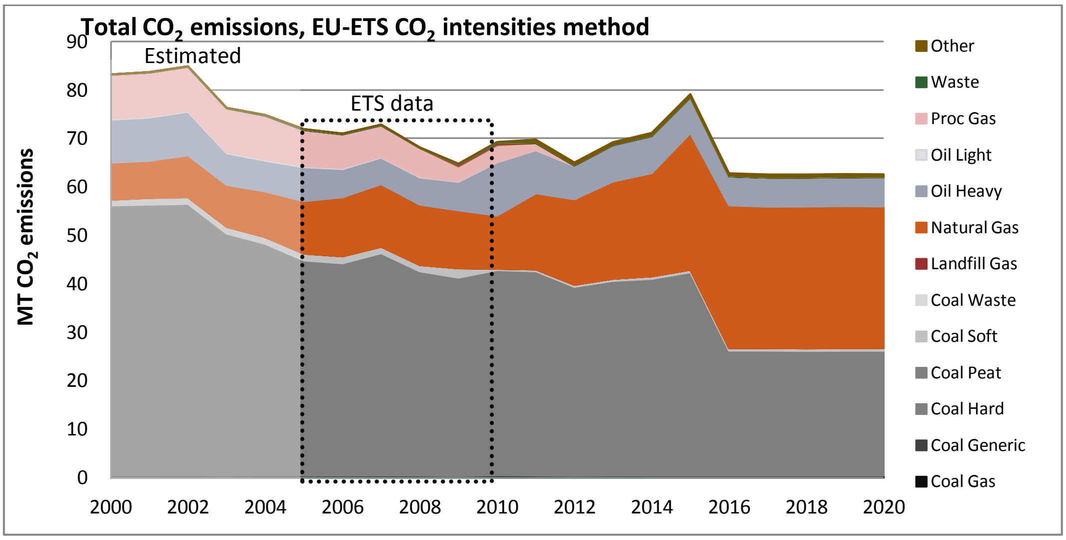

Figure 110: Total CO_2 emissions of EDF using the EU-ETS CO_2 intensities method, own calculations based on (Platts, 2010 Q1), (European Commission, 2010a) and (EDF Group, 2009b)

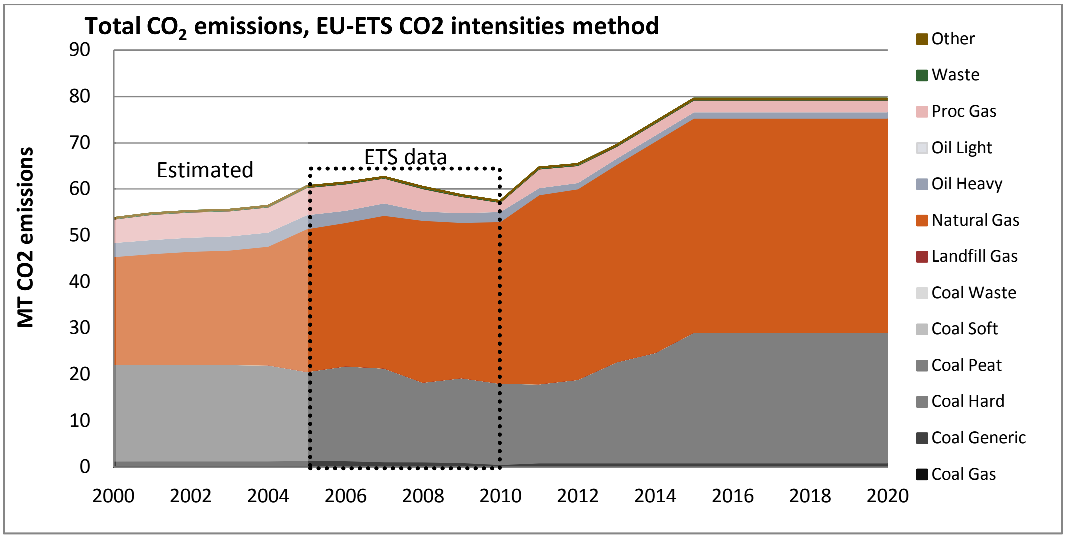

Figure 112: Total emissions of GDF Suez using the EU-ETS CO_2 intensities method, own calculations based on (Platts, 2010 Q1), (European Commission, 2010a) and (GDF Suez, 2009)