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Analysis of Global Energy Market and Drivers of Investments for Energy Efficiency Solutions in the Iron & Steel Industry

Master Thesis

Mechanical Engineering and Business Economics

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Institute of Industrial Management and Innovation Research

Univ. Prof. Dipl.-Ing. Dr.techn. Christian Ramsauer

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Statutory declaration

I declare that I have authored this thesis independently, that I have not used other than the declared sources/ resources, and that I have explicitly marked all material which has been quoted either literally or by content from the used sources.

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Abstract

Siemens VAI Metals Technologies GmbH is a life-cycle partner for the metallurgy industry with solutions for integrated steel and metallurgical facilities. Existing steel facilities constantly strive to improve their production process to increase cost effectiveness and to comply with laws and regulations. Siemens VAI provides energy efficiency and CO_2 abatement solutions and is interested in knowledge about energy markets for electricity, natural gas and coal as these are the main fuels for the steel production process. In addition to prices background information like price history and an outlook are also of interest. Governments are often interested in greener production processes and influence decision making in industry by setting regulations or helping investments with incentives, low interest loans or information campaigns. These regulations and funding measures are also interesting for Siemens VAI as they can provide the security for investments and help keep payback time low.

This work was started with research on three main energy sources (electricity, natural gas and coal) for steel producers and includes prices for industry. Further, background information about how the market works, supply security and stability were researched. The second part of the research was to find out about laws and restrictions specific to the steel industry. Governments and other institutions also help invest in improvements concerning energy efficiency and/or CO_2 abatement. The work concludes with an energy price outlook for natural gas and coal.

The outcome of the thesis are end user prices for industry. In Europe prices are at the higher end, except for Russia, with some countries in America setting the lower boundaries. The energy price outlook for natural gas and coal, which was done by the *International Energy Agency (IEA)* predicts raising prices for the whole world with Japan at the upper and the United States at the lower end.

Also market based information was researched. In Europe most energy sectors are liberalised and a competing energy sector is at hand where energy suppliers can be chosen freely. The same applies to the Unites States and Canada but Mexico, Brazil and most of Asia are regulated.

The best candidates for Siemens VAI are Brazil and Mexico due to unstable electricity supply and high energy prices. But South Africa, Indonesia and South Korea could also be interested in products Siemens VAI can offer.

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1 Introduction

Energy is becoming increasingly important and Siemens AG is one of the world's leading suppliers of a wide range of products, solutions and services in the field of energy technology.[1] *Siemens AG* has 362.000 employees worldwide in over 200 countries with a revenue of 75,882 million EUR in 2013.[2]

Siemens AG is divided into five sectors[3]:

- Industry
    - *Metals Technologies*
    - *…*
- Financial Solutions
- Healthcare
- Infrastructure & Cities
- Energy

Siemens VAI Metals Technologies is part of the *Industry sector* within Siemens AG and provides solutions for the metallurgical industry.

1.1 Siemens VAI

The headquarters of Siemens VAI are situated in Linz, Austria and there are another 80 locations around the world. Around 8.800 employees work worldwide for Siemens VAI to provide products and innovation for the steel industry.[4]

In Figure 1 Siemens VAI Metals Technologies is shown with sectors. This masterthesis was written for the department *ECO Solutions*.

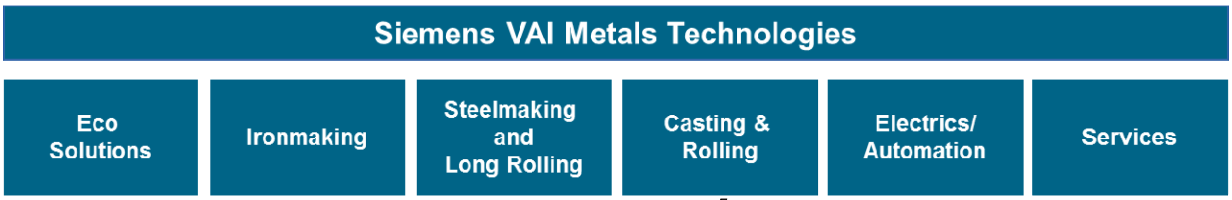

Figure 1: Organisation of Siemens VAI Metals Technologies [5]

[1] Siemens AG (2014a)
[2] Siemens VAI Metals Technologies (2014b)
[3] Siemens VAI Metals Technologies (2014b)
[4] Siemens AG (2014b)
[5] Siemens VAI Metals Technologies (2014a)

Products of the department *ECO Solutions*

For the department ECO Solutions it is interesting which steel producer could be interested in solutions offered. Primary investment drivers for energy efficiency measures are energy prices, restrictions and government fundings. Therefore prices for electricity, natural gas and coal were researched to find out in what locations energy prices are high enough to ensure a short payback time. Also environmental restrictions can bring steel producers to invest in improving the production process.

One product which enables energy savings is a blast furnace *top gas pressure recovery turbine (TRT)* generating around 30 – 40 kWh/t_{HM} electric energy from the blast furnace's top pressure and reduce CO_2 emissions.

Another one is the *selective waste gas recirculation for sinter plants* which can generate coke savings up to 10 % and reduce CO_2 emissions by up to 10 %.

If there are environmental requirements and regulations concerning dust, a state-of-the-art primary wet dedusting system for *Basic Oxygen Furnace (BOF)* could help. It is a high efficient waste gas cleaner with integrated waste gas cooling, water separation and gas recovery solution.

Steel process

To convert iron ore into steel, a single operation would be ideal, but at the moment this is technically not possible yet.[6]

State of the art are wo basic process routes:

- Blast furnace – converter route
- Electric arc furnace route[7]

The *blast furnace – converter route* consists of two stages. The first stage is the production of hot metal in the *blast furnace and the* second step is to process this melt in the *basic oxygen converter*. In the blast furnace coke is used as a reducing agent.[8]

In the *electric arc furnace route* the ore reduction happens through direct reduction. In this process ore is reduced to iron in solid state.[9] This process uses gas rather than coke.[10]

[6] Degner, Michael (2008), p.27–28
[7] Degner, Michael (2008), p.27–28
[8] Degner, Michael (2008), p.27–28
[9] Degner, Michael (2008), p.27–28
[10] Centre for European Policy Studies (2013)

Figure 2 shows the two basic process routes for steel production. For the blast furnace – converter route the raw materials are processed first. Iron ore and Limestone in the sinter plant and coal is converted to coke in coke ovens. The second step is the production fo hot metal in the blast furnace. The third step is the steelmaking in the basic oxygen furnace. The blast furnace – converter route typically uses up to 15 % scrap metal. Electric arc furnaces can use 100 % of scrap metal.[11]

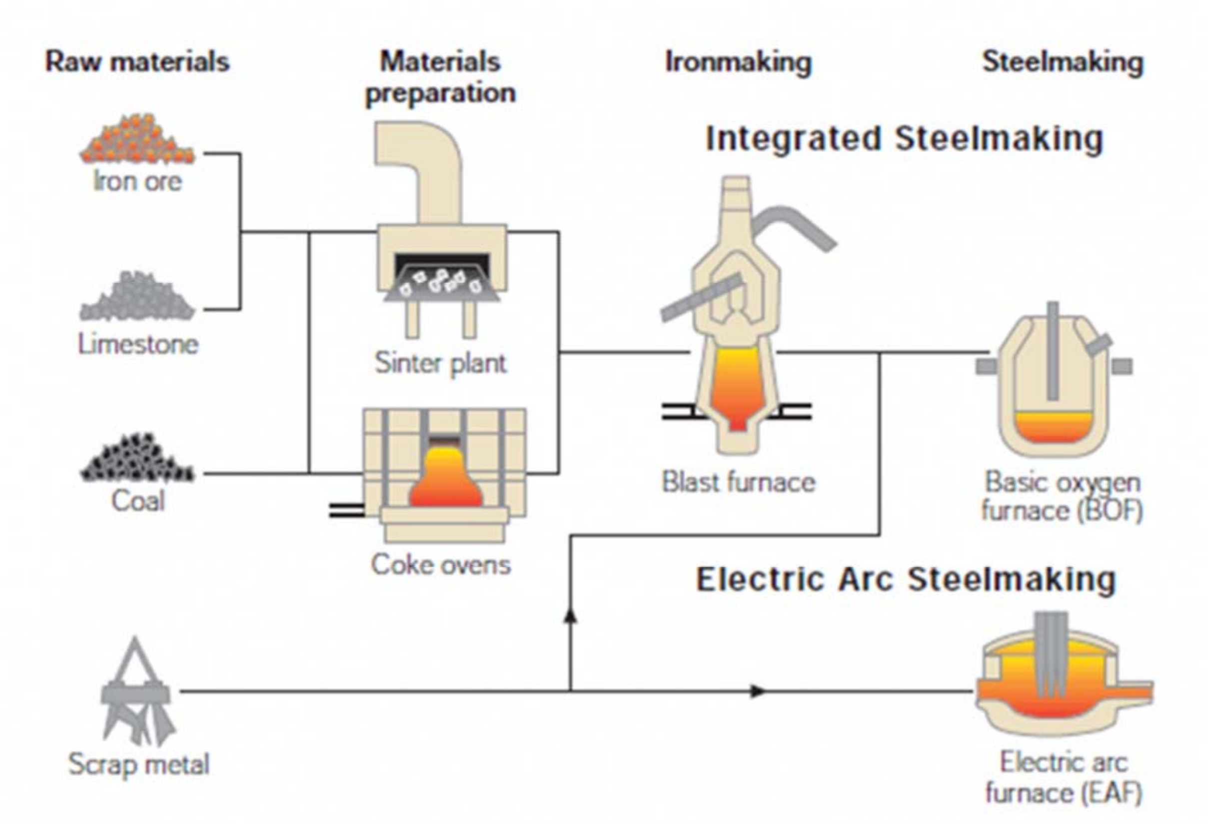

Figure 2: Steel production process routes[12]

The steel industry is characterised by economics of scale and high fixed costs. High capital is required for new installations and thus only a high production level can achieve the break-even point. Another barrier for new steel plants is that an increase in demand can easily be met by the existing capacity. The steel market is highly competitive due to the substitutability of steel in the same category from another producer. For the steel producer it is easier to reduce prices rather than to scale back production.[13]

Most steel producers are large energy consumers with a natural gas consumption of between 1 and 1,5 million MWh per year for a *basic oxygen furnace (BOF)* whereas most of the energy is needed in the rolling facilities. *Electric arc furnace (EAF)* and

[11] Steelconstruction.info (2014)
[12] Steelconstruction.info (2014)
[13] Centre for European Policy Studies (2013)

rolling facilities included in the study from the *Centre for European Policy Studies (CEPS*) about the *Steel Industry in the European Union* consume between 60.000 and 450.000 MWh per year.[14]

Electricity consumption differs between BOF and EAF with BOF process using around one-third of EAF. Given that BOF installations usually have their own generation capacities to produce electricity out of recycled waste gas from furnaces. According to the study the BOF producer needs to buy around 60 % of its total electricity consumption. For EAF installations this makes up between 150 and 600 GWh per year and for BOF plants this is between 350 and 750 GWh per year. Typical plant sizes of BOF variy from 2 million t to 4,5 million t capacity per year. EAF plants start with less than 400.000 t up to 1,3 million t capacity per year. An average BOF plant is bigger than an EAF plant which explains the higher usage of electricity.[15]

The steel industry is very energy intensive and that's why energy prices influence the competitiveness of different locations. This is one reason why voestalpine AG is building a new *direct reduction plant (DRI plant)* in the United States.[16]

1.2 Assignment

The aim of this work was to find out what the energy price situation, price background and political environment looked like in the selected countries. Also of interest is if there are any indicators for development in the future. Energy prices for industry are interesting and in particular the ones for electricity, natural gas and coal are important for the steel industry. But not only the energy price is interesting, also price background, tendency over the last few years and an energy price outlook into the future are of interest. For investments in energy efficiency measures or CO_2 abatement not only energy prices are relevant. Often incentives exist like tax allowances, low interest loans or information programs to help companies.

For Siemens VAI it is relevant to know which steel producers could be interested in investing in energy efficiency systems for economic reasons or triggered by restrictions. This would allow contacting these production sites and offering help with products and knowledge.

[14] Centre for European Policy Studies (2013)
[15] Centre for European Policy Studies (2013)
[16] voestalpine AG (2014)

1.3 Approach

First of all, countires which could interest Siemens VAI were evaluated with data from the *World Steel Association* by sorting them according to production capacity. It is interesting that China has by far the biggest production capacity, with 503.004.000 t/yr in 2013, which accounts for 49 % of crude steel production worldwide in 2013.[17] The second step was to combine these findings with knowledge from Siemens VAI by talking to company representatives. The outcome was shown in Figure 3 which shows the relevant countries. Countries were grouped in four continents to enable a better overview:

- Africa,
- America,
- Asia and
- Europe.

Top producing nations would also include Japan, but it was excluded due to matters of market entry restrictions. Austria, which is also one of the world's top steel producers was excluded because of the in-house knowledge of Siemens VAI.

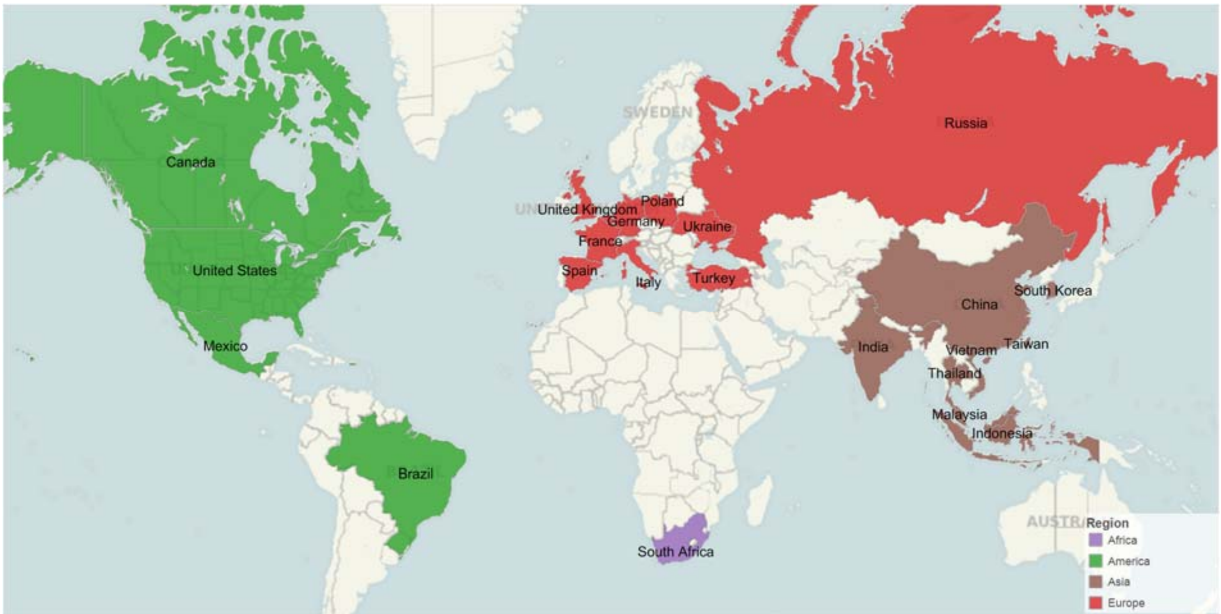

Figure 3: Selected countries and regions

[17] World Steel Association (2014b)

The second step was researching the main topics of electricity, natural gas and coal in relation to how the markets work. Also the supply security and stability were researched.

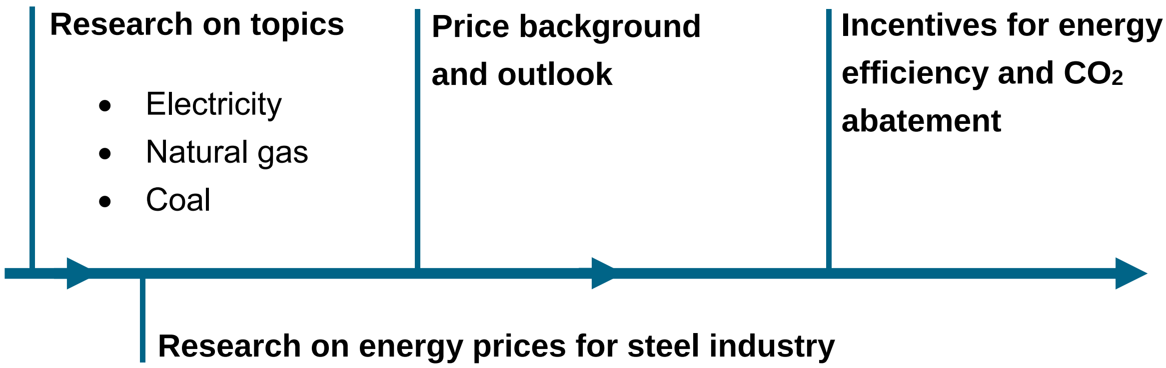

Figure 4: Timeline of master thesis

The third step was gathering information on energy prices for industry. Other sources were government agencies and energy suppliers in the countries which publish prices on the internet or helped with information when asked.

The fourth step was to get information about the price background in from three publications and the published price outlook by *IEA* in the *World Energy Outlook 2013*. It was difficult to find information about the energy efficiency measures and environmental restrictions in certain countries because of language barriers, but *Wirtschaftskammer Österreich (WKO)* with offices all over the world helped. The work related timeline is shown in Figure 4.

Sources

The main indicator for steel producers to invest in energy efficiency measures is the energy price. In Table 1 different sources are listed. For this thesis information from *EIA, EUROSTAT, IEA* and various sources published by countries were used.

Prices interesting for the steel industry are very rarely available. The only publication with prices for steel producers was *The Steel Industry in the European Union* from *Centre for European Policy Studies*[18].

[18] Centre for European Policy Studies (2013)

Table 1: Sources of energy prices and background information

Source	Information
EIA	The *United States Energy Information Administration (EIA)* collects, analyses and publishes independent energy information to help policy making and understanding of energy.[19]
ENERDATA	*ENERDATA* provides energy price information, outlooks and market reports.[20]
EUROSTAT	*EUROSTAT* is provider of statistics about members of the European union and candidate states.[21]
IEA	The *International Energy Agency (IEA)* is an autonomous organisation which works to provide reliable, affordable and clean energy to its 28 member countries. Main Areas of IEA: • Energy security • Economic development • Environmental awareness • Engagement worldwide[22]
IHS	*Institute for Advanced Studies (IHS)* is an independent, non-profit research organisation. The IHS CERA, which is one Service of IHS, analyses the energy market. It delivers independent analyses on energy markets, geopolitics and industry trends.[23]

It is hard to compare figures between publications due to a varying definition of the term industry. Table 2 shows all different sources used in this thesis and their definitions. Most sources don't define their path of data collection and there is no explanation available about published data. It can be assumed that market prices are often specific for industries with less annual consumption than those of the steel industry. Natural gas prices per m^3 are converted into MWh using gross calorific value for comparison. This is necessary because of different quality of natural gas across the world. Exchange rates used for the calculation can be found on page 109.

Table 2: Energy price sources and definition of industry

Source	Definition of industry
ANEEL	No definition available.[24]
China mail	No definition available. For more detailed prices look at page 64 and following.[25]
EIA	Energy end-use prices, including taxes.[26]

19 Energy Information Administration
20 ENERDATA (2014a)
21 COMM/ESTAT (2014)
22 International Energy Agency (2014b)
23 IHS CERA
24 ANEEL (2014)
25 Siemens AG (2013)
26 Energy Information Administration (2014t)

<table>
<tr><th>Source</th><th>Definition of industry</th></tr>
<tr><td>ENERDATA</td><td>No definition available. Data is from the Data Country Sample.[27]</td></tr>
<tr><td>ESKOM</td><td>Business rate for annual consumption of 100.000 MWh.[28]</td></tr>
<tr><td>EUROSTAT</td><td>EUROSTAT data show two different methodologies of data acquiring. Which explains the jump in prices in 2007, where methodology changed. In both methodologies VAT and other recoverable taxes for industry are excluded.[29]
For electricity definition of industry is:
<table>
<tr><td>Old methodology</td><td>Annual consumption: 2.000 MWh; maximum demand: 500 kW; annual load: 4.000 hours</td></tr>
<tr><td>New methodology</td><td>500 MWh < Consumption < 2 000 MWh</td></tr>
</table>
For natural gas definition of industry is:
<table>
<tr><td>Old methodology</td><td>Annual consumption: 41.860 GJ; annual load: 1.600 hours</td></tr>
<tr><td>New methodology</td><td>10.000 GJ < Consumption < 100.000 GJ</td></tr>
</table></td></tr>
<tr><td>IEA</td><td>International Energy Agency Energy Prices & Taxes (IEA EP&T) define prices as actually paid, which means net of rebates, include transportation costs and also include taxes which are paid by the customer but are not refunded. Prices are average for every year except for 2013 where data is available for the first and second quarter which is averaged.[30]</td></tr>
<tr><td>Ukraine mail</td><td>No definition available.[31]</td></tr>
<tr><td>MIDA</td><td>Tariff for medium voltage supply. For detailed information go to 0 at page 70.[32]</td></tr>
<tr><td>NUS</td><td>No definition available.[33]</td></tr>
<tr><td>Vietnam EVN</td><td>No definition available.[34]</td></tr>
</table>

2 Energy efficiency and economic drivers

Climate change, resource shortage and growing world population are leading to increased energy demand. Today energy consumption and energy production attracts more and more attention. One reason is climate change with various environmental impacts and the other one is the economy itself which is reliant on affordable energy.

[27] ENERDATA (2014b)
[28] ESKOM (2014b)
[29] EUROSTAT (2014)
[30] International Energy Agency (2013b), p.19
[31] WKO (2014)
[32] Malaysian Investment Development Authority (MIDA) (2014)
[33] BusinessTech (2014)
[34] Vietnam Electricity (2014)

There are different approaches for dealing with this situation. In the United States for instance global warming is ignored for economic reasons[35], in Europe environmental care is a big topic and many countries have incentives and governmental support to invest in energy efficient solutions or to build efficient energy management. Asia is the fastest growing region[36] and environmental awareness is just starting.

In this master thesis questions from Wohinz and Moor were used to look at the energy situation in regard to location choice: [37]

1. How “secure” or available is energy?
2. How “expensive” or cheap is energy?
3. How “environmentally friendly” or invasive is energy?

The first question is about ensuring energy supply in the right quantity and at the right time which is a technical and a political problem. Nature as an energy resource is not indefinite and we also have the obligation to ensure resources for future generations.[38]

Economically speaking the second question is very interesting. Low energy costs tend to bring environmental problems and on the other hand high energy prices have negative tendencies for the economy.

The third question points directly at the environment and pollution resulting from energy production and use. Nosko defines the *natural environment* in three functions:

- The environment as natural habitat for all living beings.
- The environment as supplier of all natural resources.
- The environment as medium for residues from production and consumption processes.[39]

These elements are finding their way more and more into business management levels but have an even more important role for political decisions and regulations.

One way to reduce greenhouse gas (GHG) emissions is to become more energy efficient. There are several stages of energy efficiency, which are differentiated through general conditions.

[35] WKO (2013)
[36] IHS (2014)
[37] Wohinz, J. W. and M. Moor (1989), p.2
[38] Wohinz, J. W. and M. Moor (1989), p.3
[39] Nosko, H. (1986), p.85

Schmid defines four different potentials:

- Theoretical potential
- Technical potential
- Economical potential
- Market potential [40]

Theoretical potential is the difference between actual process and ideal process which is not possible in practice.
Technical potential means current existing, energy efficiency technology, also including prototypes.
Economical potential also includes costs. Will an investment be cost effective in a certain time span? How high is my return on investment? For example, a Deloitte study about resources asked businesses about investments in energy efficiency and came to the conclusion that the average payoff-period of 3,5 – 4 years and an internal rate of return (IRR) of 20 % is the requirement.[41] *Market potential* also looks at the possibility that there are organizational barriers like market failure.[42]

2.1 Definition of efficiency

The EUR-Lex defines energy as all forms of commercially available energy including electricity, natural gas with liquefied natural gas (LNG), liquefied petroleum gas, any fuel for heating and cooling, coal and lignite, peat, transport fuels and biomass for electricity production. Energy efficiency is the ratio between output of performance, service, goods or energy and the input of energy. Energy efficiency improvements can be reached by technological, behavioural and/or economic changes. Energy savings are defined as energy consumption reduction achieved by an energy efficiency improvement. Energy audits are systematic procedures to obtain information about the energy consumption profile and to identify cost-effective energy saving potentials.[43]

2.2 Energy systems in change

So far, debates about energy were mainly focused on energy supply. The source of oil and natural gas and how long these resources will last were a main focus. Today, also the impact on the environment influences decision making. Renewable energy is one

[40] Posch, Wolfgang (2011), p.121–122
[41] Deloitte (2013), p. 20
[42] Posch, Wolfgang (2011), p.121–122
[43] EUR-Lex (2014)

solution, energy efficiency another.[44] From the government's point of view energy efficiency can be seen from various perspectives. First energy can be seen as a commodity, secondly as an ecological resource. The third view is the social necessity of consumers having the right to receive energy and the fourth factor is a strategic one. This strategic factor includes geographic location in the world and the political situation there. Regarding the energy supply from a country's point of view it can be said that energy efficiency is crucial for everyone.[45] From the perspective of industrial companies increasing global warming does not receive much attention nor does the energy supply security as long as their demand is covered. However, some companies go green and also include the environment in their decisions.[46] The complexity of environmental problems is shown in Figure 5.

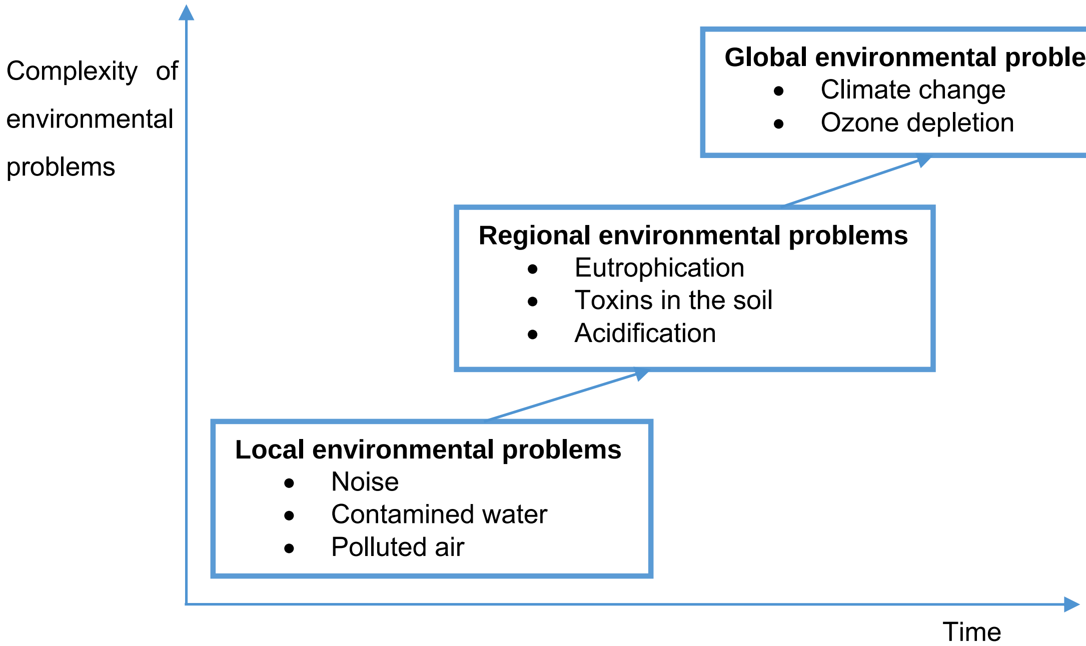

Figure 5: Environmental problems over time[47]

A survey in the European Union found out that in general, these green companies are exceptions. Nearly two thirds (63 %) of small and medium-sized companies (SME's) in the European Union lack even simple devices for saving energy and only 29 % have taken measures to save energy in their operations. Only 4 % of SME's have environmental management systems in place whereas in larger companies this figure is 19 %. 70% of companies with fewer than 10 employees stated that they did not care. In comparison, 57% of companies with less than 50 employees and 44% of those with fewer than 250 employees stated the same.[48]

[44] Thollander, Patrik and Jenny Palm (2013)
[45] Stern PC, Aronson E (2006), p. 315–331
[46] Nattrass B, Altomare M (2001)
[47] Thollander, Patrik and Jenny Palm (2013)
[48] European Commission (2006a)

Understanding the energy use and energy efficiency in industry is very important for working out company specific theories and methods and to share relevant knowledge. In order to reach this goal an interdisciplinary approach is necessary that combines knowledge, helps industry to become more energy efficient and to solve problems in all stages.

Today energy is key to many processes and involved systems have to be improved not only technologically but also from a management perspective. Caffal researched in-house management programs combined with technology which can lead to energy savings from 4 – 40 %.[49] Today, there is an energy management standard in place which is defined by the *International Organization for Standardization (ISO)* 5001 and the European EN 16001. Figure 6 shows that energy management can be seen as continuous development. .

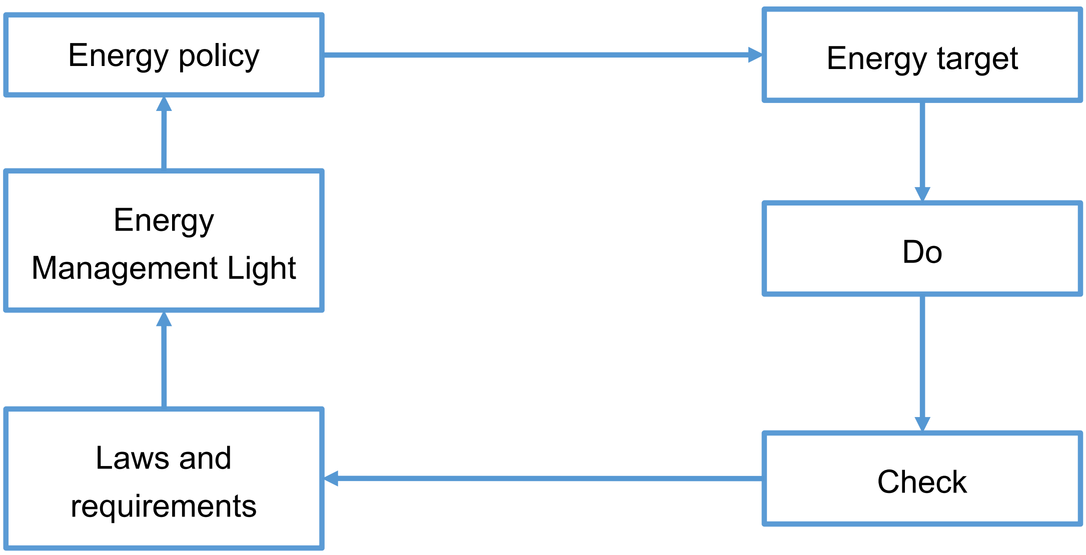

Figure 6: Continuous improvements of an single energy management system[50]

Caffal also published a strategic approach for successful industrial management that requires full support from top management. The strategic approach includes following elements:[51]

- Initial energy audit,
- Senior management support,
- Energy use monitoring,
- Use of management and not only technology,
- Strategic and coordinated program for energy-saving projects.

[49] Caffal (1995)
[50] Hrustic A, Sommarin S, Thollander P, Söderström M (2011)
[51] Caffal (1995)

For the last point these items should be included:

- Long-term saving scenario,
- Factory-wide plan for medium term,
- Detailed plan for the first year,
- Actions to improve the management and an energy monitoring system.

Energy efficiency includes many steps and there is no “one-size-fits-it-all” solution available.[52] In energy intensive industries with great possibilities in energy-saving a full scale energy management is justified. For smaller companies or non-energy intensive ones energy management could be included in quality management or environmental management systems.[53]

2.3 Environment and sustainability

Usually, the energy price is what customers pay for without including any environmental or social costs associated with production, conversion, transportation and usage of energy. These additional environmental costs are hard to calculate but the resulting energy price would be much higher thus energy efficiency measures would have a shorter payback time.[54] There are three major factors that affect the environment which originates from human activity:

1. Population growth,
2. Material usage and
3. Energy usage.

Our earth’s environmental problems are shifting from local ones to affect regions and are reaching global scale. To address these problems everyone has to work together as a local solution cannot solve a global problem.

Robert and Broman defined a sustainable society where nature is not subject to systemically increase of:[55]

- Concentrations of substances extracted from earth’s crust and
- Concentrations of substances produced by society

To achieve a sustainable environment business, cities and regions must work together worldwide and have to work in line with global social trends. However, there is a risk

[52] Christoffersen LB, Larsen A, Togeby M (2006)
[53] Caffal (1995)
[54] Hirst E, Brown MA (1990), p. 267–281
[55] Robèrt K-H, Broman G (2011)

of adopting the sustainable principles too fast which could result in bankruptcy. Given that energy prices and material costs are rising as soon as they are becoming rare it can be a big benefit for companies to be sustainable.[56]

2.4 Political environment and barriers for energy efficiency

Reaching the goal of stopping the climate to change is a global untertaking and there are many players who have to act in a coordinated way.

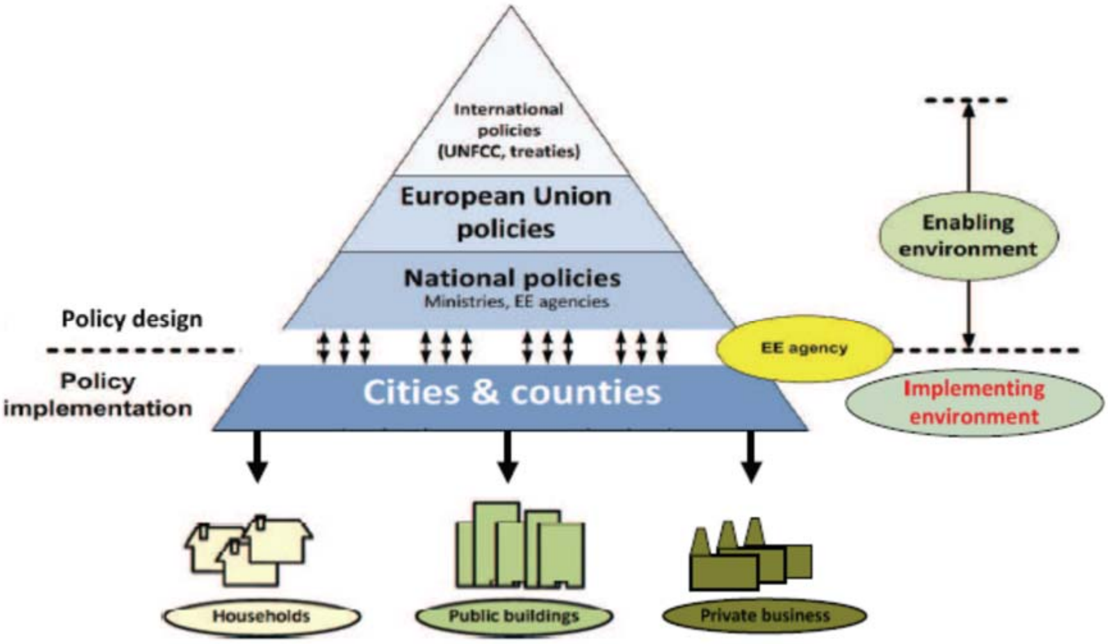

Figure 7: Levels of energy efficiency policy[57]

In Figure 7 all levels of energy efficiency decision making are shown with the policy design role of international agencies, regions like the European Union and national policies. Also the policy implementation is illustrated on the level of cities and counties with households, public buildings and private businesses. Many international programmes and treaties are supported by financial tools but there is little help on how to implement policy measures.[58]

In the debate over climate change four blocks can be identified in Figure 8. The European Union is forerunner in terms of climate protection and energy efficiency measures with some other OECD members included. The United States and BRIC countries (Brazil, Russia, India and China) are more concerned about their national interests and try to avoid any commitments concerning greenhouse gas emissions.

[56] Thollander, Patrik and Jenny Palm (2013)
[57] Zoran Morvaj and Vesna Bukarica (2010)
[58] Zoran Morvaj and Vesna Bukarica (2010)

Developing countries represent the fourth and also significant block. For them energy efficiency is very important because of the related cost reduction for energy.

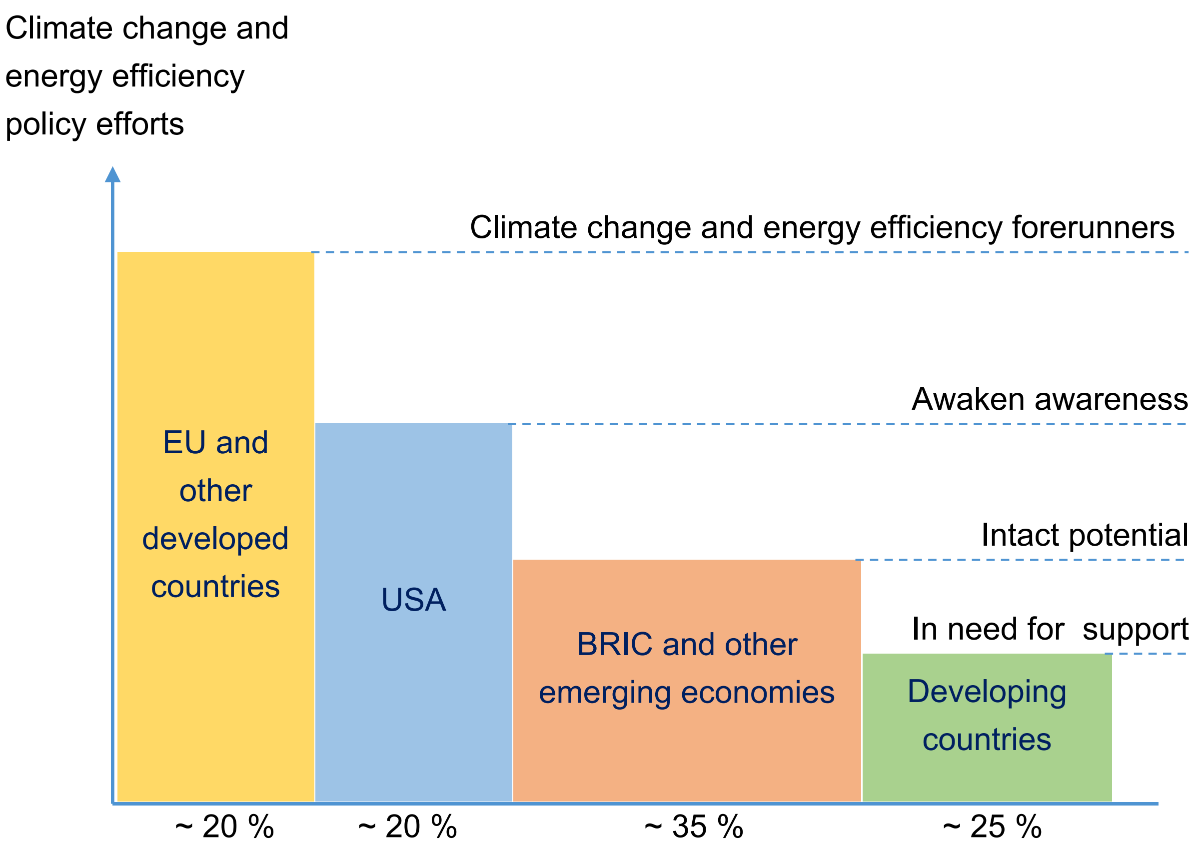

Figure 8: Share of GHG emissions worldwide[59]

Energy decision making is controversial and is approached differently around the globe. Often assumptions such as a rational decision making based on perfect information available for buyers and sellers are used to describe the market. Market failures and barriers are used as justification for political intervention.[60]

Perfect information for buyers and sellers with raising energy prices would cause companies to invest in energy efficiency measures, even without political interference.[61] This theory is closely related to the ideas of the economist Adam Smith who stated that in a decentralised market individual acts lead to collectively beneficial results.

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[59] Zoran Morvaj and Vesna Bukarica (2010)
[60] Brown MA (2001), p. 1197-1207
[61] Sutherland RJ (1996), p. 361–370

Some of the axioms used in this theory are:[62]

- An open market where everybody can access goods
- Consumers and producers act competitively and try to maximize their profit by minimizing costs
- Market prices are well known by all customers and companies
- No transaction costs

All axioms have to apply otherwise a market failure or market imperfection will occur which may be the reason for political intervention. There are four types of market failure which are:[63]

1. Incomplete markets,
2. Imperfect competition,
3. Imperfect information and
4. Asymmetric information.

For energy efficiency imperfect information and asymmetric information are of special interest.[64] Sanstad and Howarth wrote that it is not hard to observe that these market failures are not rare but may occur on a daily basis.[65]

While declining energy prices are leading to greater energy use[66] the contrary increasing energy prices do not lead to more energy efficiency in short term[67]. Market mechanism solutions alone are not enough for more energy efficiency. There is also a political interference needed to ensure investments in a more efficient production process. The energy efficiency gap as it is called assumes that technology, methods and processes are available on the market which can reduce energy consumption but that existing barriers prevent their usage.

Many reasons have been identified which are suspected to cause this gap whereby it is not sure if they are market failures or barriers:[68]

- Lack of information,
- Lack of knowledge,
- Lack of time and
- Lack of funding.

[62] Thollander, Patrik and Jenny Palm (2013)
[63] Sorrell S, Schleich J, Scott S, O'Malley E, Trace F, Boede E, Ostertag K, Radgen P (2000)
[64] Sorrell S, Schleich J, Scott S, O'Malley E, Trace F, Boede E, Ostertag K, Radgen P (2000)
[65] Sanstad A, Howarth R (1994), p. 811–818
[66] Trygg L, Karlsson B (2005)
[67] Bertoldi P, Rezessy S, Bürer MJ (2005), p. 1-12
[68] Thollander, Patrik and Jenny Palm (2013)

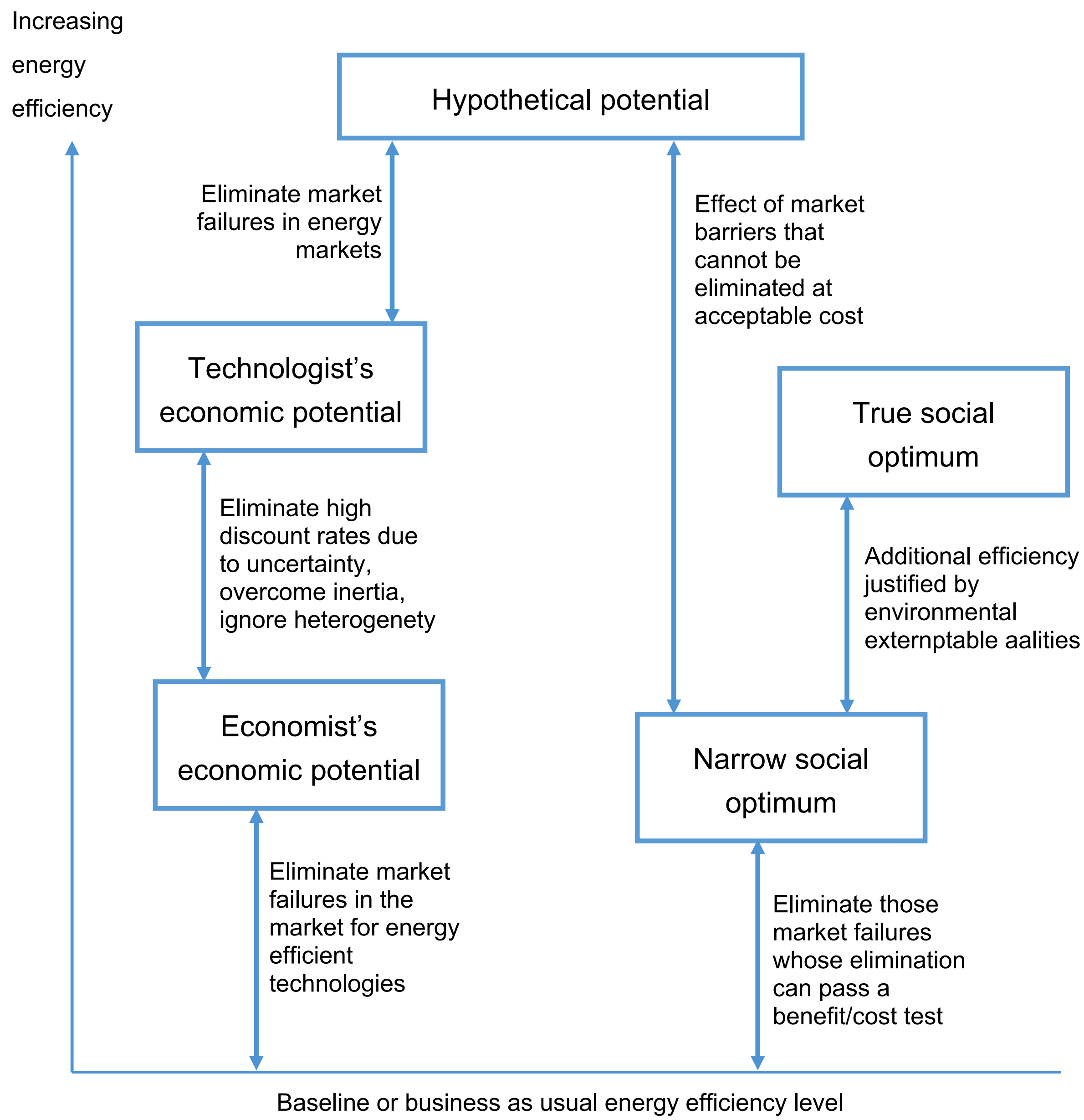


Figure 9: Various levels of energy efficiency potential[69]

To explain the gap Jaffe and Stavins used Figure 9 where different potentials and their gap to a baseline are drawn. The baseline indicates business as usual and the text in between the boxes describes the gap among the scenarios. Jaffe and Stavins suggest an economic concept and a social one with both leading to a hypothetical potential.[70]

Sorrell defines barriers for energy efficiency as follows:" A postulated mechanism that inhibits investments in technologies that are both energy-efficient and economically efficient"[71] and classified barriers as it is shown in Table 3.

[69] Jaffe AB, Stavins RN (1994), p. 60-71
[70] Jaffe AB, Stavins RN (1994), p. 60-71
[71] Sorrell S, O'Malley E, Schleich J, Scott S (2004)

Table 3: Classification of barriers to energy efficiency[72]

Category	Theoretical barriers	Comment
Market failure/market imperfection	Imperfect information	Information imperfection, for example, lack of information, may lead to cost-effective energy efficiency measures not being undertaken.
	Adverse selection	If a seller knows more about the energy performance of a technology than the buyer does, the buyer may select goods on the sole basis of price or visible aspects such as colour and design.
	Principal-agent relationship	Strict monitoring and control by the principal, since he or she cannot observe what the agent is doing, may result in the overlooking of energy efficiency measures.
	Split incentives	If a person or department cannot benefit from an energy efficiency investment, most likely the measure will not be implemented.
Non Market failures/non Market imperfection	Hidden costs	Hidden costs include overhead costs related to the investment, cost of collecting and analysing information and production disruption.
	Access to capital	Limited access to capital to capital may inhibit cost-effective energy efficiency measures from being implemented.
	Risk	Risk aversion may result in cost-effective energy efficiency measures not being undertaken.
	Heterogeneity	A technology or measure may be cost-effective in most locations but not in others, leading to excessive potential being claimed for the technology.
Behavioural barriers	Form of information	Research has demonstrated that to increase the diffusion and acceptance of information on cost-effective energy efficiency technologies the information should be specific, vivid, simple and personal.
	Credibility and trust	The source of information must be considered credible and trustworthy by the receiver in order to successfully deliver information about cost-effective energy efficiency technologies.

[72] Sorrell S, O'Malley E, Schleich J, Scott S (2004)

Category	Theoretical barriers	Comment
	Values	Energy efficiency improvements are more likely to be of interest if the organization consists of individuals with real ambition.
	Inertia	Individuals are often hesitant to change, which may, in turn, result in the overlooking of cost-effective energy efficiency measures.
	Bounded rationality	Instead of being made based on, for example, perfect information and complete rationality, decisions are often made in constrained environments that result in limited, in bounded, decisions, i.e., non optimal from a fully rational point of view.
Organizational	Power	Low status of energy managers may lead to energy issues being assigned a low priority in industrial organizations.
	Culture	Over time, organizations may encourage energy efficiency investments by developing a culture characterized by environmental values, for example, the core values of an industrial organization may inhibit or promote energy efficiency.

To overcome these barriers *energy services* are seen as a promising tool. Energy services for example use audits, maintenance and financial help for energy efficiency measures. One way of promoting efficiency projects is to use risk-free state loans or to set up guidelines how agreements can look like. This would reduce the trust barrier by giving information to both parties and would reduce the risk of asymmetric information barriers.[73]

When all information is at the right place companies can only be attracted to energy efficiency solutions in two ways:[74]

1. High energy prices force the company to cut costs in energy to stay competitive and
2. A global environmental crisis forces companies to decrease production or improve energy efficiency.

[73] Thollander, Patrik and Jenny Palm (2013)
[74] Thollander, Patrik and Jenny Palm (2013)

The second reason is very unlikely as the climate change has no impact on the production process itself and global warming and other climate-related disasters are happening very slowly.[75]

On one hand increasing energy prices will negatively affect competitiveness and could lower production and in some cases even cause companies to relocate. This would have negative effects for the region.[76]

On the other hand increasing the energy efficiency decreases the overall costs for a company and can lead to greater productivity and an increase in profits.[77]

Energy audit programs revealed that implementing energy efficiency measures in non-energy intensive industries seem easier than in energy intensive industries. This is closely related to the initial investment costs. Many energy efficiency measures in support processes like ventilation, space heating and lightning have lower initial costs compared to a capital-intensive production process.[78]

Helping industry to identify possible ways to get more efficient is often used in form of government funded energy audits. Sometimes companies are not aware of possible energy efficiency measures and its benefits for production costs. To overcome this information barrier an energy audit can help and can be the start for further improvements.[79]

Policy instruments are one way politicians can influence the way involved parties behave.[80] They work in different ways depending on how much time is needed, public acceptance and how much it will cost compared to other variations. The way policies influence behaviours depends on the target group.[81]

The most powerful policy instruments are prohibitions which force people to refrain from certain behaviour. Such instruments are not very flexible and can have unforeseen effects as reality is often more complex than policy makers can predict.[82]

Incentives on the other hand are market based instruments where the predetermined direction is either pushed towards by increased costs and/or reduced costs in other areas which leads to a higher profit. Such tools are taxes and fees which can be increased for certain products and make them less profitable. Or subsidies, tax or fee

[75] Thollander, Patrik and Jenny Palm (2013)
[76] Centre for economic analysis AB (2003)
[77] Worrell E, Laitner J, Ruth M, Finman H (2003), p. 1081-1098
[78] Thollander P, Rohdin P, Danestig M (2007), p. 5774–5783
[79] Thollander, Patrik and Jenny Palm (2013)
[80] Schneider A, Ingram H (1990)
[81] Thollander, Patrik and Jenny Palm (2013)
[82] Schneider A, Ingram H (1990)

reductions to steer the market in a direction. However, these instruments are hard to administer and to predict in the first place. As written before there are many barriers like imperfect information or people acting irrationally.[83]

Energy policy making originates from the 1970s oil crises where the awareness started that resources a not indefinite and access to energy is not garanteed. In the 1990s the environment discussion started and various standards to protect the environment were enacted in additions to tax regulations and subsidies.[84]

Linden defines four categories of policy instruments:[85]

1. Information
2. Economic
3. Administrative
4. Physical improvement instruments

Information instruments represent different ways of information distribution such as written information, labelling and advertisement. Small- and middle-sized companies often don’t have anybody directly responsible for energy efficiency. Thus, information can raise awareness about different ways of energy savings.[86]

Economic instruments include incentives which were described before and try to motivate actors to monitor and plan in an efficient way. For instance this could involve directing companies in a more efficient way by helping them getting their taxes reduced. [87]

Administrative instruments such as CO_2 limitation, prohibitions and regulations have immediate effect but it is difficult to consider all possibilities and not to favour some parties. However, these measures are very inflexible.[88]

Physical improvement instruments are direct help in form of energy meters or immediate feedback to encourage the new behaviour.[89]

Neij and Öfverholm found out that there are not many studies about the effects of these instruments. What they also found was that energy labelling influenced the supply of energy efficient refrigerators and freezers. Their suggestion is to combine technology procurement with other policy instruments which will lead to improved technology,

[83] Schneider A, Ingram H (1990)
[84] Palm J (2006)
[85] Lindén A-L, Carlsson-Kanyama A, Eriksson B (2006)
[86] Lindén A-L, Carlsson-Kanyama A, Eriksson B (2006)
[87] Lindén A-L, Carlsson-Kanyama A, Eriksson B (2006)
[88] Lindén A-L, Carlsson-Kanyama A, Eriksson B (2006)
[89] Lindén A-L, Carlsson-Kanyama A, Eriksson B (2006)

improved stakeholder knowledge and the successful entry of new technology. They concluded that the most effective way of control is the combination of various policy instruments.[90]

2.5 Energy usage and technical potential for energy efficiency improvements in industry

To compare industries a differentiation has to be made between all processes that are needed to produce a product. Additionally, support processes which are not directly needed for production but are requried for a successful process need to be included. Söderström defined 11 general production processes which are: decomposition, mixing, cutting, joining, coating, forming, heating, melting, drying/concentration, cooling/freezing, packing and also 7 support processes: lightning, compressed air, ventilation, pumping, space heating and cooling, hot tap water and internal transport.[91]

In non-energy intensive industries the most energy is used in support processes whereas for energy intensive industries this happens in the production process. Figure 10 shows an example of a medium sized non-energy intensive Swedish engineering company with a usage of 70 % of energy in support processes. Compared to Figure 11 where a medium sized foundry is shown with around half of the energy used in production process. Another energy intensive industry sector is illustrated in Figure 12 where only 16,2 % of energy is used in support processes labeled as “other”.

[90] Neij L, Öfverholm E (2002)
[91] Söderström M (1996)

Engineering company under study	
Electricity	479.390 EUR/yr
	7.834 MWh/yr
District heating	170.730 EUR/yr
	2.900 MWh/yr
Total energy cost	650.120 EUR/yr

Processes	EUR/yr	MWh/yr	%
Metal cutting etc.	151.030	2368	22,1
Space heating	145.300	2438	22,7
Ventilation	106.590	1836	17,7
Compressed air	81.240	1360	12,7
Lighting	76.640	1308	12,2
Metal chip collecting	35.320	610	5,7
Tap hot water	34.750	600	5,6
Phosphate finishing	11.030	103	1,0
Engine heating	6260	86	0,8
Office equipment operation	1390	26	0,2

Figure 10: Energy use of a medium-sized non-energy intensive Swedish engineering company[92]

Electricity	26.600
LPG	1.300
District heating	6.700

Processes	
Melting/holding (P)	13.800
Space heating (S)	5.530
Ventilation (S)	4.700
Transformation losses (S)	2.330
Compressed air (S)	2.100
Moulding (P)	2.020
Ladle heating (P)	1.300
Hot tap water (S)	1.200
Lighting (S)	490
Sand preparation (P)	580
Lab/Office processes (S)	350
Sandblasting/cleaning (P)	230

Figure 11: Energy use in a medium-sized energy intensive Swedish iron foundry in MWh/yr[93]

These differences influence how energy efficiency is worked with in these companies and how the potentials for improvements are seen. For the support process in energy intensive and non-energy intensive industries information programs such as energy

[92] Thollander P, Rohdin P, Danestig M (2007), p. 5774–5783
[93] Thollander P, Rohdin P, Danestig M (2007), p. 5774–5783

audits are important to identify opportunities for energy savings. In energy intensive production processes government funding is more important.

Electricity	380
Heat	2030

Processes	Electricity [GWh/yr]	Heat [GWh/yr]	% of total energy use
Evaporator	20	690	29,5 %
Drying	80	420	20,7 %
Digester	110	340	18,7 %
Other	70	320	16,2 %
Bleaching	70	130	8,3 %
Boilers and feed water	30	130	6,6 %

Figure 12: Energy use in a Swedish energy intensive chemical pulp mill in GWh/yr[94]

A big potential for energy savings are motorized systems as Waide and Brunner found out that 68 % of all electricity is used in motorized systems such as pumps, fans, compressors and mechanical movement.[95] They also revealed that there are several energy efficiency measures possible in electric motorized systems. One example is pumping where savings can be reached through effective time control and improvements in gears and transmission. Reducing air leaks in applications using compressed air would help and Waide and Brunner stated that this would have a short payback period. Space heating could be made more efficient by using waste heat from components used in production processes, changing windows, insulation of the roof and walls and so on.. Lightning can also be subject to efficiency improvements by using less electricity consuming illumination.

A + B International carried out a survey about electricity demand in 2009 which is shown in Figure 13. This usage is split up into end usage of electricity and shown for the sector industry in more detail in Figure 14. In this chart it can be clearly seen that electric motors account for the highest energy demand. Small motors with less than 0,75 kW output are the most common. Four major motor applications dominate the electric demand from motors: compressors (32 %), mechanical movement (30 %), pumps (19 %) and fans (19 %). The average efficiency of electric motors is about 50 % with the other 50% lost in the motor itself as well as in throttles, gears, transmissions, clutches, brakes, etc.[96]

[94] Klugman S, Karlsson M, Moshfegh B (2007), p. 461–467
[95] Waide P, Brunner C (2011)
[96] A+B International (2006)

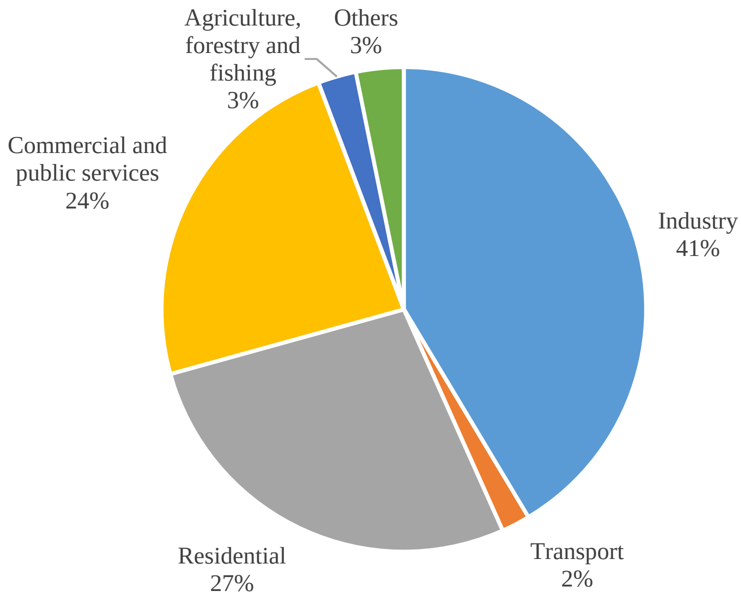


Figure 13: Estimated share of global electricity demand in 2006

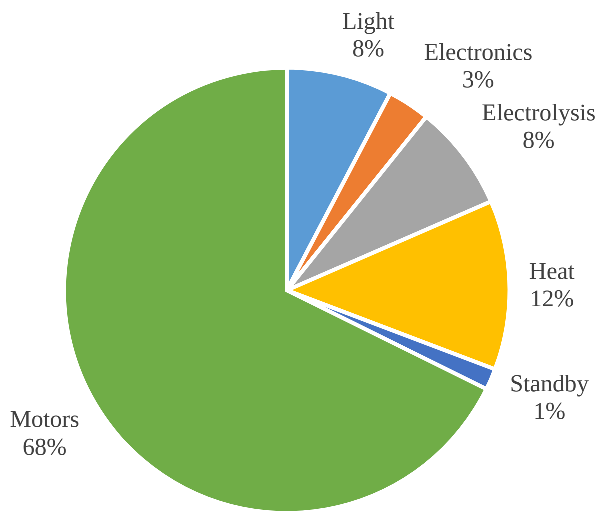


Figure 14: Estimated share of global electricity demand in industry in 2006 [97]

The European commission published a paper 2006 claiming that energy efficiency measures in the manufacturing industry have a potential of saving 25 % of energy. The highest potential for savings is found in motors, fans and lightning. Energy saving potentials in end-user sectors are shown in Table 4 where energy consumption for 2020 is calculated using the business as usual method explained on page 88.[98]

[97] A+B International (2006)
[98] European Commission (2006b)

Table 4: Estimates for energy saving potential in end-use sectors [99]

Sector	Energy consumption in Mtoe 2005	Energy consumption in Mtoe 2020 (Business as usual)	Energy saving potential in Mtoe	Energy saving potential in %
Households	280	338	91	27 %
Commercial buildings	157	211	63	30 %
Transport	332	405	105	26 %
Manufacturing industry	297	382	95	25 %

To achieve these energy savings the European Commission proposed several actions like equipment labelling, building efficiency requirements, making power generation and distribution more efficient, fuel efficiency for cars, investment packages for energy efficiency measures in industry and programs to raise the awareness of energy efficiency.

To improve energy efficiency a system wide view should be used and everybody should be made aware that energy efficiency is a continuing process with many small steps involved. An energy audit from an external company can be an excellent way to start the process. Government funded industrial energy programs are very common worldwide and are seen as the best way to help companies to increase knowledge about how they can improve in terms of energy efficiency.[100]

In previous sections the importance of different approaches for energy intensive and non-energy intensive industry were explained. There are several ways in which a manufacturing industry can reduce energy costs independent from the energy intensity:[101]

- Negotiations with the energy supplier,
- Investing in self-generation capacity and
- Using the energy more cost effective in terms of technology and management.

To invest in self-generation capacity is often not cost effective for non-energy intensive industries and it is more reasonable to look into opportunities Waide and Brunner suggested. To ensure constant development a permanent monitoring should be installed after the initial energy audit.

[99] European Commission (2006b)
[100] Thollander, Patrik and Jenny Palm (2013)
[101] Thollander, Patrik and Jenny Palm (2013)

2.6 The rebound effect

All effects discussed before have positive impact on industries as long as they are cost effective. They strengthen the competitiveness by lowering production costs and help the environment. One critique point on energy efficiency is always the rebound effect. Which means that efficiency measures will not always have these positive effects to reduce energy usage. It can also go the other way which can be split in two categories:[102]

1. Direct rebound effect: Where a new and more efficient technology reduces energy demand and results in lower energy price. Low energy prices tend to increase the energy demand.103
2. Indirect rebound effect: Lower production costs because of energy efficiency measures lead to more investment in other goods and services.

These rebound effects don't have a big impact as studies revealed. Greening found out that the direct rebound effect was less than 20 % and indirect rebound effect about half a percent.[104]

2.7 Conclusion

In this chapter theoretical approaches were explained and further discussed how energy efficiency can be seen including barriers which prevent efficiency measures. Energy efficiency is an ongoing process which is becoming more important in the fight against global warming. Implementing measures to save energy needs to be seen as cyclic process where improvements come in stages.

The next chapter explains how the energy markets work that are specifically interesting for steel producers (electricity, natural gas and coal). It is also discussed how prices are compounded and how networks are built up in order to supply end user.

[102] Herring H (2006), p. 10-20
[103] Bentzen J (2004), p. 123-134
[104] Greening LA, Greene DL, Difiglio C (2000), p. 389-401

3 Electricity

In this chapter basics about electricity and how the electricity market works are described. The composition of the electricity price and the electricity supply network will be shown as well. Top electricity producing and consuming countries are listed in Table 5.

Table 5: Top electricity producing and consuming countries in 2012[105]

Top electricity producers	Top electricity consumers
1. China 4.604 billion kWh	1. China 4.693 billion kWh
2. USA 3.953 billion kWh	2. USA 3.741 billion kWh
3. Japan 937,6 billion kWh	3. Japan 859,7 billion kWh
4. Russia 925,9 billion kWh	4. Russia 857,6 billion kWh

Electricity is a grid bounded media and cannot be stored effectively. For this reason power generation has to follow consumption over time. Most electricity grids are statewide connected and controlled with certain interconnections to other countries which makes electricity trading mostly national. Electricity can also just be bought when a network capacity between generation and consumer is available. Trading happens on electricity exchanges (stock markets) and with multi annual contracts which are traded *Over the Counter (OTC).*

3.1 Electricity price composition

The price of electricity basically consists of the energy production price, the grid costs and non-recoverable taxes and levies which are shown in Figure 15. Taxes and levies can be divided into value added taxes, energy levy and renewables levy.

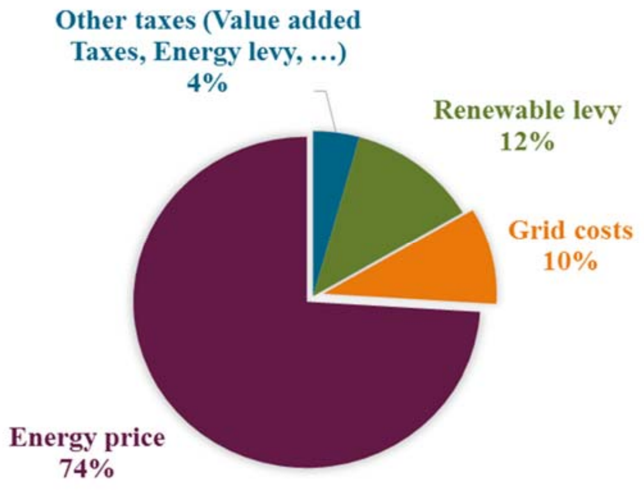


Figure 15: Average Electricity Price Composition for steel producer in the European Union [106]

[105] Central Intelligence Agency (2014)
[106] Centre for European Policy Studies (2013)

The *Centre for European Policy Studies (CEPS)* did a study on the steel industry and looked into the composition and drivers of energy prices and costs.

Europe was split in three regions for this reasearch:

- Centre-East Europe
- North-West Europe
- South Europe

Figure 16 shows these regions and included states.

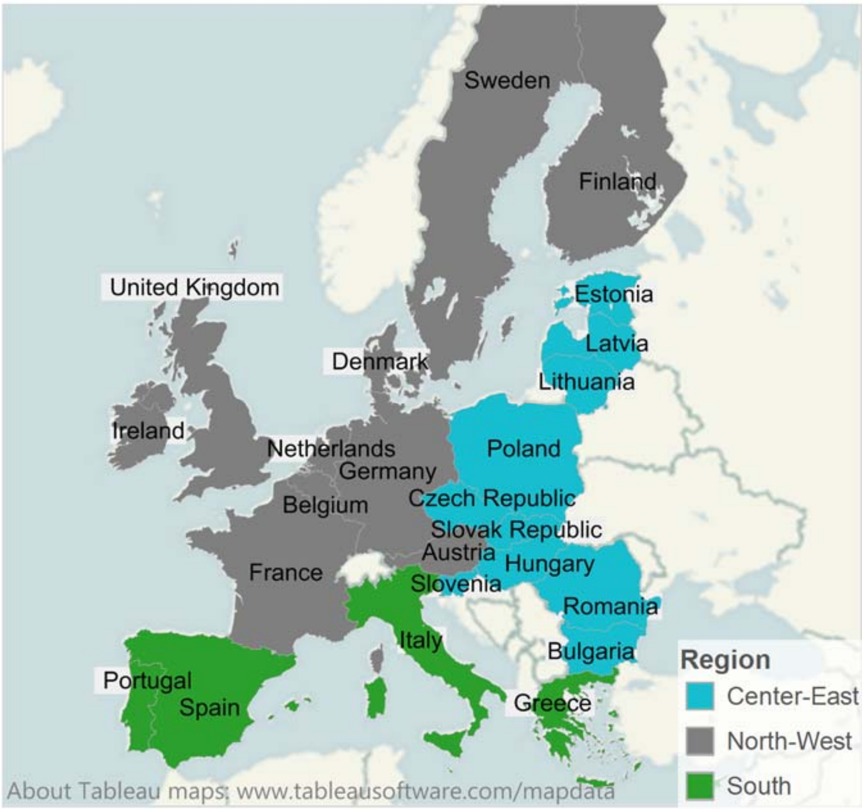


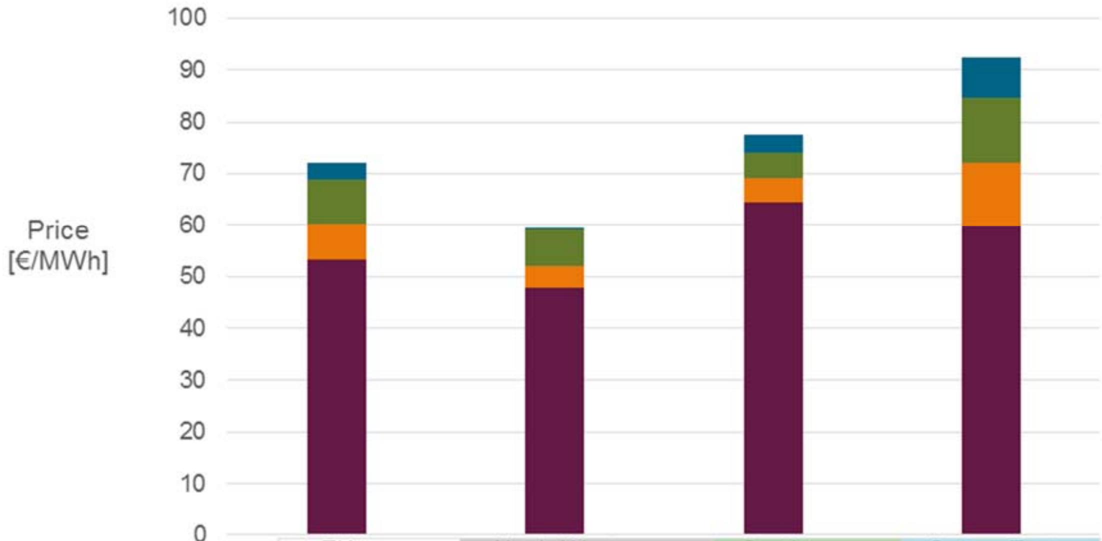
Figure 16: Regions within Europe [107]

The study includes *Basic Oxygen Furnaces (BOF)* integrated sites, *Electric Arc Furnace (EAF)* plants and rolling mills. The result is shown in Figure 17. In the Nort-West around 80 % of the electricity bill is production costs and in comparison this share is around 65 % in the Centre-East. The rest are other taxes, renewable levies and grid costs.

For the study seventeen steel producers provided data. Most BOF installations have their own self-generation facility to produce electricity out of recycled waste gases from furnaces. Installations in the Centre-East face the highest electricity costs with 92 EUR/MWh compared to the South with 60 EUR/MWh in 2012. The European

[107] Centre for European Policy Studies (2013)

average that was paid by steel industry was 72 €/MWh. Prices in this study are net prices with certain fees, taxes or levies and reductions already included.[108]



	EU	North-West	South	Center-East
Other taxes	3	0,4	3	8
Renewable levy	9	7	5	13
Grid costs	7	4	5	12
Energy price	53	48	65	60
Sum	72	60	78	92

Figure 17: Electricity bill components of sample steel producer 2012 [109]

3.2 Electricity market

Electricity is mostly nationwide traded and the two trading instruments are:

- Over the Counter (OTC)
- Electricity Exchanges

Mainly, trading *Over the Counter (OTC)* is used, which includes a direct contract between an electricity producer and end user in form of multiannual contracts. Examples and explanations used in this chapter are all from energie-lexikon.info.[110]

An *electricity exchange (stock exchange)* on the other hand is not based on supply and market demand rules. Here the *merit order* trading system is in place which ranks available sources. On an electricity exchange many different products are traded. There is a *spot market* where the next day is traded, an *intraday market* to trade

[108] Centre for European Policy Studies (2013)
[109] Centre for European Policy Studies (2013)
[110] Paschotta, Rüdiger (2014b)

balancing energy (operating reserve) till 45 min before demand and a *futures market* to trade base load in future for the next weeks, month or quarter.

On *spot market (Day ahead market)* traded packages are:

- Base load
- Peak load
- Off-peak load
- Hourly contracts

Figure 18 shows the spot and derivatives market with its products. There is a *base load* which is traded in 24 h packages, a *peak load* between 8 am and 8 pm and *hourly contracts* to fill the gaps and reduce the need for balancing energy. All packages are with constant electric load.

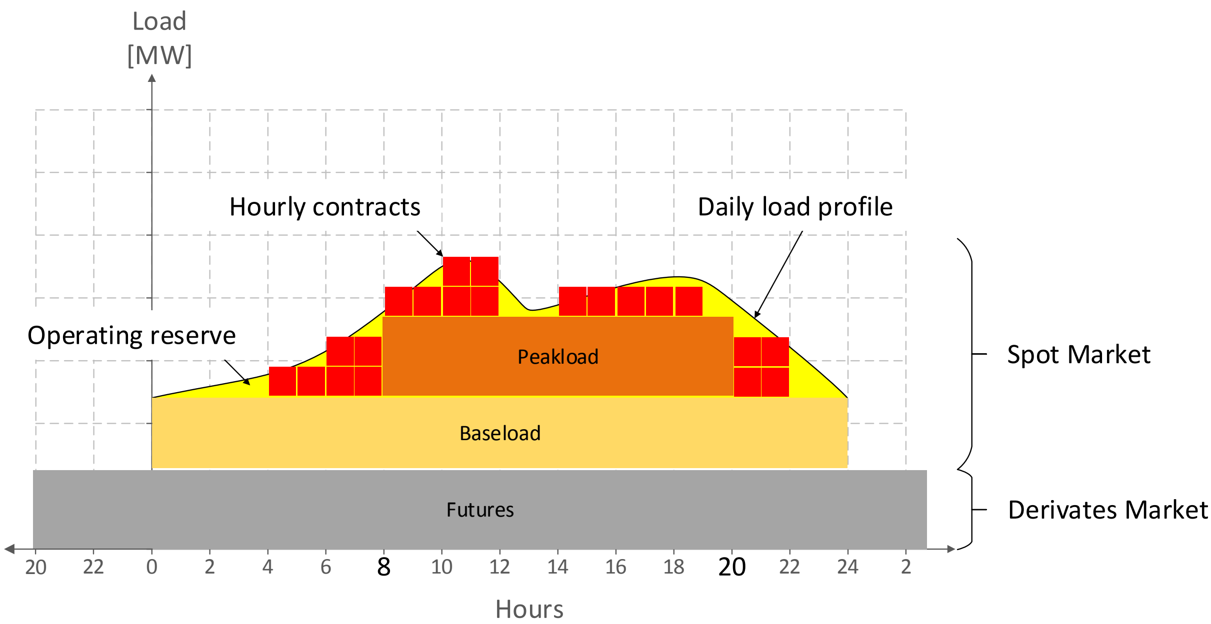


Figure 18: Traded products on electricity exchanges [111]

Merit order principle

The exchange trading works with the *merit order* principle to rank available sources. It works in three steps (Prices and load figures are just for illustration and fictitious):

1. Offers: Electricity producer proposes a price [€/MWh] for a certain electric load [GW], like it is shown in Figure 19. Here sample offers are shown and proposed offers were sorted by specific costs.

[111] Paschotta, Rüdiger (2014a)

2. Demand: Electricity consumers also name the price they would pay [€/MWh] for a certain electric load [GW]. On the demand side the prices were sorted by falling prices as it is also shown in Figure 19.
3. Clearing: The delivered electric load and the price for the whole delivery is found where consumer offere prices that meet proposed producer prices. This intersection is called clearing point. In Figure 19 this means that hydropower, nuclear power, coal and natural gas sell 10,9 GW at 75 €/MWh and Oil sells .

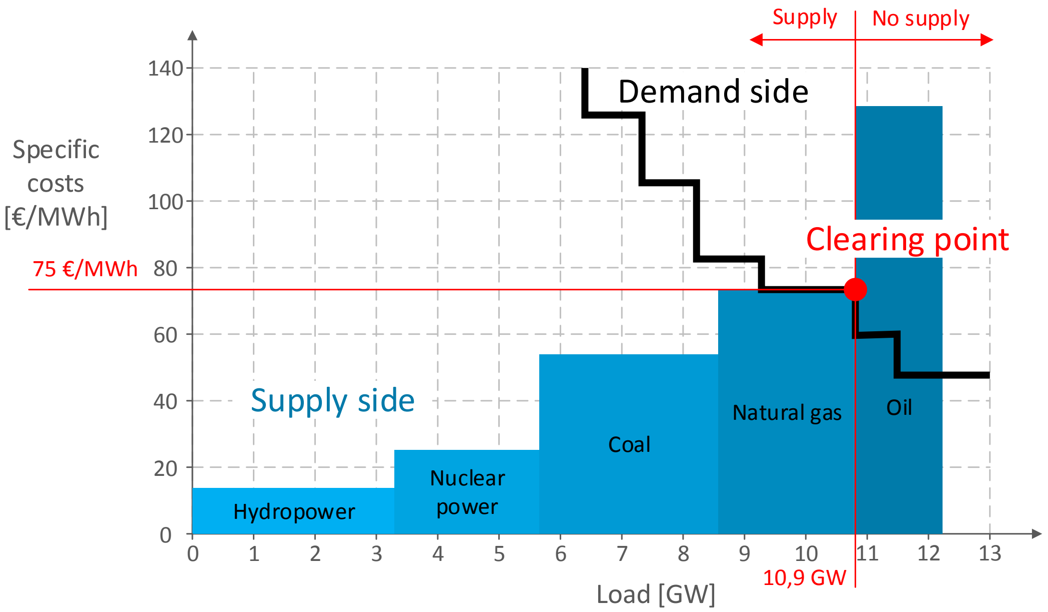


Figure 19: Clearing on an electricity exchange [112]

If it would be a supply and demand market every power unit would be sold at the proposed price and that's how *Over the Counter (OTC)* works. Big consumers try to buy a certain amount of their electric power needs OTC and the rest on exchanges.[113]

3.3 Emission certificate trade

The *European Emission Certificate Trade (EU ETS)* is the largest multi-country, multi sector *greenhouse gas (GHG)* emissions trading system in the world. It includes power stations, oil refineries, offshore platforms and industries that produce iron and steel, cement and lime, paper, glass, ceramics and chemicals.[114]

Figure 20 shows all four EU ETS phases of which three have been delivered with the plan to further continue.

[112] Paschotta, Rüdiger (2014a)
[113] Paschotta, Rüdiger (2014b)
[114] GOV.UK (2014)

Phase 1 was a three year pilot period of "learning by doing" to establish a price for carbon in free certificate trading and the necessary infrastructure for monitoring, reporting and verifying actual emissions. In the absence of reliable emission data, caps were set on basis of best guesses. In practice, there was an over allocation of certificates and the price fell to zero. It was not possible to bank allowances for phase two. The penalty for non-compliance was 40 €/t_{CO2}. Nearly all allowances in phase one were allocated for free.

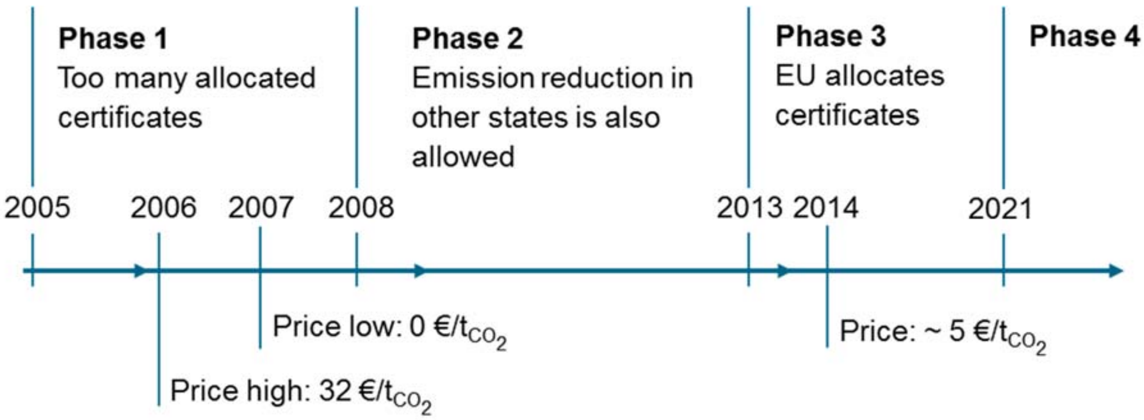


Figure 20: Phases of EU ETS [115]

Phase 2 began in 2008 when Iceland, Liechtenstein and Norway joined the EU ETS. 90% of allocations were given away for free and some states started actions. The penalty for non-compliance increased to 100 EUR/t_{CO2}. In phase two it was possible to invest in developing countries to decrease the output of CO_2, which was the main driver of developing energy efficiency in these countries.[116] In Figure 21 the timeline of allowance prices in phase 2 are shown which started at around 23 EUR/t_{CO2} and fell under 5 EUR/t_{CO2} in the beginning of 2013. In the middle of 2008 also the highest point with around 30 EUR/t_{CO2} was reached.[117]

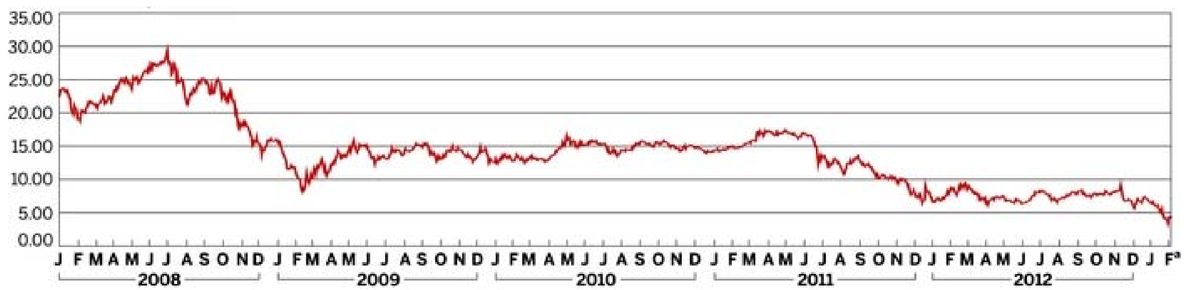


Figure 21: Carbon allowance price in EUR [118]

[115] Scott, Alex (2014)
[116] COMM/CLIMA/0002 (2013)
[117] Scott, Alex (2014)
[118] Scott, Alex (2014)

Cap and Trade

The EU ETS works on market principle *cap and trade, which* means that there is a limit of total greenhouse gas emission allowances which were allocated to participants in the market via a mixture of free allocation and auctions. One allowance means that the owner can emit one tonne of CO_2 or the equivalent. Participants must monitor their emissions each year and surrender enough certificates to cover their annual emissions. A participant who emits more can either reduce its emissions or buy certificates from companies who don’t need them. It doesn’t matter where emissions are reduced because the effects on the environment are the same.[119]

There are also other emission trading schemes active around the world but only the EU ETS and the New Zealand ETS (NZ ETS) operate on a nationwide basis. The NZ ETS has a completely different approach as it is allowed to trade with the international Kyoto Protocol market. It also has an economy wide coverage and is not only for certain industries. In Switzerland and the United Kingdom certificate trading schemes are also nationwide but sit within a larger context. In particular, this is the CO_2 levy in Switzerland and the EU ETS in the United Kingdom. Other schemes have been established on a regional level like in Alberta, New South Wales, United States Regional Greenhouse Gas Initiative (RGGI) and Tokyo. The targets are different with the example from the United States Regional Greenhouse Gas Initiative and the New South Wales which are only for the power sector. In Alberta it only applies to industry and in Tokyo to the commercial sector.[120]

These schemes are different in purpose, coverage, ambition and design of its features. All of them provide information about the practical implementation of such a political instrument and there are many other countries considering to use such a scheme as well. Not all of these countries are members of the Kyoto Protocol but there is a common sense in the need for reducting emissions.[121]

A common element of all schemes is the ambition to reduce emissions without cutting the economic power and losing jobs. Despite the problems these measures had at the beginning, it is envisaged to work together and link all emission trading systems one day.[122]

[119] Paschotta, Rüdiger (2014a)
[120] International Energy Agency (2010)
[121] International Energy Agency (2010)
[122] International Energy Agency (2010)

3.4 Electricity grid structure

The grid is needed to transform and distribute electricity and is divided in seven network levels. Figure 22 shows all seven network levels and highlights that level two, four and six are there for elcetricity transformation whereas the others exist to distribute it.

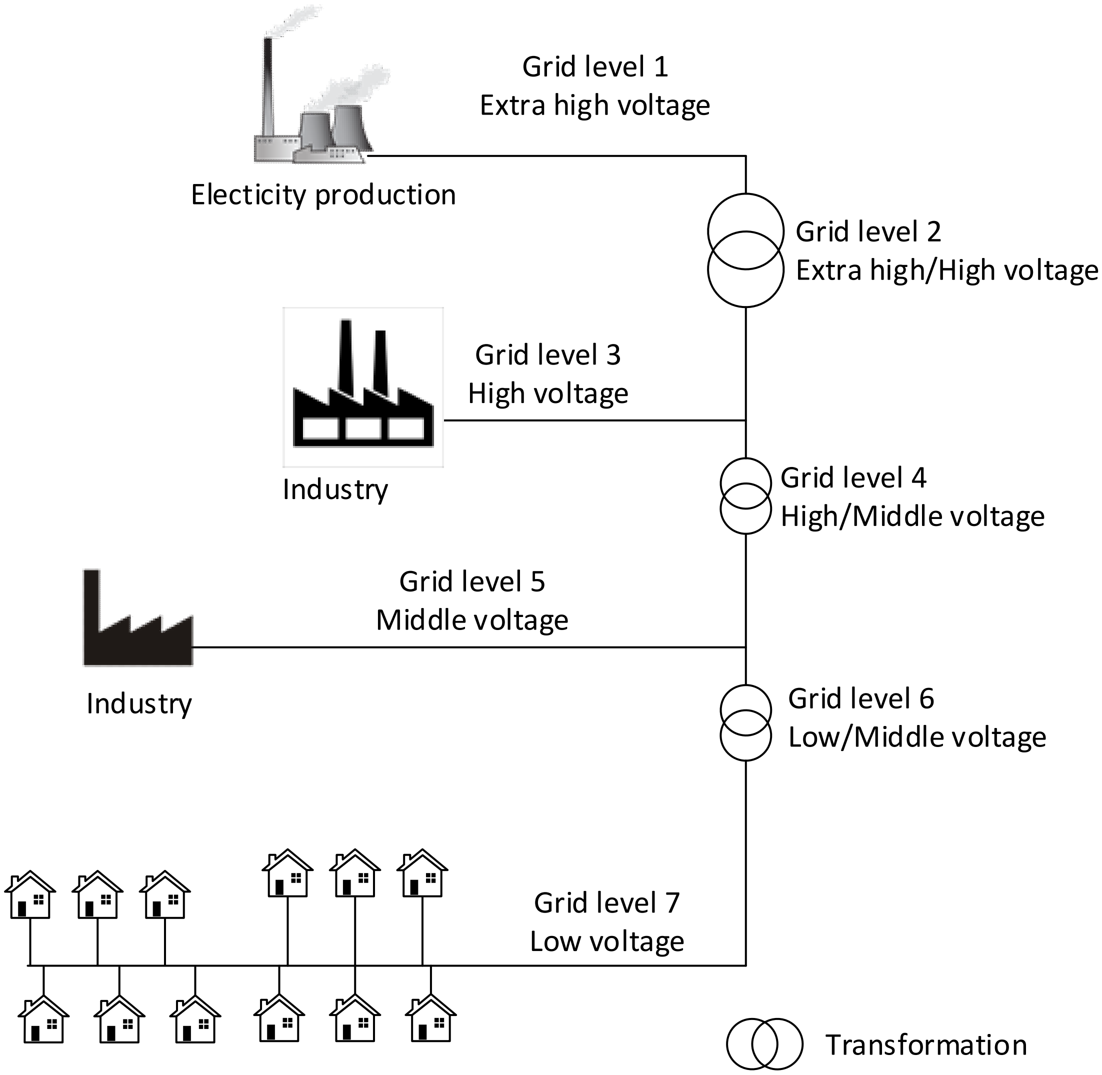


Figure 22: Electricity grid structure [123]

Table 6 shows all seven network levels with the occurring voltage as examples for Germany.

[123] Verifox (2014)

Table 6: Network level and voltage [124]

Network level	Voltage
1	Extra high voltage with 380/220 kV
2	Transformation from extra high voltage to high voltage
3	High voltage with 110 kV
4	Transformation from high voltage to middle voltage
5	Middle voltage with 10 - 30 kV
6	Transformation from middle voltage to low voltage
7	Low voltage with 400 V

Usually at level one the production of electricity takes place followed by transportation over long distances as ohmic losses are lower when the voltage is high. Level three and five are only for big consumers like the steel industry and level seven represents private households.

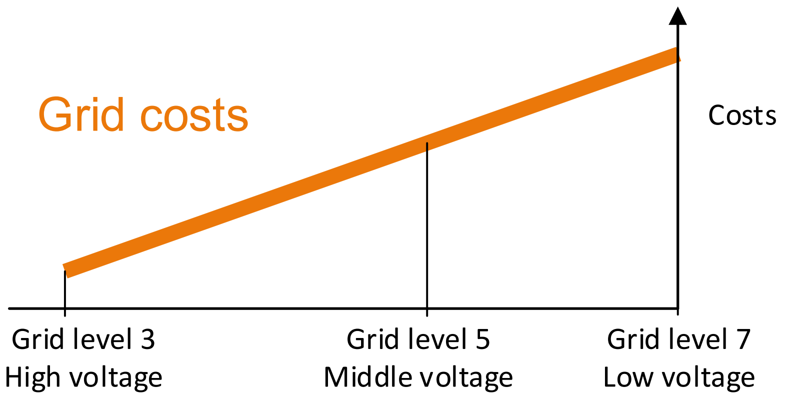


Figure 23: Electricity grid costs [125]

Network costs increase with rising network level which means that level seven pays the most. The reason for this is the increased cost from the grid network as this level uses more infrastructure than the others which can be easily seen in Figure 23. [126]

3.5 Electricity price

In Table 7 all electricity prices from considered countries are shown with representative data. For detailed information about sources and background information please go to Source on page 6 and country analysis starting on page 54. The average calculated in Table 7 is averaged with information from countries that have atimeline that is nearly complete.

[124] Verifox (2014)
[125] Verifox (2014)
[126] Verifox (2014)

Table 7: Electricity end user price for industry in selected countries [EUR/MWh]

Region/State	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Source	Market regulation	Network stability
Africa													
South Africa	18	18	18	-	-	-	-	-	-	67*	EIA[127] and ESKOM*[128]	Regulated	Unstable
America													
Brazil	55	84	107	115	106	114	136	142	137	103	ANEEL[129]	Regulated	Unstable
Canada	39	45	47	47	48	44	55	58	-	-	EP&T[130]	Liberalised	Stable
Mexico	62	71	79	75	86	62	79	83	89	91	EP&T[131]	Regulated	Unstable
United States	42	46	49	47	47	49	51	49	52	50	EP&T[132]	Liberalised	Stable
Average: America	50	61	70	71	72	67	80	83	93	82	-	-	-
Asia													
China	-	-	-	-	-	-	-	-	-	79	China mail[133]	Regulated	Stable
India	-	-	-	-	-	-	-	80	-	-	EIA[134]	Regulated	Unstable
Indonesia	51	47	54	50	44	-	-	-	-	52	EIA[135]	Regulated	Unstable
Malaysia	-	-	-	-	-	-	-	-	-	53	MIDA[136]	Regulated	Stable
South Korea	42	47	52	51	41	42	-	-	-	-	EP&T[137]	-	Unstable
Taiwan	44	45	46	43	45	54	59	59	-	-	ENERDATA[138]	Regulated	Stable

[127] Energy Information Administration (2014w)
[128] ESKOM (2014a)
[129] ANEEL (2014)
[130] International Energy Agency (2013b)
[131] International Energy Agency (2013b)
[132] International Energy Agency (2013b)
[133] Siemens AG (2013)
[134] Energy Information Administration (2014w)
[135] Energy Information Administration (2014w)
[136] Malaysian Investment Development Authority (MIDA)
[137] International Energy Agency (2013b)
[138] ENERDATA (2014b)

Region/State	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Source	Market regulation	Network stability
Thailand	51	53	62	53	51	-	-	78	-	-	EIA[139]	Regulated	-
Vietnam	-	-	-	-	-	-	-	-	-	43	Vietnam EVN[140]	Regulated	-
Average: Asia	41	42	46	49	45	48	50	53	56	59	-	-	-
Europe													
Belgium	77	81	101	95	102	110	106	112	109	109	EUROSTAT[141]	Liberalised	Stable
France	58	58	58	57	63	69	75	83	87	89	EUROSTAT[142]	Liberalised	Stable
Germany	86	92	101	99	107	113	116	125	129	143	EUROSTAT[143]	Liberalised	Stable
Italy	106	111	130	140	144	145	142	159	182	168	EUROSTAT[144]	Liberalised	Stable
Poland	50	55	58	91	90	92	98	98	94	90	EUROSTAT[145]	Liberalised	Stable
Russia	24	26	29	28	34	-	-	39	-	-	EIA[146]	Monopoly	Unstable
Spain	57	72	78	96	101	114	113	115	121	122	EUROSTAT[147]	Liberalised	Stable
Turkey	-	-	-	66	77	78	90	77	91	93	EUROSTAT[148]	Liberalisation ongoing	-
Ukraine	-	-	-	-	-	-	-	-	-	95	Ukraine mail[149]	Regulated	-
United Kingdom	52	63	86	109	103	106	99	101	118	120	EUROSTAT[150]	Liberalised	Stable
Average: Europe	64	70	80	87	91	103	105	101	116	114	-	-	-

[139] Energy Information Administration (2014w)
[140] Vietnam Electricity (2014)
[141] EUROSTAT (2014)
[142] EUROSTAT (2014)
[143] EUROSTAT (2014)
[144] EUROSTAT (2014)
[145] EUROSTAT (2014)
[146] Energy Information Administration (2014w)
[147] EUROSTAT (2014)
[148] EUROSTAT (2014)
[149] WKO (2014)
[150] EUROSTAT (2014)

In the table, a market was set as regulated as soon as there is a state monopoly in electricity production or if there is any interference in any way. This is mostly the case in Asia. In America there are regulated countries as well which tend to liberalize after the model of Canada and the United States. The United States is probably the most liberalized country worldwide and they have had problems with it in the past. As it was cheaper to buy electricity on the market than to build own generation capacity and when it peaked there was not enough generation capacity to fulfill the need. In the European Union all countries have liberalized energy systems as this is one of the directives from the EU.

Network stability was set as stable as there were documented incidents where power outages occur often or for a long duration. Developing countries tend to have these problems because of insufficient generation capacity or network capacity.

It can be seen in electricity price trends that Africa and Asia are on the upper end and Europe is on the lower with America in the middle.

4 Natural Gas

Natural gas is a grid bound media like electricity, but it can be stored in underground storage facilities for later usage and it can also be transported as *Liquid Natural Gas (LNG)* via ships if there are no pipelines or the capacity is not sufficient.

The quality of natural gas varies worldwide which is the reason MWh is used as unit to compare prices instead of m³ in which it is traded.

Table 8: Top natural gas producers and consumers in 2012[151]

Top natural gas producers			Top natural gas consumers		
1.	USA	611 billion m³	1.	USA	683 billion m³
2.	Russia	589 billion m³	2.	Russia	414 billion m³
3.	Canada	152 billion m³	3.	Iran	138 billion m³
4.	Iran	139 billion m³	4.	China	129 billion m³

Globally, most contracts are *Over the Counter (OTC)*, multiannual and often with a price binding to oil via indexes. Nevertheless, there are also exchanges/HUB's starting to sell futures or on day-ahead/spot market products.[152] HUB's are used to set special pricing and delivery points and don't have to be physical locations.

4.1 Natural gas price composition

The Centre for European Policy Studies also looked at the natural gas prices and their composition. They split Europe into three regions which are the same as are used for electricity. This is shown in Figure 24.

Figure 25 shows the outcome of the study using three components of natural gas bills:

- Taxes
- Grid costs and
- Energy price

Around 90 % of a natural gas bill for a steel producer is the energy price. Concerning this the South is the most expensive area with 47 €/MWh and the North-West the cheapest with 29,1 €/MWh. The European average is at 32,4 €/MWh. Electricity prices in this study are net prices with certain fees, taxes or levies already included.[153]

[151] Central Intelligence Agency (2014)
[152] [Der Titel "#27" kann nicht dargestellt werden – Die Vorlage "Fußnote - Unklarer Dokumententyp - (Standardvorlage)" beinhaltet nur Felder, welche bei diesem Titel leer sind.]
[153] Centre for European Policy Studies (2013)

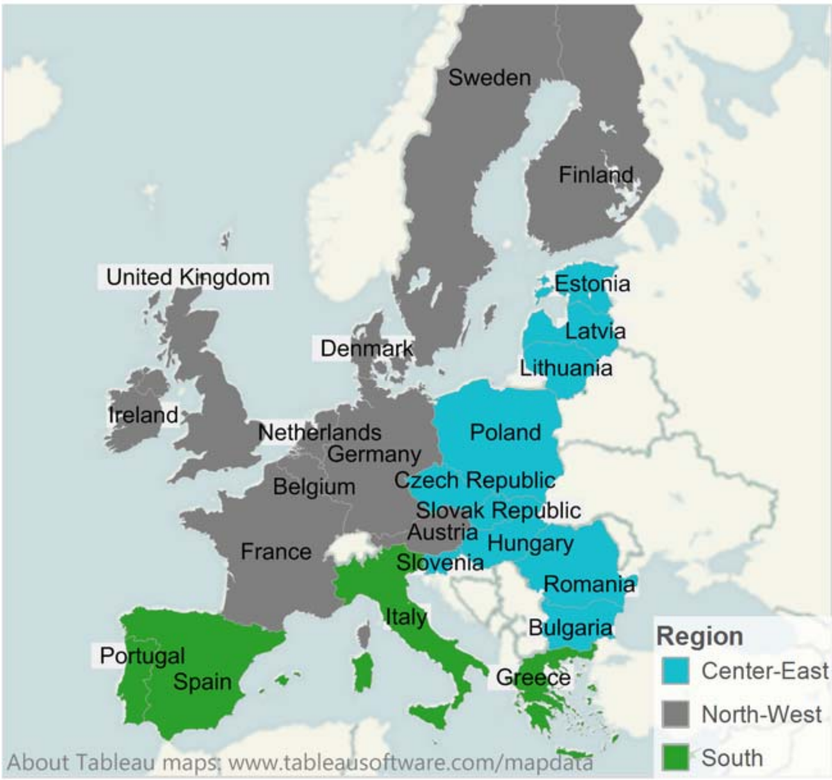
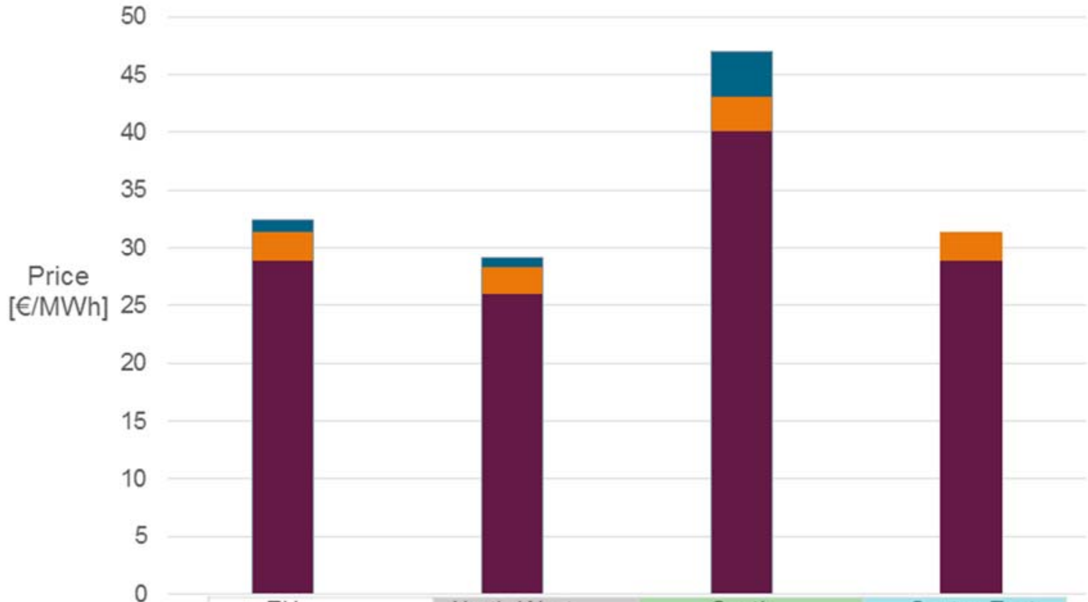


Figure 24: Regions within Europe [154]



	EU	North-West	South	Center-East
Taxes	1	0,8	3,9	0
Grid costs	2,5	2,3	3	2,5
Energy price	28,9	26	40,1	28,9
Sum	32,4	29,1	47	31,4

Figure 25: Natural gas bill components of sample steel producer 2012 [155]

[154] Centre for European Policy Studies (2013)
[155] Centre for European Policy Studies (2013)

Shale gas

Shale gas is natural gas, which is trapped within shale gas formations. With horizontal drilling it is possible to gain access to sedimentary rocks which are sources of natural gas. Following this, it is possible to produce natural gas through hydraulic fracking.[156] Hydraulic fracking is the process of pumping water, sand and chemicals into the earth in order to create small fractures in the rock formation which sets the trapped natural gas free.[157]

Shale gas is an unconventional gas and was first extracted in 1947. But due to technical problems (horizontal drilling) the economic shale gas boom didn't start until 2007 in the United States. Since then sample drillings started all over the world as more countries watned to profit from shale gas. In the Ukraine for example, Chevron will start to produce shale gas in 2018.[158] China also wants to exploit shale gas and started to hand out licences.[159] In Poland on the other hand investors are already withdrawing funding as there are not enough recoverable reserves.[160] Figure 26 shows active shale gas mining sites in the United States and the type of resource found.

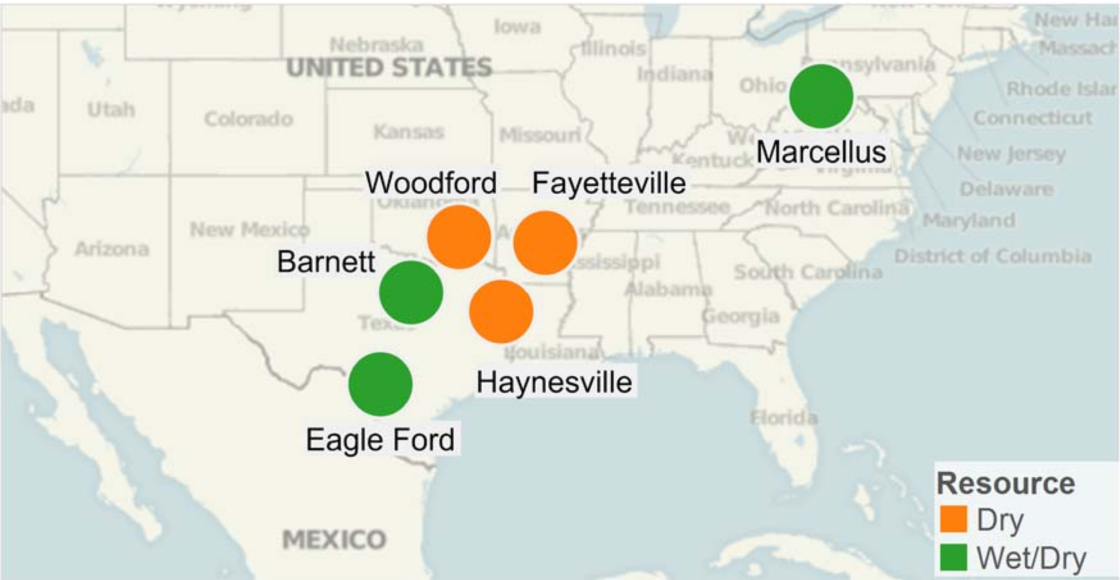


Figure 26: United States active shale gas mining sites [161]

There are two different sources of shale gas:

- Dry shale gas and
- Wet shale gas

[156] Energy Information Administration (2014c)
[157] FracFocus Chemical Disclosure Registry (2014)
[158] INDUSTRIEMAGAZIN
[159] World review (2014)
[160] INDUSTRIEMAGAZIN (2014)
[161] FERC (2013)

Dry gas is basically methane whereas wet gas also includes *Natural Gas Liquids (NGL)* which can be separated and sold on its own. These natural gas liquids are ethane, propane, butane and many others that can be separated and sold on their own.[162]

Unconventional gas will account for nearly half of the increase in global gas production until 2035 with most of the increase coming from China, the United States and Australia. [163]

4.2 Natural gas price

The transport of natural gas is by ship, in the form of liquid natural gas as some countries don't have enough pipeline capacity to cover all consumption or don't have any pipelines at all. Figure 27 shows liquid natural gas landing prices for 2012. The landed price means "after regasification".[164]

The price gap between the United States' and the world's natural gas price creates interest in exporting liquid natural gas. This won't happen until 2016 as it will take a long time to build export facilities.[165] Due to import dependence on liquid natural gas Asian prices are very high, which is referred to as "Asian Premium"..

Figure 27: Liquid natural gas landing prices 2012 [166]

In 2007 the economic crisis had an impact on natural gas prices all over the worldand also influenced the resource boom that followed in 2008.

[162] StateImpact (2014)
[163] International Energy Agency (2012d)
[164] Energy Information Administration (2014u)
[165] Federal Energy Regulatory Commision (2012), p.8
[166] Federal Energy Regulatory Commision (2012)

In Table 9 all natural gas prices from considered countries are shown. For detailed information about sources and background information please go to Sources on page 6 and country analysis starting on page 54. The Average calculated in Table 9 is averaged using information from countries that have a nearly timeline that is nearly complete.

Table 9: Natural gas end user price for industry in selected countries [EUR/MWh]

Region/State	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Source	Market regulation	Trading balance
Africa													
South Africa	18	22	-	-	-	-	-	-	-	96	EIA[167]	Regulated	Net import
America													
Brazil	-	-	-	-	-	-	-	-	-	41	EP&T[168]	-	Net import
Canada	15	20	19	14	21	11	10	11	9	11	EP&T[169]	Liberalised	Net export
Mexico	21	25	24	22	25	-	-	-	-	-	EP&T[170]	Regulated	Net import
United States	17	23	21	18	22	13	13	12	10	12	EP&T[171]	Liberalised	Net import
Average: America	18	22	21	18	23	12	12	12	10	11	-	-	-
Asia													
China	-	-	-	-	-	-	-	40	-	-	EP&T[172]	Regulated	Net import
India	-	-	-	-	-	-	-	-	-	21	India[173]	Regulated	Net import
Indonesia	-	-	-	-	-	-	-	-	-	-	-	Regulated	Net export
Malaysia	-	-	-	-	-	-	-	-	-	13	Malaysia[174]	Regulated	Net export

[167] Energy Information Administration (2014y)
[168] International Energy Agency (2013b)
[169] International Energy Agency (2013b)
[170] International Energy Agency (2013b)
[171] International Energy Agency (2013b)
[172] International Energy Agency (2013b)
[173] WKO (2013)
[174] WKO (2014)

Region/State	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Source	Market regulation	Trading balance
South Korea	24	27	34	35	29	30	40	43	50	59	EP&T[175]	-	Net import
Taiwan	23	27	28	30	38	33	39	-	-	-	EIA[176]	Regulated	Net import
Thailand	9	12	15	14	18	18	19	-	-	-	EIA[177]	-	Net import
Vietnam	-	-	-	-	-	-	-	-	-	-	-	-	-
Average: Asia	19	22	26	26	29	27	32	42	50	-	-	-	-
Europe													
Belgium	19	20	26	28	36	32	29	33	35	37	EUROSTAT[178]	Liberalised	Net import
France	20	24	30	31	36	34	34	37	40	41		Liberalised	Net import
Germany	28	33	43	39	47	39	40	48	48	48		Liberalised	Net import
Italy	22	25	29	31	37	34	30	33	41	42		Liberalised	Net import
Poland	16	20	24	26	32	29	31	32	36	36		Liberalised	Net import
Russia	3	4	4	5	6	5	7	-	-	-	EIA[179]	-	Net export
Spain	16	17	26	26	30	29	28	31	37	39	EUROSTAT[180]	Liberalised	Net import
Turkey	-	-	-	25	29	26	24	21	28	31		-	Net import
Ukraine	-	-	-	-	-	-	-	-	-	29	Ukraine mail[181]	-	Net import
United Kingdom	18	23	35	29	30	25	23	26	33	35	EUROSTAT[182]	Liberalised	Net import
Average: Europe	18	21	27	26	31	28	27	33	37	39	-	-	-

175 International Energy Agency (2013b)
176 Energy Information Administration (2014y)
177 Energy Information Administration (2014y)
178 EUROSTAT
179 Energy Information Administration (2014y)
180 EUROSTAT
181 WKO (2014)
182 EUROSTAT

Markets are labeled as regulated if there is any inference between the state and any kind of market. Usually the markets are wholesale markets, so-called hubs where natural gas is bought in a liberalized system. In Asia there are regulated markets that depend on the market situation of electricity. In the EU the natural gas market is also liberalized because of the energy market directive.

For natural gas prices it is often good to know the trading balance. Countries with their own natural gas tend to have lower prices and can hold them down in a regulated market. The United States are also a big producer of natural gas and will start to export in the next few years.

In America the prices for natural gas are the lowest due to available resources. A lack of resources caused the prices in Europe, excepting Russia, to be the highest until 2009. Since 2009 Asia's demand for natural gas is great and can often only be satisfied by importing LNG which again is very expensive.

5 Coal

Coal is a common commodity worldwide and often used for electricity generation. Today, the usage of coal is often discussed because of environmental impacts. Coal is usually traded *Over the Counter* (OTC) in multi annual contracts. Table 10 shows top coal producers and consumers in 2012.

Table 10: Top coal producing and consuming countries worldwide in 2012[183]

Top coal producers			Top coal consumers		
1.	China	3549 Mt	1.	China	4150 Mt
2.	USA	935 Mt	2.	USA	889 Mt
3.	India	595 Mt	3.	India	745 Mt
4.	Indonesia	443 Mt	4.	Russia	274 Mt

There are different types of coal occurring which are ranked by energy value: [184]

1. Anthracite
2. Bituminous
3. Sub-Bituminous
4. Lignite (Brown coal)

Bituminous coal is the most commonly used coal and includes two subtypes:

- Steam coal (Thermal coal)
- Coking coal (Metallurgical coal)

Steam coal is mainly used in power generation and coking coal, which is also called metallurgical coal, is mainly used for creating coke necessary for steel production. [185]

5.1 Coal price composition

Prices for coal are mainly related to the mining itself and transportation costs which are shown in Figure 28. The figure describes the costs for a German power station when using coal mined in Russia. The mining itself accounts for around 49% of the total coal cost followed by railway transportation to the harbour. There, the coal is loaded onto a ship that brings the freight to a German harbour where it is again transportet via railway to the relevant power station. Shipping costs with loading and

[183] World Coal Association (2012)
[184] Energy About (2014a)
[185] Energy About (2014b)

unloading have a share of costs of 16 %. In total 51 % of costs are transportation. There are no fees or taxes on Coal.[186]

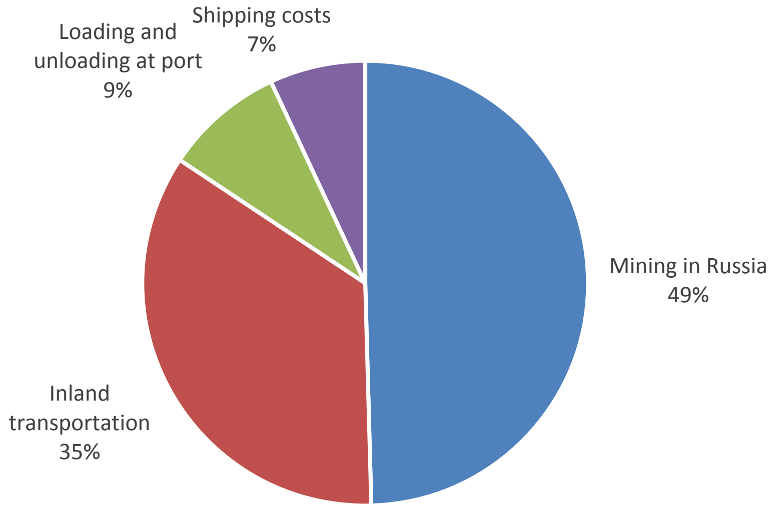


Figure 28: Coal price composition from Russian mining site to German power station[187]

5.1.1 Coal sea transportation costs

Coal is internationally traded and sea transportation costs influence the coal price. In Figure 29 steam coal import and export costs are shown with steam coal sold in Australia and bought in Europe. Export costs for Australia are free on board (FOB) and prices for Europe are shown in terms of cost insurance freight (CIF). Transportation costs shown in Figure 29 are the difference between export and import costs. In 2007 a decrease of transportation costs can be recognised as the economic crisis reduced prices followed by 2008 when the resource boom pushed the prices up again. [188]

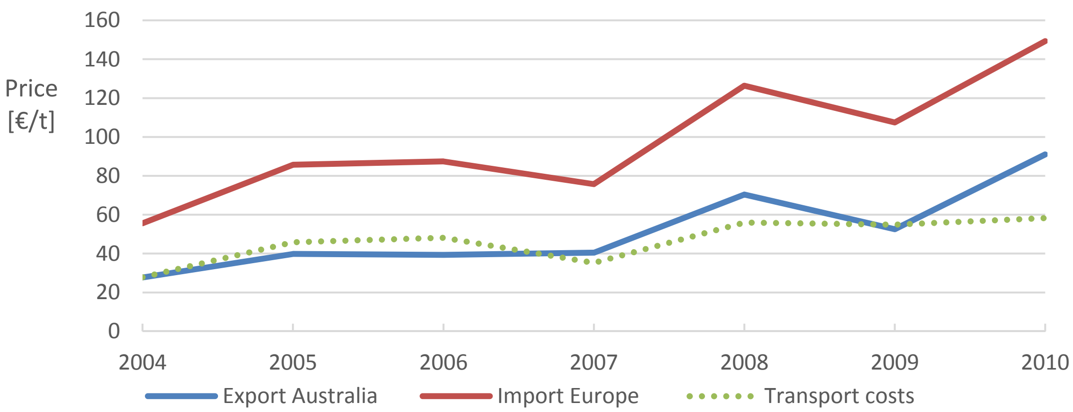


Figure 29: Transportation for steam coal from Australia to Europe [189]

[186] Bayer and Rademacher (2012)
[187] Bayer and Rademacher (2012)
[188] International Energy Agency (2012a)
[189] International Energy Agency (2012a)

5.2 Coal price

Coal is mainly sold *Over the Counter* and on stock exchanges. Coal Futures on EEX can be traded up to six years in advance and the trading volume is in 1000 t.[190]

Coal prices are rarely available because some countries have their own reserves and these prices are mostly not published.

Steam coal prices which are shown in the following tables refer to a standard coal quality in each country.

The prices are not necessarily comparable between countries. Only in Austria, the United Kingdom and the United States prices are available as averaged unit values.

5.3 Steam coal price

In Table 11 all steam coal prices from considered countires are shown. For detailed information about sources and background information please see Sources on page 6 and country analysis starting on page 54. Trend calculated in Table 11 is averaged using information from countries that have a timeline that is nearly complete. In this case only one average was calculated including all states. Steam coal is traded internationally and over the counter and therefore it is very hard to get detailed information on coal prices.

[190] European Energy Exchange

Table 11: Steam coal end user price for industry in selected countries [EUR/t]

Region/State	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Source
Africa											
South Africa	15	17	-	-	-	-	-	-	-	-	EIA[191]
Asia											
China	-	-	-	-	-	-	-	-	-	76	China mail[192]
India	27	30	28	29	28	-	-	-	-	-	EIA[193]
Indonesia	-	-	-	-	-	-	-	-	-	-	-
Malaysia	-	-	-	-	-	-	-	-	-	-	-
South Korea	44	51	46	52	81	64	-	-	-	-	EP&T[194]
Taiwan	-	-	-	-	-	-	-	-	-	-	-
Thailand	32	36	35	40	47	-	-	-	-	-	EIA[195]
Vietnam	-	-	-	-	-	-	-	-	-	-	-
America											
Brazil	-	-	-	-	-	-	-	-	-	-	-
Canada	-	-	-	-	-	-	-	-	-	-	-
Mexico	-	-	-	-	-	-	-	-	-	-	-
United States	35	42	45	44	48	51	53	57	63	61	EP&T[196]
Europe											
Belgium	-	-	-	-	-	-	-	-	-	-	-
France	-	-	-	-	-	-	-	-	-	-	-
Germany	-	-	-	-	-	-	-	-	-	-	-

191 Energy Information Administration (2014x)
192 Hochschule Ludwigshafen am Rhein (2013)
193 Energy Information Administration (2014x)
194 International Energy Agency (2013b)
195 Energy Information Administration (2014x)
196 International Energy Agency (2013b)

Region/State	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Source
Italy	51	59	55	63	98	82	85	101	-	-	EP&T[197]
Poland	42	49	52	57	72	68	73	79	85	79	EP&T[198]
Russia	20	22	25	27	29	-	-	-	-	-	EIA[199]
Spain	-	-	-	-	-	-	-	-	-	-	-
Turkey	33	38	39	51	63	61	63	62	76	88	EP&T[200]
Ukraine	-	-	-	-	-	-	-	-	-	46	Ukraine mail[201]
United Kingdom	63	72	71	74	80	72	89	107	116	115	EP&T[202]
Average	36	42	44	48	61	66	72	81	85	86	-

Coal is internationally traded and transported via ships or trains. In most countries markets are unregulated and no fees or taxes for coal are charged. Prices shown in Table 11 refer to prices in specific countries and can hardly be compared with each other as there is no information available about the coal quality. For many countries coal is a main power source for electricity generation.

There are many places around the world where coal is produced and influences on prices are not as big as for natural gas. Trends show a steady increase over years, only the resource boom in 2008 makes a small difference.

[197] International Energy Agency (2013b)
[198] International Energy Agency (2013b)
[199] Energy Information Administration (2014x)
[200] International Energy Agency (2013b)
[201] WKO (2014)
[202] International Energy Agency (2013b)

5.4 Coking coal price

In Table 12 all steam coal prices from considered countries are shown. For detailed information about sources and background information please go to Sources on page 6 and country analysis starting on page 54. Average calculated in Table 12 is averaged using information from countries that have a nearly full timeline. In this case only one trend was calculated including all countries. Coking coal is traded internationally and over the counter and therefore it is difficult to get detailed information on coal prices and transportation as this is also a portion of the costs.

Table 12: Coking coal end user price for industry in selected countries [EUR/t]

Region/State	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Source
Africa											
South Africa	-	-	-	-	-	-	-	-	-	-	-
Asia											
China	42	50	-	-	-	-	-	-	-	-	EIA[203]
India	43	52	50	51	50	-	-	-	-	-	EIA[204]
Indonesia	-	-	-	-	-	-	-	-	-	-	-
Malaysia	-	-	-	-	-	-	-	-	-	-	-
South Africa	-	-	-	-	-	-	-	-	-	-	-
South Korea	55	88	90	76	159	115	-	-	-	-	EP&T[205]
Taiwan	-	-	-	-	-	-	-	-	-	-	-
Thailand	-	-	-	-	-	-	-	-	-	-	-
Vietnam	-	-	-	-	-	-	-	-	-	-	-
America											
Brazil	-	-	85	-	-	-	-	-	-	-	EIA[206]

[203] Energy Information Administration (2014v)
[204] Energy Information Administration (2014v)
[205] International Energy Agency (2013b)
[206] Energy Information Administration (2014v)

Region/State	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Source
Canada	-	-	-	-	-	-	-	-	-	-	-
Mexico	-	-	-	-	-	-	-	-	-	-	-
United States	55	74	82	77	96	114	121	144	158	151	EP&T[207]
Region/State	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Source
Europe											
Belgium	-	-	-	-	-	-	-	-	-	-	-
France	60	89	106	91	148	148	164	208	212	231	EP&T[208]
Germany	-	-	-	-	-	-	-	-	-	-	-
Italy	62	83	89	86	130	104	133	174	-	-	EP&T[209]
Poland	77	93	76	82	153	94	143	184	144	119	EP&T[210]
Russia	57	75	64	74	127	-	-	-	-	-	EIA[211]
Spain	-	-	-	-	-	-	-	-	-	-	-
Turkey	83	104	112	128	154	169	179	159	182	191	EP&T[212]
Ukraine	-	-	-	-	-	-	-	-	-	-	-
United Kingdom	-	-	-	-	-	-	-	-	-	-	-
Average	66	86	88	89	135	126	148	174	174	173	-

Coking coal is only used in the steel process and traded internationally over the counter. Markets are liberalized and there are no special fees and taxes on this commodity. Prices on coking coal vary greatly but the resource boom in 2008 can still be seen very clearly.

[207] International Energy Agency (2013b)
[208] International Energy Agency (2013b)
[209] International Energy Agency (2013b)
[210] International Energy Agency (2013b)
[211] Energy Information Administration (2014v)
[212] International Energy Agency (2013b)

6 Country specific insights

In this chapter countries are looked at in terms of political environment and supply security. Questions were asked about problems with supply security or shortages of resources. Further, the political environment was researched for restrictions and other laws that can make steel producers to invest in new equipment. Another focus was given to programs that could help industry to invest in energy efficiency measures such as information campaignsas well as low interest loans or other incentives.

6.1 Africa

In Africa only one country is of interest for Siemens VAI in relation to steel production capacity and this is South Africa.

6.1.1 South Africa

Until 1994 the energy sector was mainly focused on needs of the white minority and industry. Since then there have been many steps taken to give everybody access to energy. Today, the energy markets are dominated by governmental companies but many initiatives were taken to get private players into the energy sector.[213]

Electricity

The electricity market is liberalised but dominated by state owned companies. An ambitious goal is the *Integrated Resource Plan* which should attract private investors with the aim that in 2030 around 30 % of the electricity producing capacity is privately owned. There are problems with network stability so that the state owned provider ESKOM signed contracts with big consumers to minimize the electricity consumption or even stop production sites for several months. To relief the electricity grid when the demand is too high they started load shedding. Load shedding means scheduled and controlled power cuts by rotating available capacity between all customers when the demand is greater than supply to avoid blackouts.[214] There is a big dependency on coal in electricity production.[215]

[213] WKO (2012c), p.4
[214] WKO, p. 206
[215] WKO (2012c), p.4

On the official ESKOM homepage it is announced that 2014/15 tariffs for industrial customers will rise up to 8 %.[216]

Natural gas

In South Africa no sources of natural gas have been found and natural gas is imported from Mozambique via pipeline. There is also a large amount of shale gas expected to be in South Africa but companies are still waiting for licences to explore the resource.[217]

Coal

South Africa is dependent on oil and coal but they have own coal reserves and export coal. Oil on the other hand has to be imported.[218] It is among the top ten coal producer in the world.[219]

Political environment

The *Department of Energy (DoE)* develops policies and strategies for demand side? management, efficiency and power conservation.

Policies and Planning:

- Integrated Energy Plan: The purpose of the IEP is to provide a roadmap of energy policy and technology development.
- The National Energy Efficiency Strategy: It sets the target for improved energy efficiency to 12 % by 2015. This should be implemented in public buildings, industry, mining, commerce, transport and the residential sector.
- National Energy Act: Its purpose is to create mechanisms and institutions that can evaluate energy efficiency savings.
- The Power Conservation Programme (PCP): Is there for providing demand side? solutions to challenge South Africa's electricity problems.
- Medium Term Risk Mitigation Project for Electricity in South Africa (MTRMP): The Integrated Resource Plan is a long term plan to avoid supply shortages.

There is a *standard offer* mechanism from ESKOM, where the company pays for *verified energy saving* using a pre-determined and pre-published rate for the implementation of an approved technology.

[216] ESKOM (2014a)
[217] Energy Information Administration (2014g)
[218] WKO (2012c), p.4
[219] World Coal Association (2012)

Standard Offer:

- Pay for energy savings
- Focus on daytime hours between 6am and 10pm on weekdays
- Contract duration of three years
- Everybody with verifiable energy savings from 50 kW to 5 MW can apply

There is also an income tax allowance on energy efficiency products and financial institutions were set up to provide competitive rates.[220]

6.2 America

In America; Brazil, Canada, Mexico and the Unites States are of interest due to their steel production capacity. The United States are of special interest because of the shale gas boom in the last few years.

6.2.1 Brazil

Brazil is by far South America’s biggest economic power and one of the top ten economies in the world. Steel production is concentrated in four federal states:

- Sao Paulo
- Minas Gerais
- Espirito Santo
- Rio de Janeiro

Figure 30 shows these four federal states which have about 90 % of Brazil’s steel production capacity[221] with prices for industrial customers.[222]

[220] WKO, p. 206
[221] WKO (2013d)
[222] Sistema FIRJAN (2011)

Figure 30: Location of Brazilian steel industry[223] with prices for electricity 2011 [224]

Last few year's exchange rate BRL/USD was good for imports and there were many investments made on plant equipment. But as Figure 31 shows the exchange rate is already climbing again.[225]

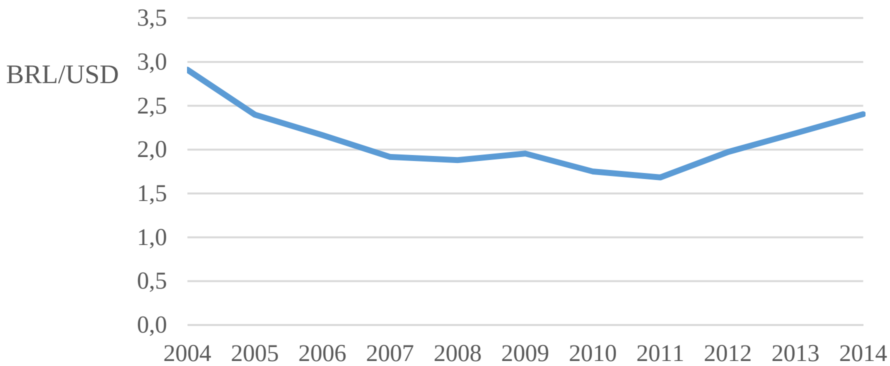


Figure 31: Brazilian exchange rate [226]

Electricity

Electricity generation is dominated by water power with a share of 80 % in 2011. The rest is coming from other renewables, fossil fuels and a small amount from nuclear. [227] Brazil has a huge transmission network in which the regions are connected through the state owned *National Interconnected System (SIN)*. There were steps taken to privatise the electricity sector but state owned holding company *Eletrobras* is still the dominant player.[228] There are problems with the transmission network, which leads to blackouts.[229] In 2004 the government implemented a new model for the electricity sector where the sector was split in a regulated and an unregulated market. This

[223] WKO (2013d)
[224] Sistema FIRJAN (2011)
[225] WKO (2013d)
[226] International Energy Agency (2013b)
[227] Energy Information Administration (2014l)
[228] Energy Information Administration (2014l)
[229] WKO (2013d)

allowed private parties to invest in generation and distribution capacity. ANEEL is the *Brazilian Electricity Regulatory Agency.*[230]

Natural gas

Brazil is a net importer of natural gas but this resource only plays a small part in the energy mix with less than 10 % of the overall energy consumption. Petrobras is dominant in the natural gas supply chain but in 2009 a framework was created to attract private investors into the sector.[231]

Coal

Coal is even less used in Brazil than natural gas with a 5 %s hare of the primary energy consumption in 2011.[232] One of Brazil’s specifics is that charcoal is sometimes used instead of coking coal. There are many projects to use environmentally friendly charcoal but there is a big problem with illegal deforestation.[233]

Political environment

The government is currently focusing on centralised energy supply, mostly in the form of hydropower and there is little incentive to conserve energy.[234] The main program is the *Energy Efficiency Program (EEP)* which is regulated and inspected by *ANEEL*. Its aim is to reduce consumption and to fight wasting electricity.[235]

6.2.2 Canada

Canada is one of the world's five biggest energy producers and a primary source for energy imports to the United States.[236]

Steel is produced in 13 steel plants in five provinces:

- Alberta
- Saskatchewan
- Manitoba
- Ontario
- Quebec

[230] Energy Information Administration (2014l)
[231] Energy Information Administration (2014l)
[232] Energy Information Administration (2014l)
[233] Profor (2014)
[234] Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (2014)
[235] ANEEL, p. 4
[236] Energy Information Administration (2014m)

Figure 32 shows main steel producing provinces. Steel industry is concentrated in Ontario with six plants.[237]

Figure 32: Canada's steel producing provinces [238]

Electricity

Hydropower takes the biggest part of electricity production in Canada with 63,3% in 2012.[239] Canada is a net exporter of electricity and the stable grid is highly integrated with the United States electricity grid.[240]

Natural gas

Canada is the fourth-largest exporter of natural gas after Russia, Norway and Qatar and there are plans to find new customers by starting to export *Liquid Natural Gas (LNG).* At the moment all exports go to the United States via pipeline.[241]

Coal

Canada has 24 producing coal mines which are located in:

- British Columbia (10 mines)
- Alberta (9 mines)
- Saskatchewan (3 mines)
- Nova Scotia (2 mines)

Canada is a big exporter of coking coal.[242]

[237] Canadian Industry Program for Energy Conservation (2007)
[238] Canadian Industry Program for Energy Conservation (2007)
[239] Canadian Electricity Association
[240] Energy Information Administration (2014m)
[241] Energy Information Administration (2014m)
[242] Coal Association of Canada (2014)

Political environment

The *Canadian Industry Program for Energy Conservation (CIPEC)* provides information services and financial services in form of funding for industry. There are *Income Tax Regulations* to help industry to recover costs more effectively.[243] The *Natural Resources Canada (NRCan)* also has a program in place named *CanmetENERGY* with one focus on *Industrial Energy Systems – Metallurgical Fuels* for GHG abatement.[244]

Every province has its own funding programs. In Ontario there are many different programs to help industry to implement energy efficiency and GHG abatement measures.

For instance:[245]

- Industrial Accelerator
- SaveOnEnergy

Industrial Accelerator is in place to help industries implement energy efficiency projects with competitive payback rates. Financial incentives are max. 10 million CAD, 70 % of project costs or 230 CAD per MWh for annualised electricity savings for capital projects and preliminary engineering studies are funded up to 10,000 CAD per project.[246]

The second program is the *SaveOnEnergy* which is designed to support investment for large capital projects. The incentive covers up to 70 % of project costs or 200 CAD per MWh of annual electricity savings. The Incentive range is 1 million CAD or greater.[247]

6.2.3 Mexico

The energy sector in Mexico is nearly entirely governmental with a monopole on oil and oil products.[248] It is one of the ten largest oil producers in the world and oil plays a big role in primary energy consumption with 53 % in 2012. Second is natural gas with

[243] Natural Resources Canada (2014)
[244] Canada, Governement of, Natural Resources Canada, Energy Sector and Office of Energy Efficiency (2014)
[245] Canada, Governement of, Natural Resources Canada, Energy Sector and Office of Energy Efficiency (2014)
[246] Industrial accelerator (2014)
[247] saveONenergy (2014)
[248] WKO, p. 62

36 % followed by small parts of coal, nuclear power, hydroelectric and non-hydro renewables which combined accounts for 11 %.[249]

In Mexico *Comision Federal de Electricidad (CFE)* is responsible for the electricity supply. Large industries are trying to be self-supplying because of the unattractive electricity price. As an example cement producer CEMEX invested in wind power to become autonomous. Infrastructural problems cause shortages in supply sometimes.[250]

Mexico is a net importer of natural gas, mostly from the United States via pipeline but also liquid natural gas. PEMEX is a state owned company and had a monopoly on natural gas exploration but since energy reforms in 2013 private participants are also allowed.[251]

Coal does not play a big role in the Mexican energy mix with only 5 % of total energy consumption in 2012.[252]

The *National Commission for the Efficient Use of Energy (Conuee)* promotes energy efficiency measures. There are some funds from the *Inter-American Development Bank (IDB)* waiting for implementation in Mexican law which aims at energy efficiency and GHG abatement.[253]

6.2.4 United States

Prices are low because steel overproduction in the United States and steel producers suffer from decreasing profit margins because of competition from Chinese cheap steel. The shale gas boom helps energy intensive industries, like steel producers to reduce production costs.[254]

Electricity

In Figure 33 the on-peak spot electric prices are shown.[255] Nationwide on-peak prices were low in 2011 because of the low natural gas prices. This trend started in 2009 which was increased by low electricity demand from a weak economy. [256]

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[249] Energy Information Administration (2014n)
[250] WKO, p. 62
[251] Energy Information Administration (2014n)
[252] Energy Information Administration (2014n)
[253] Inter-American Development Bank (2014)
[254] WKO (2013), p. 16
[255] FERC (2013)
[256] Federal Energy Regulatory Commision (2012), p.4

In 2012 a great amount of gas-fired generation displaced coal-fired generation in the east due to low natural gas prices.

Figure 33: Average on-peak spot electric prices 2012 without any taxes and levies, Updated: 6.1.2013[257]

Natural gas

The natural gas prices in 2012 were nearly the lowest they have been when looking at the last 10 years. New England was not able to fully profit from shale gas due to problems with pipeline capacity.[258]

Shale gas has been the price driver for natural gas in the United States over the past few years. It is expected that the growth in shale gas production will still increase in next few years.

Figure 34: United States active shale gas mining sites [259]

[257] FERC (2013)
[258] Federal Energy Regulatory Commision (2012), p.27
[259] Federal Energy Regulatory Commision (2012)

Six major shale gas production sites are active in the United States and shown in Figure 34 including the type of resource. [260]

Coal

The *Energy Information Administration (EIA)* predicts a declining coal production until 2016 but a growth afterwards because of more exports and increasing natural gas prices.[261]

Political environment

In the United States global warming is conveniently neglected for competitiveness and energy efficiency is seen as a problem and not a solution.[262] There are different ways of helping industry to achieve their energy efficiency and environmental goals like knowledge sharing programs, energy management programs or direct incentives.[263] There is a *Federal Energy Efficiency Tax Incentive* available for combined heat and power (CHP) production with an extension to get a grant from the United States Department of Treasury.[264] Most of the programs aim at knowledge sharing and energy management. Unfortunately there was no information available about incentives suitable for the steel industry.[265]

6.2.5 Conclusion

It can be stated that America is divers with Mexico regulating the energy sector and the United States being the most liberal state worldwide. Canada is also liberal and Brazil is trying to get there. In Mexico inefficient control of all important natural resources and supply routes results in high energy prices and low electricity supply security. The United States on the other hand are one of the top ten energy producers and also is a big consumer benefiting from low energy prices.

6.3 Asia

In Asia several states are of interest but a focus has to be given to China as one of the drivers for economic growth in the last decade. China is very energy demandingand its economic growth is still continuing.

[260] Federal Energy Regulatory Commision (2012), p.32
[261] Energy Information Administration, p.85, p. 244
[262] WKO (2013)
[263] The State and Local Energy Efficiency Action (2014)
[264] U.S. Department of ENERGY
[265] DSIRE (2014)

6.3.1 China

China is the world's most populous country with a fast-growing economy and the largest energy consumer and producer in the world.[266]

Figure 35 shows main regions where steel industry China is situated in China[267] and the electricity end user prices for industrial customers in these regions[268].

Figure 35: Electricity industrial end user prices in China's steel producing regions [269]

Electricity

Most coal, natural gas, hydro, wind and solar load sources are over 1.000 kilometres away from the populous east and south. At the moment, China's power transmission lines are still incapable of distributing electricity long distances from rural wind farm's to densely populated centres. Better transmissions lines are needed and for this reason China is currently rolling out a smart grid system which should be capable of handling these long distances.[270]

Compared to other developing countries power outages in China are not a major problem but do occur in less developed areas.[271]

[266] Energy Information Administration (2014b)
[267] World Steel Association (2014a)
[268] Siemens AG (2013)
[269] Siemens AG (2013)
[270] Greentech Media (2014)
[271] WKO (2014)

The electricity price was calculated based on prices from *Siemens Energy Sector*.[272] Energy prices used in 3.5 Electricity price on page 36 are averaged prices of steel producing regions shown in Figure 35.

Natural gas

Natural gas usage in China has increased rapidly in recent years and China has increased its natural gas imports via pipeline and liquefied natural gas. In 2007 China became a natural gas net importer. The government plans to increase the share of natural gas as part of total energy consumption by up to 10 % in 2020.[273]

China's major natural gas producing regions can be divided into four areas:

- *Southwest*: In the Sichuan Province, especially in Sichuan Basin. Other major discoveries are the Yuanba and Puguang fields in the Sichuan Province.
- *Northwest*: Xinjiang is one of China's largest gas producing provinces though much of the area is still underexplored. Costs in this region are fairly high because of its complex geological features and the far distance to China's main consumption centres. However, PetroChina has built two cross country West-East Gas Pipelines, which have greatly improved the upstream potential for supplying markets in eastern China from the Tarim Basin. Other important regions in the northwest are the Junggar Basin (Xinjiang Province) and the Qaidam Basin (Qinghai Province).
- *Northeast*: The changing oil and gas province in the Ordos basin (Shanxi Province) is the largest gas producing region in China. Development of this region is geologically and technically challenging, but progress is made.
- *Offshore*: Important natural gas fields are located in the Bohai Basin (Yellow Sea) and the Panyu complex of the Pearl River Mouth Basin (South China Sea). China is currently exploring more options and expanding its offshore natural gas production.[274]

[272] Siemens AG (2013)
[273] Energy Information Administration (2014b)
[274] Energy Information Administration (2014b)

Shale gas

The government is also currently exploring shale gas resources with the help of foreign companies. Most of China's proven shale gas resources are located in three giant basins:

- Tarim Basin (Northwest)
- Ordos Basin (North-Central) and
- Sichuan Basin (Southwest).

In Figure 36 shale gas resources and coalbed methane, which is a form of natural gas extracted from coal beds are plotted.

The United States Energy Information Administration estimates that China's technically recoverable shale gas resources are almost 50 % higher than shale gas resources of the United States.[275]

Figure 36: Shale gas and Coalbed methane resources in China [276]

China also secured imports by installing a major pipeline from Myanmar to Yunnan province to be able to benefit from Myanmar's significant offshore natural gas reserves. In the future it is also expected that the United States and Canada, which both are experiencing a boom in shale gas exploration, are starting to export to China. Another big player could be Australia.[277]

[275] Energy Information Administration (2014b)
[276] Energy Information Administration (2014b)
[277] Energy Information Administration (2014b)

Coal

China is the world's top coal producer, consumer, and importer and accounted for about half of global coal consumption in 2012. This is important for world energy related carbon dioxide emissions considering that at the moment, coal provides around 70 % of China's total energy consumption.

Furthermore, China has the third largest reserves of coal in the world with around 13 % of total world reserves. There are 27 provinces in China that produce coal of which Inner Mongolia and Shanxi possess most of China's easily accessible coal. Additionally, China started importing coal mainly from Australia and Indonesia.[278]

Political environment

In China's 12th five-year plan the steel industry is included with the objective to lower sulphur output.[279] The action plan against climate change 2012 – 2020 also states that the steel industry has to reduce CO_2 by 18 % in 2015 compared to emissions in 2010.[280]

Table 13 shows all main targets for the steel industry in the 12th five-year plan 2011 - 2015.[281]

Table 13: Targets for steel industry in the 12th five-year plan

Indicator	2010	2015	Cumulative change
Energy use per ton produced steel (kg Ce)	605	580	– 4 %
Water consumption per ton produced steel (m^3)	4,1	4	– 2,4 %
SO2 – Emission per ton produced steel (kg)	1,63	1,0	39 %
Emission chemical oxygen demand (COD) per ton produced steel (kg)	0,07	0,065	– 7 %
Recycling rate of industry solid waste (%)	94	97	3 %

The steel industry is also in the *Cleaner Production Law* of China where the aim is to build *Clean Production Centres* in following industrial sectors: metallurgy, chemical, light construction industry, nonferrous metal industry, mechanical engineering and others. The steel industry has to conduct a *Clean Production audit*.[282]

[278] Energy Information Administration (2014b)
[279] National People's Congress (2011b)
[280] National People's Congress (2011c)
[281] National People's Congress (2011a)
[282] National People's Congress (2011a)

On the 21st of June in 2011 *National Development and Reform Commission (NDRC)* and *Ministry of Finance (MOF)* announced requirements to get public support for reconstruction projects in terms of environmental care.

Requirements to receive public support for environmental care are:

- Reconstructed facilities are already three years running.
- Energy consumption before reconstruction must be over 20.000 t Ce per year.
- Energy saving potential must be over 5.000 t Ce per year.

If all requirements are fulfilled there is a standard public fund of:

- 240 RMB/t Ce for realised energy savings in East China and
- 300 RMB/t Ce for realised energy savings in West China.[283]

6.3.2 India

In India economic policies are implemented via five-year plans that are developed, executed and monitored by the *Planning Commission*.[284]

India had the third highest energy demand in 2009 after China and the United States but the per-capita energy consumption is still at a much lower level compared to developed countries and even some of the developing countries.[285]

Energy security is a big problem as India has to import most of its required oil. India is rich in coal but has problems digging it up, mainly because state mining monopolies have the control. Natural gas is not pumped enough and has to be substituted by expensive liquid natural gas.[286]

India is the third biggest exporter of iron ore. More than half of the extracted ore is exported and not used on the local market. Steel industry in India can't produce enough steel to fulfil demand so that in 2011 more than 7 million t of steel had to be imported. Old technology, lack of automation, low steel quality and low energy efficiency are big problems in India.[287]

[283] gov.cn (2014)
[284] International Energy Agency (2012c)
[285] International Energy Agency (2012c)
[286] Economist (2014)
[287] WKO (2012a)

Electricity

India has problems with blackouts and many regions have no access to electricity at all. The country suffers from the major shortage in generating capacity.[288]

In 1990 India started to deregulate the power sector and in 2003 the electricity act created a framework for generation, transmission, distribution, trading and consumption influenced by market-based mechanism. In 2006 the National Tariff Policy came to strengthen the financial viability in the sector and to attract investors by guaranteeing a fixed return on investments. The Ministry of Power (MOP) is responsible for the power sector and installed a Bureau of Energy Efficiency (BEE) to promote energy saving measures.[289]

Natural gas

The natural gas sector is more liberalised than other energy sectors in India. The country started in 2004 to import liquid natural gas from Qatar and increasingly relies on imports since then. In India natural gas serves mainly as a substitute for coal in electricity generation.[290]

Coal

Coal is the primary source of energy in India and is the country was the third largest coal producer and consumer in 2011 after China and the United States. 90 % of the coal industry is in the hands of two state owned companies which leaves limited space for private companies. In recent years coal production stagnated which was the reason for power plants not operating on an optimal level.[291]

Political environment

The *National Action Plan on Climate Change (NAPCC)* was released in 2008 to achieve a sustainable development path that simultaneously advances economic and environmental objectives. The NAPCC has eight missions to achieve its goal with one addressing energy efficiency. The *National Mission for Enhanced Energy Efficiency (NMEEE)* is based on a demand side management and includes market based mechanism, energy efficient appliances and financial mechanism to support demand side management programs.[292]

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[288] International Energy Agency (2012c)
[289] International Energy Agency (2012c)
[290] Energy Information Administration (2014d)
[291] International Energy Agency (2012c)
[292] International Energy Agency (2012c)

6.3.3 Indonesia

The country is reorienting energy production from primarily export to serve its own growing market. Generation capacity growth for electricity has been lower than demands, leading to power outages. The bigger part of electricity generation comes from *Perusahaan Listrik Negara (PLN)* with about three-quarters in 2012 and is state owned. The rest comes from *independent power producers (IPP's).* PLN announced to increase power tariffs for industrial users by up to 38 % in May 2014.[293] There are nearly no governmental incentives for energy efficient measures and as a result of daily outages industry has its own power generation capacity.[294]

Indonesia is a net exporter of natural gas but in order to meet export obligations it had to buy liquid natural gas on the spot market. This was triggered by problems with production and rising domestic gas demand.[295]

6.3.4 Malaysia

The Malaysian economy grew in the last few years because of rich fossil resources and recovered fast after the economic crisis. It is suggested that due to low energy prices not much development happened in the area of environmental care. In order to address these problems the *Ministry of Energy, Green Technology and Water (KeTTHA)* and the *Sustainable Energy Development Authority of Malaysia (SEDA)* were put in place.[296]

Electricity

Malaysia's electricity demand is mostly met by using natural gas and coal[297]. However, the country is seeking to diversify its electricity generation fuels by investing in renewable energy sources.

Malaysia has three main electricity power producing companies with Tenaga Nasional Berhad (TNB, www.tnb.com.my) as the main generator and supplier in the peninsular region. Sabah Electricity Sdn. Bhd. (SESB, www.sesb.com.my) generates and distributes in the State of Sabah and the Federal Territory of Labuan, Malaysia's international offshore financial centre and Sarawak. Electricity Supply Corporation

[293] The Jakarta Globe (2014)
[294] WKO (2013b)
[295] Energy Information Administration (2014e)
[296] WKO (2013c)
[297] Energy Information Administration (2014f)

(SESCO, www.sesco.com.my) supplies the state of Sarawak. A map of Malaysia and regions where these three companies operate is plotted in Figure 37.[298]

Figure 37: Malaysia with three power producing companies [299]

Table 14 lists prices of different distributors in Malaysia. The weighted price is calculated under the assumption that there is a constant usage of electricity and the percentage of off-peak hours taken into account. These prices are for industrial customers with a small exception in peninsular Malaysia where TNB is the generator and supplier. Here a special tariff is offered to industrial customers whose total annual electricity cost are 5 % or more of its total annual cost of operations.[300]

Table 14: Electricity distributor prices for industry[301]

Distributor	Peak period price [EUR/MWh]	Off-peak period price [EUR/MWh]	Weighted price [EUR/MWh]
TNB	71	39	58
SESB	63	40	54
SESCO	54	33	48
		Average:	**53**

Natural gas

Malaysia is one of the most important natural gas exporter worldwide.[302] State owned *Petronas* dominates the natural gas sector. Petronas also holds 63 % of Malaysia *International Shipping Corporation (MISC)* which owns and operates ships for transporting hydrocarbons and chemicals around the world. Its fleet has 27 LNG tankers and is the second-largest LNG fleet operator in the world.[303]

298 Malaysian Investment Development Authority (MIDA)
299 WKO (2013c)
300 Tenaga Nasional Berhad (2006)
301 Malaysian Investment Development Authority (MIDA) (2014)
302 WKO (2013c)
303 Energy Information Administration (2014f)

Coal

Malaysia is also one of the biggest coal importers as the country chooses to use cheap coal for electricity generation instead of its own oil which is exported.[304]

Political environment

Malaysia has also its five-year plans in which environmental care and energy efficiency is included. The current 10th Malaysia plan 2011 – 2015 is in place and focuses on two main areas:

- Developing a roadmap for climate resilient growth and
- Enhancing conservation of nation's ecological assets.

There are also two policies in place:

- National Green Technology Policy
  - Reducing energy usage rate and at the same time increasing economic growth
  - Increasing national capability and capacity for innovation in green technology development
  - Ensuring sustainable development and conserve the environment for future generations
  - Enhancing public education and awareness of green technology and encourage its widespread use
- National Policy on Climate Change
  - Mainstreaming climate change through wise management of resources and enhanced environmental conservation
  - Integration of responses into national policies, plans and programmes to strengthen the resilience of development from arising and potential impacts of climate change
  - Strengthening of institutional and implementation capacity to better harness opportunities to reduce negative impacts of climate change.[305]

[304] WKO (2013c)
[305] Malaysian Prime Minister's Department

Incentives

- *Pioneer status*: 100 % tax allowance on company income for 10 years.
- *Investment tax Allowance*: 100 % allowable invest costs in the first 5 years can be used as investment incentives.
- *Import taxes*: No import taxes for any machinery, material, spare parts or consumables.[306]

6.3.5 South Korea

South Korea is 97 % depending on energy imports and has no international oil or natural gas pipelines which means that they exclusively rely on tanker shipments of LNG and crude oil. Energy consumption and economic growth are driven by exports. The biggest exports are electronics and semiconductors.[307]

Electricity

Korea Electric Power Corporation (KEPCO) is the main player in the South Korean electricity market with 93 % of the total generated electricity in Korea. It is a government-invested companyand is at the same time also the only company responsible for transmission and distribution.[308] Because of electricity shortagessome companies were forced to cut back on energy as an emergency measure. As an example steel producer POSCO had to shut down its casting house in Gwangyang. Another example is SAMSUNG Electronics as it was forced to interrupt semiconductor production partially.[309] Energy and environmental policies focus on low-carbon and green technology. This was proclaimed by President Lee Myung-bak in 2008 as guide to long-term development.[310] All companies that have a production capacity bigger than 500 MW in South Korea are shown in Table 15.

Natural gas

South Korea imports 99 % of its natural gas in form of LNG. Most imports in 2011 came from Qatar and Indonesia.[311] *Korea Gas Corporation (KOGAS)* dominates South Korea’s gas sector. The government tries to liberalize the LNG import market and allows other LNG importers to sell their gas. However, at the moment KOGAS is still the main player in purchasing, importing and the wholesale distribution of natural

[306] WKO (2013c)
[307] Energy Information Administration (2014h)
[308] IBM (2011)
[309] KBS (2014)
[310] International Energy Agency (2012b)
[311] KyungMi Cho, p. 5

gas.[312] The greatest challenge for South Korea is a long-term vision for the natural gas market as there was little progress in the last few years.[313]

Table 15: Electricity producing companies with generation capacity greater than 500 MW [314]

	Companies
Sub company from public enterprise Korea Electric Power Corporation KEPCO (www.kepco.co.kr)	Korea Hydro and Nuclear Company, www.khnp.co.kr
	Korea South-East Power Company Ltd., www.kosep.co.kr
	Korea Midland Power Company Ltd., www.komipo.co.kr
	Korea Western Power Company Ltd., www.westernpower.co.kr
	Korea Southern Power Company Ltd., www.kospo.co.kr
	Korea East-West Power Company Ltd., www.ewp.co.kr
Public enterprises	Korea District Heating Corporation, www.kdhc.co.kr
	Korea Water Resources Corporation, www.kwater.or.kr
Private enterprises	Posco Power Corporation, www.poscopower.co.kr
	SK E&S Co., Ltd., www.skens.com
	GS EPS Co., Ltd., www.gseps.com
	GS Power Co., Ltd., www.gspower.co.kr
	MPC Yulchon Generation Co., Ltd.

Coal

South Korea is one of the biggest coal importers worldwide because of insignificant production. Australia and India deliver the majority of South Koreas coal imports.[315] It has to be mentioned that Korea's coal demand increased even throughout the financial crisis. Coal is the backbone of its power system and makes up for 45,2 % of electricity generation.[316]

[312] Energy Information Administration (2014h)
[313] International Energy Agency (2012b)
[314] WKO (2014)
[315] Energy Information Administration (2014h)
[316] International Energy Agency (2012b)

Political environment

The government provides long-term, low-interest loans for consumers and manufacturers of New & Renewable Energy systems.[317] The government introduced the *First National Energy Plan* and the *Fourth Energy Use Rationalization Plan* in 2008 to improve energy efficiency by 46 % until 2030.[318]

6.3.6 Taiwan

Taiwan is ranked 16th in the *World Bank 2014* annual report for places where it is easiest to do business in the world.[319]

The electricity network is stable and prices are regulated by the government.[320] Nevertheless, the energy supply in Taiwan is highly import dependent. There are only small amounts of proven oil reserves and almost all of the consumed natural gas comes from LNG imports, mainly from Qatar, Malaysia and Indonesia.[321]

Taiwan's *Master plan on Energy Conservation and GHG Emission Reduction* also includes industry to reduce CO_2 emission and promote energy conservation. The *Low Carbon Industrial Structure* under the *Master plan* is organized by *the Ministry of Economic Affairs*.[322]

There are low interest loans for new investments in energy efficiency and CO_2 reduction for local companies.[323]

6.3.7 Thailand

Thailand imports a significant part of its country's oil consumption. Primary energy consumption is mostly covered by fossil fuels with oil accounting for 39 % of the primary energy consumption in 2010. Natural gas is the second most important resource accounting for 31 % and solid biomass and waste also had a share of 16 %. The rest is coal, hydroelectric power and biofuels.[324]

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[317] Korea Energy Management Corporation (2013), p. 28
[318] International Energy Agency (2012b)
[319] Invest Taiwan (2014)
[320] WKO (2014)
[321] Energy Information Administration (2014i)
[322] Energy, Bureau of, Ministy of Economic Affairs and R. O. C (2012)
[323] WKO (2014)
[324] Energy Information Administration (2014j)

Electricity

There is one main electricity producer in Thailand, which is the *Electricity Generating Authority of Thailand (EGAT).* Independent power producers (IPP's) sell electricity to EGAT. EGAT also owns the majority of the transmission network and sells most of the electricity to the *Metropolitan Electricity Authority*, supplying Bangkok, Nonthaburi and Samut Prakarn and the *Provincial Electricity Authority*, supplying the rest of the country. Only a small amount is sold directly by the EGAT. Regarding the reliability of electricity services it has to be mentioned that occasional brownouts occur.[325]

Natural gas

The country is still a net importer of natural gas but has its own resources and production is growing. Almost all natural gas fields are located offshore in the Gulf of Thailand. Despite several projects to increase natural gas output, imports via pipeline and LNG are required to cover growing demand. The power sector accounts for around 60 % of natural gas consumption and generated 71 % of electricity from natural gas in 2011.[326]

Coal

There are no significant coal reserves in Thailand which makes imports necessary to cover all demands. Coal accounted for 21 % of electricity generation in 2011.[327]

Political environment

Thailand's authority is aware of energy conservation and environmental issues. It has an *Investment Promotion Policy for Sustainable Development* in place to promote sustainable development and to enhance the country's competitiveness in science and technology. Also encouraging the improvement of manufacturing quality and reducing environmental impact is part of it.

There are two incentives for encouraging the metal industry to reduce environmental impact:

- Exemption from import duty on machinery for machinery improvements.
- Three-year corporate income tax exemption on the revenue of existing projects, accounting for 70% of the investment value.[328]

[325] Dr. Pallapa Ruangrong (2012)
[326] Energy Information Administration (2014j)
[327] Energy Information Administration (2014j)
[328] BOI (2014)

6.3.8 Vietnam

Vietnam had continued economical growth of more than 5 % over the last few years and a stable political environment which made it interesting for foreign investors.[329]

Over the past few decades Vietnam became an important oil and natural gas producer. Currently Vietnam is the third-largest holder of crude oil reserves in Asia behind China and India. Its offshore fields are still relatively underexplored with 4,4 billion barrels of proven crude oil reserves.[330]

PetroVietnam is the key company in oil and natural gas business and foreign companies have formed partnerships with PetroVietnam.[331]

Vietnam is a net coal exporter and government increased export tax from 10 to 13 % in 2013 to satisfy growing energy demand, particularly in the power sector. Other sources for electricity are hydropower, natural gas and coal.[332]

6.3.9 Conclusion

In Asia energy prices tend to be the highest worldwide often related to the high energy demand of evolving economies. Regarding electricity, many markets are regulated and prices are set by the government. The same applies to natural gas prices as they are state controlled as well. Coal is an internationally traded good and prices are market regulated. Asia had the biggest economic growth in the past decade and the economic crisis didn’t influence local markets as much as it did in Europe or America.

6.4 Europe

In Europe the European Union plays a big role and for that reason it was looked at separatly. Within the European Union state programs for energy efficiency measures are often based on directives set by the EU. Russia is very important for Europe in regard to natural resources and Europe’s has a great dependency on these especially on natural gas.

[329] WKO (2013), p. 86
[330] Energy Information Administration (2014k)
[331] Energy Information Administration (2014k)
[332] Energy Information Administration (2014k)

6.4.1 European Union

Market liberalisation for electricity and natural gas began between 1996 and 1998. It is still continuing with the aim to improve market competitiveness and a reduction of market barriers. Member countries meet the requirements but are still facing issues like too high concentration of actors, the limitation of independence for network operators and major differences in havingregulatory power. The aim is to address these issues and to detach power generation from its distribution and transmission in order to prevent discrimination against third parties.[333]

A key component is energy efficiency, which is perhaps the only domain that works for all goals:

- To reduce GHG emissions,
- Strengthens energy security,
- Lower the costs of energy services for customers and
- Improves economic competitiveness.[334]

The European Union aims to ensure that energy is available without interruption and is doing this by developing stable and competitive sources of energy.[335]

Electricity

A pilot project for European Union wide electricity trade started on the 4th of February, 2014. This project aims at having an *Internal Energy Market* in 2014. Grid operators and power exchanges from 14 EU member states (Belgium, Denmark, Estonia, Finland, France, Germany, Austria, United Kingdom, Latvia, Lithuania, Luxembourg, The Netherlands, Poland, Sweden and Norway) were joined.

Electricity trading was joinedto a so called day-ahead market coupling. The coupling combines all bids and offers in a region and creates a large integrated electricity market combining 75 % of today's electricity consumption in the EU.[336]

Natural gas

Natural gasas the "cleanest" fossil fuel has raised some concerns about supply security because of the dependency on imports especially from Russia.[337] Like it was done for

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[333] EUROSTAT, p. 150
[334] EUROSTAT, p. 150
[335] COMM/TREN (2009b)
[336] COMM/PRESS/01 (2014)
[337] EUROSTAT, p. 150

electricity the aim is a single market for natural gas as a measure to improve security of supply.[338]

Natural gas now provides 28 % of energy in the European Union and it is expected to become the second most important energy source for power generation after coal.[339]

Coal

The use of coal is declining since 1990 and the *European Commission (EC)* aims to secure energy supplies and a well-functioning internal market.[340] In power generation it has been replaced by natural gas and in steel production it is linked to the move towards electric arc furnaces. Because of environmental impact and the EU ETS the comeback of coal is unlikely.[341]

Political environment

The EU requested member states to draft the *National Energy Action Plans (NEAPs)* for a better co-ordination of energy efficiency policies and measures. For cost effective CO_2 emission reduction the *European Emission Trading System (ETS)* was introduced which is a market based instrument to improve energy efficiency. It is the first cross border system of its kind and had significant problems at the beginning. Achieving energy efficiency in a cost effective way is one of the *Europeans Commission* goals to increase supply security.[342]

6.4.2 Belgium

Belgium has several measures to promote energy efficiency and public funding for energy research and development is available. The government started many initiatives to avoid future problems with energy security, economic growth and environmental protection. Specifically, the creation of the *Energy Observatory* is expected to help energy policy making and more market transparency.[343]

338 COMM/TREN (2009c)
339 International Energy Agency (2008), p. 217
340 COMM/TREN (2009a)
341 International Energy Agency (2008), p. 217
342 ODYSSEE-MURE (2013)
343 International Energy Agency (2009), p. 217

Belgium is divided in three regions which are responsible for energy efficiency, distribution and supply of electricity and natural gas:

- Flanders,
- Wallonia and
- Brussels-Capital.

Electricity is liberalized but about 80 % of generating capacity was owned by *Electrabel* in 2009. Nuclear energy plays a big role with a share of 55 % of electricity generation. To establish a competitive market *Belpex*, an electricity spot market, was introduced in 2006. Generally speaking it can be said that the electricity network is stable.[344]

Nevertheless, Belgium is heavily dependent on energy imports. As an example, natural gas is imported from the Netherlands and Norway. Declining imports from these countries increase the dependency on natural gas from Russia and the Middle East. In Zeebrugge two major pipelines cross, the Zeepipe with natural gas coming from Norway and the Interconnector with natural gas coming and leaving from the United Kingdom. Also there is a LNG regasification in Zeebrugge port with a capacity of 9 bcm per year. All facilities in Zeebrugge have an annual throughput capacity of 40 bcm which accounts for around 7 % of gas consumption in OECD Europe.[345]

There are a variety of measures in place to improve efficiency such as:

- Investment subsidies,
- Low- or zero-interest loans and
- Information campaigns.[346]

6.4.3 France

In France around 75 % of the electricity production came from nuclear power in 2012, which is internationally one of the highest rates. Since 1981 France is a net exporter of electricity and with export of 74 TWh in 2012 even one of the biggest worldwide. Electricity production, transport and distribution is mainly in the hand of state owned *Electricite de France (EDF)* which was heavily critisiced by the European Union. Liberalisation started 2000 and since 2007 it is possible for every customer to choose an electricity supplier.[347]

[344] International Energy Agency (2009), p. 217
[345] International Energy Agency (2009), p. 217
[346] International Energy Agency (2009), p. 210
[347] WKO (2013a)

France has very small own resources of oil and natural gas and relies on imports. It imports natural gas through pipelines from the Netherlands, Norway and Russia. Liquid natural gas is also imported.[348]

The French *Environment and Energy Management Agency (ADEME)* had a budget of 387 million € in 2011 allocated to energy efficiency and renewables. They offer energy audits and subsidies to industry.[349]

6.4.4 Germany

Germany is the biggest economy in Europe. Its gross production of electricity was 614,5 TWh in 2011 and the country had the fourth largest economy of the world in 2012.[350] In the last decade Germany was able to decouple greenhouse gas emissions with economic growth and is on a good path to reach Kyoto targets. Energy efficiency is a main point in the green energy transition. Germany's targets are to reduce primary energy consumption by 20 % in 2020 based on figures from 2008 and has a target of 50 % until 2050.[351]

Germany has the highest non-recoverable taxes in the EU[352] and it was the fifth largest generator of nuclear energy in 2012 but the government decided to close all reactors until 2022.[353] The 2050 long term strategy is to use renewables as significant power source.[354]

Germany is 89 % depending on natural gas imports mainly from Russia and has no liquid natural gas terminal.[355] The Eco tax for industry is 0,33 EUR/MWh.[356] In the last few years Germany could diversify its natural gas imports.[357]

Bituminous coal was the third biggest part of the primary energy mix in Germany in 2011 and they needed to import 79 % of it, mainly from Russia. Lignite is the most important domestic energy source with around 25 % coverage for electricity generation.[358] In 2007 the decision was made to close all bituminous coal mines in Germany by 2018. Despite closing coal power plants based on EU restrictions there

[348] Energy Information Administration (2014o)
[349] ODYSSEE-MURE (2013)
[350] Energy Information Administration
[351] International Energy Agency (2013a)
[352] EUROSTAT
[353] Energy Information Administration
[354] International Energy Agency (2013a)
[355] Energy Information Administration
[356] International Energy Agency (2013b)
[357] International Energy Agency (2013a)
[358] WKO (2012b)

are several new onesin construction with a planned livespan beyond 2050 to ensure energy supply security.[359]

There are many information campaigns and incentives for industry to invest in energy efficiency measures. One is to make the production process more energy efficient. The requirements for government support are a minimum Of 5 % energy savings and investment costs have to be over 50.000 EUR. The maximum incentive is 20 % of investment costs or 1,5 million EUR.[360]

6.4.5 Italy

Italy has minimal domestic resources and has to import 85 % of its primary energy. Even electricity has to be imported because of insufficient generation capacity. This results in high energy costs which are a bigger problem than high interest rates.[361] Energy markets are insufficiently liberalised and in combination with high import dependencies these are reasons for price fluctuations in Italians power markets. Electricity prices tend to be very high.[362]

In the last few years the Italian government has undergone reorganisation and reform changes of the electricity and natural gas market have been made. Other achievements are incentive schemes for renewable energy and investments in capture and storage (CCS) research. The *International Energy Agency (IEA)* proposes to continue the good work of the white certificate scheme and other tax related tools. It also encourages to take greater steps in energy efficiency strategy.[363]

6.4.6 Poland

Coal is the main fuel for Poland and is seen as key to a secure future in energy supply. Coal accounts for 55 % of its primary energy supply and the associated climate problems are addresses insufficiently. The International Energy Agency wants to promote competition in energy markets so that they canbecome more efficient and also wants a decarbonisation of Poland.[364]

Electricity generation in Poland is 90 % from coal but many power plants are aged, inefficient and would need to be replaced.[365] Electricity generation capacity grew only

[359] International Energy Agency (2013a)
[360] Bundesministerium für Wirtschaft und Energie and Referat Öffentlichkeitsarbeit (2011)
[361] Germany Trade and Invest GmbH, p. 5
[362] Germany Trade and Invest GmbH, p. 5
[363] International Energy Agency (2009b)
[364] International Energy Agency, p. 190
[365] WKO, p. 114

modest in the last few years while demand has grown faster but Poland still remains a net exporter of electricity.[366]

The country is import dependant in terms of natural gas because of too few natural gas fields. Most of the imported gas comes from Russia. There are large shale gas fields located in Poland and work to explore this resource has started in 2011. Conventionally extractable shale gas would be enough to satisfy Poland's natural gas demand for the next 35 to 65 years.[367]

Poland has 48 million t of bituminous coal resources which would last for another 150 years at today's extraction rate.[368] Coal-washing capacity has increased since 1990 to ensure quality standards of internationally traded coal. Hard coal production declined over the last few years because of reduced demand and the poor economy of Polish deep mines. Still, the country is the 9th largest coal producer worldwide and second in the EU behind Germany.[369]

Energy efficiency is also included in Poland's new energy policies to reach the 20 % efficiency mark. Therefore incentives for efficiency measures are planned and examples are co-financing for energy audits and a co-financing for energy efficiency investments.[370]

6.4.7 Russia

Russia is the second-largest producer of dry natural gas and has significant reserves of coal.[371] In the last few years major investments in new production centres in east Siberia were undertaken to satisfy Asia's and in particular China's thirst for energy. Russia's energy intensity is about two times higher than average IEA levels and energy efficiency measures are just starting. [372]

The only power exchange in Russia is called ATS. The competitive sector of the wholesale market is split in a day-ahead market and in non-regulated bilateral contracts.[373] The *Ministry of Energy* regulates Russia's power sector, which is separated in eight regions from which seven are connected to the main power grid.[374]

[366] International Energy Agency (2013a)
[367] WKO, p. 114
[368] WKO, p. 114
[369] International Energy Agency (2013a)
[370] International Energy Agency, p. 190
[371] Energy Information Administration (2014p)
[372] International Energy Agency (2014a)
[373] Dmitry Ponomarev (2007)
[374] Energy Information Administration (2014p)

State owned *Gazprom* dominates Russia's natural gas market with a share of around 74 % of total output. Around 76 % of natural gas export is going to Western Europe with Germany, Turkey, Italy, France and the United Kingdom receiving the majority of this volume. Russia is also an exporter of liquid natural gas mainly to Japan and South Korea.[375] Today, new players have made their way into the natural gas business named Novatek and Rosneft and form part of Russia's approach to diversify the market. For export deliveries to Europe Gazprom is still key player.[376]

Russia held the world's second largest recoverable coal reserves after the United States in 2008. But it produces just modest amounts of it.[377]

There are state guarantees to ensure loans for efficiency projects which have lower interest rates and longer payment periods as well as tax benefits.[378] Biggest challenge is access to funding as there are no private banks yet that have developed services for energy efficiency measure.[379]

6.4.8 Spain

In Spain the metal industry is mainly situated in the Basque country. Spain is the fifth largest energy consumer in Europe and has nearly no domestic production of liquid fuels. In order to ensure diversity of supply the government regulates limits of oil and gas imports for every exporting country.[380]

In Spain green energy sources play a big role and wind power has come up strongly over the past few years.[381] To ensure that a maximum of wind power can be utilised the transmission system operator and industry are developing pumped water storages and other ways of electricity storage. The plan is also to increase the use of electric vehicles with the target of one million hybrid and electric cars in 2014.[382]

Spain was the third largest importer of *Liquid Natural Gas* in the world after Japan and South Korea in 2011[383] and in 2008 natural gas was the second most important fuel. The natural gas market is highly transparent and is regulated by the *Ministry of Industry, Tourism and Trade* and the *National Energy Commission (CNE)*.[384]

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[375] Energy Information Administration (2014p)
[376] International Energy Agency (2014a)
[377] Energy Information Administration (2014p)
[378] WKO
[379] International Energy Agency (2014a)
[380] Energy Information Administration
[381] Energy Information Administration
[382] International Energy Agency (2009a)
[383] Energy Information Administration
[384] International Energy Agency (2009a)

Plan de Ahorro y Eficiencia Energetica 2011 – 2020 is a key element of Spain's energy policies and also includes incentives for energy efficiency measures.[385] Energy efficiency is increasingly guided by directives from the EU.[386]

6.4.9 Turkey

Turkey's domestic oil and gas production meets less than 3 % of its energy requirements.[387] Over the past three years Turkey has experienced one of the fastest economic growths in the OECD[388] with a comparatively low energy use . Hence energy demand is expected to grow over the next few years. In Politics energy security is given higher priority than market reform or energy efficiency. Large investments are needed in energy infrastructure to avoid bottlenecks in the next few years.[389]

Figure 38 shows firms of metal industry in Turkey and their locations divided in copper, aluminium and iron and steel industry.[390]

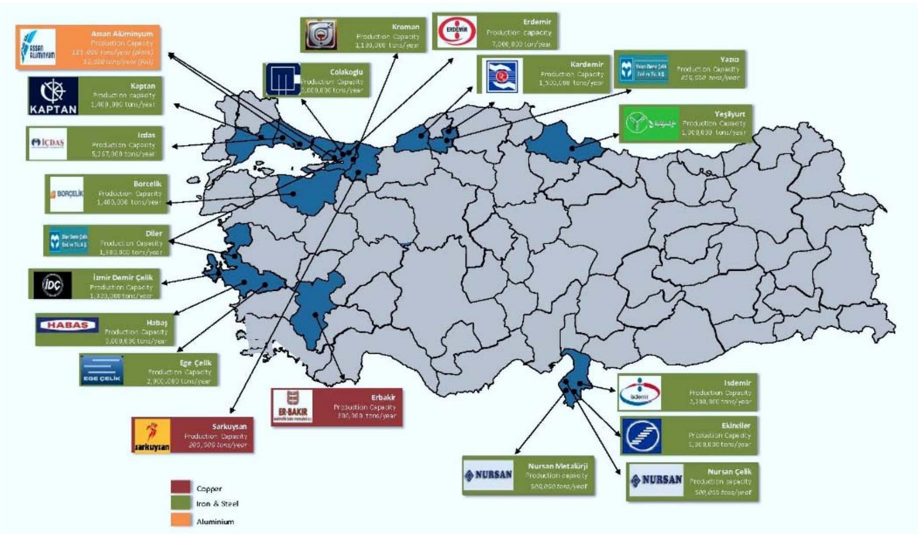

Figure 38: Top 20 operating firms of metal industry in Turkey [391]

Liberalisation of electricity markets is ongoing and an open market for all customers is planned until 2015.[392] Growth of electricity demand requires big investments and the Turkish government is thinking about utilising hydro and wind power to diversify its energy mix.[393]

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[385] WKO
[386] International Energy Agency (2009a)
[387] Selman Cagman, p. 31
[388] Energy Information Administration (2014q)
[389] International Energy Agency (2010), p. 159
[390] Republic of Turkey Prime Ministry (2010)
[391] Republic of Turkey Prime Ministry (2010)
[392] Energy Information Administration (2014q)
[393] International Energy Agency (2010), p. 159

The country is an important energy corridor between continental Europe's market of natural gas and the Middle East. It also imports LNG via two terminals.[394] Natural gas consumption is expected to increase fast in all sectors long term, driven by economic growth.[395]

Coal is important to the electricity generation mix and 23 % of it was imported in 2012.[396] Lignite production decreased in 2004 but increased rapidly in the years to 2007 mostly because of two lignite fired power stations. All lignite is produced in Turkey but hard coal is imported.[397]

6.4.10 Ukraine

Ukraine is very important as a transit country for oil and natural gas coming from Russia to Europe. Shale gas discoveries let Ukraine hope to become more independent from Russia and to start exporting it in 2020.[398]

Ukraine's energy sector is crippled with high energy intensity and poor efficiency. Natural gas and electricity providers are dominated by governmental entities and the challenge is to make the energy market interesting for investors.[399]

6.4.11 United Kingdom

The United Kingdom is the second largest producer of natural gas in the European Union but became a net importer in 2004. Oil with 38 % and Natural gas with 35 % of primary energy consumption in 2011 are the main energy sources. Because of declining domestic production of natural gas the UK had to import it via pipeline mainly from Norway and via *Liquid Natural Gas* terminals.[400] The government has ambitious targets to lower the dependency on fossil fuels and sees the development of green technologies as creator for jobs and growth. Primarily investments in infrastructure and energy efficiency are foreseen.[401]

Fossil fuel is the dominating resource for electricity generation and coal used as top up fuel. The electricity sector is privatised and the network is stable.[402] To achieve a

[394] Energy Information Administration (2014q)
[395] International Energy Agency (2010), p. 159
[396] Energy Information Administration (2014q)
[397] International Energy Agency (2010), p. 159
[398] Energy Information Administration (2014r)
[399] IEA, p. 34
[400] Energy Information Administration (2014s)
[401] International Energy Agency (2012), p. 1 online resource (178
[402] Energy Information Administration (2014s)

low carbon electricity generation the government has suggested three ways forward: renewable sources, nuclear power and carbon capture storage (CCS).[403]

In order to improve energy efficiency the government enacted the *Enhanced Capital Allowance (ECA)* which provides businesses with a tax relief for investments and equipment.[404]

6.4.12 Conclusion

In Europe especially the EU global warming and dependency on imports are seen as a threat and there are many approaches to reduce energy consumption. The EU is world leader in energy efficiency and continues to fight the waste of energy. Nearly all energy markets are liberalized or on the way there and supply is secure in most cases.

[403] International Energy Agency (2012), p. 1 online resource (178
[404] ETL (2014)

7 Energy price outlook

Predicting energy prices is very difficult due to various price influencing factors such as crises or changes in a political framework. Key drivers are hard to predict partly because they interact with each other. Other factors like population growth or technological evolution are unlikely to change much compared to initial assumptions. On the other hand the biggest uncertainty is the economic growth which directly corresponds with energy usage. These trends also relate to energy security, the environment and economic development. The model used for the price outlook also includes economic and population growth. Prices are hard to predict accurately and the *World Energy Outlook* presents several scenarios mainly differentiated by underplaying assumptions of governmental policies. The price outlook that was carried out by the *International Energy Agency (IEA),* shows a price prediction for coal and natural gas in different regions.[405]

A non-policy assumption is the economic growth, which strongly correlates with energy demand. So projections are highly sensitive to the underlying assumption about the growth of the gross domestic product (GDP).

Table 16: Real GDP growth assumptions by region[406]

	Compound average annual growth rate			
	1990-2010	**2010-15**	**2010-20**	**2010-35**
OECD	**2,2 %**	**2,1 %**	**2,2 %**	**2,1 %**
Americas	2,5 %	2,6 %	2,7 %	2,4 %
Europe	2,0 %	1,5 %	1,8 %	1,8 %
Asia Oceania	1,9 %	2,0 %	2,0 %	1,8 %
Non-OECD	4,9 %	6,1 %	5,9 %	4,8 %
E. Europe/Eurasia	0,5 %	3,9 %	3,8 %	3,4 %
Asia	7,5 %	7,5 %	7,0 %	5,5 %
Middle East	4,3 %	3,7 %	3,9 %	3,8 %
Africa	3,8 %	4,4 %	4,6 %	3,8 %
Latin America	3,4 %	4,2 %	4,1 %	3,4 %
World	3,2 %	4,0 %	4,0 %	3,5 %
European Union	1,8 %	1,3 %	1,7 %	1,8 %

[405] International Energy Agency (2012d)
[406] 2012 (IMF), 2012 (OECD) and Economist Intelligence Unit and World Bank database

The world bounced back after the regression of 2008-2009 but there are many continuing risks like the fiscal cliff in the United States or the escalation of the crisis in the euro-zone.

Another factor could be the slowing of key emerging economies including China, India and Brazil which were the drivers for global economy in the past decade. The GDP in the World Energy Outlook is mainly based on assumptions from the *International Monetary Fund (IMF)* shown in Table 16 with adjustments to reflect information available on regional, national and other sources. The IEA assumed that the GDP will grow on average 3,5 % per year over the period 2010-2035 which is marginally lower than last years growth rate. India is taking over China's place and is becoming the fastest growing region because of its growing population, rising labour participation and early stage of development.[407]

Population growth is an important driver for energy usage. Directly through size and composition of energy demand and indirectly through its effect on GDP. Projections are based on assumptions made by the United Nations and are shown in Table 17. Growth rates presented in Table 17 are the same for all scenarios. The world population is expected to grow from 6,8 billion in 2010 to 8,6 billion in 2035.

Table 17: Population assumptions by region[408]

	Population growth		
	2010-20	2020-35	2010-35
OECD	**0,5 %**	**0,3 %**	**0,4 %**
Americas	0,9 %	0,7 %	0,7 %
Europe	0,4 %	0,2 %	0,3 %
Asia Oceania	0,2 %	-0,1 %	0,0 %
Non-OECD	1,2 %	0,9 %	1,0 %
E. Europe/Eurasia	0,1 %	-0,1 %	0,0 %
Asia	0,9 %	0,6 %	0,7 %
Middle East	1,8 %	1,4 %	1,6 %
Africa	2,3 %	2,0 %	2,1 %
Latin America	1,0 %	0,7 %	0,8 %
World	1,1 %	0,8 %	0,9 %
European Union	0,2 %	0,1 %	0,1 %

Population growth will slow down from 1,1 % per year between 2010 and 2020 to 0,8 % per year between 2020 and 2035. Almost all of the increase in population will take

[407] International Energy Agency (2012d)
[408] UNPD and World Bank Database

place in Africa and Asia. India will overtake China soon after 2025 and become the most populous country in the world. [409]

In the model there are also several policy assumptions which the IEA defines. Various scenarios in which they calculate the possible future outcome of energy prices are shown in Table 18. None of these scenarios is a forecast. These scenarios are intended to show how markets could evolve under certain conditions.

Table 18: Definitions and Objectives of scenarios[410]

Scenario	Definition	Objectives
Current policies scenario	Government policies that had been enacted or adopted by mid-2012 continue unchanged.	To provide a baseline that shows how energy markets would evolve if underlying trends in energy demand and supply are not changed.
New policies scenario	Existing policies are maintained and recently announced commitments and plans, including those yet to be formally adopted, are implemented in a cautious manner.	To provide a benchmark to assess the potential achievements (and limitations) of recent developments in energy and climate policy.
450 scenario	Policies are adopted that put the world on a pathway that is consistent with having around a 50 % chance of limiting the global increase in average temperature to 2 °C in the long term, compared with pre-industrial level. 450 stands for the ppm level of pre-industrial time.	To demonstrate a plausible path to achieve the climate target.

The *Energy Information Administration* (EIA) carries out an energy outlook till 2040 but only for the United States.

[409] International Energy Agency (2012d)
[410] International Energy Agency (2012d)

Their primary cases:[411]

- Reference case
- Low Economic Growth
- High Economic Growth
- Low Oil Price
- High Oil Price

Key results of the *Annual Energy Outlook 2014* are the growing domestic production of natural gas and oil. Further, a boost in industrial production is the result of low natural gas prices and increases in natural gas usage. The shift in electricity generation from using coal to natural gas is expected to stabilize CO_2 emissions. Figure 39 shows expected natural gas prices on Henry Hub until 2040 differentiated in five cases. In all cases the price is expected to grow.[412]

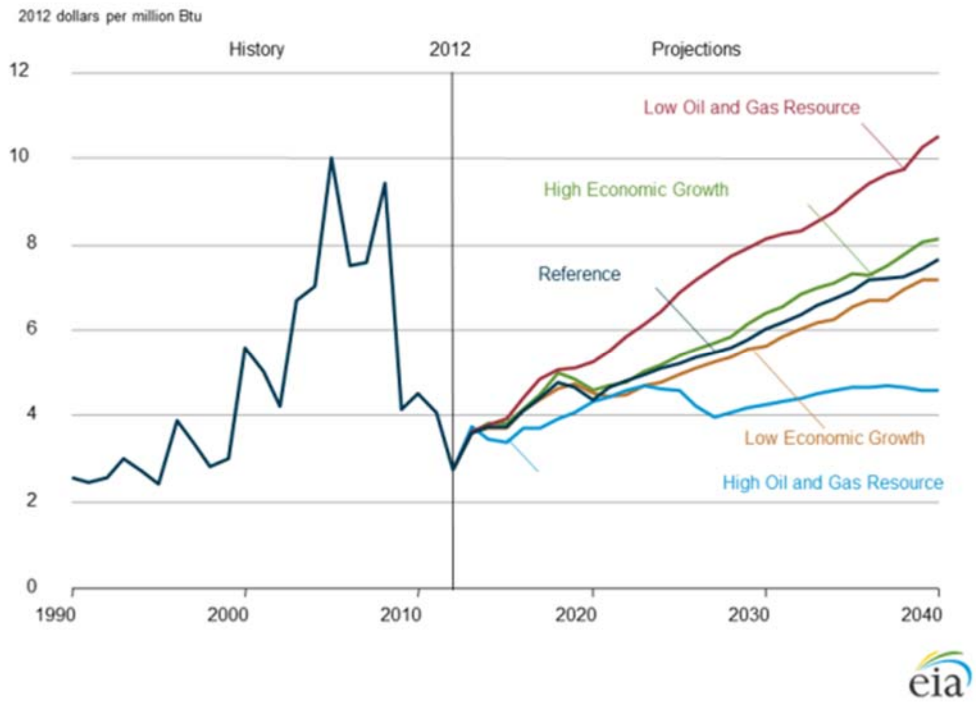

Figure 39: Annual average Henry Hub spot prices for natural gas in five cases[413]

Figure 40 shows three scenarios for natural gas import in Europe. This energy price outlook was published in *World Energy Outlook 2012* with price data from 2011. Conversion from USD to EUR was done with exchange rate from 2011.[414]

[411] Energy Information Administration (2014a)
[412] Energy Information Administration (2014a)
[413] Energy Information Administration (2014a)
[414] International Energy Agency (2012d)

In Figure 41 a new policies scenario is shown for different regions. Also included is the natural gas price for the United States, which has become a net exporter, and import prices for Europe and Japan, which is dependent on imports of LNG. The figure also shows an assumption of the steam coal import price for the OECD. All prices show a steady increase over the next few years except for the steam coal price which is slightly decreasing until 2015 after then it will also increase.[415]

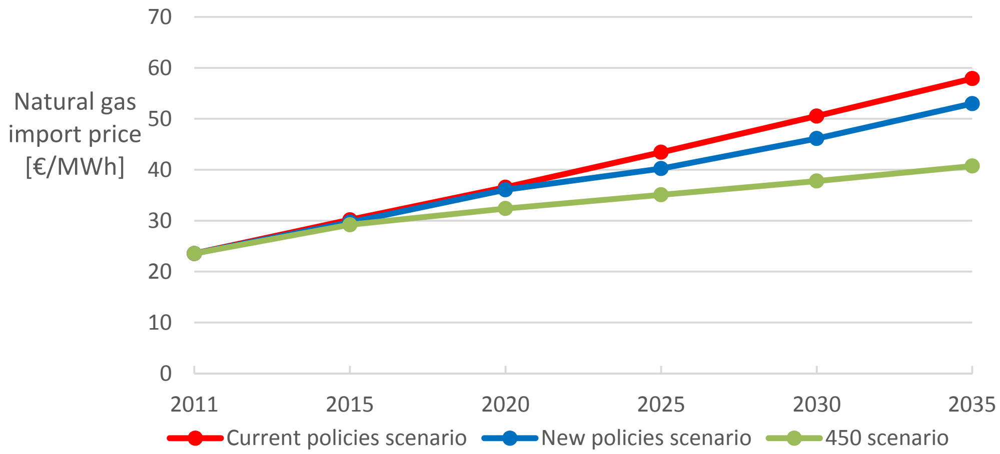

Figure 40: Import price assumption in Europe for natural gas [416]

Other analysts predict that the gas price in Germany will stay the same and Asia will lose its "Asia Premium" because of more diversified suppliers. After the shale gas boom in the United States is over prices will recover again. This trend will be accelerated with the new LNG terminal starting in 2017 when natural gas from the United States enters the international market.[417]

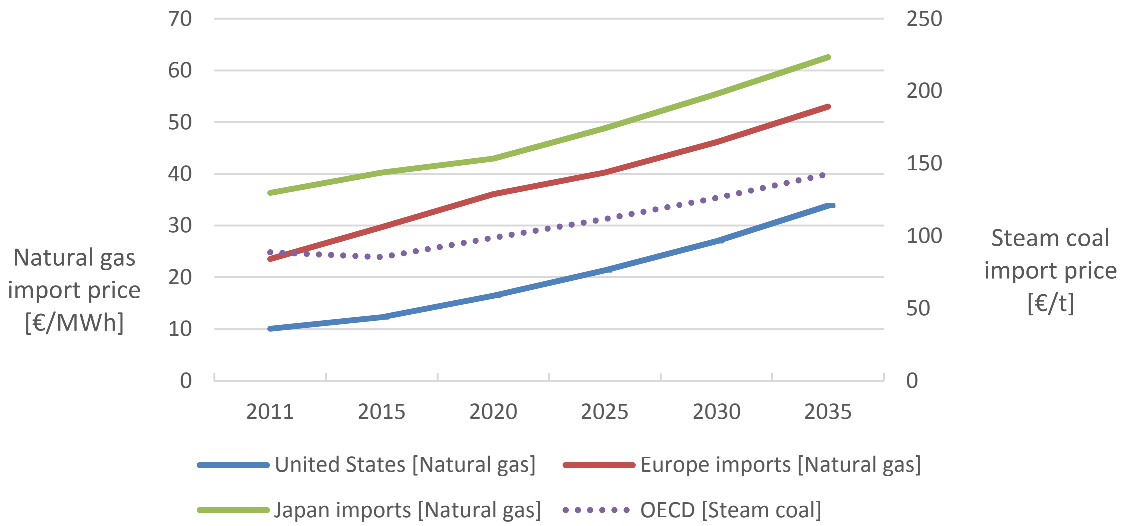

Figure 41: Import price assumption for new policies scenario [418]

[415] International Energy Agency (2012d)
[416] International Energy Agency (2012d)
[417] EnergyComment (2014)
[418] International Energy Agency (2012d)

8 Conclusion and recommendations

Improving energy efficiency is a key element to stopping global warming by reducing greenhouse gas (GHG) emissions. The European Union is a leader in energy efficiency policy and other programs to reduce GHG emissions. In Asia this is just starting but in America the environment doesn't influence decision making much. Barriers for achieving energy efficiency are discussed in this thesis and it is concluded that information campaigns and incentives are the best solution for overcoming them. To tackle the gobal emission problem market based instruments like the emission trading scheme (ETS) are in place and are working now after a problematic start. Furthermore there are many other ways of influencing decision making in companies towards a more efficient futureand it can be said that measures always have to be aligned with the specific targets. Energy intensive industries are aware of possible efficiency solutions but will only implement them when they are cost effective. Therefore incentives for such improvements or fees on the other hand are possible ways of encouraging implementation. Non-energy intensive industries often don't have the knowledge about what is possible and a start would be to inform them. One way of doing that are energy audits with the result of specific options for energy savings.

The environment is not the only driver for better implemented energy efficiency. Often it is the increasing profitability when using less energy during production. For countries as a whole import dependency is also a reason for investing in energy efficiency which in a way is an investment in the economy itself. New companies will create additional jobs and generate know how, which leads to an advantage in international trade.

There are many different drivers for energy intensive industries to invest in energy efficiency and/or CO_2 abatement. The main reason is an *economical* one. An investment should have a *payback-period* of 3,5 to 4 years and an *Internal Rate of Return (IRR)* of 20 %.[419] Mostly high energy prices or incentives are drivers for more efficiency. For the steel industry, main energy sources are electricity, natural gas and coal. Energy prices are shown in Figure 42 to Figure 44 used for energy production in steel process. Another reason for investments in energy efficiency can also be insufficient supply because of low network capacity, problems with suppliers, and shortages in energy production. It is often cheaper for companies to have their own power production capacity than to interrupt production because of problems with energy supply.

[419] Deloitte (2013), p. 20

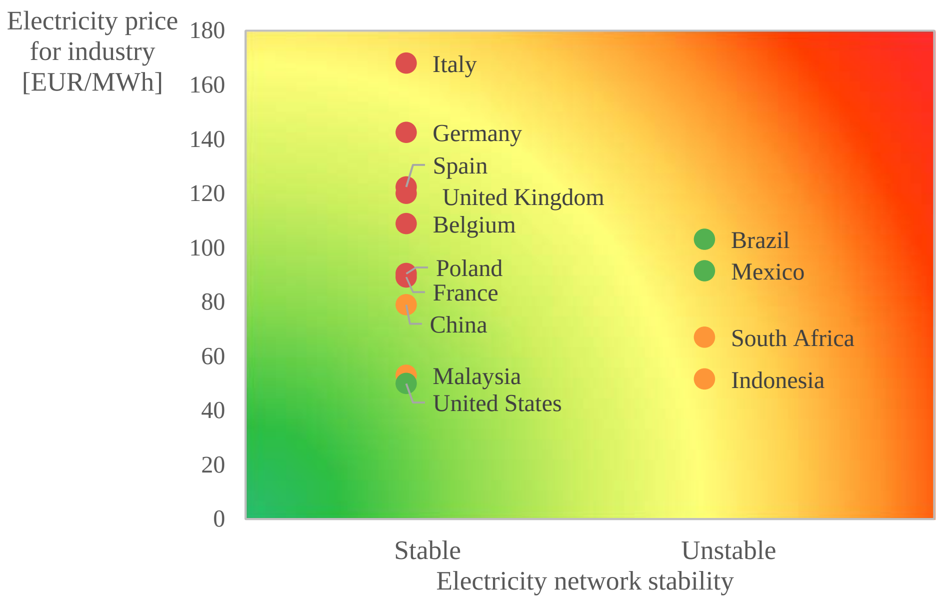

Figure 42: Situation analysis for electricity market[420]

For a steel producer this means that the best time to invest in energy efficiency is when energy prices are high and especially good incentives for such investments exist. Most countires have tax allowances and/or import regulations to make it easier for industry to invest in energy efficiency or environmental care.

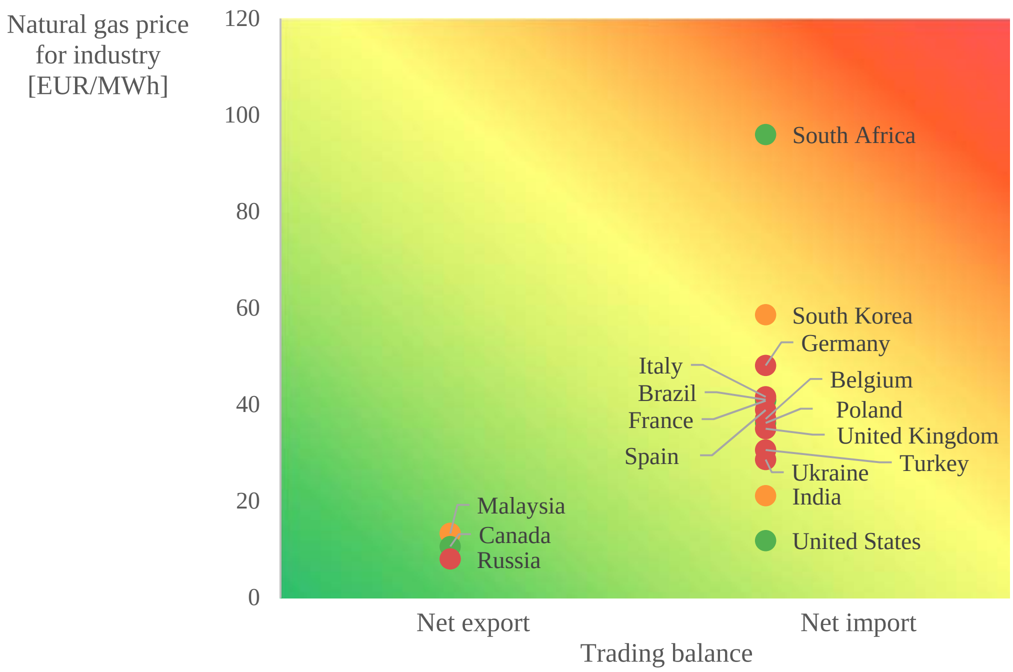

Figure 43: Situation analysis for natural gas market [421]

[420] ANEEL, China Mail, EIA, ENERDATA, ESKOM, EUROSTAT, IEA, Ukraine mail, MIDA, NUS and Vietnam EVN

[421] ANEEL, China Mail, EIA, ENERDATA, ESKOM, EUROSTAT, IEA, Ukraine mail, MIDA, NUS and Vietnam EVN

Figure 43 shows prices in industry for natural gas and the trading balance. This shows the price dependency of net importers and the advantage of own natural gas resources in Malaysia, Canada and Russia. It has to be mentioned that the United States will start to export natural gas in the next few years as they are currently having a shale gas boom.

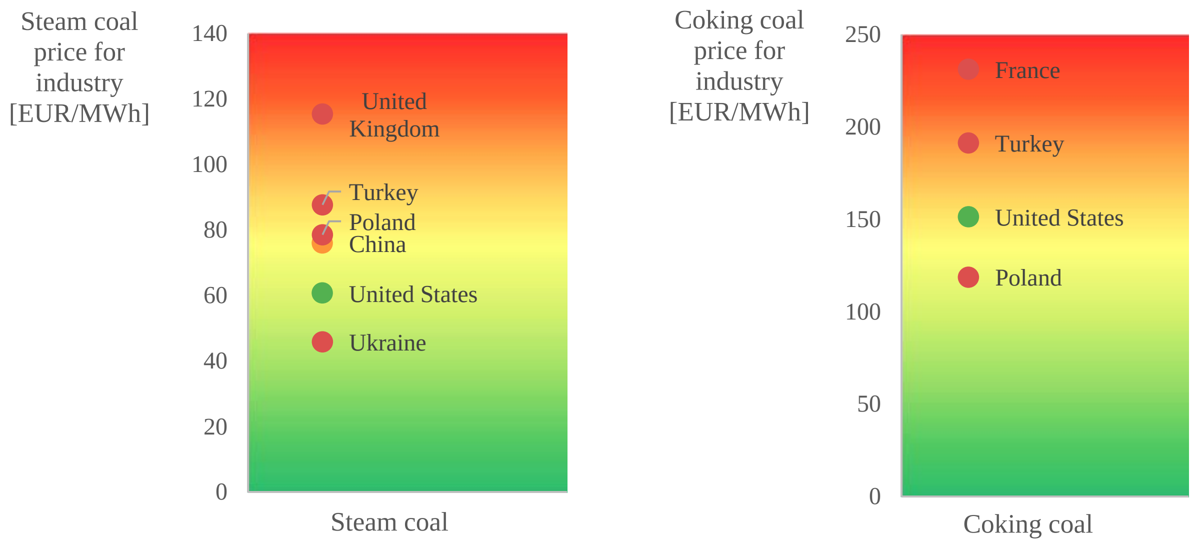

Figure 44: Situation analysis for coal market

In these figures the best situation for manufacturing industry is at the bottom where energy prices are low for industry. For Siemens VAI the top is interesting, where high energy prices ensure short payback time for energy efficiency measures. The energy price situation is very important in the decision making process but other factors like network stability are equally important. This is also shown in Figure 42. In many countries the manufacturing industry is investing in self-generating capacity because of unstable electricity networks. Payback time can be higher in these countries because of high costs due to interruptions in production processes. With natural gas and coal these problems usually don’t occur. There are also often incentives like low interest loans or tax allowances available for energy efficiency projects. Sometimes regulations are also in place where emissions are limited and therefore measures are needed. All these factors lead to following countries that could be attractive to Siemens VAI:

- Brazil,
- Germany,
- Italy,
- Mexico and
- South Africa.

In *Italy* high electricity prices because of insufficient liberalisation of energy markets and not enough electricity generation capacity are the reason for short payback time. *Germany* also has high electricity prices and high targets concerning energy efficiency. In Brazil a lack of investment in infrastructure and a lack of reforms for the energy market leads to high energy prices and the need for self-generation capacity. For *Mexico* the same reasons apply as for *Brazil*. In *South Africa* huge investments in electricity generating capacity with more diversification and infrastructure is needed. Also diversification through more private players would help the market. The natural gas market also needs reforms to bring prices down. In Indonesia electricity network stability is the main problem and as a result industry is trying to create self-generation capacities.

In this thesis energy prices for industry and drivers for energy efficiency measures were looked at. The next step would be to calculate payback times and internal rates on return for products Siemens VAI offers specifically for all countries. After calculation of the market suitability the search for interested companies in these countries would be the next step. With this background in mind, the final aim is to receive new orders for energy efficiency projects.

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10 Image index

11 Table directory

12 Abbreviations and Units with conversion

Table 19: Abbreviations

Abbreviation	Explanation
ANEEL	Brazilian Electricity Regulatory Agency
bcm	Billion cubic metres
Blackout	Electric power is being cut.[422]
BOF	Basic oxygen furnace
Brownout	A temporary reduction in electric power. Lights may flicker and dim.[423]
CEPS	Centre for European Policy Studies
CIF	Cost Insurance Freight[424]
EAF	Electric arc furnace
EIA	United States Energy Information Administration
ESKOM	South Africa's electricity producer
EU ETS	European emission trading system
EUROSTAT	Statistical office for the European Union
FAS	Free at shipside[425]
FOB	Free on board[426]
GHG	Greenhouse gas
IEA	International Energy Agency
IHS	Institute for Advanced Studies
LNG	Liquid natural gas
MIDA	Malaysian Investment Development Authority
Mtoe	Million tonnes of oil equivalent
NUS	NUS Consulting Group
OTC	Over the counter
yr	Year

Table 20: Conversion factors

$Gcal = 1{,}163 * 10^{-3}\ GWh$
$MBtu = 2{,}931 * 10^{-4}\ GWh$
$TJ = 0{,}2778\ GWh$
$kg\ Ce = 8{,}141 * 10^{-6}\ GWh$ [427]

[422] Wisegeek
[423] Wisegeek
[424] Transport-Informations-Service (2013)
[425] Transport-Informations-Service (2013)
[426] Transport-Informations-Service (2013)
[427] European Nuclear Society (2014)

A Appendix

Exchange rates used in thesis are listed in Table 21. USD was used as base for conversion.

Table 21: Currency exchange rates

State	Abbreviation	2004	2005	2006	2007	2008	2009	2010
South Africa	ZAR	6,360	6,374	6,861	7,031	8,499	8,219	7,275
Brazil	BRL	2,912	2,398	2,164	1,917	1,881	1,954	1,752
Canada	CAD	1,301	1,212	1,134	1,074	1,068	1,141	1,030
China	CNY	8,277	8,176	7,950	7,561	6,916	6,830	6,750
Germany	EUR	0,805	0,805	0,797	0,730	0,684	0,720	0,755
India	INR	45,120	44,105	45,243	40,931	44,567	48,356	45,806
Indonesia	IDR	9.006,284	9.732,962	9.135,198	9.161,514	9.820,588	10.248,728	9.068,765
Iran	IRR	7.900,000	8.330,703	9.175,619	9.280,471	9.521,147	9.875,625	10.106,582
Malaysia	MYR	3,800	3,782	3,645	3,417	3,357	3,508	3,193
Mexico	MXN	11,281	10,890	10,903	10,929	11,153	13,504	12,632
Poland	PLN	3,651	3,234	3,104	2,765	2,410	3,119	3,015
Russia	RUB	28,732	28,326	27,025	25,405	25,454	31,585	30,394
South Korea	KRW	1.145,000	1.024,000	952,000	929,000	1.101,000	1.275,000	1.155,000
Taiwan	TWD	33,271	32,175	32,590	32,837	31,624	32,916	31,302
Thailand	THB	40,224	40,338	37,551	31,866	33,373	34,177	31,512
Turkey	TRY	1,426	1,341	1,430	1,300	1,299	1,547	1,499
Ukraine	UAH	5,321	5,083	5,036	5,031	5,530	8,043	7,941
United Kingdom	GBP	0,546	0,550	0,543	0,500	0,546	0,641	0,648
Vietnam	VND	15.746,613	15.867,537	16.001,404	16.074,778	16.567,748	17.834,935	19.214,733

Table 22: Second part of currency exchange rates

State	Abbreviation	2011	2012	2013	2014
South Africa	ZAR	7,347	8,273	9,818	11,112
Brazil	BRL	1,683	1,974	2,188	2,403
Canada	CAD	0,989	0,999		
China	CNY	6,440	6,309	6,179	6,104
Germany	EUR	0,719	0,778	0,752	0,737
India	INR	47,574	53,796	59,161	62,291
Indonesia	IDR	8.770,117	9.416,842	10.633,125	12.059,371
Iran	IRR	10.687,263	12.267,468	19.046,223	24.891,000
Malaysia	MYR	3,063	3,081	3,172	3,334
Mexico	MXN	12,434	13,150		
Poland	PLN	2,962	3,252		
Russia	RUB	29,498	30,972	32,141	34,954
South Korea	KRW	1.107,000	1.126,000		
Taiwan	TWD	29,462	29,493	29,792	30,363
Thailand	THB	30,568	30,936	30,961	32,864
Turkey	TRY	1,672	1,792		
Ukraine	UAH	7,992	8,086	8,174	8,633
United Kingdom	GBP	0,624	0,631		
Vietnam	VND	20.743,320	20.856,320	21.043,972	21.085,750