Towards sustainable energy consumption in German industrial sector: Is ISO 50001:2011 leading the way?

By

Mauricio Flores Argüelles

Student ID: 51211623

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DECLARATION

I am the author of the thesis entitled "Towards sustainable energy consumption in German industrial sector: Is ISO 50001:2011 leading the way?" submitted for the Degree of MASTER OF SCIENCE IN INTERNATIONAL COOPERATION POLICY at Ritsumeikan Asia Pacific University. This thesis is the result of my own research, except where otherwise acknowledged, and this thesis in whole or in part has not been submitted for an award to any other university or institution

Place: Konolfingen, Bern, Switzerland

NAME: MAURICIO FLORES ARGÜELLES

Date: July 13th 2013

Signature of the candidate.

Mauricio Flores A.

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ABSTRACT

The Oslo Symposium (1994) in 1994 proposed a definition of sustainable consumption as *"the use of goods and services that respond to basic needs and bring a better quality of life, while minimising the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardise the needs of future generations"* (iisd, 1994). But current energy consumption worldwide is far from being sustainable. According to the International Energy Agency, in 2010 the total world energy consumption was 12,717 Mtoe compared to the 6,107 Mtoe consumed in 1973 (IEA, 2012). This change represents an increment of more than 100%. Additionally, the scenario is not very favourable for Europe in terms of energy dependency. As the information provided by Eurostat (2012) showed, the energy dependency of the European Union (EU) on imported energy has increased over the last years. The total dependency on energy imports of the EU in 1999 was 45% while in 2009 this value increased to 54%.

In 2012 the CIA published a document in which elaborates on the current situation of energy supply in Germany and explains that after the Fukushima nuclear power plant disaster occurred on March 2011, the German government decided to shut down immediately eight of the 17 nuclear reactors operating at that time in Germany and which provided 23% of the total electricity demand of the country. In addition to this decision, the government also set the ambitious goal to close the remaining operating nuclear reactors by 2022, substituting that energy with renewables (CIA, 2012). All these issues combined urge government and companies to take appropriate actions to maintain competiveness and improve energy independency.

Energy efficiency is a key component in reducing fossil energy consumption and by reducing fossil energy consumption reducing both air pollution and climate change as well (Pardo Martinez, 2009). Therefore not only production cost savings, but also environmental cost reductions can be achieved by reducing energy consumption. (Park, et al., 2009). Measures implemented by German government (i.e. energy checks, Directive 2012/27/EU and subsidies) and international energy management standards such as ISO 50001 can help to reverse this trend.

In this research the energy efficiency tools implemented by the German government to reduce dependency on energy imports and improve competitiveness of German industrial sector will be depicted and examined. One of these tools is the implementation of ISO 50001. The objective of this research is to answer the questions: What is the current status of energy consumption of Germany? Is ISO 50001 implementation leading the way towards a more sustainable energy consumption in the industry sector in Germany? What are the benefits expected from the implementation of this Energy Management System? And, why should companies implement ISO 50001?

Along this research the benefits and obstacles of implementing energy efficiency measures in industry sector are described and analysed, showing how joint efforts of international and local stakeholders can help to reduce greenhouse gases emissions, improve competitiveness, increase energy independency and achieve a sustainable energy consumption in Germany. On the other hand, it was also found that only few of the big multinational companies part of the DAX 30 index are playing an active role in the implementation of the ISO 50001, but paradoxically they show a strong commitment to reduce energy consumption and improve their environmental

performance. This paradox suggests that maybe implementation of ISO 50001 is not the only solution currently available for companies to achieve their environmental and economic objectives.

German industry sector is peculiar since Small and Medium sized enterprises comprise more than 80% of the sector. Energy checks, subsidies and technical assistance offered by the government are the main resources currently available to improve energy efficiency of the SMEs in Germany. Therefore, implementation of ISO 50001 alone is not leading the way towards sustainable energy consumption in Germany; in fact ISO 50001 along with all the other initiatives are creating a strong synergy that is delivering good results as the trends of GDP and energy intensity of Germany show.

1 Introduction

The World Bank (2007) described how over the last years, the importance of standardization as a main promoter of economic development became more evident to governments; during this period, also most of the nations started taking part of the new globalized economic models and this caused that the amount and type of goods traded changed in an unprecedented way. One of these changes is the increasing significance of manufacturing sector as part of the national economies because of its high important role on the exports of any country; in fact manufacturing sector already overcame other economic sectors that were more important in former years. But globalization has brought some drawbacks too, such as the increasing competition among the manufacturing sectors generating additional economic pressures that have to be overcome by producers. (The World Bank, 2007)

All the issues mentioned above have an important and direct impact on climate change and resources scarcity, demanding for immediate actions. Increasing dependence on fossil and imported energy carriers and inefficient use of resources put consumers and producers in a vulnerable situation. Unexpected changes on fossil fuels and raw materials prices have costly effects and affect both economy of a country and global climate in a serious way. World's population is continuously increasing impacting global competition for natural resources and at the same time putting additional pressure on local, national and global environment. (European Commission, 2010).

According to the European Commission (2011) from the year 1999 to 2009, the dependency of the 27 European Union State Members (EU-27) on imported energy carriers reached almost a 54%; this is almost a 9% growth compared to the year 1999. On the other hand, energy generation from Renewable Energy Sources (RES) increased by 60% over the same period. The industry sector is among the top 3 of the energy consumers, just after transport sector and households. Total energy consumption of the industry sector alone, decreased by 15% since 2009 (European Commission, 2011). This reduction shows how industrial sector is taking the first steps necessary to reduce energy consumption.

Energy policies implemented in every country try to achieve three main goals: security of energy supply, environmental protection and economical growth. Energy efficiency is one powerful measure that can be implemented in order to achieve all the aforementioned objectives. (IEA, 2007) As part of the efforts of the EU to reduce energy dependency, on 25 October 2012 the EU adopted the Directive 2012/27/EU on energy efficiency. This directive establishes a common framework of measures for the promotion of energy efficiency within the Union in order to ensure the achievement of the Union's 2020 strategy and its 20% ultimate target on energy efficiency. All these efforts will smooth the way for further energy efficiency improvements beyond that date (The European Parliment and The Council of the European Union, 2012).

Thollander and Palm (2013) define energy management as *"the procedures by which a company works strategically on energy"* and energy management system is *"a tool for implementing these procedures"*; these two similar but different concepts are sometimes misunderstood and misused by organizations (Thollander & Palm, 2013). Energy management systems are not only to do with measurement, documentation, audits and action plans; implementation of these management systems requires also the right people who will lead the execution of the system and encourage other staff members and partners to be active members of the change process. A successful implementation of energy management system can save up to 40% of the energy consumed by the company and therefore increase its competitiveness.

One of the first energy management standards published was the international standard EN 16001:2009 Energy Management Systems Standard which was developed to ensure that energy management becomes integrated into organisational business structures, so that organisations save energy, save costs and improve energy and business performance. The aim of the standard was to put a set of practices in place that were effective, and result in measurable energy savings. (I.S. EN 16001:2009 Energy management systems – Requirements with guidance for use, 2007)

On 24 April 2012, the German standards institute DIN withdrew the EN 16001:2009 European standard and replaced it with the international ISO 50001:2011 standard. An energy management system (EnMS) is the critical factor for a company when achieving systematic, integrated and sustainable reduction of its energy

consumption. Within the scope of establishing an energy management system, organizations need to develop and implement sustainable organizational and operational procedures that will lead the way to improve energy use. (TUV SUD, 2012)

The main objective of this thesis is to describe energy consumption patterns of German industry and based on this information, elaborate on how implementation of ISO 50001 can help industry sector in Germany to achieve a higher competitiveness and reduce its dependence on energy imports by reducing their energy intensity. Along this documents some other energy efficiency initiatives will be described; by doing so, it will be possible to conclude if the efforts of industry in Germany to achieve a sustainable energy consumption are mainly driven by the implementation of ISO 50001 or if the current energy efficiency measures implemented in Germany are the ones which are leading the implementation of this recently introduced international standard.

The first part of the document describes the energy consumption and production patterns worldwide and intends to describe the current scenario in terms of energy production and consumption from a global, regional and national perspective. The following part elaborates on the different measures that industry sector in Germany has implemented to improve energy efficiency of the sector. On this section, more detailed information about composition of the industry sector and its energy consumption patterns in Germany is presented. Additional figures and trends of production of high energy-intensive products in Germany, highlighting the importance of improving energy efficiency are presented on this part too. Afterward, history, development, implementation and expected results of the ISO 50001 are presented. A set of conclusions on energy efficiency measures and ISO 50001 in Germany are provided at the end of the document.

2 Energy

2.1 Definition of sustainable energy consumption

Since the objective of this document is to identify sustainable consumption patterns in the industry sector, it is of high importance to start by defining the meaning of sustainable consumption. The Oslo Symposium (1994) in 1994 proposed a definition of sustainable consumption as "*the use of goods and services that respond to basic needs and bring a better quality of life, while minimising the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardise the needs of future generations*" (iisd, 1994). Based on this definition, it is possible to define sustainable energy consumption as: the use of energy that responds to basic needs and brings better quality of life, while minimising the use of natural resources, toxic materials and emissions of waste and pollutants over the life cycle, so as not to jeopardise the needs of future generations.

Consumption process is a multi-component process where more than one actor takes part in it. Demand-side, supply-side and socio-political aspects are the three main figures interacting when any good or service is consumed, as stated by Rennings (2013) (Rennings, 2013). These interactions have to be clearly understood so we can propose accurate and effective modifications that can lead a change on the energy consumption behaviour.

- Demand-side can be understood as the final stage of the consumption process. This stage is led by individual choices that result in the consumption of certain good or service that is offered in the market by a company or individuals. Demand side heavily influences the amount of goods or services that should be produced.
- Supply side includes economical activities of both private companies and governmental institutions that offer goods or/and services. Technological innovations implemented on manufacturing processes (for example, acquisition of state of the art boilers with a lower energy consumption or equipment able to produce a higher number of units using the same amount of energy) are one example of how suppliers and producers can influence supply-side by changing the characteristics of the products or services they offer.

- Socio-political aspects group all the activities of organisations, companies and governments that help to establish the legal framework in which the consumption process takes place. Tax rates and subsidies are two examples of how governments can influence consumption

Since energy consumption is a consumption process, it is clear that demand-side, supply-side and socio-political aspects can influence this process; based on this, changes on consumption behaviour, production and policies and regulations can lead the change from unsustainable to sustainable consumption.

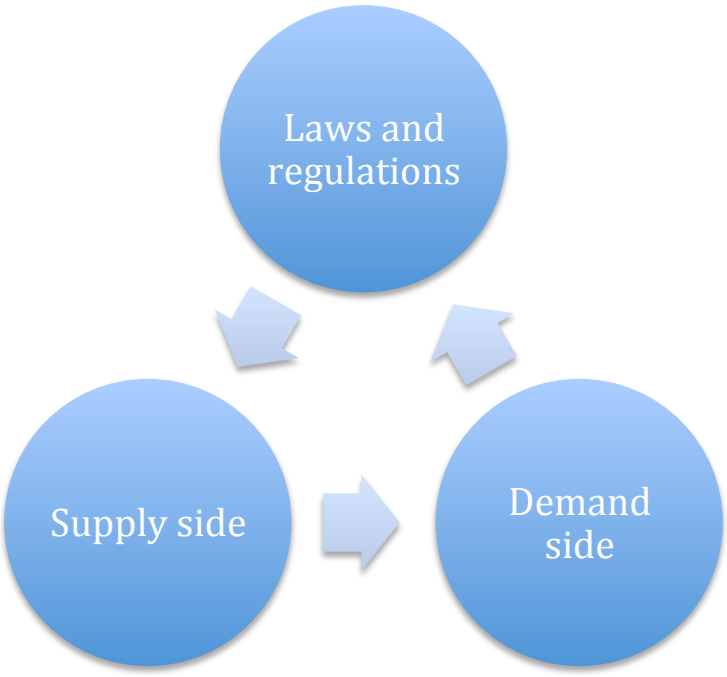

Diagram 2-1 Main actors of good consumption process

Even though consumers are motivated by personal or corporate decisions, supply side can influence behaviour of consumer. Summarizing, consumers play an important part on changing the energy consumption patterns of industry, for example by creating consumer associations or Non-Governmental Organizations that will demand more energy-efficient process to the industry. Along with the influence of the suppliers, governments influences consumption process as well by implementing policies and regulations.

Energy efficiency is a key component in reducing fossil energy consumption and by reducing fossil energy consumption reducing both air pollution and climate change as well (Pardo Martinez, 2009). Therefore not only production cost savings, but also environmental cost reductions can be achieved by reducing energy consumption. (Park, et al., 2009)

2.2 Energy consumption worldwide

According to the International Energy Agency, in 2010 the total world energy consumption was 12,717 Mtoe compared to the 6,107 Mtoe consumed in 1973 (IEA, 2012). This change represents an increment of more than 100%. The energy consumption by fuel is shown in the Figures 2.1 and 2.2[1]

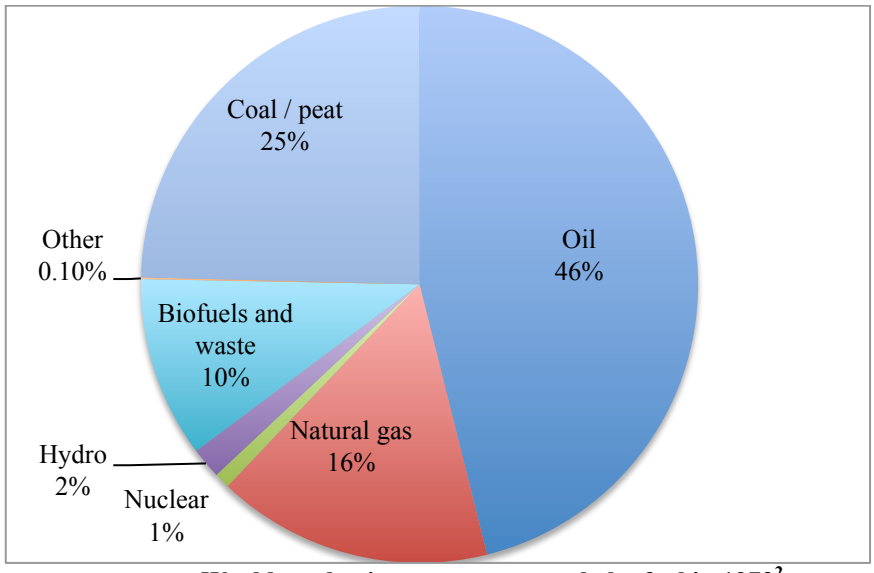

Figure 2.1 World total primary energy supply by fuel in 1973[2].

(IEA, 2012)

There are several reasons for this increasing energy demand. As explained by Malhotra (2013), booming economies of China, India and Brazil are eager for more energy and resources in order to continue developing. Another aspect that is leading this

[1] Other includes geothermal, solar, wind, heat and biomass.

[2] Total primary energy supply (TPES) is made up of: production + imports – exports – international marine bunkers – international aviation bunkers ± stock changes. For the world total, international marine bunkers and international aviation bunkers are not subtracted from TPES. (Eurostat, 2012)

growing energy consumption is the high densely populated Asia-Pacific region which is growing in terms of economy and population and is demanding as well for more energy and resources to satisfy the basic living conditions of its inhabitants; if this region were to consume the current world average demand, the amount of additional energy that would have to be supplied will be similar to the total energy consumed by the United States. (Malhotra, 2013)

Oil, natural gas and coal are energy carriers widely used to produce energy worldwide. According to the International Energy Agency (2012), in 2011 Saudi Arabia, the Russian Federation and United States were the top oil producers with 12.9, 12.7 and 8.6% of the total world production respectively. As for the natural gas production the Russian Federation produced 20% of the total natural gas in the world, closely followed by the United States with 19.2% being these two countries the top natural gas producers worldwide in 2011. In terms of coal production the main coal producers in 2011 were China with almost 46% of the total production and United States with 12.9%, therefore only two countries concentrate more than 50% of the coal production of the world. (IEA, 2012)

The Reserves – to - production ratio is a value that indicates the length of time that a given amount of fuel reserves can be used if the production keeps its same rate. According to the BP Group (2012), the current reserves – to - production ratio worldwide of oil is around 54 years, and the current reserves-oil-production ratio of natural gas is around 64 years. As to the Europe and Eurasia region, the scenario is more challenging regarding oil resources since the reserves – to - production ratio of oil is 22 years; on the other hand, the reserves – to - production ratio of natural gas of this region is 76 years and higher than the worldwide average mainly because of the increasing reserves recently found in the Turkmen region. (BP Group, 2012)

Share of the energy carriers as part of the total primary energy supply has been changing over the last decades. The main changes can be observed on the share of natural gas, nuclear and oil while the others remain more or less the same or with slight changes. The international Energy Agency (2012) published information on the amount and type of energy carriers consumed over the period from 1973 to 2010. Over this period, the share of natural gas increased from 16% to more than 21%, nuclear energy

increased its share from 0.9% to 5.7%. On the contrary, share of oil behaved in a different way, reducing its share from 46% in 1973 to 34% in 2010. (IEA, 2012)

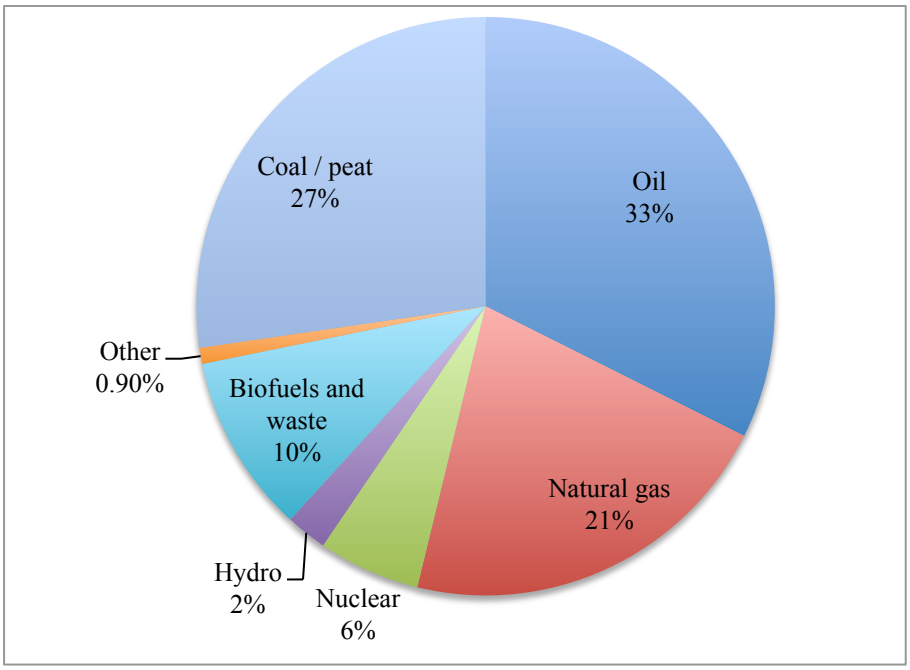

Figure 2.2 World total primary energy supply by fuel in 2010.

(IEA, 2012)

According to the International Energy Agency (2009), industry sector consumes one third of the total final energy consumption worldwide and the CO_2 emissions from this sector represents 40% of the total energy-related CO_2 emissions. Over the last years, energy efficiency measures in the industry sector have reduced the CO_2 emissions of this sector but constant growing rate of industry have offset these reductions. Based on the information collected from international agencies working on the energy field (IEA, 2009), it is calculated that it is possible to save between 25 to 37 EJoules[3] per year if new technologies and best practices are implemented. To keep this figure in perspective, this amount of energy is 1.5 times the annual consumption of Japan in 2007.

[3] 1 EJoule = $1x10^{18}$ Joules

2.3 Economic scenario and energy consumption of Germany

Porter (1990) defines competitiveness as the *"set of institutions, policies, and factors that determine the level of productivity of a country"*. But potentials to improve competitiveness varies from country to country; for example: some countries posses high amounts of resources while other countries have higher amounts of capital; when one of these differences put a country in a more advantageous position compared to others, we can say that the country has a *"competitive advantage"* (Porter, 1990). The main change that global economy has suffered over the last decades is the change on the type of resource that creates this competitive advantage as explained by Pillania (2009). In former times countries traded mainly natural resources such as wood, energy carriers and food but nowadays "trade" of knowledge has become the main competitive advantage that any country can posses since knowledge can impact national economies in a very effective and long lasting way and it can be traded very easily. This is the reason why present world economy is much more competitive than before (Pillania, 2009)

The type of research conducted so far on competitiveness of nations has not been as comprehensive and deep as competitiveness analysis of companies but that trend has changed over the last years (Garelli, 2006). Nowadays it is possible to find very detailed country competitiveness reports issued mainly by The Global Competitiveness Ranking and the World Competitiveness ranking by the World Economic Forum. Schwab (2011) explains that competitiveness plays a key role in economic development since a country with a higher degree of competitiveness offers more certainty on the investments that can be translated in more attractive economic benefits. One of the most important benefits of being a highly competitiveness is that the stability in the country will be translated at the end of the day in a better quality of life for the inhabitants. (Schwab, 2011)

Germany is a very competitive country and its 6th place on the list of the most competitive countries in the world, as published by The Global Competitiveness Report 2012-2013 (2012) speaks for itself. Germany holds a remarkable 3rd place in terms of the quality of the infrastructure that makes transport of any type of goods possible across the whole country whether by plane, train, ship or truck. National market in

Germany has advantages over most of the countries in the world; it is a market mainly driven by local competitors and presence and control of national market by big companies is not so dominant. This, in addition to the quite large domestic market and an important export sector creates a healthy national economic environment. Furthermore, German companies as a whole occupy the 4th place in R&D investments and this can give a better picture of what can be achieved in Germany in terms of innovations on energy efficiency measures in industry. (The World Economic Forum, 2012)

As to the current economic scenario in Germany, the Central Intelligence Agency of the United States (2012) states that German economy is the fifth largest economy in the world and the largest economy of Europe. Industrial sector in Germany is very diversified and the main exports of Germany are: motor vehicles, machinery, chemicals, computer and electronic products, electrical equipment, pharmaceuticals, metals, transport equipment, foodstuffs, textiles, rubber and plastic products. As October 2012, the industry sector employed more than 5 million people in Germany, representing an increment of 1.7% higher than the value obtained in 2011 showing how this sector is growing (Statistisches Bundesamt, 2012). The main country partners of Germany in order of importance are France with 9.4% of the trade share, United States 6.8%, The Netherlands 6.6%, United Kingdom 6.2%, Italy 6.2%, China 5.7%, Austria 5.5%, Belgium 4.7 and Switzerland with 4.4%. (CIA, 2012)

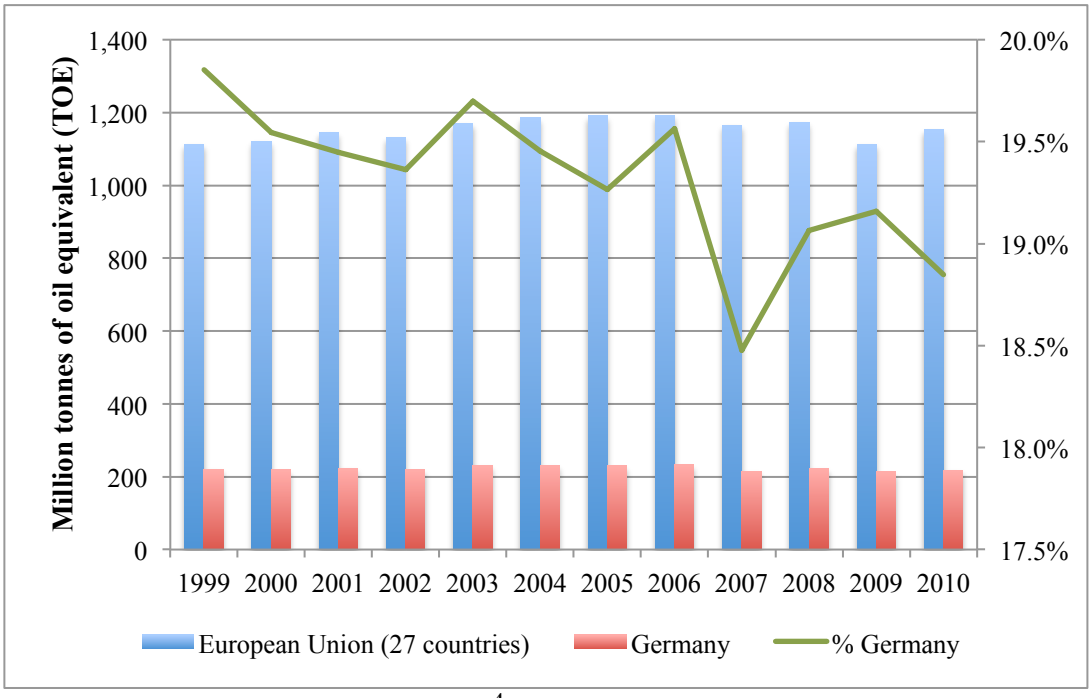

Figure 2.3 Total final energy consumption[4] in Germany and the 27 European Union member countries.

(Eurostat, 2012)

Based on the information provided by Eurostat, in 2010 the final energy consumption of Germany was around 200 Million tonnes of oil equivalent. Since 1999 share of the German energy consumption within the EU decreased from almost 20% to less than 19% in 2010. (Eurostat, 2012)

In 2012 the CIA published a document in which states that after the Fukushima nuclear power plant disaster occurred on March 2011, the German government decided to shut down immediately eight of the 17 nuclear reactors operating at that time in Germany and which provided 23% of the total electricity demand of the country. Along with this decision, the government also set the ambitious goal to close the remaining operating nuclear reactors by 2022, substituting that energy with renewables. (CIA, 2012)

[4] Final energy consumption is the total energy consumed by end users, such as households, industry and agriculture. It is the energy that reaches the final consumer's door and excludes that which is used by the energy sector itself. (Eurostat, 2012)

According to economic models developed by Blesl, Das, Fahl &Remme (2007), shutting down nuclear power plants will increase energy dependency of Germany on coal and lignite imports in the long run despite of the expected reduction on the primary energy consumption boosted by energy efficiency measures applied in the industry sector (Blesl, Das, Fahl, & Remme, 2007). This is one important reason why the share of energy produced from renewable technologies in Germany has been increasing constantly.

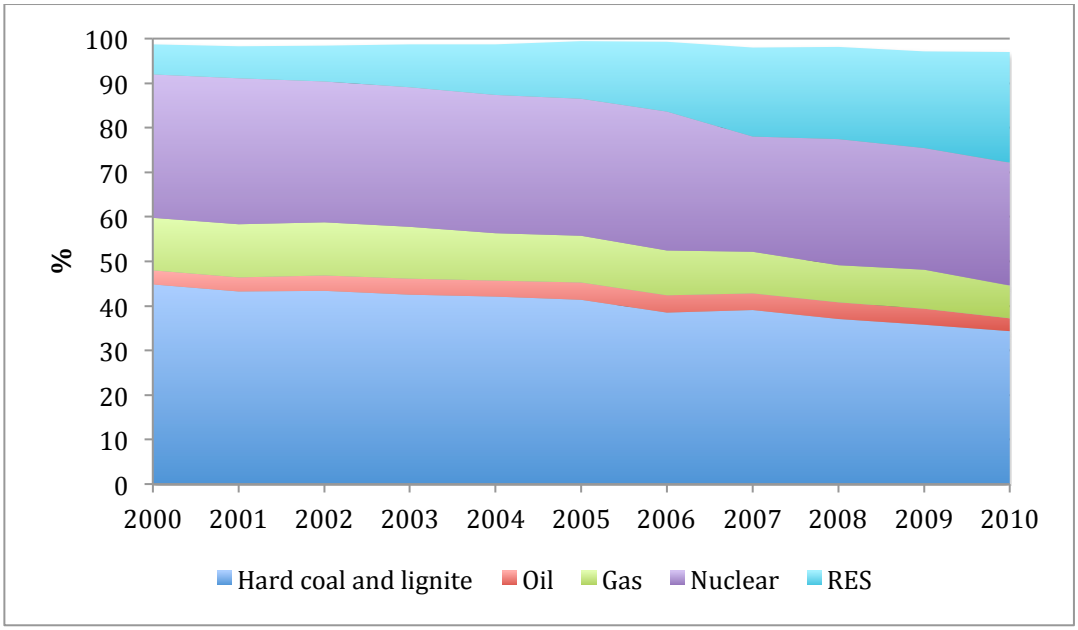

Figure 2.4 Primary energy production by fuel in Germany[5] (%)

(Eurostat, 2012)

As a result of these changes and challenges in terms of energy supply, composition of the energy mix in Germany has changed over the last years and although the type of energy carriers remains the same (coal, oil, gas, nuclear and renewables), the share of each of them as part of the total energy supply has changed. The main changes are an increasing share of renewables and a decreasing share of nuclear and natural gas; usage of oil and coal has shown a very slight change but for these two cases the result is also positive and share of both of them has decreased.

[5] RES stands for Renewable Energy Sources

As to the final energy consumption in Germany, its composition in terms of economic activity has remained almost constant over the last decade. In 2010 industry sector consumed around 28% of the total energy produced in Germany, transport and households counted each for 28% of the energy consumption and the service sector consumed the remaining 16%.

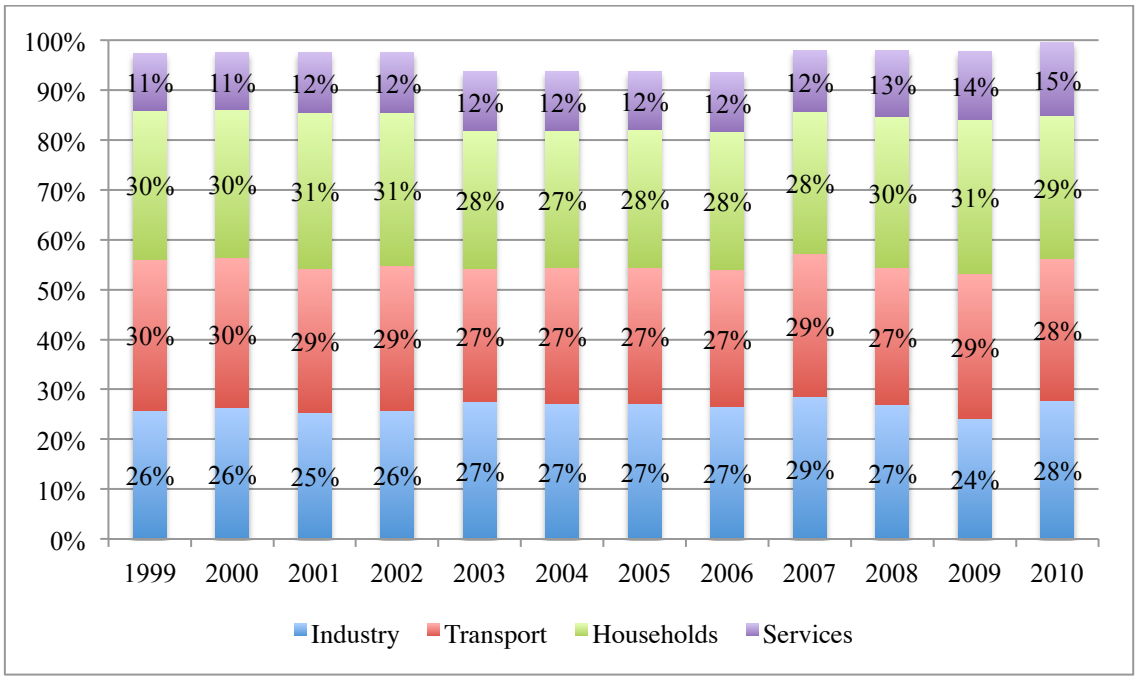

Figure 2.5 Final energy consumption in Germany by sector (%).

(Eurostat, 2012)

From 1991 to 2010, the Odyssee program calculated that ODEX index of Germany decreased by 24%. This means that energy efficiency increased by 1.2% on average each year. Despite this improvement, this positive trend of energy efficiency has not been consistent since year 2000 (Figure 2.6), principally because of energy efficiency measures that have not been implemented in energy-intensive processes such as steel and paper production caused by the lack of financial resources. Because of this discouraging trend of energy efficiency, an additional energy efficiency budget was allocated to the German National Climate Initiative and a special energy efficiency fund was created. Both of these initiatives aim to fund energy efficiency measures proposed by municipalities, industry, SME and final consumers. Additionally, German

government is supporting implementation of energy audits and energy management systems such as ISO 50001 and energy checks in industry; by embracing and implementing these initiatives, companies can apply for fiscal benefits offered by the government. (Odyssee, 2012)

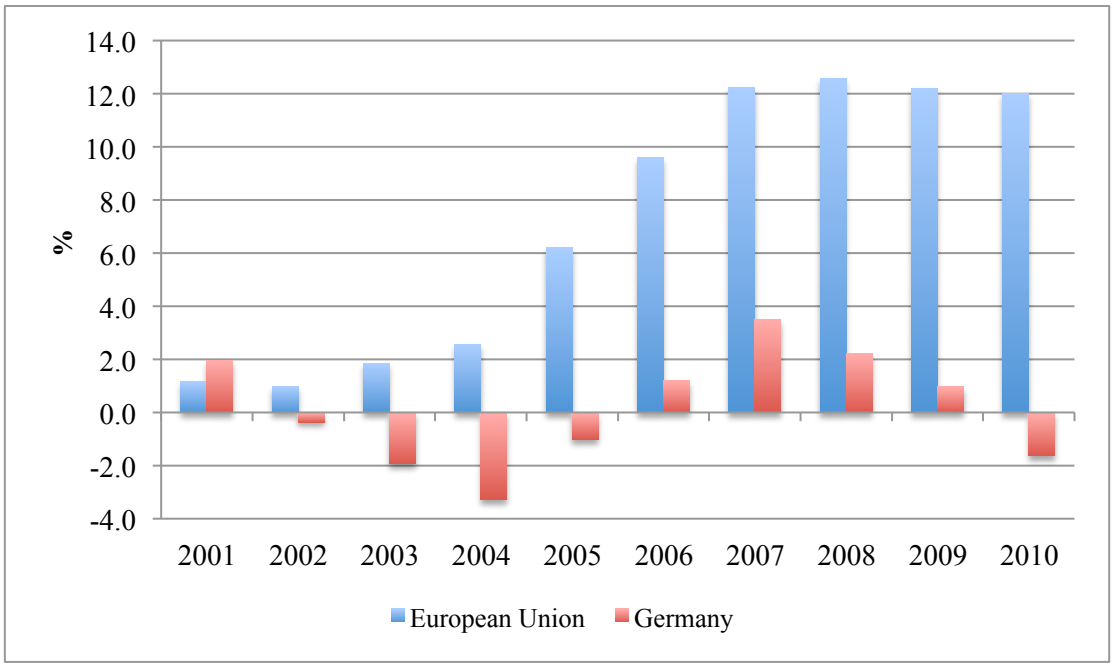

Figure 2.6 Energy efficiency gains[6] in German industry.

(Odyssee, 2012)

2.4 Economic implications of energy dependency in Europe.

The information provided by Eurostat (2012), shows that the energy dependency of the European Union (EU) on imported energy has increased over the last years. The total dependency of the EU in 1999 was 45% while in 2009 this value increased to 54%. Only one out the 27 Member States of the EU is a net energy exporter and it is Denmark; the rest of the countries import the energy carriers they need to fulfil their energy requirements. The energy dependence percentage varies widely, going from

[6] For industry, the evaluation is carried out at the level of 11 branches: 5 main branches: chemicals, food, textile & leather, machinery, transport vehicles; 3 energy intensive branches: steel, cement and pulp & paper; 3 residual branches: other primary metals (i.e. primary metals minus steel), other non-metallic minerals (i.e. non-metallic mineral minus cement) and miscellaneous branches. (Odysee, 2010)

20% of Romania to values around 100% for Luxembourg and Malta (Eurostat, 2012). The German dependency on energy imports over the last years is shown on Figure 2.6.

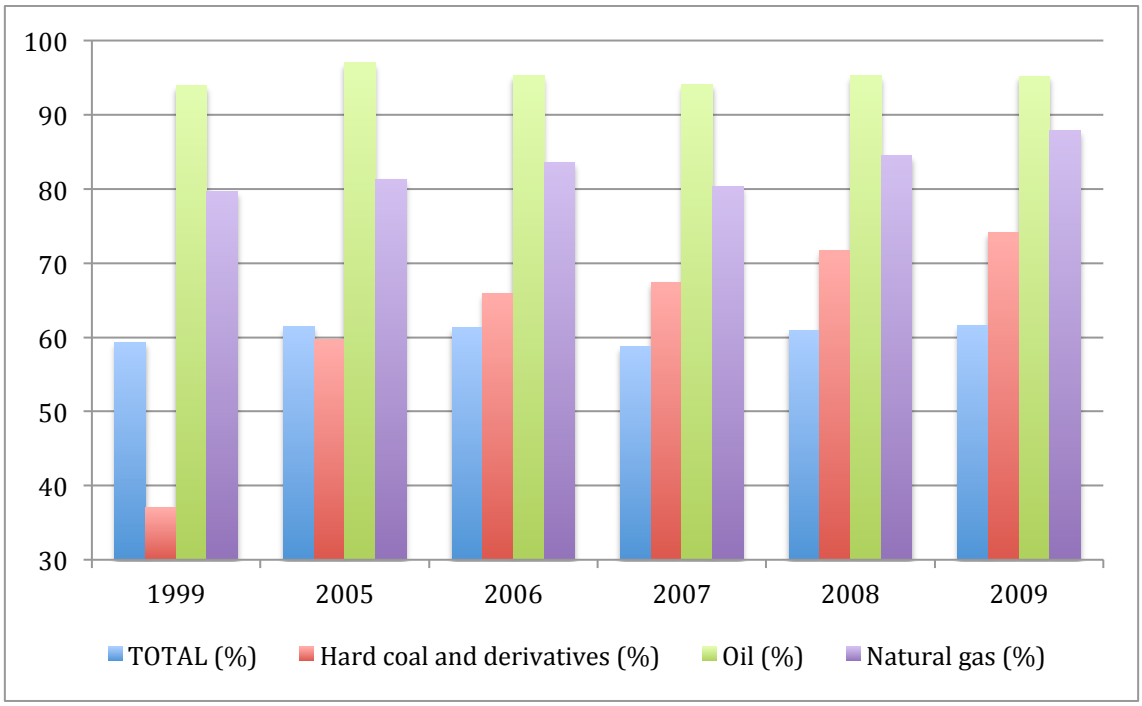

Figure 2.7 Germany energy dependency on imports by energy carrier.

(Eurostat, 2012)

As it is shown on Figure 2.6, total dependency of Germany on energy imports has increased from 59% in 1999 to more than 61% in 2009. This value is higher than the 54% average energy dependency of the European Union. If this trend is analysed along with the increasing oil price over the same period of time it is possible to understand why energy efficiency is of vital importance for the European Union and why the relevance of the efforts to improve energy efficiency.

The data on Figure 2.7 shows the trend of oil prices from 1999 to 2011. The price of the West Texas Intermediate and Europe Brent oil (two of the main indicators of oil price used worldwide) increased by more than 490% for the former and by more than 620% for the latter respectively (U.S. Department of Energy, 2012). Based on this information, the necessity of decoupling economic growth and energy consumption becomes obvious.

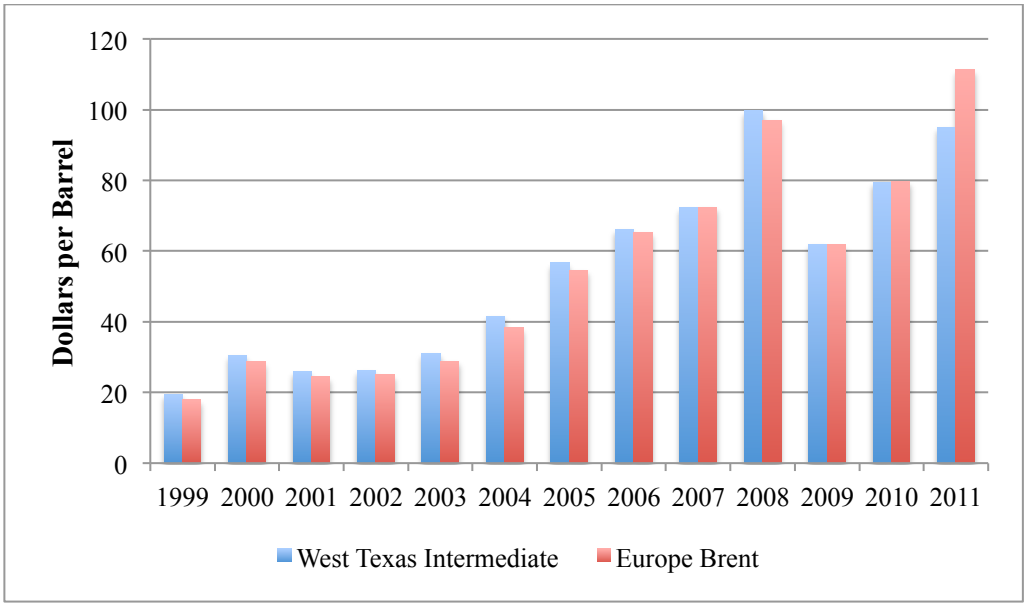

Figure 2.8 Prices of crude oil.

According to the information provided by the World Bank (2012), German Gross Domestic Product (GDP) grew constantly since 2000 until the world economic crisis in 2008 (Figure 2.8).

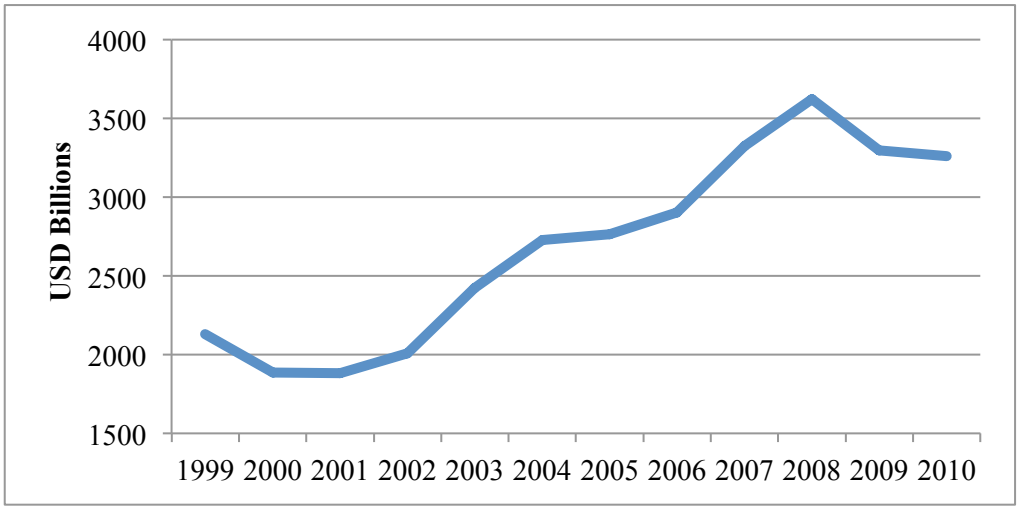

Figure 2.9 Gross Domestic Product (GDP) of Germany

(The World Bank, 2012)

It is important to highlight the fact that distribution of GDP by economic sector in Germany has remained almost the same over the last years. On average service sector makes 70% of the GDP, industry sector counts for 29% and agriculture 1%. (Figure 2.9)

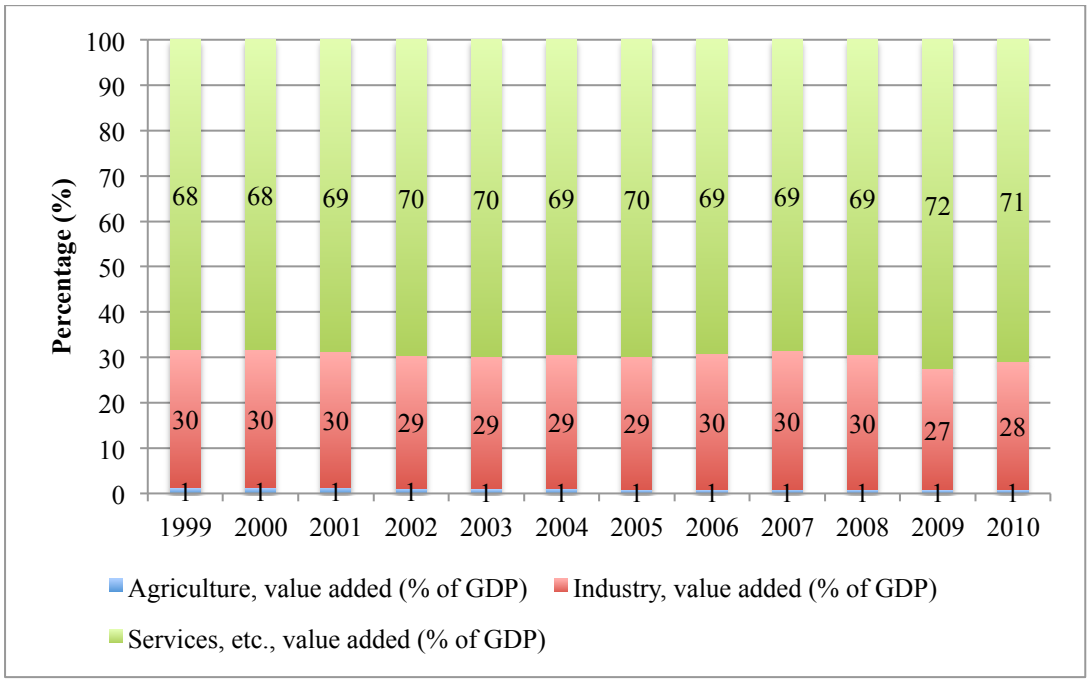

Figure 2.10 Composition of German economy in terms of GDP

(The World Bank, 2012)

An interesting fact appears when energy intensity of German economy over the same period of time is plotted, showing how energy intensity (energy consumption for every 1000 Euro of GDP) of Germany has decreased in an important and constant way since the year 2002, going from more than 160 kg of Oil Equivalent (OE) to less than 145 kg of OE per 1000 EUR in 2010. (Figure 2.10)

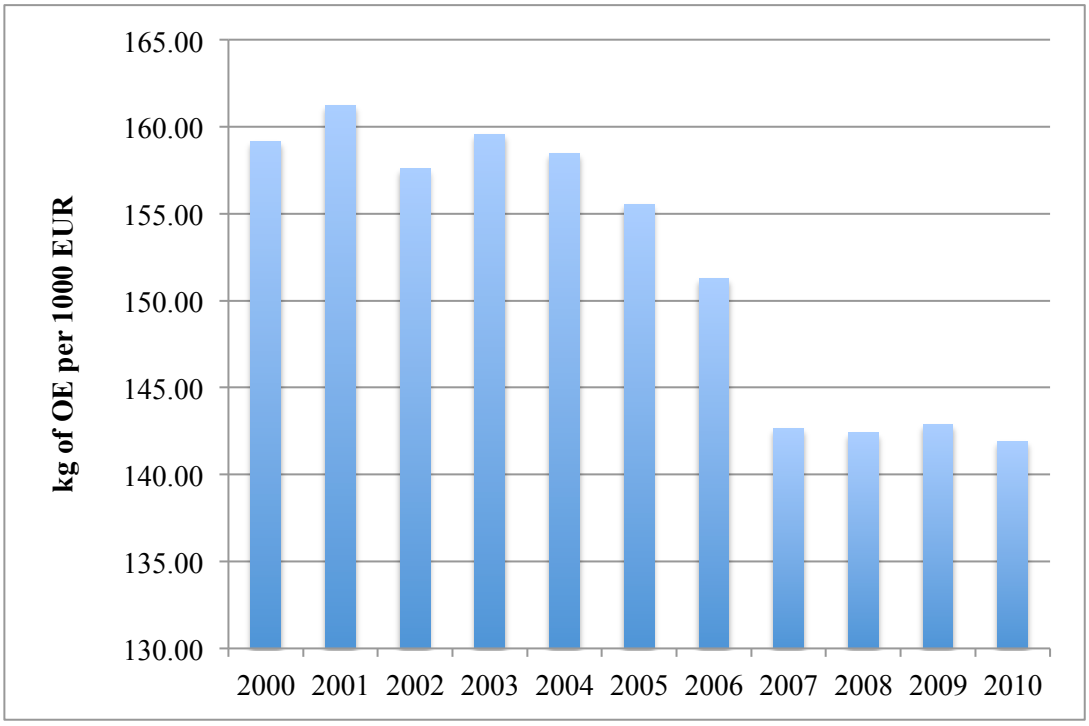

Figure 2.11 Energy intensity[7] of Germany

(Eurostat, 2012)

Since composition of GDP has remained almost constant, energy intensity has decreased but GDP has risen over the last years, it will be valuable to talk more about the composition and the efforts taken by the industry sector in Germany to identify the main reasons of these changes. The next chapter deal with this topic.

2.5 Composition of German industry sector

Since this research is focused on the industrial sector, it is necessary to know more about the composition and importance of this economic sector in Germany with the objective to identify the main players and motivations that could influence final energy consumption. Trianni & Cagno (2012) studied the composition of industrial sector in Europe and their results showed that this sector is mainly formed of SMEs (up to 90% in some cases) in almost all countries; additionally these SMEs are at the same time an important part of the domestic industrial consumption. In Italy for example, SME sector represents more than 60% of the domestic industrial consumption. The result of this

[7] This indicator is the ratio between the gross inland consumption of energy and the gross domestic product (GDP) for a given calendar year. (Eurostat, 2012)

study also shows that the energy consumption of most of the companies of this sector produce non-energy intensive goods; this means that energy costs of these companies do not exceed more than 2% of their turnovers (Trianni & Cagno , Dealing with barriers to energy efficiency and SMEs: Some empirical evidences, 2012) and therefore reduction on the energy consumption is not as urgent as other potentials to reduce operative costs.

According to the statistics of the World Steel Organization (2012), Germany is one of the main steel producers worldwide; in 2011 Germany produced almost 45 million tons of steel and this figure represents almost 30% of the total production of the European Union and almost 2% of the total amount of steel produced in the world (World Steel Organization, 2012). Germany is an important iron producer as well, in 2011 almost 28 million tons of iron were produced in Germany and is equal to the 30% of the total European production and 2.5% of all iron produced worldwide (World Steel Association, 2012). As to other high energy-intensive products and according to the United States Geological Survey (2012), Germany produced in 2011 1% of all the cement produced in the world (USGS, 2012), 1.8% of the wood pulp for paper produced in the world in 2011 was produced in Germany (FAO, 2012), 1% of the aluminium is produced in Germany (USGS, 2012). Chemical industry plays also a key role on German economy and is a high energy-intensive industry as well. Chemical industry in Germany is the largest chemical industry among the EU-27 and according to Saygin et al. (2012) this sector accounts for 22% of the total final energy consumption in the EU and 4% worldwide (Saygin, et al., 2012). Given this scenario it is very likely that the amount of potentials for energy efficiency measures in industry sector in Germany is large and it can impact national economy and dependency on energy imports in a positive and important way.

The Small Business Actor for Europe (SBA) is an initiative developed by the European Union whose main aim is to support the SME sector in Europe. One of the activities conducted by the SBA is to compile information on the number, type and economic activities of the SMEs. The SBA Fact Sheet 2012 (2012) shows that in the German industry sector, the SME sector represents 99.5% of the total number of enterprises located in the country and this share represents almost 54% of the value added of the industrial sector in 2011. The SME sector in Germany is considered as the

benchmark of SME sector of all the EU and its main products are produced with medium and high-tech technology. For this reason, these high-value-added products generate a high economic contribution to the total GDP and with a 62% of the total employees of the industry sector of Germany this sector constitutes also an important source of employment. (European Commission, 2013)

2.6 Energy efficiency efforts of German industry sector

Energy resources are limited and integration of renewable energies in the current energy mix makes access to renewables more fluctuating because of a higher volatility. As mentioned by Grimacer & Seliger (2012), alignment of industrial energy demand to energy availability is important to reduce costs caused by losses for oversupply and expensive energy storage. For all these reasons high energy and environmental awareness of decision makers and staff in general of manufacturing sites is necessary to achieve a significant change on energy consumption (Grismajer & Seliger, 2012).

Since the 1970s and triggered mainly by the oil crisis that took place on that time, leading countries of the OECD like Germany have pushed hard to achieve higher efficient energy consumption; the main change implemented by these countries in order to achieve this goal was adjustments on the policies that were on place at that time. As Geller et al. (2006) highlight on one of their research papers, by looking at the current total energy consumption and greenhouse gases emissions of these countries it is possible to notice that these changes made by the governments at that time were brought positive effects. In fact energy efficiency measures implemented by the OECD country members reduced energy consumption by 49% compared to the business as usual scenario calculated in 1998; Japan and electricity sector of the state of California in the United States are the leading players since they achieved remarkably good results on reducing energy consumption by implementing smart, effective and well designed policies. (Geller, Harrington, Rosenfeld, Tanishima, & Unander, 2006)

Concerning energy efficiency measures taken by industry, there are examples of how these efforts have contributed to reduce the energy intensity of Germany. Bittermann (2007) for instance, describes a case study that describes how industry associations like the German Pumps + Systems Association and the Deutsche Energie -

Agentur have joined efforts to help industrial sector to identify potentials for energy saving and to take appropriate measures to capitalize them. For example, just by optimizing an industrial pumping system, 37% of energy consumption can be saved and the payback period of this project is four years with a return on investment of more than 21% (Bittermann, 2007).

Energy check is another effort done by the industrial sector in Germany to improve energy consumption. The Department of Energy of the United States (2010) defines the Energy Check as an *"energy management tool for the medium to large industrial or commercial customer"* (U.S. DOE, 2010). The German Government through its Ministry of Economy launched the Energy Audits program in 2008 aimed to offer subsidies to SMEs and provide financial support to pay the services of experts that will conduct energy checks in the companies (Gruber, Fleiter, Mai, & Frahm, 2011). These energy checks in Germany are conducted by certified "Energy Checkers"; the energy checkers visit the facilities that are willing to know more about their energy consumption and saving potentials. After collecting the information on-site, the energy checker enters this information into specific software tools and documentation that will show areas of improvement and possible savings that can be achieved if implemented in the company (B.&S.U. mbH, 2006) The focus group of this initiative is mainly SME but since the scope of the tool is very wide, it is possible to apply it in larger companies as well although larger organisations cannot apply for fiscal benefits.

Implementation of energy efficiency measures in SMEs and non – energy - intensive companies are relatively easy. Based on the results of the energy checks, showed by Thollander and Palm (2013), between 60 to 90% of the potentials found during the energy checks are on the process to be implemented. Must of the measures implemented in the companies are not extremely complex neither expensive and consist mainly on changing the type of bulbs, improve the ventilation system of the facility and other similar modifications. Inexpensive and easy – to - implement energy efficiency measures in SMEs make this sector the most attractive for improving energy consumption. (Thollander & Palm, Improving Energy Efficiency in Industrial Energy Systems, 2013)

Moradi, Hajinazari, Jamasb and Paripour (2013) elaborate on distributed electricity generation and small-scale electricity generators located close to the points where electricity is consumed and these authors also explain why these solutions are good examples of how companies are improving their energy consumption and reducing the related emissions at the same time. This type of systems is attractive since it allows companies to improve the quality of energy they use and reduce also the impact on environment. Distributed generation is a very good option to optimize the energy consumption of energy-intensive (whether electricity or heat) processes because it allows also cogeneration either combined heat and power (CHP) and combined cooling heat and power (CCHP). Both CHP and CCHP technologies have shown attractive economic results and have delivered good results in terms of environment as well. (Moradi, Hajinazari, Jamasab, & Paripour, 2013)

International industry associations play also an important role when it comes to reducing energy consumption through joint efforts. German industry sector is part of the European technical association VGB PowerTech e.V. (2013), an association focused on improving generation, distribution and use of energy in the industry sector as well as the utilisation of by-products obtained from these operations. The approach of this association is very comprehensive, and takes care of the whole add-value chain going from the design and construction to operation of power plants as well. The specific objectives of this organization is to share state of the art technologies and best practices among the country members in terms of design, construction and operation of productive processes. VGB publishes a monthly magazine containing the detailed reports of the projects that are happening at the moment. One special feature of this association is that experts review the outcome of the projects, in order to assure the quality and relevance of the information that will be published. (VGB PowerTech e.V., 2013)

The local learning network is another example of how German industry sector is enlarging the impact of energy efficiency potentials. Different companies from a variety of manufacturing process compose these networks and the objective of these associations is to share successful energy efficiency measures. Even though grouping different companies into the same network can be challenging, the positive results of sharing information and learning from experience of other companies help to maintain

the group together and even growing. Jochem & Gruber (2007) calculated the benefits obtained by this type of associations and showed that by implementing the ideas generated within these networks, companies have been able to save more than 2.5% of their energy consumption by year (Jochem & Gruber, 2007).

Even tough there has been a great improvement in terms of energy efficiency measures implemented by the industrial sector, the International Energy Agency (2007) estimates that energy use and CO_2 emissions attributable from this economic sector can still be reduced by and additional 25 to 33% specially in those very energy – intensive manufacturing process such as steel, paper and pulp, cement and iron production (IEA, 2007). Convery (1998) explains that a combination of governmental support and joint efforts like industry associations and local learning networks described earlier make implementation of energy-efficiency measures less costly and more effective; therefore these reasons are additional benefits that can make these initiatives more appealing to be implemented by companies and industrial associations along with the local authorities (Convery, 1998).

3 Energy-related standards and regulations in Germany.

3.1 Current status of energy-related regulations in Germany.

As a result of the worldwide resources scarcity, the global warming caused by greenhouse gases (GHG) emissions and the increasing tendency on energy imports in Europe, in November 2012 the EU published the Directive 2012/27/EU in which is stated that in order to tackle all these problems, energy efficiency should be prioritized as one of the leading actions toward improving competitiveness, reducing energy independency and climate change mitigation. (European Union, 2012) The objectives of this directive are totally aligned with the 'Europe 2020' strategy that seeks to reduce energy consumption of the EU in 2020 by 20% compared to projections.

One of the cornerstones of the Europe 2020 strategy is the commitment of all the signing countries to shift and re-define goals of manufacturing sector related to energy consumption mainly by using the share of renewable energy sources already available along European continent in a wider way. In addition to the 'Europe 2020' strategy, the European Council and Parliament created in 2008 the EU Strategic Energy Plan (SET – Plan). As Pardo, Moya and Mercier (2011) commented, the aim of this strategy is to support and encourage new, innovative, more environmental – friendly, less costly and cleaner energy technologies by sponsoring research studies conducted by any of the different country members whether as a single member or as part of a join effort. The most energy - intensive processes such as cement, steel, paper and glass manufacturing sectors are the primary objective of this initiative since emissions from these processes count for more than 4% of the total CO_2 emitted by Europe in 2007 and energy consumption by them represents more than 40% of their total costs. (Pardo, Moya, & Mercier, 2011)

Based on projections made by the European Commission during the development of this strategy, the European Union calculated that by achieving the energy goals stated in the 'Europe 2020' strategy it will be possible to save 60 billion euro in oil and gas imports. Improving the integration of the European energy market can add and extra 0.6 to 0.8% of the regional GDP. Additionally, meeting the objective of 20% of energy from renewable sources can create more than 600,000 jobs only in the European Union.

But benefits have an impact also in the long term because by achieving this target Europe can increase also its energy independence and improve its competitiveness (European Commission, 2010).

Despite the strong effort of energy policies in Europe, the target of reducing the energy consumption of 20% by year 2020 seems unachievable. In fact, recent estimates made by Trianni, Cagno, Worrell and Pugliese (2013) show that if current trends continue, only 10% of the reduction will be achieved, therefore it is imperative for the European Commission to develop new and innovative measures to increase energy efficiency (Trianni, Cagno, Worrell, & Pugliese, 2013).

The Directive 2012/27/EU establishes that each Member State has to develop a National Reform Programme (NRP) in which the country states its individual goals, policies and targets that will contribute to achieve the goals previously set by the EU. As Stenqvist & Nilsson (2012) states, development of effective energy efficiency policies and practices for monitoring and evaluating their effectiveness has become more important; given the relevance of this task, different political levels should take its responsibility on the development of new challenging but realistic new policies (Stenqvist & Nilsson, 2012). In the German NRP, the German government expresses its aim to reduce the primary energy consumption of the country by 20% in 2020 and to achieve a 50% reduction by 2050 taking the year 2008 as baseline. According to estimations of the German government, achieving these targets requires an increase of 2.1% in the overall final energy consumption. At the same time, the German government plans to expand the use of renewable energy to 18% of the total energy consumption by 2020 (European Commission, 2011).

But this is only the first step that Germany is taking towards a more ambitious goal: 100% renewable electricity supply by the year 2050. The expected environmental benefits of this goal is a reduction of 80 to 90% of the national greenhouse gases emissions of which 80% come from energy production. Based on the studies conducted by the Federal Environment Agency of Germany (2010) and taking into consideration economic and environmental limitations, this goal is technically feasible. But to achieve this goal it is necessary first to cap all the potentials to save energy of all the economic

and social sectors in Germany; without this, the objective of 100% renewable electricity supply cannot be achieved (Federal Environment Agency of Germany, 2010).

Small and medium enterprises are the major part of industry sector in Germany. The German government has created several and specific programs to support implementation of Energy Management Systems in these companies. This support consists mainly on financial aid from government such as subsidies to conduct energy – checks and reduced electricity tariffs offered to high energy – intensive processes such as steel, iron, paper and glass production. Subsidies as part of the national strategy have delivered good results so far since more and more SME are conducting energy-checks increasing with this their competitiveness. But this policy has raised complaints from other European country members since subsidies offered to companies create an unfair economic scenario as reported by The Wall Street Journal (2012) (Hromadko & Torello, 2012). Moving from fossil fuels to renewables has a high cost that should be absorbed by the final consumers but with the subsidies offered by the government this is not happening; this market distortion can create problems at a regional level and should be analysed by policy makers.

3.2 Challenges and options to improve energy efficiency in German industry.

If energy efficiency measures are to be implemented, it is necessary to consider that industry sector has some special features that put it aside from other economic sectors and governments should take these differences into consideration when designing and implementing new regulations. In a national level, it is important to acknowledge the fact than even tough a lot of energy efficiency measures have not been implemented in industry sector, potential for energy efficiency measures in both building and transport sectors is much larger; this aspect can help authorities to set more realistic and achievable objectives based on the peculiarities of each sector.

Energy efficiency measures can be implemented in new and old facilities. The International Energy Agency (2009) describes three main reasons why energy efficiency measures in new facilities are frequently overlooked. Firstly, individual investors who want to build new power plants, factories or any other facility weight energy efficiency against other aspects like technology and design; most of the times

energy efficiency is the less important aspect. Integrating energy efficiency measures into the initial design or redesign of the existing facilities is usually less expensive and allows the developers to achieve better returns on their investments. The second aspect is the international or global presence of many industries; if regulations are not the same among the countries, carbon-leakage can occur and it will be possible that companies would choose to relocate their facilities to places with less strict regulations. Even tough there is not much evidence of this phenomena, it would be a real threat if price of CO_2 increases. The third aspect is related to the knowledge, technologies and financing resources available within the industry sector; all these potentials can be used if governments put in place attractive regulations and stable policy framework that would encourage industries to implement energy efficiency measures. (IEA, 2009)

As it was shown in a recently published research by Fleiter, Schleich & Ravivanong (2012) on how SMEs are taking part of the German energy audit program conducted, some of the Energy Efficiency Measures (EEM) are not implemented within the small and medium size (SME) companies because of high investment costs despite the fact that these investments can deliver economic benefits in the long term. (Fleiter, Schleich, & Ravivanpong, Adoption of energy-efficiency measures in SMEs—An empirical analysis based on energy audit data from Germany , 2012) It is important to mention that companies with more than 250 employees are not subject to receive the economical support offered by the German energy audit program. But companies with energy - intensive process such as steel production, paper manufacturing and glass production can receive also aid from the government as explained by the Federal Environment Agency of Germany (2012) on which it is explained that companies with this type of processes can take advantage of special electricity tariffs offered by the government if an Energy Management Systems is put in place (Federal Environment Agency, 2012).

As some of the existing barriers to the adoption of energy efficient technologies are non-monetary, Fleiter, Fehrenbach, Worrell & Eichhammer (2012) suggest that additional policy instruments could contribute to take advantage of the cost-effective saving potentials; these instruments range from energy management to R&D support. A close collaboration between industrial sectors and technology supplier is essential, particularly for complex process technologies (Fleiter, Fehrenbach, Worrell, &

Eichhammer, 2012).

Thiede, Bogdanski & Herrmann (2012) rise an interesting point by explaining why current status of implementation of energy efficiency measures particularly in SME can be confusing. This confusion lies in the fact that as mentioned earlier, on one hand different studies underline the significant potential for improving the energy and resource efficiency in manufacturing companies and on the other hand, other studies highlight strong obstacles which impede a broad implementation of promising measures specifically for SME. This phenomenon is known as *"the energy efficiency paradox"*. As explained by Abadie, Arigoni, Galarraga and Markandya (2013), there are several reasons behind this paradox. Firstly future savings that could be achieved by implementation of energy efficiency measures are uncertain although the current cost of the investment is known. Calculations of the economic benefit that the project can deliver are based on production ratios, current energy prices, discount rates and other technical and economical parameters that cannot be given for certain along the whole duration of the project. All these uncertainties compromise the expected economic benefits at the end of the project and create and additional risk that most of the companies are not willing to take. Secondly, size of the company, value on the market of the products manufactured on site and number and education of employees are peculiarities of each company that affect also the implementation of energy efficiency measures (Abadie, Arigoni Ortiz, Galarraga, & Markandya, 2013). Given this scenario of existing potentials but at the same time barriers for improvement it is necessary to implement a systematic method, which allows a fast and reliable identification of energy consumption drivers and measures for improvement. Furthermore, an appropriate method to manage energy accelerates the continuous improvement cycle and supports focusing efforts of companies to reduce their energy consumption (Thiede, Bogdanski, & Herrmann, 2012).

When it comes to accurately measuring and improving the results of energy efficiency measures in industry sector, the International Energy Agency (2008) highlights data collection and data reliability as two of the main concerns that government can overcome by putting in place incentives and regulations to promote disclosure of energy consumption patterns of industry but taking care of confidentiality of this information at the same time (IEA, 2008). Lund (2009) elaborates on the feed-in-

tariffs incentive implemented by the German government and shows how this policy can be an example of how, if decided properly, new policies and regulations on renewable energy can bring attractive results for the country. As a result of the implementation of energy – related policies in Germany in 2006 more than €21 billion and 200,000 new job places were created (Lund, 2009).

Eichhammer and Mannsbart (1997) explain that the relevance of measuring energy in industry lies in the fact that through measuring energy consumption it will be possible to obtain and understand the major influences on the final energy consumption of specific processes and industrial subsectors. The analysis of energy indicators should also help to relate energy consumption changes to energy efficiency policies or environmental policies, energy price changes, changes in foreign trade of energy-intensive intermediate or final products and structural impacts due to business cycles in order to create instruments to improve energy efficiency in a more satisfactory way. Furthermore, energy indicators are important instruments in measuring the success of political negotiations on CO_2 emission reductions, such as voluntary agreements on a national level, monitoring of national CO_2 emission reduction efforts. (Eichhammer & Mannsbart, 1997).

The challenge for governments is to find such set of incentives and regulations that will encourage companies to look at their energy consumption patterns and capitalize the opportunities detected through the implementation of energy efficiency measures. (Taylor, Govindarajalau, Levin, Meyer, & Ward, 2008). Reinaud & Goldberg (2011) explain how beside incentives and regulations, norms and standards such as the ISO energy management standard, voluntary energy audits or minimum efficiency performance standards (MEPS), play also an important role in improving results of energy efficiency efforts implemented by industry. One of the objectives of these measures is to prevent inefficient equipment to be available in the implementing country; therefore these regulations affect mainly manufacturers and importers. (Reinaud & Goldberg, 2011)

4 Energy management standards

Producing and delivering goods and services using less energy is one of the most important attempts to reduce carbon emissions and tackle global warming associated problems and it is also one of the main challenges that industrial sector is currently facing. According to the International Energy Agency (2008), energy efficiency remains as one of the most important and least costly initiatives for reducing green house gases emissions (IEA, 2008). O'Driscoll, Og Cusack & O'Donnell (2012) found that energy cost in manufacturing sector represents only a small portion of the total costs and therefore energy-associated costs do note receive big attention by companies. But in the meanwhile there are also new externalities that are pushing companies to change the way they use resources such as increasing energy prices, creation of the Kyoto protocol and more environmentally aware consumers (O'Driscoll, Og Cusack, & O'Donnell, 2012).

The United Nations Industrial Development Organization (UNIDO) (2008) explains that industrial energy efficiency is frequently overlooked by governmental dependencies which think that companies will adjust their energy consumption patterns just pushed by external pressure coming from their competitors and the final consumers and therefore additional regulations implemented by the government are not required. Higher energy price alone will not increase energy efficiency awareness within the companies of the energy savings, maintenance savings and production benefits that can be achieved by implementing energy management systems. In fact, lack of awareness from the management regarding energy management is the main obstacle to overcome. It is the top management who does not give the same priority to energy use as quality assurance, waste reduction and labour costs without realizing that efficient use of energy brings economic results and improves competitiveness as well. (UNIDO, 2008)

McKane (2007) conducted a study trying to identify what are the main drivers for energy efficiency in companies and he found that perception that increasing oil prices and pressure from external competitors will force companies to use energy more efficiently is not true. Just by looking at the results obtained by countries (e.g. Denmark, Ireland, Sweden and USA) that embrace and support energy efficiency management systems is possible to observe that implementation of energy management systems are

effective and viable policy mechanisms to promote energy implementation of energy efficiency measures in industry (McKane, 2007).

As described before, energy efficiency enhances competitiveness and reduces dependency on energy imports. Given the evident relevance of these two issues of high importance to most countries around the world, several countries have created different sets of policies and regulations across all the economic sectors to reduce energy demand. But energy efficiency in industries is not an easy task as pointed out by Giacone & Manco (2012); unlike and deep differences among industrial sectors such as production rates, complexity of the industrial sites, number and type of products and so on, are factors that complicate the implementation of energy efficiency measures in industry (Giacone & Manco, 2012). All these issues combined have urged governments and companies to create internationally recognized standards that could support implementation of energy efficiency measures among different economic sectors.

Most of the efforts to reduce and optimize energy consumption in companies have been focused on adjusting, improving or changing the existing "hardware", this means: replacing engines, changing process layout, substituting isolation materials, and so on; but on the other hand, improvements and adjustments of the "software" have not received so much attention until recent years. It is understandable why focusing only on the hardware has received so much attention since it has been proved that improving existing equipment and adoption of new technologies has a positive impact on energy consumption and economic growth of a country measured as GDP. In fact Stern (2012) elaborates on this issue and demonstrates how the rate at which new technologies are adopted is directly correlated with the savings that in terms of energy efficiency a country can achieve. Countries that develop and adapt faster new technologies to the national market have shown better results than others that cannot implement these improvements with the same speed (Stern, 2012).

But concentrating the efforts only on improving or changing the existing hardware is not the best scenario since, as mentioned by Thollander and Palm (2013), implementation of new management methods like energy management systems can be one of the most effectives ways to identify and capitalize all the opportunities to reduce energy consumption in the company. According to the research presented by these two

authors, a reduction on energy consumption between 4 to 40% can be achieved in the companies just by improving the way energy is managed and without any big investment. (Thollander & Palm, 2013)

Energy Management Systems are management tools to measure, reduce, and improve energy use. Weidong, Wei, Kunya, Huoyin and Zhihao (2011) suggest that to achieve these goals, companies are required to create and improve their documentation processes, supervise the performance of the company in terms of energy consumption and improve the system by conducting internal audits or revisions carried out by the top management. The system has to be in such a way that can be self-sustained by the corrective and preventive actions carried out when anomalies and non-conformities are found. (Weidong, Wei, Kunya, Huoyin, & Zhihao, 2011)

Several standards for Energy Management Systems have been implemented in Europe. In Europe, Energy Management Systems started in the year 2001 with the Danish standard and continues nowadays with the ISO 50001 standard despite the fact that energy efficiency was covered in some extent into the ISO 14001. The new ISO 50001 was released in June 2011 and a broad implementation of this standard is expected over the years to come.

Year	Country or region	System
2001	Denmark	DS 2403:2001
2003	Sweden	SS 627750:2003
2005	Ireland	I.S. 393:2005
2007	Spain	UNE 216391:2007
2009	EUROPE	EN 16001:2009
2011	INTERNATIONAL	ISO 50001

Table 4-1 History of the Energy Management Systems in Europe

(Kahlenborn, 2010)

As for the development and creation of the ISO standards, there is a group of requirements that have to be fulfilled before a new standard is published:

1) The standard has to respond to a need in the market.
2) It is based on opinions of global experts.
3) Developing of the standard involves different stakeholders
4) The finished standard is based on a consensus of al the parts involved.

The knowledge of this process is important to understand that the expected outcome of these steps is to produce such type of standard that is objective and unbiased. In order to fulfil these requirements, the standardization body of the International Standard Organisation consults and negotiates with a diverse group of government bodies, industries and national standard bodies before the new standards are published. (ISO, 2012)

On 24th April 2012, the German standards institute DIN withdrew the EN 16001:2009 European standard and replaced it with the international ISO 50001:2011 standard. An energy management system (EnMS) is the critical factor for a company in achieving systematic, integrated and sustainable reduction of its energy consumption. Within the scope of establishing an energy management system, organizations need to develop and implement sustainable organizational and operational procedures. (TUV SUD, 2012)

4.1 ISO 50001-2011 Energy Management Standard

The necessity to standardize quality criterion of all the goods that at time were traded among the countries that took part on the World War II set the foundation of the current standard management systems implemented worldwide (Magd & Nabulsi, 2012). As described by the ISO Central Secretariat in its publication "Friendship among equals" (1997), the International Organization for Standardization is the result of the union of two important organizations; this union took place in 1946 in London during the conference of national standards at the Institute of Civil Engineers and in which 25 countries were represented. One organization was the International Federation of the National Standardizing Associations (ISA) based in New York and created in 1926 but administrated from Switzerland since the beginning of the Second World War in 1939; the other organization was the United Nations Standards Coordinating Committee (UNSCC) established in 1944 in London. Most of the internal regulations and procedures within the International Organization for Standardization were adopted from the ISA. The number of activities, country members and importance of this organization have increased since it was founded in 1946. The ISO published in 1997 more than 1000 standards every year compared to the around 500 documents published every year in the 1980s. As to the number of country members, the ISO has grown from 90 country

members in 1980 to more than 120. The ISO 14001 and ISO 9000 series are two of the most widely implemented standards created by this institute (International Organization for Standardization, 1997).

According to the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) (2012) only in Germany, more than 50,000 certifications under ISO 90001 Quality Management System have been issued and more than 6000 companies and organisations have been certified under the ISO 14001 environmental management system. Even before the official launch of the new ISO 50001, most of German companies play a very active role and were already aware of the requirements, benefits and challenges of the new ISO standard therefore it is expected that implementation of this standard should be easier among these organisations (BMU, 2012).

As stated by the European Commission (2008), industry has been greatly influenced by the increased globalisation and integration of the world economy since 1990 and also by the enlarged EU economy. Nowadays industrial firms are offering their products at a broader market where there is more challenging competition among the countries. In such environment, companies are restructuring their processes in order to achieve a greater productivity and better product quality as well (European Comission, 2008). Under this situation members of industry sector should look at the inside of their own companies and, along with strategic partners identify and embrace additional measures that could help them to increase its competitiveness. The ISO 50001:2011 standard can help companies to overcome these obstacles.

The ISO 50001:2011, Energy management systems – Requirements with guidance for use, is a voluntary international standard developed by the International Organization for Standardization (ISO). ISO 50001 can be implemented in any type and size of company, from SMEs to national governments.

The ISO 50001:2011 Energy Management Standard replaces the EN 16001:2009 (TUV SUD, 2012) and is compatible with the popular EN ISO 9001:2008 Quality Management Standard and I.S. EN ISO 14001:2004 Environmental Management Standard. Therefore integration of ISO 50001:2011 with ISO certifications is not

complicated. It has international recognition and is now considered the benchmark standard worldwide for Energy Management.

The ISO 50001 integrates energy management as part of the business management by creating an appropriate framework under which suppliers and customers can get involved in the system and be part of the efforts done by the companies; with this approach, the benefits of the ISO 50001 can be spread along all the add-value chain. As Park et al, (2009) mention, this standard is expected to provide companies with technical strategies helpful to reduce energy consumption, reduce production costs and improve the environmental performance. The ISO 50001 standard covers energy efficiency, energy performance, energy supply, procurement process, practices for energy using equipment and systems and energy use. It also deals with measuring activities to know the current energy usage and the implementation of a measurement system to document, report, and validate continual improvement in the area of energy management (Park, et al., 2009). Commitment, involvement and leadership from the top management are key to successful implementation of ISO 150001.

The ISO 50001 energy management standard follows the same Plan-Do-Check-Act model that other management system standards do such as the Environmental System ISO 14001 and the ISO 9000 series of quality management system standard. The advantage of this is that many of the elements will be in place in the organization that already have these systems in place and also it allows for compatibility and integration of the systems.

On the other hand, there are also common challenges and obstacles during implementation of new management systems like ISO 50001 that companies should know before implementing them. Rezaei Çelic and Baalousha (2011) noticed that for companies already certified under any other ISO system, implementation can be easier but for those companies willing to implement this methodology for the first time putting in place this new management system can be challenging. Increase in the paper activities, changes on the everyday activities and responsibilities of the staff and communication challenges among the different departments of the company are just some examples of the problems that can emerge while implementing a new

management system. If not solved properly, these problems can affect morale and motivation of the staff making implementation of the system more difficult and less sustainable in the long run since employees will not embrace the methodology. (Rezaei, Celik, & Baalousha, 2011)

According to the developers of the ISO 50001 energy management system, the main benefits of the implementation of this standard by companies are:

- Sets the foundations for more efficient energy utilization.
- Helps the companies by fixing targets of energy consumption.
- Uses statistical data available at the companies to make better and more informed decisions in the company regarding energy use and consumption.
- Continually improves energy management.
- Identifying opportunities for improvement.
- Ensuring greater level of control
- Enhance image of the company
- Satisfy the expectations of stakeholders
- Reduced costs and improved business performance
- Improved compliance with energy legislation
- Reduce carbon emissions and,
- Demonstrating transparency and commitment. (ISO, 2011)

In addition to all these benefits, companies can benefit from the implementation of the ISO 50001 since the magnitude of benefits obtained from the implementation allow companies to reduce staff number and other costs (BMU, 2012)

According to the Deutsches Institut für Normung (2013), as for April 2013, the number of sites certified to ISO 50001 has surpassed the 2400 sites[8] all over the world (DIN, 2013). Interestingly, Germany is taking the lead also in this regard with more than 50% of the sites already certified belonging to this country.

[8] One site refers to one geographic location that has been certified to ISO 50001. This means that for a given company with i.e. 5 factories it is possible to have up to 5 sites certified.

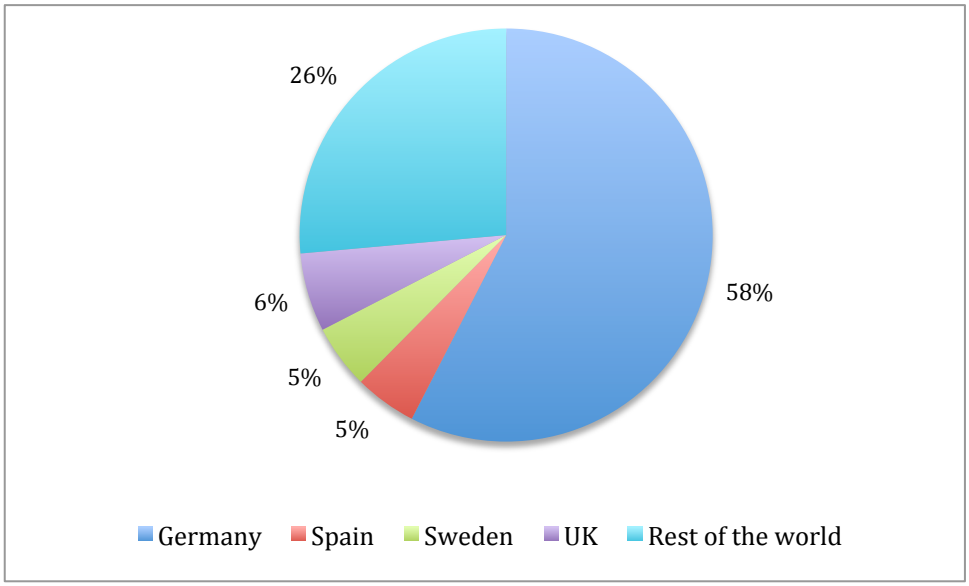

Figure 4.1 Location of companies certified to ISO 50001

Germany has more than 1394 sites certified under the ISO 50001 but only 8 DAX[9] companies out of these sites have at least one site certified under the ISO 50001. The economic activity of these 8 companies goes from car manufacturing to pharmaceutical products production. These companies are: Basf, Bayer, Continental, Daimler, Henkel, Merck, Siemens and ThyssenKrupp. Motivations to get the ISO 50001 certification vary among the companies. Siemens (2013) for example is strongly motivated to enhance its public image and it is at the same time aware of its international presence as stated on its sustainability report 2012 "*the programs launched in the company focused on reducing energy consumption are designed to improve energy and resource efficiency, to fulfil growing international requirements with regard to environmental protection, to increase customer benefits, and to proactively strengthen our position as a sustainable Company"*. Even though Siemens has reduced its total energy-related emissions there is no clear information about the energy input per unit produced so the consumer could understand in a better way what these savings mean. The report highlights the link between the energy savings achieved by the company and the reduction on GHG emissions (Siemens, 2013)

[9] Index that tracks the price development of the 30 largest and most actively traded German equities (Deutsche Borse, 2013)

Merck (2013) also deals with the energy efficiency topic on its latest sustainability report created following the Global Reporting Initiative guidelines. As Siemens did it, Merck measures its progress in energy efficiency in terms of GHG emissions, mainly CO_2 (Merck KGaA, 2013). Since information about the amount of tons that were produced in 2012 is not provided, it is difficult to conclude if the energy savings (and the related CO_2 emissions) are the result of energy efficiency measures implemented by the company or caused by other reasons. The ISO 50001 certification is not mentioned on the webpage.

Henkel AG & Co. (2013) is other company part of the DAX 30 that released its corporate sustainability report 2012 this year. In this case in particular the total energy consumption is shown along with the total tons produced in 2012. This allows the reader to make a real comparison in terms of energy efficiency over the last years. The performance of this company regarding energy efficiency is good; the number of tons produced since 2008 decreased by 2% but energy consumption decreased by 30% over the same period (Henkel AG & Co., 2013). The information presented in the report is easy to understand, allowing the lector to identify gaps that need to be closed and achievements of the company. Anyway, certification to ISO 50001 is not highlighted in the document.

Based on this short analysis of the Sustainability Reports of these important German companies, it is possible to observe that consumers do not always drive ISO 50001 certification since this achievement is neither highlighted nor communicated to the final consumer. Therefore it is possible to infer that this certification is more relevant to other stakeholders upstream the value chain and not so relevant to final consumers. Most of the companies used only GHG emissions as the main indicator to measure energy efficiency. This indicator can improve image of the company but does not describe in a comprehensive way what is the current situation of the company in terms of energy efficiency.

4.1.1 ISO 50001 Energy Management Standard implementation methodology

The methodology of the ISO 14001 Environmental Management System is based on a continuous process improvement and ISO 50001 also has this feature so all the elements that are contained in the ISO 14001 can be observed in the ISO 50001 as well. Even though energy management was covered on the ISO 14001 Environmental Management Standard, there are important differences that make the ISO 50001 unique. ISO 50001 is not only about preventing non-conformities it is also about improving the performance of the business. The ISO 50001 sets targets to improve energy efficiency and seeks for their successful implementation so the objectives can be achieved. As mentioned earlier, the ISO 50001 uses the Plan-Do-Check-Act (PDCA) cycle.

The PDCA is the foundation of all the ISO standards (NSAI, 2011). The PDCA on the ISO 50001 has the following steps:

- Plan: Establish guidelines and provisions for EnMS operation following ISO 50001.
- Do: Operate business under the established EnMS
- Check: Verify that business is operating under the established EnMS
- Act: Report the result of verification at management review

Bureau Veritas is one of the leading certification companies in the world and as part of their efforts to promote ISO 50001 Energy Standard certification, Bureau Veritas (2012) states that companies should be sure that some minimum requirements are already in place before certifying the new energy management system. By doing this, certification process of the new standard at the company can be conducted in a more smooth and effective way. These prerequisites are:

- All the employees have to posses a basic principles and training on the ISO 50001.
- To conduct a self-assessment of the current environmental and energy management already put in place.
- Be sure that the basic requirements are fulfilled, such as:
    - The company knows what the significant energy users and significant energy consumers are.

    - The company knows what the main variables that can affect the energy use and consumption patterns are.
    - Employees know the objectives and future trends of energy consumption in the company.
    - Environmental performance indicators are in place and these are monitored and they trigger action plans if the indicator is not performing as planned.
    - A continuous improvement cycle is already working in the company and this process helps to plan new investments, generate training plans and so on.
- An internal audit prior the certification was already conducted and this helped the company to detect and close gaps identified in the management system. (Bureau Veritas North America, 2011)

According to the ISO (2011), the broad implementation of this standard could reduce the world's energy consumption by 60% (ISO, 2011). Even though ISO does not describe what is the line of thinking behind this forecast, I believe that the current energy consumption level, energy resources currently available, local regulations, energy prices and geographic location of each company should be analysed beforehand to identify what would be the net reduction that can be achieved. Bureau Veritas (2011) adds that organizations can be also benefited by the new knowledge before, during and after the implementation of the ISO 50001 because of the support that the company receives from subject-matter experts. This knowledge can be translated in a new culture of continuous improvement within the company and can help to improve staff morale when effort of the organization started turning into results. (Bureau Veritas, 2011)

As May 2012, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety of Germany (2012) reported that already 280 companies and organisations underwent the ISO 50001 certification process successfully worldwide. Kappelhoff Industrietechnik GmbH located in Bottrop as well as the head office and main spare warehouse of the famous carmaker Porsche located in Stuttgart-Zuffenhausen and Sachsenheim respectively were the first two companies certified to the new ISO 50001 (BMU, 2012).

4.1.2 Comparison of ISO 50001 and ISO 14001/EMAS

Welch (2013) elaborates on the similarities between the ISO 14001 and the ISO 50001 and explains how and why these similarities can make implementation of ISO 50001 easier for companies already certified under the ISO 14001 standard. For example, there is a requirement to develop an environmental policy in both the ISO 14001 and the ISO 50001. Companies also have to identify their legal and other requirements, they have to identify the objectives and targets and develop action plans to achieve those objectives previously set. Within the ISO 14001 as in the ISO 50001 standard organizations are required to define roles and responsibilities and authorities, it is necessary also to train staff and companies are also required to develop appropriate documentation and design operational controls that are required by the ISO 14001 and other management systems as well. The checking and correcting process of ISO 50001 and ISO 14001 are similar also, therefore companies implementing the ISO 50001 have to create and implement monitoring and measurement methods in place, there are also auditing requirements and there are requirements to have corrective and preventive action plans supporting the implementation of these management system (DIN, 2005). At the end of this process, it is necessary to conduct a management review in which senior management look at the results and evaluate how company is doing on its performance and measures as well as whether or not company is achieving its objectives and targets. Given all this similarities it becomes obvious that implementation of the ISO 50001 energy management system can be integrated in an easy way when other management systems are already in place (Welch, 2013).

If methodologies of ISO 14001 and ISO 50001 are to be compared, it is possible to notice that the main difference between these two systems lies in the fact that the ISO 50001 is more performance focused and requires companies to reduce their energy usage, while the ISO 14001 is more process focused. The ISO 50001 does not tell the companies how much energy they have to reduce but organizations have to define their targets. Another specific feature of ISO 50001 is that it requires companies to develop an energy profile; the energy profile is a detailed description of how and where they use energy. Based on the information obtained from the energy profile, company can decide where the significant energy users are and then focus the efforts on these processes to reduce their energy consumption. Companies are required also to develop a baseline

energy use based upon at least 12 months of data and based on the particularities of the companies, they also have to develop energy performance indicators to track the amount of energy they are using. Additionally, energy usage in design and energy usage in procurement are also under the scope of ISO 50001.

The European Eco-Management and Audit Scheme (EMAS) is a *"voluntary tool available for any kind of organisation aiming to improve its environmental and financial performance and communicate its environmental achievements to stakeholders and society in general"* designed by the European Commission (EMAS, 2012). This scheme was launched in 1995 and originally only companies and industry were allowed to participate. In 2001 participation of other sectors was allowed. Until March 2013 more than 1280 sites and 861 organisations have taken part of this initiative only in Germany just after Italy that has more than 1650 sites and 1100 organisations with an EMAS certificate (EMAS, 2013). EMAS provides an Energy Efficiency Toolkit for small and medium sized enterprises that aims to provide guidance and a framework to companies for reducing costs and improving their environmental performance. Implementation of the Energy Efficiency Toolkit in SMEs is a good foundation for ISO 14001 or full EMAS certification (EMAS, 2004). So far, this toolkit is mainly focused on the needs and requirements of SMEs industries.

Since nowadays several management systems dealing with energy efficiency in a lower or higher degree are available such as ISO 14001, ISO 50001 and EMAS, the Table 4-2 was prepared showing the different aspects and priorities of each of these systems and how these impact the energy consumption of the company.

To summarize these differences, I would say: ISO 14001 will help organizations to identify, evaluate and improve the environmental impacts of the company, ISO 50001 is focused on detecting and capitalizing energy efficiency potentials and the cost that this consumption brings and EMAS is more focused on promoting a transparent and constant dialogue regarding environmental performance between companies and consumers.

FEATURE	DIN ISO 50001	ISO 14001	EMAS
General requirements	Continual improvement process of the EnMS	Continual improvement process of the EMS	Improvement of environmental performance required.
Top Management	Requires specifically an energy champion	Talks only about "top management"	Requires involvement of all staff
Information with stakeholders	Up to the company to decide if the energy policy is communicated	Environmental policy has to be accessible to the public	Requires only environmental reporting
Main focus of the Management System (MS)	Focused on identification of energy sources and main internal energy consumers	Is more focused on preventing pollution	More focused on environmental aspects but energy efficiency is covered as well.
Approach	Identifies opportunities to save energy in the design of existing and new facilities	Uses several KPIs related to environmental performance in general	Uses product life cycle to identify and monitor environmental impacts during procurement.
Periodicity of the review of the MS	Periodic review of energy consumption	Periodic review of the environmental performance of the company	Review after substantial changes
Documentation	Requires records of all the measurements and reviews	Similar to ISO 50001	Results have to be communicated using the environmental statement

Table 4-2 Main differences among ISO 50001, ISO 14001 and EMAS

Created with information from: (BSI, 2011 and BMU, 2012)

4.2 Evaluation of strengths and weaknesses of ISO 50001

As explained on the previous section, ISO 50001 posses unique features compared to the ISO 14001 and EMAS management systems when it comes to improving energy efficiency in companies.

Mind Tools (2013) defines the SWOT analysis as a method broadly used to spot strengths (S) and weaknesses (W) within a project or idea and to detect and foresee possible opportunities (O) and threats (T) present outside (Mind Tools Ltd., 2013). With the objective to identify strengths and weaknesses of the ISO 50001 standard, a SWOT matrix was prepared. The findings of this table will be used in the next chapter.

Strengths	**Weaknesses**
- International recognition - Developed by the ISO - Well known among consumers - Strongly focused on energy efficiency - Forces companies to do a diagnostic of the current situation and plan improvements - Improves public image.	- The implementation process requires effort if other ISO systems are not already in place - Requires increasing the management structure by creating new job positions. - Increases the workload of staff. - It is not required to disclose the information to the public.
Opportunities	**Threats**
- It supports international expansion of companies. - Implementation requires efforts, but the results are long-lasting if the system is properly maintained. - Its implementation implies a cultural change within the company. - Improves confidence of all stakeholders.	- Self-checks in Germany deliver quicker results for the companies. - If companies are already energy efficient, it will not be attractive for them to implement the new EnMS. - Superiority of EMAS over ISO in Europe.

Table 4-3 SWOT Matrix of ISO 50001 compared to ISO 14001 and EMAS

5 Conclusions

After a detailed analysis of all the sources consulted on this research it is possible to conclude that implementation of ISO 50001 alone cannot be the solution to achieve a sustainable energy consumption in Germany. The following paragraphs will elaborate on this.

Use of natural resources to produce energy in Germany has changed dramatically over the last years as a result of negative effects of climate change caused by anthropogenic greenhouse gases emissions, fossil fuels depletion and the increasing prices of these. These adversities forced governments and companies to evaluate and change the way electricity is produced and consumed in order to maintain their competitiveness and decrease energy dependency on imports. As a result of these challenges, the European Union created specific and ambitious programs to overcome these challenges and improve the economic performance of the EU. These efforts were translated into guidelines and directives such as the Europe 2020 strategy and the 2012/27 directive; both of them focused on encouraging countries to take an active role on the solution of the two main challenges of the EU: reduce energy dependency and improve energy efficiency. In addition to these strategies, the German government set the goal to achieve 100% electricity supply from renewable sources by 2050, goal that based on the studies conducted by the Federal Environment Agency of Germany is perfectly achievable if some specific and important measures are put on place. So, if we look into the motivations of all the efforts of German government and the European union to improve energy efficiency we will find that they lie on several factors (i.e. increasing energy prices and global warming) that are being tackled by German industry by implementing mainly local efforts not only using the ISO 50001 standard.

As part of the efforts to dodge the negative economic impacts of dependency on energy imports and shutting down nuclear power plants, energy intensity of Germany is changing and will change even more in the coming years. Additionally, the ambitious objectives set by the government to increase the share of electricity from renewable sources and to be energy self sufficient by 2050 are changing. At the same time, the way energy is produced has changed . These efforts are focused on avoiding economic threats and increasing national security but at the same time they are helping to improve

sustainability of energy supply in Germany and to reduce related greenhouse gases emissions.

International recognition of ISO 50001 lies on the fact that this certification allows companies to be compared within the same set of requirements; this is the reason why ISO certification plays a key role to exporting companies which are an important part of the economic strength of Germany. Therefore, it would be better for exporting companies to pursue a certification under ISO criteria. On the other hand, ISO certification is less attractive for companies focused on the local market, because through implementation of energy checks, subsidies from the government and process improvements it is also possible to achieve energy savings in a cheaper and faster way, that will be translated into economic benefits afterwards.

The share of economic activities that produce the GDP in Germany has remained almost the same over the last years but the energy intensity has been reduced over the same period of time; at the same time GDP of Germany has been increasing constantly. This trend can suggest that efforts to improve energy efficiency in Germany have contributed to enhance economic performance of the country. On the other hand, it is possible to identify a rebound effect of this trend that suggests that all the savings achieved on energy consumption in industrial sector do not necessarily imply a net energy reduction. Less energy per unit produced allows companies to produce more units so at the end of the day the total energy consumed by the company remains the same. At this point is where changes on consumption patterns of final consumers play a key role. Final consumers can lead the change towards a reduction on energy consumption by supporting companies that hold international certifications.

Anyway, implementation of Energy Management Systems is only one part of the efforts that both companies and government in Germany are doing to improve sustainability of energy consumption in Germany. These efforts along with expertise, adequate management tools and sufficient technical information will help to identify and capitalize the potentials that companies have to improve even more energy efficiency in Germany.

As most of the sustainability reports of the main companies showed, improve company image and reduce energy-related costs are the main motivation to reduce energy consumption. Total GHG emissions is the main indicator used by the companies to show their commitment to reduce energy consumption but in the end, this indicator alone does not describe the energy efficiency of a company as a whole. Indicators such as KWh/ton of product or KWh/net profit could be also used in order to help stakeholders to get a more detailed view of the performance of the company in terms of energy consumption. Given the fact that companies are mainly focused on reducing their GHG emissions, new and cheap energy sources such as shale gas (which has been marketed as a "green alternative" to renewables (The guardian, 2011)) can shift the current scenario and enhance carbon leakage, because German companies would chose to increase the share of these alternative fuels instead of reducing their energy consumption.

Summarizing, implementation of ISO 50001 is not leading the efforts to achieve sustainable energy consumption in Germany. Government policies, priorities of companies, consumers, international fuel prices, GHG emissions and CO_2 price also play an important role that affect the way energy consumption is consumed. Not only industry but also society as a whole has to combine efforts to achieve a sustainable energy consumption.

6 References

- Abadie, L. M., Arigoni Ortiz, R., Galarraga, I., & Markandya, A. (2013). *Energy Efficiency Policy in the USA: The Impact of the Industrial Assessment Centres (IAC) Programme and State and Regional Climate Policy Actions.*
- B.&S.U. mbH. (2006). *E-check for craft SME.* Retrieved March 7th, 2013 from General brochure of the E-Check project: http://www.energy-check.org/media/usermedia/files/irish-documents/Dissemenation/E-Check%20Brochure%201%20general.pdf
- Bittermann, H.-J. (2007). Germany makes stride into energy efficiency. *World Pumps , 262*, 36-39.
- Blesl, M., Das, A., Fahl, U., & Remme, U. (2007). Role of energy efficiency standards in reducing CO2 emissions in Germany: An assessment with TIMES. *Energy policy , 35*, 772-785.
- BMU. (2012, June). Energy Management Systems in Practice ISO 50001: A Guide for Companies and Organisations. Dessau-Rosslau, Germany.
- BP Group. (2012). BP Statistical Review of World Energy June 2012 . London, UK.
- BSI. (2011, September 8th). A comparison between ISO 14001 and ISO 50001 . Milton Keynes, United Kingdom.
- Bureau Veritas. (2011, June). ISO 50001: Energy management systems. Manage energy and cut costs and emissions. .
- Bureau Veritas North America. (2011). *Energy Management Systems ISO 50001. Engage best-in-class practice for Energy Saving.* From Bureau Veritas North America. Management Systems Certification: http://www.us.bureauveritas.com/wps/wcm/connect/BV_USNew/local/home/our-services/management_systems_certification/management_system_certification_services/energy_management_systems/energy+management_default
- CIA. (2012, December 18th). *The World Factbook*. Retrieved January 3rd, 2013 from Central Intelligence Agency: https://www.cia.gov/library/publications/the-world-factbook/geos/gm.html
- Convery, F. (1998). *A guide to policies for energy conservation: the European experience.* United Kingdom: Edward Elgar.

- Deutsche Borse. (2013). *Glossary*. Retrieved May 21st, 2013 from Deutsche Borse Group: http://deutsche-boerse.com/dbg/dispatch/en/kir/dbg_nav/about_us/30_Services/40_Know_how/10_Stock_Exchange_A_Z?glossaryWord=pi_glos_dax
- DIN. (2013). *Aktuelle Liste der nach DIN EN 16001 und ISO 50001 zertifizierten Organisationen.* Retrieved May 21st, 2013 from Deutsches Institut für Normung e.V.: http://www.nagus.din.de/cmd?cmsrubid=167405&2=&menurubricid=167405&level=tpl-artikel&menuid=47224&languageid=de&cmstextid=167397&cmsareaid=47224
- DIN. (2005). Environmental management systems – Requirements with guidance for use (ISO 14001:2004) . Berlin, Germany.
- Eichhammer, W., & Mannsbart, W. (1997). Indicators for a European cross-country comparison of energy efficiency in the manufacturing industry. *Industrial energy efficiency , 25*, 759-772.
- EMAS. (2004). EMAS Energy Efficiency Toolkit for Small and Medium sized Enterprises. Luxembourg.
- EMAS. (2013, March 31st). *EMAS Organisations and sites*. Retrieved May 26th, 2013 from Statistics and graphs: http://ec.europa.eu/environment/emas/pictures/Stats/2013-03_Overview_of_the_take-up_of_EMAS_in_the_participating_countries.jpg
- EMAS. (2012, November 30th). *The European Eco-Management and Audit Scheme*. Retrieved May 26th, 2013 from European Comission: http://ec.europa.eu/environment/emas/about/index_en.htm
- European Comission. (2008, April). European Energy and Transport. Trends to 2030 — Update 2007 . 2. Belgium.
- European Commission. (2010, March 3rd). Communication from the commission Europe 2020. Belgium.
- European Commission. (2011). Energy, transport and environment indicators. Luxembourg.
- European Commission. (2013, February 2nd). *European Commission. SME Performance Review.* From Enterprise and Industry. SBA Fact Sheet 2012 - Germany.:

http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/performance-review/files/countries-sheets/2012/germany_en.pdf

- European Commission. (2011, April 6th). Germany. National Reform Programme 2011. Berlin, Germany.
- European Union. (2012, November 14th). Directive 2012/27/EU of the European Parliment and of the Council. *Official Journal of the European Union L 315 , 55* . Luxembourg.
- European Union. (2011). Energy, transport and environment indicadors. Luxembourg.
- Eurostat. (2012, September 7th). *Energy glossary*. Retrieved December 8th, 2012 from Final energy consumption: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Final_energy_consumption
- Eurostat. (2012, May 24th). *Eurostat-Data Explorer*. Retrieved December 8th, 2012 from Supply, transformation, consumption - all products - annual data: http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_100a&lang=en
- FAO. (2012). *Forest products statistics*. Retrieved January 11th, 2013 from Food and Agriculture Organization of the United Nations: http://www.fao.org/docrep/016/i3005t/i3005t.pdf
- Federal Environment Agency of Germany. (2010, July). Energy target 2050: 100% renewable electricity supply. Dessau-Roßlau, Germany.
- Federal Environment Agency. (2012, October 31st). Press Release No. 41/2012. Dessau-Roßlau, Germany.
- Fleiter, T., Fehrenbach, D., Worrell, E., & Eichhammer, W. (2012). Energy efficiency in the German pulp and paper industry e A model-based assessment of saving potentials. *Energy , 40*, 84-99.
- Fleiter, T., Schleich, J., & Ravivanpong, P. (2012). Adoption of energy-efficiency measures in SMEs—An empirical analysis based on energy audit data from Germany . *Energy Policy , 51*, 863-875.
- Garelli, S. (2006, December). *IMD*. Retrieved March 6th, 2013 from International Institute for Management Development. Tomorrow's challenges: http://www.imd.org/research/challenges/TC060-06.cfm

- Geller, H., Harrington, P., Rosenfeld, A. H., Tanishima, S., & Unander, F. (2006). Polices for increasing energy efficiency: Thirty years of experience in OECD countries . *Energy Policy* , 556-573.
- Giacone, E., & Manco, S. (2012). Energy efficiency measurement in industrial processes. *Energy , 38*, 331-345.
- Grismajer, M., & Seliger, G. (2012). Information Requirements for Motivated Alignment of Manufacturing Operations to Energy Availability . *Procedia CIRP 3* , 418-423.
- Gruber, E., Fleiter, T., Mai, M., & Frahm, B.-J. (2011). Efficiency of an energy audit programme for SMEs in germany – results of an evaluation study. *ECEEE Summer Study 2011*, (pp. 663-673). Belambra Presqu'ile de Giens.
- Henkel AG & Co. (2013, March 6th). *Sustainability report 2012*. Retrieved May 22nd, 2013 from Environmental indicators: http://sustainabilityreport.henkel.com/indicators/environmental-indicators.html
- Hromadko, J., & Torello, A. (2012, November 29). EU Examines German Energy Subsidies. *The Wall Street Journal* .
- I.S. EN 16001:2009 Energy management systems – Requirements with guidance for use. (2007). Dublin, Ireland.
- IEA. (2008). Assessing measures of energy efficiency performance and their application in industry. Paris, France: International Energy Agency.
- IEA. (2009). Energy Technology Transitions for Industry. France.
- IEA. (2012). Key World Energy STATISTICS. Paris, France.
- IEA. (2007). Tracking Industrial Energy Efficiency and CO2 Emissions. France.
- IEA. (2008). Worldwide Trends in Energy Use and Efficiency.
- *iisd.* (1994). Retrieved December 7th, 2012 from Defining sustainable consumption: http://www.iisd.ca/consume/oslo004.html#top
- International Organization for Standardization. (1997). Frienship among equals. Geneve, Switzerland.
- ISO. (2012). *How does ISO develop standards?* Retrieved January 6th, 2013 from International Organization for Standardization: http://www.iso.org/iso/standards_development/standards_development
- ISO. (2011). Win the energy challenge with ISO 50001 . Geneve, Switzerland.
- Jochem, E., & Gruber, E. (2007). Local learning-networks on energy efficiency in industry – Successful initiative in Germany . *Applied energy , 84*, 806-816.

- Kahlenborn, W. (2010, November 25th). *The links between EMAS and energy management.* Retrieved January 6th, 2013 from http://ec.europa.eu/environment/emas/pdf/events/Session%202/2.EMAS_conference_2010-11-25_Walter%20Kahlenborn_adelphi.pdf
- Lund, P. D. (2009). Effects of energy policies on industry expansion in renewable energy. *Renewable energy , 34*, 53-64.
- Magd, H., & Nabulsi, F. (2012). The Effectiveness of ISO 9000 in an Emerging Market as a Business Process Management Tool: the case of the UAE. *Procedia Economics and Finance , 3*, 158-165.
- Malhotra, R. (2013). *Fossil Energy: Selected Entries from the Encyclopedia of Sustainability Science and Technology* . New York, USA: Springer Science+Business Media.
- McKane, A. (2007). Industrial Energy Management: Issues Paper. Vienna, Austria.
- Merck KGaA. (2013, April 26th). *GRI index: Environmental performance indicators*. Retrieved May 22nd, 2013 from Corporate Responsibility Report 2012: http://merck.online-report.eu/2012/cr-report/factsandfigures/griindex/environmentalperformanceindicators.html?cat=b
- Mind Tools Ltd. (2013). *SWOT Analysis.* Retrieved May 27th, 2013 from Mindtools: http://www.mindtools.com/pages/article/newTMC_05.htm
- Moradi, M. H., Hajinazari, M., Jamasab, S., & Paripour, M. (2013). An energy management system (EMS) strategy for combined heat and power (CHP) systems based on a hybrid optimization method employing fuzzy programming. *Energy , 49*, 86-101.
- NSAI. (2011). ISO 50001 Energy Management System. Detailed guide. Dublin, Ireland.
- O'Driscoll, E., Og Cusack, D., & O'Donnell, G. (2012). Implementation of energy metering systems in complex manufacturing facilities – A case study in a biomedical facility. *Procedia CIRP 1* , 524-529.
- Odysee. (2010). *Energy Efficiency Indicators in Europe*. Retrieved January 6th, 2013 from Free energy indicators: http://www.odyssee-indicators.org/online-indicators/

- Odyssee. (2012, October). *Energy Efficiency Indicators in Europe.* Retrieved January 3rd, 2013 from Odyssee-indicators: http://www.odyssee-indicators.org/publications/country_profiles_PDF/rfa.pdf
- Pardo Martinez, C. (2009). Energy efficiency developments in the manufacturing industries of Germany and Colombia, 1998–2005 . *Energy for Sustainable Development , 13*, 189-201.
- Pardo, N., Moya, J. A., & Mercier, A. (2011). Prospective on the energy efficiency and CO2 emissions in the EU cement industry. *Energy , 36*, 3244-3254.
- Park, C.-W., Kwon, K.-S., Kim, W.-B., Min, B.-K., Park, S.-J., Sung, I.-H., et al. (2009). Energy Consumption Reduction Technology in Manufacturing – A Selective Review of Policies, Standards, and Research. *International Journal of Precision Engineering and Manufacturing , 10*, 151-173.
- Pillania, R. K. (2009). *Competitiveness and emerging markets* (Vol. 10). Business strategy series.
- Porter, M. (1990). *Competitive Advantage of the Nations.* New York, United States: Free Press.
- Reinaud, J., & Goldberg, A. (2011, November). The boardroom perspective: How does energy efficiency policy influence decision making in industry? Washington, United States: Institute for Industrial Productivity.
- Rennings, K. (2013). *Sustainable Energy Consumption in Residential Buildings.* Berlin, Berlin, Germany: Springer.
- Rezaei, A. R., Celik, T., & Baalousha, Y. (2011). Performance measurement in a quality management system. *Scientia Iranica , 18*, 742-752.
- Saygin, D., Worrell, E., Tam, C., Trudeau, N., Gielen, D., Weiss, M., et al. (2012). Long-term energy efficiency analysis requires solid energy statistics: The case of the German basic chemical industry. *Energy* , 1094-1106.
- Schwab, K. (2011). The Global Competitiveness Report 2011-2012. Geneva, Switzerland.
- Siemens. (2013). Sustainability report 2012. Environmental protection and products.
- Statistisches Bundesamt. (2012, December 17th). *October 2012: number of employees in manufacturing increasing by 1.7%.* Retrieved January 3rd, 2013 from Statistisches Bundesmat:

https://www.destatis.de/EN/PressServices/Press/pr/2012/12/PE12_445_421.html

- Stenqvist, C., & Nilsson, L. (2012). Energy efficiency in energy-intensive industries—an evaluation of the Swedish voluntary agreement PFE. *Energy Efficiency , 5*, 225-241.
- Stern, D. I. (2012). Modeling international trends in energy efficiency. *Energy economics , 34*, 2200-2208.
- Taylor, R., Govindarajalau, C., Levin, J., Meyer, A., & Ward, W. (2008). Financing energy efficiency. Lessons from Brazil, India, China and beyond. New York, United States: The World Bank.
- The European Parliment and The Council of the European Union. (2012, October 25). Directive 2012/27/EU of the European Parliament and of the council.
- The guardian. (2011, April 26th). *The guardian*. Retrieved July 5th, 2013 from Shale gas fracking – the facts and figures: http://www.guardian.co.uk/environment/interactive/2011/apr/26/shale-gas-hydraulic-fracking-graphic
- The World Bank. (2007). Quality Systems and Standards for a Competitive Edge. Washington, United States.
- The World Bank. (2012). *World Databank*. Retrieved December 2012, 10 from The World Bank Databank: http://databank.worldbank.org/Data/Views/Reports/TableView.aspx?IsShared=true&IsPopular=country
- The World Economic Forum. (2012). The Global Competitiveness Report 2012–20013. Geneva, Switzerland.
- Thiede, S., Bogdanski, G., & Herrmann, C. (2012). A systematic method for increasing the energy and resource efficiency in manufacturing companies. *Procedia CIRP 2* , 28-33.
- Thollander, P., & Palm, J. (2013). *Improving Energy Efficiency in Industrial Energy Systems*. London, U. K.: Springer-Verlag.
- Thollander, P., & Palm, J. (2013). *Managing Energy Efficiency in Industry. Theory and Practice* . London, U. K.: Springer-Verlag.
- Trianni, A., & Cagno , E. (2012). Dealing with barriers to energy efficiency and SMEs: Some empirical evidences. *Energy* , 494-504.

- Trianni, A., Cagno, E., Worrell, E., & Pugliese, G. (2013). Empirical investigation of energy efficiency barriers in Italian manufacturing SMEs. *Energy* , 444-458.
- TUV SUD. (2012, January 11th). *ISO 50001 replaces EN 16001 – what companies must now do to save energy and money.* Retrieved November 25th, 2012 from Press archive: http://www.tuev-sued.de/company/press/press-archive/iso-50001-replaces-en-16001-what-companies-must-now-do-to-save-energy-and-money
- U.S. Department of Energy. (2012). *Spot Prices for Crude Oil and Other Liquids*. Retrieved December 12th, 2012 from U.S. Energy Information Administration: http://www.eia.gov/dnav/pet/pet_pri_spt_s1_a.htm
- U.S. DOE. (2010, November). Electronic Handbook of Industrial Resources. Tennessee. United States.
- UNIDO. (2008). Policies for promoting industrial energy efficiency in developing countries and transition economies. Austria.
- USGS. (2012, January). *Aluminum Statistics and Information.* Retrieved January 11th, 2013 from U.S. Geological survey: http://minerals.usgs.gov/minerals/pubs/commodity/aluminum/mcs-2012-alumi.pdf
- USGS. (2012, January). *Minerals information.* Retrieved January 11th, 2013 from U.S. Geological Survey: http://minerals.usgs.gov/minerals/pubs/commodity/cement/mcs-2012-cemen.pdf
- VGB PowerTech e.V. (2013). Media information 2013. Essen, Germany.
- Weidong, F., Wei, H., Kunya, W., Huoyin, L., & Zhihao, J. (2011). A method to establish and run management system for energy . *Energy Procedia , 5*, 1584-1588.
- Welch, T. (2013). *Cardno EM-Assist - Employee profile: Tom Welch*. Retrieved January 7th, 2013 from Cardno EM-Assist: http://em-assist.com/careers/featured-employees/tom-welch.aspx
- World Steel Association. (2012). *2011 Iron Production*. Retrieved January 11th, 2013 from World Steel Association: http://www.worldsteel.org/statistics/statistics-archive/2011-iron-production.html

- World Steel Organization. (2012). *2011 Steel Production*. Retrieved January 11th, 2013 from World Steel Association: http://www.worldsteel.org/statistics/statistics-archive/2011-steel-production.html