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Wien, im Februar 2015

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Table of Contents

List of Figures

List of Tables

Abbreviations

The following table describes the significance of various abbreviations and acronyms used throughout the thesis.

Abbreviation	Meaning
ɳ (%)	Efficiency of fossil power generation in percent
Btu	British thermal unit
Mtoe	Million tonnes of oil equivalent
kWh	Kilowatt hour
TWh	Terawatt hour
IEA	International Energy Agency
CHP	Combined Heat and Power
EPI	Environmental Performance Index
NCV	Net Calorific Value
GCV	Gross Calorific Value
DEA	Data Envelopment Analysis
SFA	Stochastic Frontier Analysis
GDP	Gross Domestic Product
GNI	Gross National Income
OECD	Organization for Economic Cooperation and Development
GHG	Green House Gas

1 Introduction

This thesis examines the fossil power generation efficiency using fossil fuels (coal & peat, oil products, and natural gas) as resources for the generation of electric power among 116 countries, in order to identify the country specific factors that have an influence on generation efficiency. The analysis that forms the basis of this thesis is done by the multiple regression method, and is explained in detail in section 3.

De facto, fossil fuels are worldwide the major resources used to generate electricity. In 2011, more than 2/3 of the worldwide electricity production, namely 22,126 *TWh*, can be ascribed to the conversion of fossil fuels. Here, the main part of electricity was generated by the use of coal & peat (41.3%), half as much was generated by the use of natural gas(21.9 %), and the smallest share (4.8%) was generated by oil products (IEA 2013; 25). But why does efficiency matter? As fossil fuels are finite resources, an increase in efficiency does not only generate fuel savings and hence is not only economically beneficial, but also contributes to the conservation of fossil fuels. As a matter of fact, an increase in efficiency increases the output by simultaneously keeping the input constant, or even by decreasing it.

This is of major importance, because "[e]lectric power has a critical function in every nation's economy" (Chen et.al. 2013; 1). As previous studies point out, a strong relationship between the availability as well as the consumption of electricity and the economic development exists. For instance, Ferguson et al. (2000) examines the relation between economic growth and the consumption of electricity in 100 countries, finding evidence that a strong correlation between these two factors exists. Other authors investigate this relationship more precisely on country levels. Ghosh (2002) focusing on India, finds evidence that causality between economic growth and electricity consumption exists. Likewise, Shiu et.al. (2004) find evidence that this causality can also be applied for China.

In addition, the conversion of fossil energy into electrical power entails a variety of pollutants, such as GHGs[1] (Green House Gases), which negatively contribute to global warming. Since global warming is a worldwide problem, more efficient generation of electricity positively contributes to the global aim of reducing the emissions of GHGs in order to achieve the goal of a global warming below 2 degrees Celsius[2]. In simple terms, if less fossil fuel is essential to generate power, less pollutants are emitted, and in conclusion less investments are needed to generate the corresponding electricity output. Consequently the lower consumption of fossil fuels entails a variety of benefits. Strictly speaking, "[…] energy efficiency is of paramount importance for conserving energy resources, decreasing production cost, and increasing economic competitiveness as well as for international climate negotiations" (Oda et.al. 2012; 118).

But talking about energy savings through increased efficiency and the energy conservation effect, likewise requires to explain the potential negative impacts on energy consumption that increased efficiency entails. This impact is known as the so called rebound effect. Greening et.al. (2000) defines it as follows: "[G]ains in the efficiency of energy consumption will result in an effective reduction in the per unit price of energy services. As a result, consumption of energy services should increase (i.e., "rebound" or "take-back"), partially offsetting the impact of the efficiency gain in fuel use." (Greening et al. 2000; 389). Hence, the rebound effect questions the positive effects of increased efficiency in terms of fuel conservation. In economic terms, the increased efficiency requires less fossil fuel input, subsequently the demand for fossil fuels decreases and the prices may adjust at a lower price level. The lower price for fossil fuels in turn causes an increase in its consumption, and finally countersteers the positive effects of energy conservation. (Sorrell et.al. 2008)

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[1] GHGs are water vapor (H2O), carbon dioxide (CO2), methane (CH4), Ozone (O_3), nitrous oxide (N2O), and other CFCs (Chlorofluorocarbons).

[2] "The Copenhagen Accord declared that deep cuts in global emissions are required so as to hold the increase in global temperature below 2 degrees Celsius." (UNEP 2010; 8)

The rest of this thesis is organized as follows. First, an overview of existing literature concerning both, measuring fossil power plants efficiency and factors influencing fossil power plant efficiency is presented. Second, the data sample that underlies the thesis is described and some comparative statistics displayed. Third the methodologies used in this thesis are described, and fourth the research procedure is illustrated. Fifth, the results are described and presented. Finally, the conclusions are derived.

2 Overview of the Literature

In this section, a brief summary of the existing literature dealing with fossil power plant efficiency is presented. At first, existing methods of measuring efficiency will be displayed, and subsequently factors that do have a reviewed effect on efficiency are presented.

2.1 Methods measuring fossil power plant efficiency

In literature, fossil power plant *efficiency* is typically defined as the *heat rate*, which illustrates the amount of heat content that flows into the combustion over the amount of electricity that is generated by the combustion process. Simply speaking, the *heat rate* describes the ratio of the fossil fuel input to the output of electricity (Bellman et.al. 2007). In order to ease the comparability, the *efficiency* is described in percentage η *(%)*. A brief description of the calculation of the *heat rate* and the *efficiency* in percentage is provided in the Appendix (A1). It is worth to underline, that the ratio refers to the *heating values* of the input fuel and "[…] neglects other variables such as installed capacity, electricity and labor used, or CO_2 emissions." (Chen et.al. 2013; 1-2)

Already in 1987, Joskow et al. examine the efficiency of fossil power plants. In their study, the authors analyze determinants that drive thermal efficiency and reliability of coal-burning power plants. For that purpose they use a comprehensive and unbalanced data set of US power plants in the years 1960-1980. Here, they focused on factors influencing the operating performance of power plants, namely the thermal efficiency as major driver of the fuel costs, and the operating reliability as determination for the output per unit of capacity (Joskow et.al. 1987). Since this study, a variety of literature dealing with this topic was published, which certainly differ in the efficiency measures and methods used.

The most frequently used measure of efficiency used by Bellman et.al. (2007); Graus et.al. (2007), (2009); Hascic et.al. (2010); and Chan et.al. (2014), is presented by Phylipsen et.al. (1997). They examine a common measure of energy efficiency, depending on technical efficiency, operation and maintenance. But this so called system energy efficiency is hard to measure, because as an efficiency of economic processes a multiplicity of serial and parallel processes take place simultaneously. Consequently the authors refer to physical indicators to facilitate comparability between countries. Hence the efficiency is defined as the ratio between power output of the power plant and power input in form of fossil fuel. The output is defined as the electricity produced in power and CHP-plants (Combined Heat and Power), plus the heat output of CHP plants which is corrected by a correction factor. The correction factor is necessary, because the heat extraction causes the efficiency of the electricity generation to decrease due to internal power use. In the context of a comparison of energy efficiencies, differentiating between the input fuels and the output electricity the authors view this measure to be sufficient. (Phylipsen et.al. 1997)

A quite different way to look at efficiency of power plants is the *data envelopment analysis method* (*DEA*)[3], used by Goto et.al. (1998); Barros et.al. (2008); and Chen et.al. (2013). The paper by Goto et.al. (1998) investigates both overall cost efficiencies and productive efficiencies (including technical and pure technical efficiency) of Japanese and US electric utilities. Whereas Barros et.al. (2008) develop a two-stage procedure to show power plants efficiency in order to find evidence for factors that drive efficiency. Therein the authors analyze the technical efficiency of Portuguese thermoelectric power plants by the use of *DEA-bootstrapping*[4] to estimate the efficiency drivers. In this context, also Chen et.al. (2013) describes the utilization efficiency of fossil power plants using *DEA*. In their study the authors evaluate power plants resource utilization efficiency across 73 countries, including undesirable

[3] "[…] is a relatively new "data oriented" approach for evaluating the performance of a set of peer entities called Decision Making Units (DMUs) which convert multiple inputs into multiple outputs. The definition of a DMU is generic and flexible. Recent years have seen a great variety of applications of DEA for use in evaluating the performances of many different kinds of entities engaged in many different activities in many different contexts in many different countries. These DEA estimates the maximum potential output for a given set of inputs, and has primarily been used in the estimation of efficiency." (Cooper et.al. 2007; 1-2)

[4] "[…] DEA bootstrapping methods are designed to deal with sampling variability. That is, they provide an indication of the degree to which the efficiency estimates are likely to vary when a different sample is randomly selected from the population" (Coelli et.al. 2005; 202).

CO_2 emission outputs. Moreover the authors examine whether GNP, urbanization and the electricity import level influence the efficiency. Therefore the author use a *Tobit Model*[5].

Another method is used by See et al. (2012). The authors use a *stochastic frontier analysis* (SFA)[6] to measure the technical efficiency levels of thermal power plants in Malaysia and investigates various factors that may or may not influence the efficiency levels of the power plants.

2.2 Factors influencing power plant efficiency

Differences in efficiencies among power plants exist due to a variety of constraints within which they were constructed and operate. For instance, they can occur when plants operate below their capacity and depend on the basic design and maintenance of the power plant (IEA et.al. 2010). In terms of efficiency, Joskow et.al. (1987) find evidence that the age of a power plant (Graus et.al. 2009; Barros et.al. 2008), the quality of fuel used (Bellman et.al. 2007; Barros et.al. 2008; See et.al. 2012), and the steam pressure of the generating plant drive the efficiency. Bellmann et.al. (2007) furthermore specify that major constraints for efficiency base on the design choice, operational practice, pollutant control (Graus et.al. 2007), parasitic load[7] and ambient conditions (Arrieta et.al. 2005).

These ambient conditions are defined as air temperature, atmospheric pressure, altitude, and humidity (Arrieta et.al. 2005; Erdem et.al. 2006; Basrawi et.al. 2011; De Sa et.al. 2011; Farouk

[5] "Tobit models refer to censored or truncated regression models with which the range of the dependent variable is constrained in some way." (Amemiya 1985; 360)

[6] "[…] is a parametric approach to that uses econometric techniques to estimate efficiency. SFA requires the specification of a functional form that characterizes the technology production but this approach permits random error that is beyond control of the management." (Melvin 2008; 47)

[7] As a parasitic load the amount of auxiliary energy for internal use is described, such as for abatement technology. Hence the adaption of environmental control systems accompany a loss in efficiency.

et.al. 2013). „Among these variables, the ambient temperature causes the greatest performance variation during operation.“ (Arrieta et.al. 2005; 261). The degree of the caused influence depends on both, the plant type and country specific, generally geographical factors. In existing literature, particularly the effect of ambient temperature on gas turbines are well investigated. For the combustion of other fossil fuels, such as coal & peat and oil products, no such elaborated investigations exist.

However, in the case of natural gas the gas turbines are designed for standard air conditions also known as ISO (International Organization for Standardization) standard 3977-2[8]. Hence, from the ISO deviant conditions can burden the turbines to deliver the power it is designed to. Therefore efficiency can vary across different ambient conditions on the one hand, and across the combustion design or technical standard used on the other. Previous literature show that ambient conditions above the ISO can have a negative effect on efficiency of gas turbines. For instance Kakaras et.al. (2005) find evidence that "[d]epending on the gas turbine type, power output is reduced by a percentage between 5 to 10 percent of the ISO-rated power output (15°C) for every […] [10°C] increase in ambient air temperature." (Farouk et.al. 2013; 439).

In addition, Verdolini et.al. (2011) identify beside the choice of fossil fuel used for the generation (Joskow et.al. 1987; Bellman et.al. 2007; Barros et al. 2008) the capacity ratio at which the plant runs (Graus et.al. 2009), and the technology used in production (Graus et.al. 2009) as efficiency driving factors. See et.al. (2012) find evidence that beside the fuel type, also ownership and plant size significantly influence the technical efficiency of power plants. Finally, Chen et.al. (2013) display that GNP and urban population also significantly influence the efficiency of fossil power plants.

As a result, the efficiency of a plant depends on both, the technical standards at the time of construction, and the change of conditions during its run time. Thus, it is not surprising that some efficiency improvements are caused by the substitution of older power plants with new

[8] "[…] 15°C ambient temperature, 101.32 kPa atmospheric pressure and 0.6 air relative humidity" (Arrieta et.al. 2005; 262)

power plants conform to the recent technical standards. But anyhow, efficiency improvements can also be achieved by refurbishing or upgrading existing fossil power plants (Bellman et.al. 2007; Verdolini et.al. 2011). These technological improvements include for instance, air heaters, pulverizers, burners, steam turbines, condensers, and control and instrumentation (Bellman et.al. 2007). Additionally, the installation of new generation capacity leads to an increase in efficiency (Lanzi et.al. 2011). Consequently it can be pointed out that organizational considerations not least have an impact on the overall performance of power plants (Joskow et.al. 1987).

The effects of particular factors on efficiency can be either positive, or negative. In fact, trend and market-share parameters are positive drivers of efficiency, and hence increase efficiency. Whereas square trend, age, gas, fuel, air pollution and water pollution are negative drivers of efficiency and hence decrease efficiency (Barros et.al. 2008). In the case of SO_2 and NO_x pollution control, they lead to a decrease in efficiency by around 2% for coal and 1% for gas fired power plants (Graus et.al. 2007). This decrease in efficiency can be tracked back to a higher internal consumption of energy due to the control of additionally installed technologies. Furthermore a high share of coal over total fossil fuel input decreases efficiency, whereas a higher capacity utilization as well as new technological instruments in plants increase the efficiency, and thus countries with a high technological availability run their plants more efficient (Verdolini et.al. 2011). Moreover significant differences in resource utilization efficiency and different stages of economic development between countries exist (Chen et.al. 2013).

However, also the difference in management practices may account for different efficiency between countries, such as between US and Indian power plants (Chan et.al. 2014). Indeed, individual human operators can likewise have an influence on the efficiency of fossil power plants, because certain workers hold the power of decision on the fossil fuels used (Bushnell et.al. 2007). In literature, the fossil fuel used to generate power is of major interest. Because the improvements in efficiency as well as a reduction in CO_2 emissions can easily be achieved by different fuel sources, especially a switch from coal to gas. Furthermore scientists are confident that the improvements in efficiency and CO_2 reduction will continue (Graus et.al. 2009), and consequently the trend of increasing efficiencies will pursue.

Summing up, this thesis will contribute to the existing literature dealing with fossil power plant efficiency taking a closer look at the fuel types used, and country specific characteristics that may influence efficiency of power generation. These country specific characteristics are elaborately explained in the following data description.

3 Data

In this section, the data assembled in the data set forming the basis of this thesis are pictured, as well as some comparative statistics provided.

3.1 Data Description

The overall data sample that forms the basis of this thesis, includes cross-sectional data[9] of 116 countries from Asia, Africa, North America, South America, Europe and Oceania for the year 2011. However, it is split into four different samples distinguishing themselves through the kind of fossil fuel used for electricity generation, containing the data for *coal & peat*, *oil products*, *natural gas*, and the entity of all these fuels labeled *all fuels*. The tables 0-1 till 0-8 showing the whole data sample and the corresponding indicators can be found in the Appendix (A2 and A3).

Notably the variable of main interest is the measure of ***efficiency***. It is used to determine the efficiency of electric power generation through the combustion of fossil fuels differentiated by fuel and country. The underlying values for the calculation of the efficiency are taken from the *IEA statistics* (International Energy Agency) published in the 2013 Edition of the *Energy Balance of OECD countries* (OECD et.al. 2013a), and the 2013 Edition of the *Energy Balance of non-OECD countries* (OECD et.al. 2013b). Therein, the *IEA* displays the supply and consumption, as well as the energy output allocated to the kind of fossil fuel of every country for the year 2011.

The illustrated data is well prepared, and thus already converted into feasible units of energy, in particular *Mtoe* and *TWh*. Consequently the energy output of *coal & peat*, which usually differs significantly among the calorific values[10] of the coal used, is already converted into the corresponding energy values and units. As the basis for this conversion served the average

[9] Cross Sectional Data contains data that is exclusively collected over a period of time.

[10] Calorific value of a fuel describes the heat generated by its combustion.

factors of the *Annual Electricity Questionnaire*, an annual reporting scheme by the *IEA* and *OECD* to gather data on fuel for electricity and heat production by country (IEA et.al. 2004) on the one hand, and the country specific *net calorific values* (*NCV*) on the other. For the calculation of the different types of *oil products*, as for instance refinery gas, ethane, liquefied petroleum gases, motor gasoline, etc. the *IEA* refers to regional conversion factors also listed in the Energy Balance. Furthermore the *IEA* provides the *gross calorific value* (*GCV*) of natural gas, or in absence of specific information applies an average gross calorific values of 38 TJ/million m^3. Finally the IEA calculates electricity production by using the energy content of electricity at a rate of 1 *TWh* = 0,086 *Mtoe*. The terms *NCV* and *GCV* are well-established expressions describing the heat value of a fossil fuels. But they differ in one crucial point. Whereas the *GCV* includes the latent heat, a waste of heat formed during combustion in form of exhaust gases that will condense in the atmosphere, the *NCV* excludes the latent heat. This differentiation is important, because the difference between *NCV* and *GCV* is typically 5% for solid and liquid fuels, and up to 10% for natural gas (IEA et.al. 2004).

In detail, the values presented in the *OECD Balances* used in this thesis are the input of a fossil fuel measured in *Mtoe* into plants that are merely designed to produce electricity, and the input of fossil fuel into CHP-plants designed to generate heat and electricity. In both cases, the plant can be main activity producer or autoproducer. By definition, a main activity producer is defined as a plant, which generates electricity and/or heat as primary activity and sales it's produced electricity to third parties. Whereas an autoproducer is defined as a plant, which generates electricity and/or heat almost exclusively for its own use. Both plants types can be owned either privately or publicly (OECD et.al. 2013a; 21). Furthermore the data sample of the thesis includes the total output of both plants, measured in *TWh* (OECD et.al. 2013a; 23). This output is provided as gross electricity produced, denoting that it includes the auxiliary electricity consumption and losses of the transformation process at the plant. In order to ensure the clarity of the data sample, the focus of this thesis lies on the efficiency of fueled electricity generation pooling the electricity output of primary electricity plants and CHP-plants. These data serve as the basis for the calculation of the heat rate and ***efficiency*** explained in the following section on the methodology. Furthermore, a detailed overview of the calculated heat rate and accordingly the efficiency of 139 countries (A2), and besides a brief numeric example of the calculation (A1) can be found in the Appendix.

As a general measure of environmental performance, the ***EPI*** (Environmental Performance Index) is employed. The *EPI* is a joint project between the *YCLEP* (Yale Center for Environmental Law & Policy) and the *CIESIN* (Center for International Earth Science Information Network) at Columbia University in New York, which is determined in cooperation with the Samuel Family Foundation and the World Economic Forum. Its aim is to provide important environmental data enabling an easy comparison of environmental performance among countries. In fact, it includes indicators for environmental health (health, air and water) as well as for the ecosystem vitality (air, water resources, biodiversity & habitat, agriculture, forests, fisheries, and climate change & energy) (Emerson et.al. 2012; 7). In this context the *EPI* indicates the performance referring to important environmental issues along time. To this effect, the authors describe the *EPI* as follows: "The […] EPI ranks how well countries perform on high-priority environmental issues in two broad policy areas: protection of human health from environmental harm and protection of ecosystems." (Hsu et.al. 2014; 1)

Measuring the value of economic activity of a country, the data sample alludes to the ***GDP*** (*Gross Domestic Product*), and the ***GNI*** (*Gross National Income*) *per capita* provided in US$. The *GDP* at purchaser's price, is defined as the "[…] sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products." (World Bank 2014b), in simple terms the *GDP* provides the value of a country's total production. The *GNI per capita* in contrast, bases on the purchasing power parity and is defined as "[…] the sum of value added by all resident producers plus any product taxes […] not included in the valuation of output plus net receipts of primary income […] from abroad." (World Bank 2014c), and hence measures the income received by a country. Summing up, *GDP* and *GNI* are two well-known indicators for the economic development of a country.

Another economic indicator included into the data set is the ***FDI*** (Foreign Direct Investment), indicating the international economic integration of a country. *FDI* is defined as "[…] the net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor." (World Bank 2014a). Thus *FDI* can also be interpreted as a measure to encourage technology and know-how transfers between countries. The values the three indicators mentioned, are taken from the

World Bank data base (World Bank 2014d), that provides data of the economic development of all countries.

A further important economic indicator reflecting a countries economic strength, is the interest rate. This thesis refers to the ***interest rates*** used by central banks to shape monetary policy, described as the interest rate at which banks can borrow money from the central bank, also known as key interest rate. Consequently this is a convenient indicator to show the current economic strength and importance of a country. The data used in the data set describe an approximated average interest rate per country for the year 2011. At this juncture, the countries of the *European Union* exhibit a specific characteristic by being represented by the *European Central Bank*, offering the same interest rate for all member states. The required data are taken from *TradingEconomics.com* providing accurate economic information and data of 196 countries (Trading Economics 2014).

In order to test for ambient conditions, the average annual ***temperature*** per country is employed into the data sample. Because among all ambient conditions that may influence the efficiency of power generation, the ambient temperature causes the greatest performance variation. These data serve as an impression for the degree of ambient conditions in a country and its differences compared to the other countries, and is measured in degree Celsius. Access to the data is enabled by the *Climate Research Unit* of the *University of East Anglia*, providing explicit monthly and yearly data sets on temperatures around the globe (Climate Research Unit (UEA) 2013).

Likewise the underlying data for the efficiency calculation, *IEA statistics* provides in the 2013 Edition of the *Energy Balance of OECD countries* (OECD et.al. 2013b), and the 2013 Edition of the *Energy Balance of non-OECD countries* (OECD et.al. 2013a) values for the ***production***, the *TPES* (*Total Primary Energy Supply*), and the *TFC* (*Total Final Consumption*) basically describing the entire consumption of the final consuming sectors. All the values are available for the fossil fuels *coal & peat*, *oil products*, and *natural gas*. What from the particular entity of all these fuels labeled *all fuels* is derived. All these values are measured in *Mtoe*. The production of fossil fuels refers to the production of primary energy and is calculated after the removal of attendant impurities.

The *TPES* is calculated as follows: *production* + *import – export – international marine bunkers – international aviation bunkers +/- stock change* (OECD et.al. 2013b; 21). To illustrate the relationship between a country's energy supply and consumption, the supply to consumption ratio, namely the ***TPES/TFC*** ratio is computed. Values <0 refer to negative *TPES* and denote that a country predominantly depends on energy imports in order to meet energy consumption. Whereas as values 0<TPES<1 show that the demand is higher than the production, hence a country meets the energy demand just partially and needs to import the absent energy. And finally values >1 show that a country produces significantly more energy than it needs to meet consumption, and hence is able to export the energy excess.

As a measure for a countries energy generating potential, the data set includes the total fossil fuels electricity installed ***capacity*** in *million kWh* of each country (EIA 2014a). The *capacity* describes the overall installed capacity allowing for the maximum electric output a country can produce. Or in other words, the capacity describes the simple performance potential of a country. In general, the higher the capacity of a country, the higher is the theoretic potential of generating electricity, and the more reliable is the energy supply. In contrast to the installed capacity, the actual electricity generated is reflected in the *TPES* as described above. The values are taken from *IEA statistics* and solely include the capacity of fossil power generating plants in million *KWh*.

Furthermore the data set contains a measure for ***technology***, composed of the technological readiness specified in *The Global Competitive Report 2011-2012* published by The World Economic Forum. Due to the fact that technology is essential for countries' energy generation to compete and prosper, it is reasonable to include *technology* into the data set. Here, the *technology* measures the "[…] the agility with which an economy adopts existing technologies to enhance the productivity of its industries […]" (Schwab 2012; 7). It is worth to mention, that the *technology* solely focuses on the access to advanced technologies and leaves a countries ability to innovate aside.

Finally, the data set includes a dummy variable[11] ***OECD*** in order to control for the differences between countries that are member of the OECD, and non-OECD countries. This dummy variable provides the possibility to control for a potential political influence of the OECD on OECD member countries, since the OECD's aim is to "[…] foster prosperity and fight poverty through economic growth and financial stability [by ensuring] the environmental implications of economic and social development." (OECD 2014b).

The goal of my thesis is to determine whether the above mentioned variables of the data set do, and to what extent have an influence on the efficiency of fossil power generation, or not. If they do so, it is of interest to determine and explain the possible cause of their influence. For this reason the data sample is constructed to allow for a cross-sectional analysis. All the countries listed in the tables in (A2), but not listed in table in (A3), were dropped from the sample due to insufficient availability of the data. Hence, the final data sample contains the data of 116 countries.

Table 3-1 provides a brief summary of the variable names, concepts and measures displayed in the data sample. More detailed information on the single variables can be found in the Appendix (A2 and A3).

Table 3-1: Description of Variables

Concept	***Variable***	**Measure**
Efficiency of Fossil Power Plants	***Efficiency***	η%=(3,412 [Btu⁄kWh])/(Heat Rate [Btu⁄kWh]*100)
Environmental Performance Index	***EPI***	general measure of environmental performance
Gross Domestic Production	***GDP***	value of a country's production
Gross National Income per capita	***GNI per capita***	income received by a country
Foreign Direct Investments	***FDI***	international economic integration

[11] In econometrics and statistics a dummy variable (DV) "[…] is an indicator that reveals (indicates) whether an observation possesses a certain characteristic." (Barreto et.al. 2006, 199)

Central Bank Interest Rate	***Interest Rate***	cost of lending money
Average Annual Temperature	***Temperature***	measure of the warmth or coldness; ambient condition
Total Electricity Produced	***Production***	Total electricity output of a country
Relationship between Energy Supply and Consumption	***TPES_TFC***	Total Primary Energy Supply divided by the Total Final Consumption
Electric Generation Potential	***Capacity***	overall installed capacity
Agility with which an Economy adopts existing Technologies	***Technology***	Technological readiness
Member of the OECD	***DV_OECD***	OECD country valued 1

3.2 Comparative Statistics of the data

Firstly, the data depending exclusively on the specific countries are described. Secondly, the data that depend on both, the country and the type of fossil fuel used for energy production, are represented.

The data that exclusively depend on the country are ***EPI***, ***GDP***, ***GNI per capita***, ***FDI***, ***Interest Rate***, ***Temperature***, ***Capacity***, ***Technology*** and ***OECD***.

Table 3-2: Environmental Performance Index (EPI)

EPI	**in points**		
Highest	Switzerland (76.69)	Latvia (70.73)	Norway (69.92)
Lowest	Iraq (25.32)	Uzbekistan (32.24)	Kazakhstan (32.94)
Mean		(53.72)	
Standard Deviation		(9.87)	

EPI: The highest EPI rating among the countries have Switzerland (76.69), Latvia (70.73), and Norway (69.92). Whereas the countries with the lowest rankings are Iraq (25.32), Uzbekistan (32.24), and Kazakhstan (32.94). The reason for the high number of points for

Switzerland can largely be traced back to its high performance in air pollution control, its good performance in access to drinking water, and a high biodiversity and high number of habitats. But in contrast to Switzerland and Norway, also Latvia as a middle income country achieves a high number of points. This shows that the environmental performance does not solely depend on the income level of a country, but rather on the policy choices and good governance of a country. The countries with the poorest performance, especially Iraq, Uzbekistan and Kazakhstan, are generally known for high water scarcity and significant sustainability challenges. Furthermore, these countries have to struggle with a very weak governance. (Emerson et.al. 2012)

Table 3-3: Gross Domestic Product (GDP)

GDP	**in million US$**		
Highest	United States (15,533,800)	China (7,321,892)	Japan (5,905,630.9)
Lowest	Panama (3,270.5)	Togo (3,756)	Kyrgyzstan (6,179.8)
Mean	(593,170.3)		
Standard Deviation	(1,750,000)		

GDP: Eye-catching are the high differences in GDP between the countries with very high values such as United States (15,533,800), China (7,321,892) and Japan (5,905,630.9), and contrary the countries with the lowest values like Panama (3,270.5), Togo (3,756), and Kyrgyzstan (6,179.8). This conspicuous high difference can be explained by thinking about the aggregate production function of these countries, or simply said by explaining why some countries are richer than others. In general, the production function includes the workforce, the physical capital, the human capital and the available level of technology. Hence, the differences in the output, or GDP, can be ascribed to differences in the input. On that account the countries with the highest GDP rates are countries that feature a single or higher inputs, in form of a high size of workforce, a high amount of physical capital, better educated and trained workforce, or superior available technology. As listed in the table above, the top countries are the United States, China and Japan, which in deed economically very strong as well as rich countries. In contrast, the countries with the weakest GDP, Panama, Togo and Kyrgyzstan, have a weak economic performance which can among other things be referred to weak governance, civil strife or political disruption. (Cooper et.al. 2012)

Table 3-4: Gross National Income (GNI) per capita

GNI per capita	**purchasing power parity (PPP) in current international $**		
Highest	Qatar (123,280)	Kuwait (88,170)	Singapore (73,520)
Lowest	Mozambique (910)	Togo (1,080)	Ethiopia (1,150)
Mean		(20,229.57)	
Standard Deviation		(19,552.17)	

GNI per capita: The GNI per capita measures the average income of a citizen in a specific country, and thus enables to compare living standards between countries. The high income of countries with large natural resources such as Qatar (123,280) or Kuwait (88,170), basically rely on their high exports of oil or gas. Therefore it is no surprise that the upper ranks are dominated by countries that are rich on natural resources. But Singapore (73,520) is an exception, because it does not possess any comparably high natural resources. But it has a very high GNI per capita because the city state attracts millionaires to immigrate. Hence it is not very surprising that 15% of the inhabitants do have an yearly income of over 1 million US$ (Wong, 2013). But Singapore is a peculiarity. Looking at the countries with very low levels, such as Mozambique (910), Togo (1,080) or Ethiopia (1,150), it catches ones eye that these countries are predominately developing countries[12], with high economic poverty, poor education systems, high levels of corruption and poor sanitation.

[12] In order to simplify the comparability between countries and income, the World Bank revises an annual country classification based on the GNI per capita, illustrated in the Appendix (A6)

Table 3-5: Foreign Direct Investment (FDI)

FDI	**in million US$**		
Highest	China (331,591.7)	United States (252,536)	Belgium (117,161.1)
Lowest	Finland (-6,008.1)	Angola (-3,023.7)	Yemen (-517.8)
Mean		(14,702)	
Standard Deviation		(41,100)	

FDI: In general, FDI can provide companies with new markets, cheaper production, access to new technology, cheap workforce, products, skills, resources and financing. Therefore, it is of interest for many companies to do FDIs. But FDIs are very capital intensive, that's why the countries with high FDIs are comparatively rich countries. The three countries with the highest FDI activities are China (331,591.7), United States (252,536), and Belgium (117,161.1). Especially for developing and emerging market countries FDIs from well developed countries are of major importance, because they provide funding, expertise, technology, skills, and other inputs necessary to emerge. Concerning the countries with very low, or even negative FDIs like Finland (-6,008.1), Angola (-3,023.7), or Yemen (-517.8), it can be said that these countries lack the attractiveness for FDIs, or to state it more drastically even feature disinvestments.

Table 3-6: Key Interest Rate

Interest Rate	**in percent (annual average) %**		
Highest	Congo (29)	Angola (22.92)	Yemen (20)
Lowest	Japan (0)	Singapore (0.03)	Switzerland (0.17)
Mean		(5.51)	
Standard Deviation		(4.86)	

Interest Rate: The countries with the lowest interest rates are Japan (0), Singapore (0.03) and Switzerland (0.17). The reason why these rates are almost zero, and in the case of Japan even zero, lie in the role the central banks play for economy. The role of the central banks is to use the interest rate to balance inflation and economic growth. Thus very low interest rates serve to recover economic growth and price stability. Taking a look at the data set, especially the industrial countries show low interest rates in this context. Whereas countries with very high interest rates, such as Congo (29), Angola (22.92), and Yemen (20), have to face major economic problems, such as a very high inflation, high unemployment, or political uncertainty, and therefore have comparative high interest rates.

Table 3-7: Temperature

Temperature	**in degree Celsius °C**		
Highest	Senegal (28.6)	Qatar (28.5)	Benin (28.2)
Lowest	Canada (-4.2)	Russian Federation (-3.4)	Mongolia (-0.2)
Mean	(17.09)		
Standard Deviation	(8.42)		

Temperature: The temperature of a country depends on its geographic location, namely the clime or climate zones. These are described by Wladimir Peter Köppen as follows: "[…] A (*Tropical*), B (*Arid*), C (*Mesothermal*), D (*Microthermal*), E (*Polar*), H (*Highland*)." (Blij et.al. 2004) and can be used to explain the large differences in temperature among countries. The countries with the highest temperatures are Senegal (28.6), Qatar (28.5) and Benin, whereas the countries with the lowest temperatures are Canada (-4.2), the Russian Federation (-3.4) and Mongolia (-0.2). The average temperature of the data sample is 17.1°C, which is 2.1°C above the ISO temperature of 15°C.

Table 3-8: Capacity

Capacity	in million kWh		
Highest	United States (786.25)	Japan (185.31)	India (171.1)
Lowest	Togo (0.018)	Congo (0.034)	Nepal (0.057)
Mean		(22.0)	
Standard Deviation		(77.8)	

Capacity: The countries with the highest capacity for fossil power generation are the United States (786.25), Japan (185.31) and India (171.1). In contrast, the countries with the lowest installed capacity are Togo (0.018), Congo (0.034) and Nepal (0.057). Hereby it becomes obvious that not the size of a country drives the installation of capacity, rather is it the hunger for energy of a country. Hence countries with a very high demand for energy possess high capacities. This hunger goes in line with the economic development of the industrial sector of a country. For that reason industrialized countries have a significantly higher energy demand than non-industrialized countries.

Table 3-9: Technology

Technology	in points		
Highest	Switzerland (6.3)	Sweden (6.29)	Iceland (6.21)
Lowest	Yemen (2.41)	Ethiopia (2.43)	Haiti (2.56)
Mean		(3.78)	
Standard Deviation		(1.44)	

Technology: The differences between the countries with high technology ratings, Switzerland (6.3), Sweden (6.29), and Iceland (6.21), and the countries with low ratings, Yemen (2.41), Ethiopia (2.43), and Haiti (2.56), can be explained by a countries access to advanced technology and products. For instance, countries with a low rating cannot fully leverage from information and communication technologies in their daily business (Schwab 2012). This can be caused by a missing or poor infrastructure necessary to profit from modern technologies on the one hand, and a want of financial capabilities of on the other. Whereas countries with high ratings have the possibility to fully exploit the current technologies.

OECD: This dummy variable simply states if a country is a member of the OECD. All the members of the OECD are listed in the Appendix (A5).

Contrary to the above mentioned variables, ***efficiency***, ***production*** and the ***TPES_TFC*** ratio depend on both, the country and the fossil fuel used for the energy generation.

Table 3-10: Efficiency

Efficiency: All Fuels	**η%**		
Highest	Haiti (47.01)	Georgia (45.13)	Japan (44.46)
Lowest	Albania (0.86)	Tajikistan (9.12)	Luxembourg (15.6)
Mean		(33.54)	
Standard Deviation		(8.74)	
Efficiency: Coal & Peat	**η%**		
Highest	Netherlands (42.61)	Ireland (42.56)	Austria (41.41)
Lowest	Latvia (1.91)	Pakistan (13.53)	Botswana (18.71)
Mean		(18.02)	
Standard Deviation		(16.88)	
Efficiency: Oil Products	**η%**		
Highest	Egypt (47.71)	Haiti (47.01)	Portugal (46.26)

Lowest	Albania (0.09)	Latvia (1.72)	Georgia (5.02)
Mean		(28.37)	
Standard Deviation		(13.27)	

Efficiency: Natural Gas **η%**

Highest	Switzerland (60.81)	Iraq (60.74)	Spain (57.23)
Lowest	Tajikistan (9.12)	Czech Republic (21.87)	Ukraine (23.13)
Mean		(31.16)	
Standard Deviation		(18.49)	

Efficiency: The countries with the highest efficiency for all fossil fuels are Haiti (47.01), Georgia (45.13) and Japan (44.46), for coal & peat Netherlands (42.61), Ireland (42.56), and Austria (41.41), for oil products Egypt (47.41), Haiti (47.01), and Portugal (46.26), and for natural gas Switzerland (60.81), Iraq (60.74), and Spain (57.23). The countries that show an efficiency of zero in one of the four categories (coal & peat, oil products, natural gas, all fuels), do not produce energy using the appropriate fuel. The only exception is Iceland, producing electricity completely free from any kind of fossil fuels, using almost exclusively geothermal power. The countries with the lowest efficiency for all fossil fuels are Albania (0.86), Tajikistan (9.12), and Luxembourg (15.6), for coal & peat Latvia (1.91), Pakistan (13.53), and Botswana (18.71), for oil products Albania (0.09), Latvia (1.72), and Georgia (5.02), and for natural gas Tajikistan (9.12), Czech Republic (21.87), and Ukraine (23.13).

It is notable, that the efficiency vary across the fossil fuel used. This can be explained by the mix of fuels. In this context, a large share of natural gas generally denotes a higher average efficiency than achieved by coal & peat or oil products. Also, the efficiency of combusting oil products is higher than the efficiency of combusting coal & peat for electricity generation. The crucial factor in the process of power generation is the so called calorific value of the fuel used. A higher calorific value leads to a higher generation of energy and hence electricity. In general, it can be said that the calorific values of natural gas is higher than the calorific values of oil products, whereupon coal has the lowest calorific value. This conclusion finds evidence in the data sample this thesis bases on. It displays an average efficiency of (31.97) for all fuels, (32.17) for coal & peat, (31.65) for oil products, and (39.73) for natural gas. Consequently it can be proved that that using natural gas for power production provides the highest efficiencies. (OECD et.al 2008)

Table 3-11: Productions

Production: All Fuels	**in Mtoe**		
Highest	China (1,909.3)	United States (1,067.28)	Russian Federation (732.77)
Lowest	Albania (0.01)	Nepal (0.01)	Uruguay (0.01)
Mean		(54.72)	
Standard Deviation		(215.45)	
Production: Coal & Peat	**in Mtoes**		
Highest	China (1823.39)	United States (536.37)	India (252.17)
Lowest	Lithuania (0.01)	Nepal (0.01)	Nigeria (0.02)
Mean		(32.88)	
Standard Deviation		(179.65)	
Production: Natural Gas	**in Mtoes**		
Highest	Russian Federation (552.73)	United States (530.91)	Qatar (134.52)
Lowest	Greece (0.01)	Albania (0.01)	Kyrgyzstan (0.02)
Mean		(21.85)	
Standard Deviation		(73.66)	

Production: The production strongly depends on a country's fortune of and access to fossil fuel resources. Hereby the values for natural gas, coal & peat and all fuels are displayed. The values of the production of oil products are zero for all countries, due to the non-availability of the data. Hence all the countries with high values of production are rich on resources of the specific fuel. For all fossil fuels these are China (1,909.3), the United States (1,067.28) and the Russian Federation (732.77), for coal & peat these are China (1823.39), United States (536.37), and India (252.17), for natural gas these are the Russian Federation (552.73), the United States (530.91) and Qatar (134.52). In contrast the values for the lowest production of coal & peat, natural gas and hence all fossil fuels are very close to zero. (OECD et.al. 2013a, 2013b)

Altogether the countries represented in the data sample produce 6,348.48 Mtoe of fossil fuels for their electricity production. Therefrom 3,813.81 Mtoe or 60% are coal & peat and 2,534.61 Mtoe or 40% are natural gas. These relative high amount of coal & peat used for power generation can be lead back to the excessive availability of coal & peat compared to the availability natural gas. But these relative numbers likewise implicate a high potential for efficiency improvements by a switch from coal & peat to natural gas in fossil power production.

Table 3-12: TPES / TFC ratio

TPES_TFC: All Fuels			
Highest	Estonia (4.18)	Malta (4.03)	Peru (3.91)
Lowest	Kuwait (-1.76)	Singapore (-1.26)	Belarus (-1.22)
Mean	(1.01)		
Standard Deviation	(0.89)		

TPES_TFC: Coal & Peat			
Highest	Morocco (198.47)	Portugal (110.5)	Greece (35.86)
Lowest	United Arab Emirates (1)	Switzerland (1)	Albania (1)
Mean	(6.64)		
Standard Deviation	(21.39)		

TPES_TFC: Oil Products

Highest	Peru (4.53)	Malta (4.03)	Lebanon (2.7)
Lowest	Trinidad and Tobago (-5.68)	Lithuania (-4.23)	Kuwait (-4.12)
Mean		(0.20)	
Standard Deviation		(1.28)	

TPES_TFC: Natural Gas

Highest	Gabon (79.5)	Philippines (42.19)	Israel (34.17)
Lowest	Kenya (0.69)	Mozambique (1.06)	Switzerland (1.09)
Mean		(3.47)	
Standard Deviation		(9.06)	

TPES_TFC: Countries with a high ratio produce more fossil fuels, coal & peat and/or natural gas than it consumes, and hence can export the excess. The countries with the highest ratio for all fuels are Estonia (4.18), Malta (4.03), and Peru (3.91), for coal & peat Morocco (198.47), Portugal (110.5), and Greece (35.86), for oil products Peru (4.53), Malta (4.03), and Lebanon (2.7), for natural gas Gabon (79.5), Philippines (42.19), and Israel (34.17). Countries with very low or negative ratios depend on imports. These are among others for all fuels Kuwait (-1.76), Singapore (-1.26), and Belarus (-1.22), for coal & peat United Arab Emirates, Switzerland and Albania (1), for oil products Trinidad and Tobago (-5.68), Lithuania (4.23), and Kuwait (-4.12), and for natural gas Kenya (0.69), Mozambique (1.06), and Switzerland (1.09). The average ratios are (1.26) for all fuels, (5.13) for coal & peat, (0.2) for oil products, and (3.62) for natural gas.

4 Methodology

The following paragraph provides the econometric and mathematical knowhow of this thesis, in order to ensure that the reader can follow the methods used. The first part deals with the calculation of fossil power plant ***efficiency***, determined and included into the data set of this thesis (A2). Here, the formula is illustrated and explained briefly, a corresponding numeric example is explained in the Appendix (A1). In contrast, the second part illustrates the basic econometric knowledge and assumptions to understand the concept of ***multiple regression analysis***. The latter analysis is the econometric method used in this thesis to determine the factors that influence the previously calculated ***efficiency***.

4.1 Fossil Power Plant Efficiency

This part provides the estimation method of the calculation of fossil power plant efficiency, and predominantly bases on Beér (2007).

In the general language use, efficiency is defined as "the quality of doing something well and effectively, without wasting time, money, or energy." (Longman 2001). However, in the context of this thesis the efficiency measures the quality of transforming the input of fossil fuels into the output as electricity generated and is provided in percentage. Or in other words, "to express the efficiency of a generator or power plant as a percentage, divide the equivalent Btu content of a kWh of electricity (which is 3,412 Btu) by the heat rate." (EIA 2014b), and is calculated as follows:

$$\eta\% = \frac{3{,}412\left[{}^{Btu}/_{kWh}\right]}{\left({}^{Input\ [Btu]}/_{Output\ [kWh]}\right) * 100} \qquad (1.1)$$

This can be rewritten as:

$$\eta\% = \frac{3{,}412\left[{}^{Btu}/_{kWh}\right]}{Heat\ Rate\left[{}^{Btu}/_{kWh}\right] * 100} \tag{1.2}$$

The big advantage of the efficiency calculation is that it enables very clear and simple comparability of efficiency among countries.

4.2 Multiple Regression Analysis

The following paragraph is based on Gujarati (2003) and describes the estimation method of the multiple regression analysis used for cross sectional data.

Before the multiple regression analysis is theoretically explained, some terms and notations need to be clarified. As in literature the terms dependent variable and explanatory variables are often described variously, this thesis will focus on the terms regressand as the dependent variable, and regressor as the explanatory variable. The data set described in section 3, contains so called cross-sectional data, existing of several variables that are collected at the same point in time, namely 2011. Due to the fact that the thesis deals with one regressand and more than one regressor, a multiple regression analysis is used to determine the dependencies of the stochastic variables.

In general multiple regression analysis is used to estimate a potential unknown effect of changing one regressor over the regressand. Therefore two general assumptions are essential to allow for an analysis. First, there is a linear relationship between the regressand and one of the regressors. Second, this relationship is additive. Hence the general multiple regression function is written as

$$Y_i = \beta_1 + \beta_2 X_{2i} + \beta_3 X_{3i} + \cdots + \beta_n X_{ni} + u_i \tag{2.1}$$

where Y is the regressand, X_2, X_3,…and X_n the regressors, u the stochastic disturbance term and i the ith observation. In Equation (2.1) β_1 describes the so called intercept term, representing all the average effect of all from the model excluded variables on Y. The partial regression coefficients describing the change in the mean value of Y , $E(Y)$, are $\beta_2, \beta_3, \ldots\ \beta_n$. Strictly speaking, β_2 measures the change in $E(Y)$, per unit change in β_2 , holding the values of the other regression coefficients constant.

Undertaking a multiple regression analysis we have to assume the following:

i. Zero mean value of u_i;

$$E(u_i|X_{2i}, X_{3i} \ldots X_{ni}) = 0 \quad \text{for each } i \tag{2.2}$$

ii. No serial correlation;

$$cov(u_i, u_j) = 0 \qquad\qquad i \neq j \tag{2.3}$$

iii. Homoscedasticity;

$$var(u_i) = \sigma^2 \tag{2.4}$$

iv. Zero covariance between u_i and each X variable;

$$cov(u_i, X_{2i}) = cov\ (u_i, X_{3i}) = \cdots = (u_i, X_{ni}) = 0 \tag{2.5}$$

v. No specification bias;

$$\text{The model is correctly specified} \tag{2.6}$$

vi. No exact linear relationship between the X variables;

$$\text{No exact linear relationship between each } X_{1\ldots n} \text{ and } X_{1\ldots n-1} \qquad (2.7)$$

Additionally it is assumed that the multiple regression model is linear in the parameters, and that the variability in the values of the regressors is sufficient. Furthermore, no collinearity is assumed, or if more than one exact linear relationship is involved no multicollinearity is assumed. This formally means that no set of numbers for $\lambda_{n-1}$and λ_n, not both zero such that

$$\lambda_{n-1}X_{n-1} + \lambda_n X_n = 0 \qquad (2.8)$$

If this linear relationship exists, than X_{n-1} and X_n are collinear or linearly dependent.

Thus the multiple regression equation can be interpreted as regression analysis conditional upon the fixed values of the regressors, obtaining the mean value of Y for the given regressors.

$$E(Y_i \mid X_{2i}, X_{3i}, \ldots, X_{ni}) = \beta_1 + \beta_2 X_{2i} + \beta_3 X_{i3} + \cdots + \beta_n X_{ni} \qquad (2.9)$$

Given that the expected value of Y is conditional upon the fixed values of $X_{1\ldots n}$.

Summing up, the multiple regression analysis explained above is a very powerful and common tool in econometrics that allows explicitly to control for many different factors that can simultaneously affect the regressand. Hence the analysis allows to accommodate many regressors that may be correlated. The procedure of the multiple regression analysis used in this thesis is presented in section 5.

4.3 Ordinary Least Squares Method

This paragraph will briefly explain the statistical fundamental of Ordinary Least Squares (OLS) used in the Multiple Regression analysis explained above, and likewise bases on Gujarati (2003).

In order to understand the OLS method presented below, it is important to firstly explain the least-squares principle:

Sample Regression Function (SRF)

$$\begin{aligned} Y_i &= \hat{\beta}_1 + \hat{\beta}_2 X_i + \hat{u}_i \\ &= \hat{Y}_i + \hat{u}_i \end{aligned} \tag{3.1}$$

where $\hat{Y}_1$ is the estimated value of Y_i.

$$\begin{aligned} \hat{u}_i &= Y_i - \hat{Y}_i \\ &= \hat{Y}_i - \hat{\beta}_1 - \hat{\beta}_2 X_i \end{aligned} \tag{3.2}$$

which shows that the residuals ($\hat{u}_i$) are simply the difference between the actual estimated Y values. In order to avoid that the algebraic sum of the residuals ($\hat{u}_i$) is small or even zero, although the residuals ($\hat{u}_i$) are widely scattered around the (SRF), the least-squares principle is adopted.

$$\begin{aligned} \sum \hat{u}_i^2 &= \sum (Y_i - \hat{Y}_i)^2 \\ &= \sum \left(Y_i - \hat{\beta}_1 - \hat{\beta}_2 X_i\right)^2 \end{aligned} \tag{3.3}$$

where $\hat{u}_i^2$ are the squared residuals. Hence it is obvious that

$$\sum \hat{u}_i^2 = f\left(\hat{\beta}_1, \hat{\beta}_2\right) \tag{3.4}$$

that is, the sum of the squared residuals is some function of the estimators $\hat{\beta}_1$ and $\hat{\beta}_2$.

Fortunately, the least-squares principle chooses $\hat{\beta}_1$ and $\hat{\beta}_2$ in such a manner that, $\sum \hat{u}_i^2$ is as small as possible. In other words, for a given sample, the method of least squares provides unique estimates of β_1 and β_2 that give the smallest possible value of $\sum \hat{u}_i^2$.

The process of differentiation yields the following equations (also known as the normal equations) for estimating β_1 and β_2, where n is the sample size.

$$\begin{aligned} \sum Y_i &= n\hat{\beta}_1 + \hat{\beta}_2 \sum X_i \\ \sum Y_i X_i &= \hat{\beta}_1 \sum X_i + \hat{\beta}_2 \sum X_i^2 \end{aligned} \tag{3.5}$$

Solving the equations,

$$\begin{aligned} \hat{\beta}_2 &= \frac{n \sum X_i Y_i - \sum X_i \sum Y_i}{n \sum X_i^2 - (\sum X_i)^2} \\ &= \frac{\sum (X_i - \bar{X})(Y_i - \bar{Y})}{\sum (X_i - \bar{X})^2} \\ &= \frac{\sum x_i y_i}{\sum x_i^2} \end{aligned} \tag{3.6}$$

where $\bar{X}$ and $\bar{Y}$ are the sample means of X and Y.

$$\begin{aligned} \hat{\beta}_1 &= \frac{\sum X_i^2 \sum Y_i - \sum X_i \sum X_i Y_i}{n \sum X_i^2 - (\sum X_i)^2} \\ &= \bar{Y} - \hat{\beta}_2 \bar{X} \end{aligned} \tag{3.7}$$

These estimators (β_1 and β_2) are the so called least-squares estimator. The resulting characteristics are presented below.

Subsequently the ordinary least square method (OLS) is to be explained in detail. As the OLS method entails a variety of very attractive statistical properties, it has become a frequently used method of regression analysis. In general, it is used to estimate the unknown parameters of the underlying linear regression, making use of the concept of residuals. The multiple regression formula can be written as

$$Y_i = \hat{\beta}_1 + \hat{\beta}_2 X_{2i} + \hat{\beta}_3 X_{3i} + \cdots + \hat{\beta}_n X_{ni} + \hat{u}_i \tag{3.8}$$

where $\hat{u}_i$ is the residual term. From this follows that

$$\hat{\beta}_1 = \bar{Y} - \hat{\beta}_2 \bar{X}_2 - \hat{\beta}_3 \bar{X}_3 + \cdots + \hat{\beta}_n \bar{X}_n \tag{3.9}$$

is describes the OLS estimator[13] of the population intercept β_1. Whereas the OLS estimators for the population partial regression coefficients $\hat{\beta}_{2 \ldots n}$ are particular functions of the regressand and the regressors,

$$\hat{\beta}_{2 \ldots n} = f_i \, (Y_i, X_{2i} \ldots, X_{ni}) \tag{3.10}$$

The resulting estimators are called the OLS estimators $\hat{\beta}_2, \hat{\beta}_3, \ldots \hat{\beta}_n$, and possess the following characteristics:

- They can be easily computed, due to the fact that they are exclusively expressed in terms of observable quantities.
- They are so called point estimators, providing only a single value of the relevant population value.
- The regression line can be easily received, once the OLS estimates[14] are obtained.
- The estimators are unbiased and have a minimum variance, and therefore are efficient.

These characteristics are contained in the Gauss-Markov Theorem, which also provides the formal justification for OLS: "Given the assumption of the classical linear regression model, the least-squares estimators, in the case of unbiased linear estimators, have minimum variance,

[13] "[…] an estimator, also known as a (sample) statistic, is simply a rule or formula or method that tells how to estimate the population parameter from the information provided by the sample at a hand." (Gujarati 2003; 49)

[14] An estimate, is described as a particular numerical value taken by the estimator.

that is, they are BLUE[15]." (Gujarati 2003; 79) More precisely, an OLS estimator $\widehat{\beta}_2, \hat{\beta}_3, \dots \hat{\beta}_n$, is BLUE estimator, if it is linear, unbiased and has an efficient estimator. The fact that estimators are blue provides the estimator with the smallest variance, and hence the estimator that fits best to the regression model. The properties of the OLS estimators of the multiple regression analysis are parallel to the assumptions (2.2 – 2.9).

[15] Best Linear Unbiased Estimator

5 Research Procedure

This section will display the multiple regression analysis done in this thesis step by step. The procedures will be shown for the *coal & peat*, *oil products*, *natural gas*, and *all fuels* separately. The regression results will be explained in section 6.

As outlined in the introduction, this thesis aims to find country specific factors that influence the efficency of electric power generation among 116 countries. Even before the data set can be analysed by the use of multiple regression analysis referred to Gujarati (2003), the data set was completed by calculating the efficiencies following the approch of Beér (2007) explained in section 4.1. The variables included in the data set are on the one hand selected referring to previous literature dealing with the topic of fossil power plant efficiency, and on the selected due to an expected potential influence.

For the sake of a clarity, the thesis defined four conspiring regression Models (*Model 1-4*). The first model, *Model 1*, examines the influence of country specific economic data on the regressand. These regressors are ***EPI***, ***GDP***, ***GNI per capita*** and ***FDI***. The second model, *Model 2* is extended with the ***interest rate***, the ***temperature***,and the ***production*** ratio. Here, the ***interest rate*** is another country specific economic indicatior, the ***temperature*** as a meteorologic factor, and the ***production*** strongly depends on the country and the fossil fuel used for electricity production. The third model, *Model 3*, is extended with the ***TPES/TFC*** ratio as a measure between supply and conusmption of a specific fuel in a country, the overall ***capacity*** of fossil power generation in a country, and ***technology*** measuring the technological readiness of a country. The final Model, *Model 4*, solely is extended with a dummy variable for ***OECD*** countries, in order to quest for a differences in efficiency among member and non-member states.

After the regression of the models, their fit needs to be examined before the outcomes can be interpreted. In order to investigate the fit, the assumptions (2.2 – 2.9) have to be tested for a potential violation. First, the assumption of normality is tested. Here, residuals need to be normally distributed. A common reason for non-normally distributed residuals are non-normally distributed regressors. Consequently, the regressors ***GDP*** and ***GNI per capita*** need to be transformed to satisfy the assumption. For both variables, it is suitable to build the natural logarithm to gain a more normal distribution (A6). The new variables created are the natural logarithms of ***GDP*** and the natural logarithm of ***GNI*** per capita and are called ***lGDP*** and ***lGNI per capita***, whereby ***l*** stand for the natural logarithm (log). Thus, ***lGDP*** and ***lGNI per capita*** replace the ***GDP*** and ***GNI per capita*** in the Models 1-4.

Next, the data set is tested for unusual and influential data. These unusual data can occur in four different ways. Firstly in form of residulas, describing the difference between the actual and the predicted value. Secondly as outliers[16], which are observations with comparatively large residuals, and consequently can be a point with high leverage or with high influence. In this context, an outlier can indicate a sample peculiarity or a data entry error. Thirdly in form of a high leverage[17], as observations with a comparatively high value on a predictor variable. Or to state it more clearly, the leverage measures how far a single observation deviates from the mean of that variable, or a data point with an extreme value on the regressor. And finally as a variable with a high influence[18]. The latter way, can be seen as a product of leverage and outliers. Such a data point can lead to a substantial change in the estimates when left aside. Therefore the data needs to be tested accurately.

In order to detect such unusual and influential data, the Cook's distance generating a combined measure for the informations on residual and leverage of the observation can be estimated. For the data samples all fuels, coal & peat, oil products, and natural gas, the Cook's distance showed no peculiar high value for any of the observations. Hence, the data sample does not contain any unusual and influential data referd to residual and leverage. Nevertheless the multiple

[16] „An outlying observation, or outlier, is an observation that is much different (either very small or very large) in relation to the observations in the sample“ (Gujarati 2003; 390)

[17] "A data point is said to exert (high) leverage if it is disproportional distant from the bulk of the values of a regressor(s)." (Gujarati 2003; 541)

[18] A variable with a high influence significantly disturbs the slope of the regression line, and affects it radically.

regression analyis was executed using a robust or resistant regression[19], in order to ensure its force of expression. Using a robust regression in OLS estimations is a very common tool that simply weighs the observations referring to their behaviour. In fact, the data samples do not show any particular large outlier that needs further investigations,even though plenty of variables that do have potential great influence on the regressor can be detected. This result is not surprising and can be explained by the high volatility of the data sample. However, there is no single observation that exhibits a high influence that can cause changes on the estimates that needs to be excluded from the data set (A7). Another advantage of using a robust regressions is that their execution on data sets that are contaminated with outliers and influential data points also allow to negate heteroscedasticity.

In order to assure the validity of the p-values, normality of residuals needs to be checked. Here, the residuals of the sample illustrate to be normally dirstributed. Furthermore multicollinearity needs to be examined. The term multicollinearity describes that two variables are almost perfect combinations of one another. This cannot be applied to any combination of variables, and hence can be negated in the models. An assumption that finds support in the models presented is the assumption of linearity, assuming that the relationship between the regressor and the regressands is linear. Table 5-1 displays the results of the VIF (Variance Inflation Factors) test, used in order to test for multicollinearity. Hereby, the rule of thumb states that values below 10 do not need further investigation, because the degree of multicollienarity does not conspicuously increase. Hence the regression model estimates are stable and the standard errors for the coefficients do not get inflated. (Stata 2015)

[19] The goal of a robust regression is to provide "[…] unbiased estimates that are unaffected by outliers or skewed residuals distribution." (Andersen 2008; 1)

Table 5-1: Test for multicollinearity

	All Fuels	Coal & Peat	Oil Products	Natural Gas
EPI	1.90	1.75	1.80	1.54
lGDP	2.22	2.07	2.55	2.08
lGNI per capita	2.82	2.58	2.86	2.27
FDI	6.22	5.26	1.79	1.72
Interest rate	1.80	1.74	1.69	1.63
Temperature	1.33	1.26	1.50	1.25
Production	8.44	4.55	-	1.57
TPES / TFC	1.32	1.07	1.31	1.08
Capacity	3.29	1.14	1.56	1.13
Technology	2.75	2.50	2.63	1.08
OECD	1.23	1.11	2.75	1.17
Mean VIF	3.03	2.28	2.04	1.50

Rule of thumb: Values <10 do not implicate further investigation

Besides, it is important to suspend endogeneity from the models, meaning that no variable is immoderately determined by other variables. Endogeneity can occur if the model is estimated false or omitted variables occur, if it contains measurement errors, or if simultaneity occurs. Therefore the models are tested for potential specification errors, that can occur when one or more variables that have an influence on the regressor are omitted. These variables are also known as omitted variables, and can cause an over- or underestimation of the effects of the other variables. Hence, it is important to ensure that the model contains no omitted variables in order to be expressive. Table 5-2 provided below, displays the results of the ovtest[20] (omitted variables test). As a matter of fact, the underlying model shows no specification errors for all fuels and oil products, whereas for natural gas minor specification errors and for natural gas specification errors do occur.

[20] “The ovtest command performs another test of regression model specification. It performs a regression specification error test (RESET) for omitted variables. The idea behind ovtest is to create new variables based on the predictors and refits the model using those new variables to see if any of them would be significant.” (Stata 2015; Ch. 2.6)

Table 5-2: Test for omitted variables

	All Fuels	Coal & Peat	Oil Products	Natural Gas
ovtest	Ramsey RESET test using powers of the fitted values of efficiency			
F(3, 101)	1.34	7.08	2.12	3.15
Prob > F	0.2670	0.0002***	0.1028	0.0282*

Legend: * p<0.05 ** p<0.01 *** p<0.001.

Furthermore simultaneity[21] between the regressor and the regressands needs to be neglected to ensure that the estimators are consistent and efficient. Testing for omitted variables, measurement errors and simultaneity exhibit sufficient results, consequently endogeneity can be suspended from the models used in the thesis. Finally the assumption that the relationship between the regressor and the regressands is linear holds to be valid for all models. Notably for the models all fuels, coal & peat, and oil products, no specification errors do occur, whereas for natural gas it does (Table 5-3). But due to the structural uniformity of the overall model, the specification error for coal & peat using the ovtest, as well as the specification error for natural gas using the linktest[22], are neglected. Concluding, the models used in this master thesis are valid, and thus are specified right to ensure the significance of the results presented in the next section.

[21] Simultaneity describes that the regressor is jointly determined with the regressands.

[22] "The linktest is based on the idea that if a regression is properly specified, one should not be able to find any additional independent variables that are significant except by chance. The linktest creates two new variables, the variable of prediction, _hat, and the variable of squared prediction, _hatsq. The model is then refit using these two variables as predictors. _hat should be significant since it is the predicted value. On the other hand, _hatsq shouldn't, because if our model is specified correctly, the squared predictions should not have much explanatory power. That is we wouldn't expect _hatsq to be a significant predictor if our model is specified correctly. So we will be looking at the p-value for _hatsq." (Stata 2015; Ch. 2.6)

Table 5-3: Test for specification errors

	All Fuels	Coal & Peat	Oil Products	Natural Gas
Linktest	The linktest command performs a model specification link test for single-equation models.			
_hat	0.029*	0,000***	0.020*	0.000***
_hatsq	0.104	0,789	0.086	0.016*

Legend: * p<0.05 ** p<0.01 *** p<0.001.

6 Results

In this section the results of the multiple regression analysis are presented and briefly summarized in the tables 6.1 – 6.4. Therein, the used models 1-4 are displayed to simplify the traceability of the analysis. Beginning with coal & peat, the results of all the fossil fuels examined will be presented separately.

For a better understanding of the output of the models 1-4 provided in the tables, the meaning of *N* and R^2 (coefficient of determination)[23] have to be explained. *N* stands for the number of observations that is how many observations have been integrated in the regression of the particular model. In contrast, the R^2 states to which extend (as percentage) variability of the efficiency is accounted by the model. In general it varies between 0 and 1, whereat the closer R^2 is to 1 the better the applied models fit. The significance levels are expressed as follows: * for $p<0.05$; ** for $p<0.01$, and *** for $p<0.001$.

6.1 Coal & Peat

Table 6.1 displays the outcomes of the multiple regression analysis basing on coal & peat as the examined fossil fuel. The results provide evidence on a significance level of $p<0.5$ that lGDP has a positive significant effect on the efficiency of electricity production with coal & peat in the Model 1-3, but not on Model 4. The positive significance of lGDP[24] denotes, that a, a 1% increase in GDP causes an increase in efficiency by 0.0138 percentage points (Model1), by 0.01278 percentage points (Model2) and by 0.01145 percentage points (Model3). Hence we can say, that GDP does have a low, but significant positive effect on efficiency. This effect can be explained by the fact that a country with a high GDP, therefore a rich country, disposes of an adequate workforce, physical capital, human capital and an available level of technology. Consequently, these countries are able to produce electricity at high efficiency rates. Taking a look at the underlying data sample, it becomes visible that among the countries with the highest

[23] „[…] is a summary measure that tells how well the sample regression line fits the data. (Gujarati 2003; 81)

[24] $Y=a + b\log(X)$: A 1% increase in X causes a b/100 units increase in Y. (Benoit 2011)

efficiency also the countries with highest GDP values are located. Whereas countries with low efficiency possess low GDP values.

Confirm with previous literature (Bellman et.al. 2007; Graus et-al. 2009) the results show that technology has a positive but weak significant ($p<0.05$) effect on efficiency. In numbers, an increase in technological readiness causes the efficiency to increase by 0.03533 percentage points (Model 3) and by 0.03564 percentage points (Model 4). This phenomena can be explained by the fact that advanced technological achievements can optimize processes and hence the same amount of electricity output can be generated by the need of less inputs. As a matter of course, these new technologies are very expensive and consequently are nearly exclusively affordable for rich countries. This commensurability becomes apparent if taking a closer look at the countries with a high technology ranking in the sample. This argument can be confirmed by the comparatively high positive correlation between ***lGDP*** or ***lGNI*** and ***Technology***.

Table 6-1: Regression Analysis Coal & Peat

	Model 1	**Model 2**	**Model 3**	**Model 4**
EPI	-0.00082	-0.00036	-0.00136	-0.00119
lGDP	0.01380*	0.01278*	0.01145*	0.01114
lGNI per capita	0.01337	0.00620	-0.01635	-0.01630
FDI	-0.00000	0.00000	-0.00000	-0.00000
Interest rate		-0.00670	-0.00452	-0.00451
Temperature		0.00132	0.00157	0.00162
Production		-0.00002	-0.00001	-0.00001
TPES / TFC			0.00008	0.00012
Capacity			-0.00002	-0.00003
Technology			0.03533*	0.03564*
OECD				0.01325
N	65	65	65	65
R^2	0.2713	0.3488	0.4148	0.4211

Legend: * $p<0.05$ ** $p<0.01$ *** $p<0.001$

6.2 Oil Products

Table 6.2 displays the outcomes of the multiple regression analysis basing on oil products as the examined fossil fuel. In contrast to coal & peat, temperature, technology and the membership in the OECD do have significant effects on the efficiency of electricity production with oil products. Notwithstanding that previous literature already showed that ambient conditions (Bellman et.al. 2007, Arrieta et.al. 2005; Erdem et.al. 2006; Basrawi et.al. 2011; De Sa et.al. 2011; Farouk et.al. 2013) have an influence on efficiency, this analysis shows that temperature as such has a positive and very significant ($p<0.001$) effect on efficiency. Thus, an increase in temperature by 1°C results in a 0.00346 percentage points (Model 2), 0.00395 percentage points (Model 3), and 0.00512 percentage points (Model 4) increase in efficiency. At first glance, this increase seems to be quite low, but having in mind the large volatility of the average annual temperature of the countries in the data set (Standard Deviation 8.52°C), at second glance it becomes more tangible. As the average temperature of the data sample is with 17.1°C, and thus 2.1°C above the ISO of 15°C, a negative effect on the efficiency would be expected due to an increase in the parasitic load disposed in the cooling processes. Consequently the fact that the temperature has a positive effect on the efficiency is quite surprising.

Once again, the results show that technology has a positive but weak significant ($p<0.05$) effect on efficiency. Here, an increase in technological readiness by 1 point causes the efficiency to increase by 0.02553 percentage points (Model 3) and by 0.02193 percentage points (Model 4). As already mentioned before, this technologies might be only accessible for rich countries. This statement can be underlined with the positive significance of an OECD membership on efficiency. It shows that being an OECD member state increases efficiency by 0.07591 percentage points.

Table 6-2: Regression Analysis Oil Products

	Model 1	Model 2	Model 3	Model 4
EPI	-0.00047	-0.00030	-0.00118	-0.00190
lGDP	0.00516	0.00504	0.00176	-0.00587*
lGNI per capita	0.00884	0.01509	0.00113	-0.00013
FDI	0.00000	0.00000	0.00000	-0.00000
Interest rate		-0.00140	-0.00012	-0.00085
Temperature		0.00346**	0.00395**	0.00512***
Production	/	/	/	/
TPES/TFC			-0.00522	-0.00710
Capacity			-0.00000	-0.00001
Technology			0.02553*	0.02193*
OECD				0.07591*
N	104	104	104	104
R^2	0.0354	0.1090	0.1701	0.2193

Legend: * $p<0.05$ ** $p<0.01$ *** $p<0.001$

6.3 Natural Gas

Table 6.3 displays the outcomes of the multiple regression analysis basing on natural gas as the examined fossil fuel. Alike at coal & peat, lGDP is positive significant even though strongly significant at the level $p<0.001$. This means that a 1% increase GDP results in an increase by 0.02535 percentage points (Model 1), 0.02588 percentage points (Model 2), 0.02803 percentage points (Model 3), and 0.02772 percentage points (Model 4).Whereas the numerical effects are different between coal & peat and natural gas, the explanation therefor is equal. Moreover the results display a weak and negative but significant effect of production on the efficiency of electric power generation with natural gas. Namely, an increase in production by 1 Mtoe corresponds to an efficiency decrease of 0.00024 percentage points (Model 2), 0.00025 percentage points (Model 3), and 0.00027 percentage points (Model 4). The significance values are $p<0.05$ for Model 2 and Model 3, and $p<0.01$ for Model 4. But due to the weak significance and the very low numerical effect, this phenomena is disregarded in this thesis.

Table 6-3: Regression Analysis Natural Gas

	Model 1	Model 2	Model 3	Model 4
EPI	0.00123	0.00103	0.00112	0.00127
lGDP	0.02535***	0.02588***	0.02803***	0.02772***
lGNI per capita	0.00511	0.00729	0.00641	-0.00635
FDI	-0.00000	0.00000	0.00000	-0.00000
Interest rate		-0.00122	-0.00023	-0.00010
Temperature		0.00171	0.00134	0.00140
Production		-0.00024*	-0.00025*	-0.00027**
TPES/TFC		0.	0.00180	0.00174
Capacity			-0.00007	-0.00011
Technology			-0.00897	-0.00934
OECD				0.01352
N	91	91	91	91
R^2	0.2509	0.3087	0.3714	0.3747

Legend: * p<0.05 ** p<0.01 *** p<0.001

6.4 All Fuels

Finally, *Table 6.4* displays the outcomes of the multiple regression analysis basing on all fuels. Merging the values of the single fossil fuels to and collective sample, the results show a minor change in significance. Still significant are the values for lGDP and temperature, while the values for production, technology and OECD membership are not. This change can be traced back to the merge of these data samples. Nevertheless, as for coal & peat and natural gas, the lGDP for all fuels is positive significant. This denotes again, that a 1% increase in GDP generates an increase in efficiency for electric power generation for all fossil fuels by 0.01506 percentage points (Model 1), 0.01528 percentage points (Model 2), 0.01528 percentage points (Model 3), and 0.01253 percentage points (Model 4). The corresponding significance levels are p<0.05 (Model 1, 3, and 4) and p<0.01 (Model 2). In the same way, an increase by 1°C in temperature causes the efficiency to increase by 0.00282 percentage points (Model 2), 0.00315 percentage points (Model 3), and 0.00315 percentage points (Model 4). Here, the results are highly significant at a level of p<0.001.

Table 6-4: Regression Analysis All Fuels

	Model 1	**Model 2**	**Model 3**	**Model 4**
EPI	-0.00004	-0.00043	-0.00079	-0.00075
lGDP	0.01506*	0.01528**	0.01528*	0.01253*
lGNI per capita	0.00094	0.00015	-0.00406	-0.00079
FDI	-0.00000	0.00000*	0.00000*	0.00000
Interest rate		-0.00241	-0.00192	-0.00136
Temperature		0.00282***	0.00315***	0.00315***
Production		-0.00012*	-0.00011	0.00009
TPES/TFC			0.00186	0.00075
Capacity			0.00002	-0.00005
Technology			0.01062	0.01029
OECD				0.02235
N	114	114	114	114
R^2	0.1196	0.2428	0.2674	0.2817

Legend: * p<0.05 ** p<0.01 *** p<0.001

7 Conclusion

Previous literature dealing with fossil power plant efficiencies focused on system energy efficiency, technical efficiency, cost efficiencies or productive efficiency in a specific country or region. Thereby the authors discovered different factors, depending on both, stationary as well as ambient factors that influence the efficiencies either positive or negative. In accordance to that, this thesis applies their findings on elementary factors in a global scale.

In doing so, the thesis investigates fossil power plant efficiency by focusing on the efficiency in terms of the heat rate *(η%)* on the one hand, and by investigating a limited number of country specific factors on the other. These factors are EPI, GDP, GNI, FDI, Interest Rate, Temperature, Production, TPES/TFC, Capacity, Technology, and OECD-membership. A limitation to these most common factors makes sense, because they ensure the comparability across the countries and simultaneously are at least partially well-known parameters in economic research. Additionally the thesis does not only investigate the cumulative use of fossil fuels in electric power production, but also distinguishes between the types of fossil fuel used.

Hence, the aim is to target country specific, as well as fuel specific factors that have a significant influence on efficiency of fossil power generation. Unlike most of the existing literature, using econometric methods like *DEA* and *SFA*, the approach presented in this thesis is a multiple regression analysis and goes in line with the econometric techniques to survey potential influences on efficiency. Hereby, the calculation of the fossil power generation efficiency is calculated separately and in real values.

Comparing the different values of the parameters of the data sample as well as examining the efficiency ratios calculated the following becomes obvious. In both cases tremendous differences between the surveyed countries do exist. This leaves room for a variety of economic and environmental suggestions coherent with the power generation efficiency. This assumption is confirmed by the outcome of the multiple regression analysis, displaying that (1) for the use of coal & peat GDP and technology have a positive effect on efficiency. (2) For oil products GDP, temperature, technology and OECD are significant and hence have an effect on efficiency. (3) Whereas for natural gas, solely the GDP has a positive effect on efficiency. (4) However, for the cumulative use of these fossil fuels, GDP and temperature are the factors that positively influence efficiency.

What do the results indicate? Therefore it is important to reconsider the following: First, energy is crucial for the economic development of a country. Second, fossil fuels are the worldwide major source for the generation of energy. Third, all fossil fuels are finite resources. And fourth, the transformation of fossil fuels into electricity releases GHGs into the atmosphere, which are the major drivers for global warming.

In consideration of these facts, the results of the thesis indicate that increasing the efficiency of fossil power generation can positively contribute to a variety of current urgent and crucial problems of our time. Firstly, energy consumption as such is a major driver for countries future development as well as to sustain economic competitive. In order to do so, countries need to invest into new technologies enabling them to decrease energy production costs by being more efficient. This implicates that these countries can produce more energy output by keeping the resource input constant or even decreasing it. Consequently these countries become more competitive and develop. This phenomena can be displayed by the high technological energy production standards of wealthy countries with a comparably high GDP. However, this indication can only hold true if the involved rebound effect is not sufficiently large enough to "[…] undermine the rationale for policy measures to encourage energy efficiency." (Sorrell et.al. 2008; 632).

Secondly, as fossil fuels are finite as well as the major resource used for energy generation, increasing efficiency positively contributes to the conservation of resources. This conservation of fossil fuels, or put it simple the ability to use less fossil fuel to generate more electricity, also generates monetary savings and therefore is economically beneficial. Strictly speaking, this thesis illustrates that in particular poor counties lack efficiency in fossil power generation. Notably low and lower income countries such as in Sub-Saharan Africa, Southeast Asia or Southern Asia demonstrate a high need for efficiency improvements. In the context of fossil fuels used, coal & peat shows the biggest room for improvements. Ideally, a switch from the combustion of coal & peat to natural gas induces tremendous improvements.

Whereas in terms of high income countries such as in the European Union, featuring a high GDP and high technological standards, further increases in efficiency also serve as a countermeasures against increasing public environmental concerns. These environmental concerns incremental interest because the public perception of global warming plays an increasingly big role in wealthy countries. This movement is reflected in the high media exposure of environmental issues, such as the avoidance of a global warming above the global 2 degree Celsius aim. Moreover this thesis shows that there is one component that matters in fossil power generation, but cannot be influenced by the countries, namely the temperature. This fact simply shows that there are ambient conditions that do influence the efficiency of fossil power generation that need to be taken as given.

As the thesis points out clearly, increasing efficiency in fossil power generation is a global concern, although the incitements to do so differ between countries.

The political implications that can be reasoned from the results of this thesis can be drawn separately for middle and high income countries, and for low and lower income countries. The former countries need to invest in new technologies predominately to ensure the global warming aim of less than 2 degree Celsius, and hence to decrease their GHG releases. This would also satisfy the environmental concerns of the public. The latter need essential investments into current technologies in power generation in order to gain economic development.

Even though the thesis displayed several influencing factors, it bases on a comparable limited data set. Therefore it shows, even though it is in line with previous literature, that a deeper analysis including more data is necessary. Such an analysis could be done likewise using a multiple regression analysis, but should be based on times series data, including observations across a time period of several years (at least >5 years). Additional, using time series data allows for an examination of trend effects that also may have an influence on efficiency. Such an investigation of trend effects would moreover allow to take a closer look at the rebound effect. Here, tracking the increase in efficiency and the trend of fossil fuel conservation can be surveyed explicitly, in order to examine the degree of the rebound effect in fossil power generation.

Appendix

A1 Numeric Example

The following calculation is an example of the efficiency calculations in electricity production for the *world* by the use of *natural gas*.

First of all, the input *711.28 Mtoe* is transformed into *Btu*, by multiplying the value with the factor *39,680,000,000*.

I. $$711.28\ [Mtoes] * 39{,}680{,}000{,}000 = 28{,}223{,}590{,}400{,}000\ [Btu]$$

Secondly, the output *3,671.55 TWh* is transformed into *kWh*, by multiplying the value with the factor *1,000,000,000*.

II. $$3{,}671.55\ [TWh] * 1{,}000{,}000{,}000 = 3{,}671{,}549{,}000{,}000\ [kWh]$$

As an alternative, or in order to calculate the heat rate separately the input and output calculated in I. and II. are inserted into the following equation.

III. $$\frac{28{,}223{,}590{,}400{,}000[Btu]}{3{,}671{,}549{,}000{,}000\ [kWh]} = 7.69\ \left[{}^{Btu}/_{kWh}\right]$$

Finally, the transformed input and output calculated in I. and II. can be inserted into the formula (1) as is shown in IVa., or the in III. calculated heat rate can be inserted into formula (2) as shown in IVb..

IVa. $$\eta\% = \frac{3.412\left[{}^{Btu}/_{kWh}\right]}{\left({}^{28,223,590,400,000[Btu]}/_{3,671,549,000,000}\,[kWh]\right) * 100} = 44.39$$

IVb. $$\eta\% = \frac{3.412\left[{}^{Btu}/_{kWh}\right]}{7.69\left[{}^{Btu}/_{kWh}\right] * 100} = 44.39$$

Hence, by the use of formula (1.1) or (1.2), the efficiency of electric power generation of the *world*, by the use of *natural gas*, results in *44.39%*.

A2 Power Generation Efficiency (η%):

The following data from *IEA* statistics of OECD (OECD et.al. 2013a) and non-OECD countries (OECD et.al.2013b) contains the values, except the ones named *without CHP*, including both, the input and output values of electricity and CHP plants. The illustrated values merely refer to the electricity generated in the certain country, hence generated heat is not included. Furthermore the data is listed for *all fuels*, *coal & peat*, *oil products*, and *natural gas*.

Table 0- 1: Power Generation Efficiency All Fuels

ALL FUELS: Country	Input in Mtoe	Input in Btu	Output in TWh	Output in kWh	heat rate	η%
World *without CHP*	2,989.970	118,642,009,600,000	13,028.78	13,028,784,000,000	9.11	**37.47**
World	3,510.270	139,287,513,600,000	14,912.87	14,912,869,000,000	9.34	**36.53**
OECD Total *without CHP*	1,187.340	47,113,651,200,000	5,635.52	5,635,520,000,000	8.36	**40.81**
OECD Total	1,321.990	52,456,563,200,000	6,287.82	6,287,820,000,000	8.34	**40.90**
OECD Americas *without CHP*	665.020	26,387,993,600,000	3,098.98	3,098,980,000,000	8.52	**40.07**
OECD Americas	722.220	28,657,689,600,000	3,383.68	3,383,680,000,000	8.47	**40.29**
OECD Asia Oceania *without CHP*	281.810	11,182,220,800,000	1,276.55	1,276,550,000,000	8.76	**38.95**
OECD Asia Oceania	297.340	11,798,451,200,000	1,336.86	1,336,860,000,000	8.83	**38.66**
OECD Europe *without CHP*	240.510	9,543,436,800,000	1,182.58	1,182,580,000,000	8.07	**42.28**
OECD Europe	372.260	14,771,276,800,000	1,748.12	1,748,120,000,000	8.45	**40.38**
IEA *without CHP*	1,115.920	44,279,705,600,000	5,285.92	5,285,920,000,000	8.38	**40.73**
IEA	1,318.800	52,329,984,000,000	6,190.77	6,190,770,000,000	8.45	**40.36**
Australia *without CHP*	54.110	2,147,084,800,000	216.32	216,320,000,000	9.93	**34.38**

Australia	56.350	2,235,968,000,000	227.06	227,060,000,000	9.85	**34.65**
Austria *without CHP*	2.450	97,216,000,000	13.63	13,630,000,000	7.13	**47.84**
Austria	4.100	162,688,000,000	20.73	20,730,000,000	7.85	**43.48**
Belgium *without CHP*	3.240	128,563,200,000	19.04	19,040,000,000	6.75	**50.53**
Belgium	5.290	209,907,200,000	31.10	31,100,000,000	6.75	**50.55**
Canada *without CHP*	30.270	1,201,113,600,000	134.01	134,010,000,000	8.96	**38.07**
Canada	32.780	1,300,710,400,000	145.00	145,000,000,000	8.97	**38.04**
Chile *without CHP*	8.640	342,835,200,000	39.70	39,700,000,000	8.64	**39.51**
Chile	8.640	342,835,200,000	39.70	39,700,000,000	8.64	**39.51**
Czech Republic *without CHP*	8.110	321,804,800,000	32.97	32,970,000,000	9.76	**34.96**
Czech Republic	14.990	594,803,200,000	51.16	51,160,000,000	11.63	**29.35**
Denmark *without CHP*	0.020	793,600,000	0.07	70,000,000	11.34	**30.10**
Denmark	4.560	180,940,800,000	20.23	20,230,000,000	8.94	**38.15**
Estonia *without CHP*	3.150	124,992,000,000	11.06	11,060,000,000	11.30	**30.19**
Estonia	3.420	135,705,600,000	11.71	11,710,000,000	11.59	**29.44**
Finland *without CHP*	1.860	73,804,800,000	8.66	8,660,000,000	8.52	**40.04**
Finland	5.850	232,128,000,000	25.62	25,620,000,000	9.06	**37.66**
France *without CHP*	7.970	316,249,600,000	32.49	32,490,000,000	9.73	**35.05**
France	13.240	525,363,200,000	47.51	47,510,000,000	11.06	**30.86**
Germany *without CHP*	61.260	2,430,796,800,000	290.48	290,480,000,000	8.37	**40.77**
Germany	79.240	3,144,243,200,000	365.67	365,670,000,000	8.60	**39.68**
Greece *without CHP*	8.940	354,739,200,000	39.72	39,720,000,000	8.93	**38.20**
Greece	11.700	464,256,000,000	50.93	50,930,000,000	9.12	**37.43**
Hungary *without CHP*	2.380	94,438,400,000	10.44	10,440,000,000	9.05	**37.72**
Hungary	4.080	161,894,400,000	17.47	17,470,000,000	9.27	**36.82**
Iceland *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Iceland	0.000	0	0.00	0	0.00	**0.00**
Ireland *without CHP*	3.690	146,419,200,000	20.12	20,120,000,000	7.28	**46.89**

Ireland	4.000	158,720,000,000	22.24	22,240,000,000	7.14	**47.81**
Israel *without CHP*	12.950	513,856,000,000	59.30	59,300,000,000	8.67	**39.38**
Israel	12.950	513,856,000,000	59.30	59,300,000,000	8.67	**39.38**
Italy *without CHP*	22.800	904,704,000,000	118.31	118,310,000,000	7.65	**44.62**
Italy	44.190	1,753,459,200,000	214.57	214,570,000,000	8.17	**41.75**
Japan *without CHP*	146.390	5,808,755,200,000	760.39	760,390,000,000	7.64	**44.66**
Japan	146.390	5,808,755,200,000	760.39	760,390,000,000	7.64	**44.66**
Korea *without CHP*	66.880	2,653,798,400,000	309.42	309,420,000,000	8.58	**39.78**
Korea	79.610	3,158,924,800,000	356.87	356,870,000,000	8.85	**38.55**
Luxembourg *without CHP*	0.310	12,300,800,000	1.95	1,950,000,000	6.31	**54.09**
Luxembourg	0.430	17,062,400,000	2.34	2,340,000,000	7.29	**46.79**
Mexico *without CHP*	46.520	1,845,913,600,000	238.78	238,780,000,000	7.73	**44.14**
Mexico	46.520	1,845,913,600,000	238.78	238,780,000,000	7.73	**44.14**
Netherlands *without CHP*	7.680	304,742,400,000	45.05	45,050,000,000	6.76	**50.44**
Netherlands	17.120	679,321,600,000	94.61	94,610,000,000	7.18	**47.52**
New Zealand *without CHP*	1.480	58,726,400,000	8.55	8,550,000,000	6.87	**49.68**
New Zealand	2.040	80,947,200,000	10.68	10,680,000,000	7.58	**45.02**
Norway *without CHP*	0.630	24,998,400,000	4.14	4,140,000,000	6.04	**56.51**
Norway	0.650	25,792,000,000	4.18	4,180,000,000	6.17	**55.30**
Poland *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Poland	36.990	1,467,763,200,000	149.71	149,710,000,000	9.80	**34.80**
Portugal *without CHP*	4.110	163,084,800,000	21.60	21,600,000,000	7.55	**45.19**
Portugal	5.460	216,652,800,000	27.46	27,460,000,000	7.89	**43.25**
Slovak Republic *without CHP*	0.220	8,729,600,000	1.28	1,280,000,000	6.82	**50.03**
Slovak Republic	2.180	86,502,400,000	7.78	7,780,000,000	11.12	**30.69**
Slovenia *without CHP*	0.180	7,142,400,000	0.74	740,000,000	9.65	**35.35**
Slovenia	1.500	59,520,000,000	5.78	5,780,000,000	10.30	**33.13**
Spain *without CHP*	22.950	910,656,000,000	115.90	115,900,000,000	7.86	**43.42**

Spain	26.620	1,056,281,600,000	144.22	144,220,000.000	7.32	**46.59**
Sweden *without CHP*	0.010	396,800,000	0.04	40,000.000	9.92	**34.40**
Sweden	1.300	51,584,000,000	4.34	4,340,000.000	11.89	**28.71**
Switzerland *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Switzerland	0.150	5,952,000,000	1.04	1,040,000.000	5.72	**59.62**
Turkey *without CHP*	29.290	1,162,227,200,000	151.07	151,070,000.000	7.69	**44.35**
Turkey	31.850	1,263,808,000,000	159.87	159,870,000.000	7.91	**43.16**
United Kingdom *without CHP*	46.010	1,825,676,800,000	235.05	235,050,000.000	7.77	**43.93**
United Kingdom	50.110	1,988,364,800,000	259.10	259,100,000.000	7.67	**44.46**
United States *without CHP*	579.600	22,998,528,000,000	2.686.48	2,686,480,000.000	8.56	**39.86**
United States	634.290	25,168,627,200,000	2.960.19	2,960,190,000.000	8.50	**40.13**
Non-OECD Total *without CHP*	1.648.650	65,418,432,000,000	6.846.53	6,846,528,000.000	9.55	**35.71**
Non-OECD Total	1.913.480	75,926,886,400,000	7.737.78	7,737,784,000.000	9.81	**34.77**
Africa	128.670	5,105,625,600,000	560.49	560,488,000.000	9.11	**37.46**
Non-OECD Americas	68.250	2,708,160,000,000	312.66	312,664,000.000	8.66	**39.39**
Asia (excluding China)	448.590	17,800,051,200,000	1.761.13	1,761,127,000.000	10.11	**33.76**
China (P.R. of China and Hong Kong)	926.850	36,777,408,000,000	3.854.15	3,854,151,000.000	9.54	**35.76**
Non-OECD Europe and Eurasia	361.730	14,353,446,400,000	1.138.95	1,138,953,000.000	12.60	**27.07**
Middle East	184.390	7,316,595,200,000	739.41	739,413,600.000	9.90	**34.48**
Albania	0.010	396,800,000	0.00	1,000.000	396.80	**0.86**
Algeria	11.923	473,104,640,000	50.72	50,722,000.000	9.33	**36.58**
Angola	0.707	28,053,760,000	1.64	1,644,000.000	17.06	**19.99**
Argentina	19.191	761,498,880,000	89.47	89,467,000.000	8.51	**40.09**
Armenia	0.402	15,951,360,000	2.39	2,390,000.000	6.67	**51.12**
Azerbaijan	3.953	156,855,040,000	17.67	17,668,000.000	8.88	**38.43**
Bahrain	3.557	141,141,760,000	13.83	13,826,000.000	10.21	**33.42**
Bangladesh	10.220	405,529,600,000	43.19	43,189,000.000	9.39	**36.34**
Belarus	9.734	386,245,120,000	31.98	31,979,000.000	12.08	**28.25**

Benin	0036	1,428,480,000	0.15	153,000.000	934	**36.54**
Bolivia	1.328	52,695,040,000	4.63	4,629,000.000	11.38	**29.97**
Bosnia and Herzegovina	3.762	149,276,160,000	10.89	10,893,000.000	13.70	**24.90**
Botswana	0.171	6,785,280,000	0.37	372,000.000	18.24	**18.71**
Brazil	11.168	443,146,240,000	45.52	45,516,000.000	9.74	**35.04**
Brunei Darussalam	1.139	45,195,520,000	3.72	3,723,000.000	12.14	**28.11**
Bulgaria	7.348	291,568,640,000	27.29	27,293,000.000	10.68	**31.94**
Cambodia	0.252	9,999,360,000	0.95	951,000.000	10.51	**32.45**
Cameroon	0.413	16,387,840,000	1.54	1,537,000.000	10.66	**32.00**
China, People's Republic of	918.799	36,457,944,320,000	3,815.12	3,815,123,000.000	9.56	**35.70**
Chinese Taipei	41.776	1,657,671,680,000	198.01	198,006,000.000	8.37	**40.76**
Colombia	2.381	94,478,080,000	10.90	10,904,000.000	8.66	**39.38**
Congo	0.126	4,999,680,000	0.50	502,000.000	9.96	**34.26**
Congo, Democratic Republic of	0.009	357,120,000	0.04	35,000.000	10.20	**33.44**
Costa Rica	0.199	7,896,320,000	0.86	863,000.000	9.15	**37.29**
Côte d'Ivoire	1.137	45,116,160,000	4.26	4,261,000.000	10.59	**32.22**
Croatia	1.345	53,369,600,000	5.96	5,955,000.000	8.96	**38.07**
Cuba	2.999	119,000,320,000	9.75	9,746,000.000	12.21	**27.94**
Cyprus	1.131	44,878,080,000	4.75	4,751,000.000	9.45	**36.12**
Dominican Republic	3.118	123,722,240,000	11.42	11,417,000.000	10.84	**31.49**
Ecuador	1.947	77,256,960,000	8.57	8,567,000.000	9.02	**37.84**
Egypt	28.992	1,150,402,560,000	141.69	141,694,000.000	8.12	**42.03**
El Salvador	0.441	17,498,880,000	1.98	1,977,000.000	8.85	**38.55**
Eritrea	0.091	3,610,880,000	0.34	335,000.000	10.78	**31.65**
Ethiopia	0.012	476,160,000	0.03	33,000.000	14.43	**23.65**
Gabon	0.247	9,800,960,000	0.95	951,000.000	10.31	**33.11**
Georgia	0.439	17,419,520,000	2.30	2,304,000.000	7.56	**45.13**
Ghana	0.692	27,458,560,000	2.72	2,724,000.000	10.08	**33.85**

Gibraltar	0.040	1,587,200,000	0.17	171,000.000	9.28	**36.76**
Guatemala	0.667	26,466,560,000	2.70	2,696,000.000	9.82	**34.76**
Haiti	0.075	2,976,000,000	0.41	410,000.000	7.26	**47.01**
Honduras	0.819	32,497,920,000	4.03	4,027,000.000	8.07	**42.28**
Hong Kong, China	8.589	340,811,520,000	39.03	39,028,000.000	8.73	**39.07**
India	241.400	9,578,752,000,000	835.71	835,711,000.000	11.46	**29.77**
Indonesia	40.483	1,606,365,440,000	160.40	160,395,000.000	10.02	**34.07**
Iran, Islamic Republic of	52.145	2,069,113,600,000	227.07	227,069,000.000	9.11	**37.44**
Iraq	13.712	544,092,160,000	40.65	40,647,000.000	13.39	**25.49**
Jamaica	1.005	39,878,400,000	4.72	4,720,000.000	8.45	**40.38**
Jordan	3.189	126,539,520,000	14.58	14,581,000.000	8.68	**39.32**
Kazakhstan	21.062	835,740,160,000	78.70	78,703,000.000	10.62	**32.13**
Kenya	0.736	29,204,480,000	2.57	2,569,000.000	11.37	**30.01**
Korea, Democratic People's Republic of	2.733	108,445,440,000	8.43	8,430,000.000	12.86	**26.52**
Kosovo	1.546	61,345,280,000	5.70	5,696,000.000	10.77	**31.68**
Kuwait	13.009	516,197,120,000	57.46	57,457,000.000	8.98	**37.98**
Kyrgyzstan	0.381	15,118,080,000	1.02	1,019,000.000	14.84	**23.00**
Latvia	0.706	28,014,080,000	3.02	3,017,000.000	9.29	**36.75**
Lebanon	7.436	295,060,480,000	31.12	31,120,000.000	9.48	**35.99**
Libya	6.494	257,681,920,000	27.61	27,614,000.000	9.33	**36.56**
Lithuania	0.958	38,013,440,000	2.88	2,876,000.000	13.22	**25.81**
Former Yugoslav Republic of Macedonia	1.365	54,163,200,000	5.44	5,442,000.000	9.95	**34.28**
Malaysia	28.928	1,147,863,040,000	121.12	121,118,000.000	9.48	**36.00**
Malta	0.592	23,490,560,000	2.18	2,181,000.000	10.77	**31.68**
Moldova, Republic of	1.399	55,512,320,000	5.43	5,431,000.000	10.22	**33.38**
Mongolia	1.942	77,058,560,000	4.75	4,753,000.000	16.21	**21.05**
Montenegro	0.418	16,586,240,000	1.45	1,452,000.000	11.42	**29.87**
Morocco	5.214	206,891,520,000	22.31	22,308,000.000	9.27	**36.79**

Mozambique	0.007	277,760,000	0.02	20,000.000	13.89	**24.57**
Myanmar	0.679	26,942,720,000	2.29	2,287,000.000	11.78	**28.96**
Namibia	0.009	357,120,000	0.03	26,000.000	13.74	**24.84**
Nepal	0.001	39,680,000	0.00	3,000.000	13.23	**25.80**
Netherlands Antilles	0.288	11,427,840,000	1.31	1,305,000.000	8.76	**38.96**
Nicaragua	0.562	22,300,160,000	2.52	2,524,000.000	8.84	**38.62**
Nigeria	4.667	185,186,560,000	21.38	21,384,000.000	8.66	**39.40**
Oman	6.612	262,364,160,000	21.87	21,874,000.000	11.99	**28.45**
Pakistan	13.884	550,917,120,000	61.48	61,476,000.000	8.96	**38.07**
Panama	0.854	33,886,720,000	3.74	3,736,000.000	9.07	**37.62**
Paraguay	0.000	0	0.00	0	0.00	**0.00**
Peru	4.597	182,408,960,000	16.92	16,916,000.000	10.78	**31.64**
Philippines	10.122	401,640,960,000	49.33	49,331,000.000	8.14	**41.91**
Qatar	6.439	255,499,520,000	30.73	30,730,000.000	8.31	**41.04**
Romania	10.031	398,030,080,000	33.94	33,937,000.000	11.73	**29.09**
Russian Federation	237.414	9,420,587,520,000	710.90	710,895,000.000	13.25	**25.75**
Saudi Arabia	46.345	1,838,969,600,000	174.53	174,530,000.000	10.54	**32.38**
Senegal	0.655	25,990,400,000	2.65	2,651,000.000	9.80	**34.80**
Serbia	7.527	298,671,360,000	29.36	29,357,000.000	10.17	**33.54**
Singapore	8.725	346,208,000,000	44.34	44,343,000.000	7.81	**43.70**
South Africa	58.155	2,307,590,400,000	243.61	243,609,000.000	9.47	**36.02**
Sri Lanka	1.389	55,115,520,000	5.85	5,846,000.000	9.43	**36.19**
Sudan	0.556	22,062,080,000	2.13	2,134,000.000	10.34	**33.00**
Syrian Arab Republic	9.083	360,413,440,000	37.80	37,796,000.000	9.54	**35.78**
Tajikistan	0.181	7,182,080,000	0.19	192,000.000	37.41	**9.12**
Tanzania, United Republic of	0.637	25,276,160,000	2.69	2,687,000.000	9.41	**36.27**
Thailand	28.364	1,125,483,520,000	143.44	143,437,000.000	7.85	**43.48**
Togo	0.009	357,120,000	0.03	34,000.000	10.50	**32.48**

Trinidad and Tobago	1.914	75,947,520,000	8.87	8,867,000.000	8.57	**39.84**
Tunisia	3.143	124,714,240,000	15.97	15,967,000.000	7.81	**43.68**
Turkmenistan	7.467	296,290,560,000	17.22	17,220,000.000	17.21	**19.83**
Ukraine	28.240	1,120,563,200,000	93.50	93,500,000.000	11.98	**28.47**
United Arab Emirates	25.260	1,002,316,800,000	99.14	99,137,000.000	10.11	**33.75**
Uruguay	0.656	26,030,080,000	2.91	2,907,000.000	8.95	**38.10**
Uzbekistan	13.140	521,395,200,000	42.20	42,200,000.000	12.36	**27.62**
Venezuela	10.557	418,901,760,000	38.39	38,389,000.000	10.91	**31.27**
Vietnam	14.033	556,829,440,000	69.22	69,217,000.000	8.04	**42.41**
Yemen	1.318	52,298,240,000	6.21	6,206,000.000	8.43	**40.49**
Zambia	0.011	436,480,000	0.04	40,000.000	10.91	**31.27**
Zimbabwe	0.817	32,418.560,000	2.29	2,285,000.000	14.19	**24.05**

Table 0- 2: Power Generation Efficiency Coal & Peat

COAL & PEAT:						
Country	**Input in Mtoe**	**Input in Btu**	**Output in TWh**	**Output in kWh**	**heat rate**	**η%**
World *without CHP*	2,075.410	82,352,268,800,000	8,528.14	8,528,139,000,000	9.66	**35.33**
World	2,256.180	89,525,222,400,000	9,144.32	9,144,320,000,000	9.79	**34.85**
OECD Total *without CHP*	766.260	30,405,196,800,000	3,309.80	3,309,800,000,000	9.19	**37.14**
OECD Total	778.480	30,890,086,400,000	3,359.42	3,359,420,000,000	9.20	**37.11**
OECD Americas *without CHP*	454.250	18,024,640,000,000	1,955.91	1,955,910,000,000	9.22	**37.02**
OECD Americas	466.470	18,509,529,600,000	2,005.53	2,005,530,000,000	9.23	**36.97**
OECD Asia Oceania *without CHP*	160.280	6,359,910,400,000	693.80	693,800,000,000	9.17	**37.22**
OECD Asia Oceania	167.000	6,626,560,000,000	716.31	716,310,000,000	9.25	**36.88**
OECD Europe *without CHP*	151.730	6,020,646,400,000	660.10	660,100,000,000	9.12	**37.41**
OECD Europe	214.820	8,524,057,600,000	895.84	895,840,000,000	9.52	**35.86**

IEA *without CHP*	742.220	29,451,289,600,000	3,209.09	3,209,090,000,000	9.18	**37.18**
IEA	822.840	32,650,291,200,000	3,512.00	3,512,000,000,000	9.30	**36.70**
Australia *without CHP*	44.240	1,755,443,200,000	171.36	171,360,000,000	10.24	**33.31**
Australia	44.770	1,776,473,600,000	173.30	173,300,000,000	10.25	**33.29**
Austria *without CHP*	1.370	54,361,600,000	6.84	6,840,000,000	7.95	**42.93**
Austria	1.520	60,313,600,000	7.32	7,320,000,000	8.24	**41.41**
Belgium *without CHP*	1.120	44,441,600,000	5.18	5,180,000,000	8.58	**39.77**
Belgium	1.180	46,822,400,000	5.38	5,380,000,000	8.70	**39.20**
Canada *without CHP*	17.630	699,558,400,000	76.36	76,360,000,000	9.16	**37.24**
Canada	17.630	699,558,400,000	76.36	76,360,000,000	9.16	**37.24**
Chile *without CHP*	4.790	190,067,200,000	19.62	19,620,000,000	9.69	**35.22**
Chile	4.790	190,067,200,000	19.62	19,620,000,000	9.69	**35.22**
Czech Republic *without CHP*	8.090	321,011,200,000	32.88	32,880,000,000	9.76	**34.95**
Czech Republic	14.470	574,169,600,000	49.89	49,890,000,000	11.51	**29.65**
Denmark *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Denmark	3.100	123,008,000,000	13.97	13,970,000,000	8.81	**38.75**
Estonia *without CHP*	3.140	124,595,200,000	11.02	11,020,000,000	11.31	**30.18**
Estonia	3.340	132,531,200,000	11.42	11,420,000,000	11.61	**29.40**
Finland *without CHP*	1.790	71,027,200,000	8.33	8,330,000,000	8.53	**40.02**
Finland	4.040	160,307,200,000	15.75	15,750,000,000	10.18	**33.52**
France *without CHP*	3.430	136,102,400,000	16.76	16,760,000,000	8.12	**42.02**
France	3.850	152,768,000,000	17.31	17,310,000,000	8.83	**38.66**
Germany *without CHP*	54.900	2,178,432,000,000	252.18	252,180,000,000	8.64	**39.50**
Germany	61.580	2,443,494,400,000	273.82	273,820,000,000	8.92	**38.24**
Greece *without CHP*	5.560	220,620,800,000	22.35	22,350,000,000	9.87	**34.57**
Greece	7.870	312,281,600,000	31.07	31,070,000,000	10.05	**33.95**
Hungary *without CHP*	1.590	63,091,200,000	6.41	6,410,000,000	9.84	**34.67**
Hungary	1.760	69,836,800,000	6.58	6,580,000,000	10.61	**32.15**

Iceland *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Iceland	0.000	0	0.00	0	0.00	**0.00**
Ireland *without CHP*	1.390	55,155,200,000	6.90	6,900,000,000	7.99	**42.68**
Ireland	1.400	55,552,000,000	6.93	6,930,000,000	8.02	**42.56**
Israel *without CHP*	7.670	304,345,600,000	35.19	35,190,000,000	8.65	**39.45**
Israel	7.670	304,345,600,000	35.19	35,190,000,000	8.65	**39.45**
Italy *without CHP*	10.370	411,481,600,000	46.19	46,190,000,000	8.91	**38.30**
Italy	11.310	448,780,800,000	50.14	50,140,000,000	8.95	**38.12**
Japan *without CHP*	58.460	2,319,692,800,000	281.14	281,140,000,000	8.25	**41.35**
Japan	58.460	2,319,692,800,000	281.14	281,140,000,000	8.25	**41.35**
Korea *without CHP*	49.550	1,966,144,000,000	204.53	204,530,000,000	9.61	**35.49**
Korea	55.580	2,205,414,400,000	224.52	224,520,000,000	9.82	**34.74**
Luxembourg *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Luxembourg	0.000	0	0.00	0	0.00	**0.00**
Mexico *without CHP*	8.270	328,153,600,000	34.13	34,130,000,000	9.61	**35.49**
Mexico	8.270	328,153,600,000	34.13	34,130,000,000	9.61	**35.49**
Netherlands *without CHP*	3.530	140,070,400,000	17.44	17,440,000,000	8.03	**42.48**
Netherlands	4.990	198,003,200,000	24.73	24,730,000,000	8.01	**42.61**
New Zealand *without CHP*	0.370	14,681,600,000	1.58	1,580,000,000	9.29	**36.72**
New Zealand	0.530	21,030,400,000	2.17	2,170,000,000	9.69	**35.21**
Norway *without CHP*	0.010	396,800,000	0.08	80,000,000	4.96	**68.79**
Norway	0.030	1,190,400,000	0.12	120,000,000	9.92	**34.40**
Poland *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Poland	35.370	1,403,481,600,000	141.44	141,440,000,000	9.92	**34.39**
Portugal *without CHP*	2.210	87,692,800,000	9.85	9,850,000,000	8.90	**38.32**
Portugal	2.210	87,692,800,000	9.85	9,850,000,000	8.90	**38.32**
Slovak Republic *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Slovak Republic	1.250	49,600,000,000	4.04	4,040,000,000	12.28	**27.79**

Slovenia *without CHP*	0.180	7,142,400,000	0.74	740,000,000	9.65	**35.35**
Slovenia	1.400	55,552,000,000	5.30	5,300,000,000	10.48	**32.55**
Spain *without CHP*	10.640	422,195,200,000	44.51	44,510,000,000	9.49	**35.97**
Spain	10.710	424,972,800,000	44.93	44,930,000,000	9.46	**36.07**
Sweden *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Sweden	0.640	25,395,200,000	1.99	1,990,000,000	12.76	**26.74**
Switzerland *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Switzerland	0.000	0	0.00	0	0.00	**0.00**
Turkey *without CHP*	13.650	541,632,000,000	54.34	54,340,000,000	9.97	**34.23**
Turkey	13.850	549,568,000,000	54.92	54,920,000,000	10.01	**34.10**
United Kingdom *without CHP*	25.280	1,003,110,400,000	107.75	107,750,000,000	9.31	**36.65**
United Kingdom	25.470	1,010,649,600,000	108.62	108,620,000,000	9.30	**36.67**
United States *without CHP*	423.570	16,807,257,600,000	1,825.79	1,825,790,000,000	9,21	**37.06**
United States	435.790	17,292,147,200,000	1,875.41	1,875,410,000,000	9.22	**37.00**
Non-OECD Total *without CHP*	1,309.150	51,947,072,000,000	5,218.34	5,218,339,000,000	9.95	**34.28**
Non-OECD Total	1,407.890	55,865,075,200,000	5,526.64	5,526,643,000,000	10.11	**33.75**
Africa	63.130	2,504,998,400,000	262.12	262,119,000,000	9.56	**35.70**
Non-OECD Americas	5.310	210,700,800,000	22.20	22,200,000,000	9.49	**35.95**
Asia (excluding China)	304.660	12,088,908,800,000	1,072.24	1,072,243,000,000	11.27	**30.26**
China (P.R. of China and Hong Kong)	904.280	35,881,830,400,000	3,751.03	3,751,025,000,000	9.57	**35.67**
Non-OECD Europe and Eurasia	129.820	5,151,257,600,000	418.63	418,631,000,000	12.31	**27.73**
Middle East	0.150	5,952,000,000	0.43	425,000,000	14.00	**24.36**
Albania	0.000	0	0.00	0	0.00	**0.00**
Algeria	0.000	0	0.00	0	0.00	**0.00**
Angola	0.000	0	0.00	0	0.00	**0.00**
Argentina	0.816	32,378,880,000	3.24	3,238,000,000	10.00	**34.12**
Armenia	0.000	0	0.00	0	0.00	**000**
Azerbaijan	0.000	0	0.00	0	0.00	**0.00**

Bahrain	0.000	0	0.00	0	0.00	**0.00**
Bangladesh	0.205	8,134,400,000	0.78	780,000,000	10.43	**32.72**
Belarus	0.000	0	0.00	0	0.00	**0.00**
Benin	0.000	0	0.00	0	0.00	**0.00**
Bolivia	0.000	0	0.00	0	0.00	**0.00**
Bosnia and Herzegovina	3.738	148,323,840,000	10.81	10,806,000,000	13.73	**24.86**
Botswana	0.171	6,785,280,000	0.37	372,000,000	18.24	**18.71**
Brazil	1.603	63,607,040,000	5.63	5,625,000,000	11.31	**30.17**
Brunei Darussalam	0.000	0	0.00	0	0.00	**0.00**
Bulgaria	6.476	256,967,680,000	25.08	25,079,000,000	10.25	**33,.30**
Cambodia	0.000	0	0.00	0	0.00	**0.00**
Cameroon	0.000	0	0.00	0	0.00	**0.00**
China, People's Republic of	898.428	35,649,623,040,000	3,723.24	3,723,244,000,000	9.57	**35.63**
Chinese Taipei	28.165	1,117,587,200,000	127.03	127,030,000,000	8.80	**38.78**
Colombia	0.596	23,649,280,000	2.14	2,142,000,000	11.04	**30.90**
Congo	0.000	0	0.00	0	0.00	**0.00**
Congo, Democratic Republic of	0.000	0	0.00	0	0.00	**0.00**
Costa Rica	0.000	0	0.00	0	0.00	**0.00**
Côte d'Ivoire	0.000	0	0.00	0	0.00	**0.00**
Croatia	0.558	22,141,440,000	2.58	2,582,000,000	8.58	**39.79**
Cuba	0.000	0	0.00	0	0.00	**0.00**
Cyprus	0.000	0	0.00	0	0.00	**0.00**
Dominican Republic	0.489	19,403,520,000	1.99	1,992,000,000	9.74	**35.03**
Ecuador	0.000	0	0.00	0	0.00	**0.00**
Egypt	0.000	0	0.00	0	0.00	**0.00**
El Salvador	0.000	0	0.00	0	0.00	**0.00**
Eritrea	0.000	0	0.00	0	0.00	**0.00**
Ethiopia	0.000	0	0.00	0	0.00	**0.00**

Gabon	0.000	0	0.00	0	0.00	**0.00**
Georgia	0.000	0	0.00	0	0.00	**0.00**
Ghana	0.000	0	0.00	0	0.00	**0.00**
Gibraltar	0.000	0	0.00	0	0.00	**0.00**
Guatemala	0.289	11,467,520,000	1.18	1,176,000,000	9.75	**34.99**
Haiti	0.000	0	0.00	0	0.00	**0.00**
Honduras	0.030	1,190,400,000	0.13	126,000,000	9.45	**36.11**
Hong Kong, China	6.391	253,594,880,000	27.78	27,781,000,000	9.13	**37.38**
India	216.393	8,586,474,240,000	714.95	714,954,000,000	12.01	**28.41**
Indonesia	21.882	868,277,760,000	81.00	81,000,000,000	10.72	**31.83**
Iran, Islamic Republic of	0.146	5,793,280,000	0.43	425,000,000	13.63	**25.03**
Iraq	0.000	0	0.00	0	0.00	**0.00**
Jamaica	0.000	0	0.00	0	0.00	**0.00**
Jordan	0.000	0	0.00	0	0.00	**0.00**
Kazakhstan	18.956	752,174,080,000	70.22	70,220,000,000	10.71	**31.85**
Kenya	0.000	0	0.00	0	0.00	**0.00**
Korea, Democratic People's Republic of	2.483	98,525,440,000	7.85	7,850,000,000	12.55	**27.19**
Kosovo	1.540	61,107,200,000	5.68	5,675,000,000	10.77	**31.69**
Kuwait	0.000	0	0.00	0	0.00	**0.00**
Kyrgyzstan	0.187	7,420,160,000	0.48	482,000,000	15.39	**22.16**
Latvia	0.009	357,120,000	0.00	2,000,000	178.56	**1.91**
Lebanon	0.000	0	0.00	0	0.00	**0.00**
Libya	0.000	0	0.00	0	0.00	**0.00**
Lithuania	0.000	0	0.00	0	0.00	**0.00**
Former Yugoslav Republic of Macedonia	1.322	52,456,960,000	5.29	5,286,000,000	9.92	**34.38**
Malaysia	13.013	516,355,840,000	52.98	52,983,000,000	9.75	**35.01**
Malta	0.000	0	0.00	0	0.00	**0.00**
Moldova, Republic of	0.000	0	0.00	0	0.00	**0.00**

Mongolia	1.861	73,844,480,000	4.52	4,520,000,000	16.34	**20.88**
Montenegro	0.418	16,586,240,000	1.45	1,452,000,000	11.42	**29.87**
Morocco	2.957	117,333,760,000	11.68	11,679,000,000	10.05	**33.96**
Mozambique	0.000	0	0.00	0	0.00	**0.00**
Myanmar	0.179	7,102,720,000	0.67	671,000,000	10.59	**32.23**
Namibia	0.007	277,760,000	0.02	20,000,000	13.89	**24.57**
Nepal	0.000	0	0.00	0	0.00	**0.00**
Netherlands Antilles	0.000	0	0.00	0	0.00	**0.00**
Nicaragua	0.000	0	0.00	0	0.00	**0.00**
Nigeria	0.000	0	0.00	0	0.00	**0.00**
Oman	0.000	0	0.00	0	0.00	**0.00**
Pakistan	0.061	2,420,480,000	0.10	96,000,000	25.21	**13.53**
Panama	0.146	5,793,280,000	0.51	510,000,000	11.36	**30.04**
Paraguay	0.000	0	0.00	0	0.00	**0.00**
Peru	0.211	8,372,480,000	0.64	637,000,000	13.14	**25.96**
Philippines	6.194	245,777,920,000	25.34	25,342,000,000	9.70	**35.18**
Qatar	0.000	0	0.00	0	0.00	**0.00**
Romania	7.192	285,378,560,000	24.80	24,803,000,000	11.51	**27.12**
Russian Federation	59.005	2,341,318,400,000	164.35	164,348,000,000	14.25	**23.95**
Saudi Arabia	0.000	0	0.00	0	0.00	**0.00**
Senegal	0.000	0	0.00	0	0.00	**0.00**
Serbia	7.188	285,219,840,000	28.79	28,785,000,000	9.91	**34.43**
Singapore	0.000	0	0.00	0	0.00	**0.00**
South Africa	58.107	2,305,685,760,000	243.41	243,412,000,000	9.47	**36.02**
Sri Lanka	0.000	0	0.00	0	0.00	**0.00**
Sudan	0.000	0	0.00	0	0.00	**0.00**
Syrian Arab Republic	0.000	0	0.00	0	0.00	**0.00**
Tajikistan	0.000	0	0.00	0	0.00	**0.00**

Tanzania, United Republic of	0.017	674,560,000	0.06	60,000,000	11.24	**30.35**
Thailand	8.765	347,795,200,000	34.81	34,809,000,000	9.99	**34.15**
Togo	0.000	0	0.00	0	0.00	**0.00**
Trinidad and Tobago	0.000	0	0.00	0	0.00	**0.00**
Tunisia	0.000	0	0.00	0	0.00	**0.00**
Turkmenistan	0.000	0	0.00	0	0.00	**0.00**
Ukraine	21.165	839,827,200,000	74.49	74,494,000,000	11.27	**30.26**
United Arab Emirates	0.000	0	0.00	0	0.00	**0.00**
Uruguay	0.000	0	0.00	0	0.00	**0.00**
Uzbekistan	0.931	36,942,080,000	2.14	2,140,000,000	17.26	**19.77**
Venezuela	0.000	0	0.00	0	0.00	**0.00**
Vietnam	5.140	203,955,200,000	20.92	20,920,000,000	9.75	**35.00**
Yemen	0.000	0	0.00	0	0.00	**0.00**
Zambia	0.000	0	0.00	0	0.00	**0.00**
Zimbabwe	0.808	32,061,440,000	2.26	2,258,000,000	14.20	**24.03**

Table 0- 3: Power Generation Efficiency Oil Products

OIL PRODUCTS: **Country**	**Input in Mtoe**	**Input in Btu**	**Output in TWh**	**Output in kWh**	**heat rate**	**η%**
World *without CHP*	203.280	8,066,150,400,000	829.10	829,096,000,000	9.73	**35.07**
World	228.830	9,079,974,400,000	916.44	916,440,000,000	9.91	**34.44**
OECD Total *without CHP*	54.040	2,144,307,200,000	246.17	246,170,000,000	8.71	**39.17**
OECD Total	68.010	2,698,636,800,000	297.30	297,300,000,000	9.08	**37.59**
OECD Americas *without CHP*	21.050	835,264,000,000	88.61	88,610,000,000	9.43	**36.20**
OECD Americas	23.270	923,353,600,000	100.78	100,780,000,000	9.16	**37.24**
OECD Asia Oceania *without CHP*	25.180	999,142,400,000	48.05	48,050,000,000	20.79	**16.41**

OECD Asia Oceania	26.840	1,065,011,200,000	52.96	52,960,000,000	20.11	**16.97**
OECD Europe *without CHP*	7.810	309,900,800,000	32.09	32,090,000,000	9.66	**35.33**
OECD Europe	17.910	710,668,800,000	66.14	66,140,000,000	10.74	**31.75**
IEA *without CHP*	39.810	1,579,660,800,000	187.03	187,030,000,000	8.45	**40.40**
IEA	53.780	2,133,990,400,000	238.15	238,150,000,000	8.96	**38.08**
Australia *without CHP*	0.760	30,156,800,000	3.03	3,030,000,000	9.95	**34.28**
Australia	0.790	31,347,200,000	4.10	4,100,000,000	7.65	**44.63**
Austria *without CHP*	0.080	3,174,400,000	0.36	360,000,000	8.82	**38.69**
Austria	0.300	11,904,000,000	1.01	1,010,000,000	11.79	**28.95**
Belgium *without CHP*	0.020	793,600,000	0.11	110,000,000	7.21	**47.29**
Belgium	0.070	2,777,600,000	0.29	290,000,000	9.58	**35.62**
Canada *without CHP*	1.820	72,217,600,000	6.52	6,520,000,000	11.08	**30.80**
Canada	1.860	73,804,800,000	6.53	6,530,000,000	11.30	**30.19**
Chile *without CHP*	1.440	57,139,200,000	6.36	6,360,000,000	8.98	**37.98**
Chile	1.440	57,139,200,000	6.36	6,360,000,000	8.98	**37.98**
Czech Republic *without CHP*	0.010	396,800,000	0.02	20,000,000	19.84	**17.20**
Czech Republic	0.060	2,380,800,000	0.10	100,000,000	23.81	**14.33**
Denmark *without CHP*	0.020	793,600,000	0.07	70,000,000	11.34	**30.10**
Denmark	0.120	4,761,600,000	0.45	450,000,000	10.58	**32.25**
Estonia *without CHP*	0.010	396,800,000	0.04	40,000,000	9.92	**34.40**
Estonia	0.010	396,800,000	0.04	40,000,000	9.92	**34.40**
Finland *without CHP*	0.030	1,190,400,000	0.13	130,000,000	9.16	**37.26**
Finland	0.090	3,571,200,000	0.42	420,000,000	8.50	**40.13**
France *without CHP*	0.680	26,982,400,000	2.61	2,610,000,000	10.34	**33.00**
France	1.520	60,313,600,000	3.44	3,440,000,000	17.53	**19.46**
Germany *without CHP*	1.140	45,235,200,000	6.02	6,020,000,000	7.51	**45.41**
Germany	1.580	62,694,400,000	8.22	8,220,000,000	7.63	**44.74**
Greece *without CHP*	1.160	46,028,800,000	4.98	4,980,000,000	9.24	**36.92**

Greece	1.440	57,139,200,000	5.92	5,920,000,000	9.65	**35.35**
Hungary *without CHP*	0.030	1,190,400,000	0.14	140,000,000	8.50	**40.13**
Hungary	0.030	1,190,400,000	0.15	150,000,000	7.94	**42.99**
Iceland *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Iceland	0.000	0	0.00	0	0.00	**0.00**
Ireland *without CHP*	0.050	1,984,000,000	0.20	200,000,000	9.92	**34.40**
Ireland	0.100	3,968,000,000	0.42	420,000,000	9.45	**36.11**
Israel *without CHP*	1.590	63,091,200,000	4.36	4,360,000,000	14.47	**23.58**
Israel	1.590	63,091,200,000	4.36	4,360,000,000	14.47	**23.58**
Italy *without CHP*	1.240	49,203,200,000	3.88	3,880,000,000	12.68	**26.91**
Italy	6.550	259,904,000,000	19.88	19,880,000,000	13.07	**26.10**
Japan *without CHP*	20.380	808,678,400,000	105.29	105,290,000,000	7.68	**44.42**
Japan	20.380	808,678,400,000	105.29	105,290,000,000	7.68	**44.42**
Korea *without CHP*	2.450	97,216,000,000	12.80	12,800,000,000	7.60	**44.92**
Korea	4.080	161,894,400,000	16.63	16,630,000,000	9.74	**35.05**
Luxembourg *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Luxembourg	0.000	0	0.00	0	0.00	**0.00**
Mexico *without CHP*	11.190	444,019,200,000	48.37	48,370,000,000	9.18	**37.17**
Mexico	11.190	444,019,200,000	48.37	48,370,000,000	9.18	**37.17**
Netherlands *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Netherlands	0.470	18,649,600,000	1.45	1,450,000,000	12.86	**26.53**
New Zealand *without CHP*	0.000	0	0.00	0	0.00	**0.00**
New Zealand	0.000	0	0.00	0	0.00	**0.00**
Norway *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Norway	0.000	0	0.00	0	0.00	**0.00**
Poland *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Poland	0.500	19,840,000,000	2.45	2,450,000,000	8.10	**42.13**
Portugal *without CHP*	0.240	9,523,200,000	1.16	1,160,000,000	8.21	**41.56**

Portugal	0.500	19,840,000,000	2.69	2,690,000,000	7.38	**46.26**
Slovak Republic *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Slovak Republic	0.270	10,713,600,000	0.58	580,000,000	18.47	**18.47**
Slovenia *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Slovenia	0.000	0	0.00	0	0.00	**0.00**
Spain *without CHP*	2.850	113,088,000,000	12.24	12,240,000,000	9.24	**36.93**
Spain	3.210	127,372,800,000	14.77	14,770,000,000	8.62	**39.57**
Sweden *without CHP*	0.010	396,800,000	0.04	40,000,000	9.92	**34.40**
Sweden	0.190	7,539,200,000	0.80	800,000,000	9.42	**36.21**
Switzerland *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Switzerland	0.010	396,800,000	0.05	50,000,000	7.94	**42.99**
Turkey *without CHP*	0.140	5,555,200,000	0.54	540,000,000	10.29	**33.17**
Turkey	0.240	9,523,200,000	0.90	900,000,000	10.58	**32.25**
United Kingdom *without CHP*	0.330	13,094,400,000	1.11	1,110,000,000	11.80	**28.92**
United Kingdom	0.870	34,521,600,000	3.67	3,670,000,000	9.41	**36.27**
United States *without CHP*	6.600	261,888,000,000	27.36	27,360,000,000	9.57	**35.65**
United States	8.780	348,390,400,000	39.52	39,520,000,000	8.82	**38.70**
Non-OECD Total *without CHP*	149.780	5,943,270,400,000	582.93	582,929,000,000	10.20	**33.47**
Non-OECD Total	161.350	6,402,368,000,000	619.14	619,144,000,000	10.34	**33.00**
Africa	16.080	638,054,400,000	69.49	69,492,000,000	9.18	**37.16**
Non-OECD Americas	28.000	1,111,040,000,000	131.73	131,727,000,000	8.43	**40.45**
Asia (excluding China)	37.740	1,497,523,200,000	142.77	142,771,000,000	10.49	**32.53**
China (P.R. of China and Hong Kong)	1.840	73,011,200,000	7.97	7,972,000,000	9.16	**37.26**
Non-OECD Europe and Eurasia	12.520	496,793,600,000	38.86	38,863,000,000	12.78	**26.69**
Middle East	65.180	2,586,342,400,000	228.32	228,319,600,000	11.33	**30.12**
Albania	0.010	396,800,000	0.00	1,000,000	396.80	**0.86**
Algeria	0.835	33,132,800,000	2.82	2,816,000,000	11.77	**29.00**
Angola	0.707	28,053,760,000	1.64	1,644,000,000	17.06	**19.99**

Argentina	4.528	179,671,040,000	19.59	19,591,000,000	9.17	**37.20**
Armenia	0.000	0	0.00	0	0.00	**0.00**
Azerbaijan	0.081	3,214,080,000	0.39	388,000,000	8.28	**41.19**
Bahrain	0.000	0	0.00	0	0.00	**0.00**
Bangladesh	0.751	29,799,680,000	2.10	2,101,000,000	14.18	**24.06**
Belarus	0.106	4,206,080,000	0.34	341,000,000	12.33	**27.66**
Benin	0.036	1,428,480,000	0.15	153,000,000	9.34	**36.54**
Bolivia	0.035	1,388,800,000	0.12	115,000,000	12.08	**28.25**
Bosnia and Herzegovina	0.009	357,120,000	0.04	38,000,000	9.40	**36.31**
Botswana	0.000	0	0.00	0	0.00	**0.00**
Brazil	4.615	183,123,200,000	14.80	14,796,000,000	12.38	**27.57**
Brunei Darussalam	0.010	396,800,000	0.04	37,000,000	10.72	**31.82**
Bulgaria	0.109	4,325,120,000	0.14	137,000,000	31.57	**10.81**
Cambodia	0.252	9,999,360,000	0.95	951,000,000	10.51	**32.45**
Cameroon	0.312	12,380,160,000	1.10	1,098,000,000	11.28	**30.26**
China, People's Republic of	1.800	71,424,000,000	7.86	7,857,000,000	9.09	**37.53**
Chinese Taipei	2.433	96,541,440,000	9.64	9,636,000,000	10.02	**34.06**
Colombia	0.145	5,753,600,000	0.51	507,000,000	11.35	**30.07**
Congo	0.003	119,040,000	0.01	9,000,000	13.23	**25.80**
Congo, Democratic Republic of	0.002	79,360,000	0.01	6,000,000	13.23	**25.80**
Costa Rica	0.199	7,896,320,000	0.86	863,000,000	9.15	**37.29**
Côte d'Ivoire	0.010	396,800,000	0.03	33,000,000	12.02	**28.38**
Croatia	0.177	7,023,360,000	0.75	752,000,000	9.34	**36.53**
Cuba	2.557	101,461,760,000	7.69	7,691,000,000	13.19	**25.86**
Cyprus	1.131	44,878,080,000	4.75	4,751,000,000	9.45	**36,12**
Dominican Republic	1.930	76,582,400,000	6.17	6,174,000,000	12.40	**27.51**
Ecuador	1.573	62,416,640,000	6.63	6,632,000,000	9.41	**36.25**
Egypt	4.447	176,456,960,000	24.68	24,676,000,000	7.15	**47.71**

El Salvador	0.441	17,498,880,000	1.98	1,977,000,000	8.85	**38.55**
Eritrea	0.091	3,610,880,000	0.34	335,000,000	10.78	**31.65**
Ethiopia	0.012	476,160,000	0.03	33,000,000	14.43	**23.65**
Gabon	0.121	4,801,280,000	0.37	367,000,000	13.08	**26.08**
Georgia	0.012	476,160,000	0.01	7,000,000	68.02	**5.02**
Ghana	0.000	0	0.00	0	0.00	**0.00**
Gibraltar	0.040	1,587,200,000	0.17	171,000,000	9.28	**36.76**
Guatemala	0.378	14,999,040,000	1.52	1,520,000,000	9.87	**34.58**
Haiti	0.075	2,976,000,000	0.41	410,000,000	7.26	**47.01**
Honduras	0.789	31,307,520,000	3.90	3,901,000,000	8.03	**42.51**
Hong Kong, China	0.037	1,468,160,000	0.12	115,000,000	12.77	**26.73**
India	6.225	247,008,000,000	12.22	12,223,000,000	20.21	**16.88**
Indonesia	10.350	410,688,000,000	42.31	42,305,000,000	9.71	**35.15**
Iran, Islamic Republic of	19.098	757,808,640,000	66.63	66,633,000,000	11.37	**30.00**
Iraq	8.945	354,937,600,000	6.97	6,972,000,000	50.91	**6.70**
Jamaica	1.005	39,878,400,000	4.72	4,720,000,000	8.45	**40.38**
Jordan	2.317	91,938,560,000	10.62	10,623,000,000	8.65	**39.42**
Kazakhstan	0.156	6,190,080,000	0.54	543,000,000	11.40	**29.93**
Kenya	0.736	29,204,480,000	2.57	2,569,000,000	11.37	**30.01**
Korea, Democratic People's Republic of	0.250	9,920,000,000	0.58	580,000,000	17.10	**19.95**
Kosovo	0.006	238,080,000	0.02	21,000,000	11.34	**30.10**
Kuwait	7.645	303,353,600,000	35.62	35,616,000,000	8.52	**40.06**
Kyrgyzstan	0.000	0	0.00	0	0.00	**0.00**
Latvia	0.005	198,400,000	0.00	1,000,000	198.40	**1.72**
Lebanon	3.718	147,530,240,000	15.56	15,560,000,000	9.48	**35.99**
Libya	2.976	118,087,680,000	12.06	12,064,000,000	9.79	**34.86**
Lithuania	0.047	1,864,960,000	0.21	209,000,000	8.92	**38.24**
Former Yugoslav Republic of Macedonia	0.017	674,560,000	0.07	69,000,000	9.78	**34.90**

Malaysia	2.204	87,454,720,000	9.98	9,977,000,000	8.77	**38.92**
Malta	0.592	23,490,560,000	2.18	2,181,000,000	10.77	**31.68**
Moldova, Republic of	0.014	555,520,000	0.02	17,000,000	32.68	**10.44**
Mongolia	0.081	3,214,080,000	0.23	233,000,000	13.79	**24.73**
Montenegro	0.000	0	0.00	0	0.00	**0.00**
Morocco	1.595	63,289,600,000	6.58	6,578,000,000	9.62	**35.46**
Mozambique	0.000	0	0.00	0	0.00	**0.00**
Myanmar	0.007	277,760,000	0.03	28,000,000	9.92	**34.40**
Namibia	0.002	79,360,000	0.01	6,000,000	13.23	**25.80**
Nepal	0.001	39,680,000	0.00	3,000,000	13.23	**25.80**
Netherlands Antilles	0.288	11,427,840,000	1.31	1,305,000,000	8.76	**38.96**
Nicaragua	0.562	22,300,160,000	2.52	2,524,000,000	8.84	**38.62**
Nigeria	0.989	39,243,520,000	4.27	4,271,000,000	9.19	**37.13**
Oman	1.037	41,148,160,000	3.94	3,937,000,000	10.45	**32.65**
Pakistan	7.427	294,703,360,000	33.73	33,730,000,000	8.74	**39.05**
Panama	0.708	28,093,440,000	3.23	3,226,000,000	8.71	**39.18**
Paraguay	0.000	0	0.00	0	0.00	**0.00**
Peru	0.726	28,807,680,000	2.27	2,272,000,000	12.68	**26.91**
Philippines	0.796	31,585,280,000	3.40	3,398,000,000	9.30	**36.71**
Qatar	0.000	0	0.00	0	0.00	**0.00**
Romania	0.369	14,641,920,000	0.77	769,000,000	19.04	**17.92**
Russian Federation	9.149	363,032,320,000	27.35	27,345,000,000	13.28	**25.70**
Saudi Arabia	16.681	661,902,080,000	66.15	66,147,000,000	10.01	**34.10**
Senegal	0.640	25,395,200,000	2.60	2,598,000,000	9.77	**34.91**
Serbia	0.118	4,682,240,000	0.07	71,000,000	65.95	**5.17**
Singapore	1.902	75,471,360,000	8.46	8,464,000,000	8.92	**38.27**
South Africa	0.048	1,904,640,000	0.20	197,000,000	9.67	**35.29**
Sri Lanka	1.389	55,115,520,000	5.85	5,846,000,000	9.43	**36.19**

Sudan	0.556	22,062,080,000	2.13	2,134,000,000	10,34	**33.00**
Syrian Arab Republic	4.085	162,092,800,000	16.28	16,283,000,000	9.95	**34.28**
Tajikistan	0.000	0	0.00	0	0.00	**0.00**
Tanzania, United Republic of	0.014	555,520,000	0.04	41,000,000	13.55	**25.18**
Thailand	0.440	17,459,200,000	2.06	2,062,000,000	8.47	**40.30**
Togo	0.009	357,120,000	0.03	34,000,000	10.50	**32.48**
Trinidad and Tobago	0.005	198,400,000	0.02	24,000,000	8.27	**41.27**
Tunisia	0.003	119,040,000	0.01	10,000,000	11.90	**28.66**
Turkmenistan	0.000	0	0.00	0	0.00	**0.00**
Ukraine	0.216	8,570,880,000	0.56	555,000,000	15.44	**22.09**
United Arab Emirates	0.653	25,911,040,000	1.68	1,684,000,000	15.39	**22.18**
Uruguay	0.637	25,276,160,000	2.82	2,816,000,000	8.98	**38.01**
Uzbekistan	0.155	6,150,400,000	0.54	543,000,000	11.33	**30.12**
Venezuela	5.116	203,002,880,000	17.41	17,414,000,000	11.66	**29.27**
Vietnam	1.266	50,234,880,000	4.75	4,749,000,000	10.58	**32.26**
Yemen	1.001	39,719,680,000	4.86	4,864,000,000	8.17	**41.78**
Zambia	0.011	436,480,000	0.04	40,000,000	10.91	**31.27**
Zimbabwe	0.009	357,120,000	0.03	27,000,000	13.23	**25.80**

Table 0- 4: Power Generation Efficiency Natural Gas

NATURAL GAS: **Country**	**Input in Mtoe**	**Input in Btu**	**Output in TWh**	**Output in kWh**	**heat rate**	**η%**
World *without CHP*	711.280	28,223,590,400,000	3,671.55	3,671,549,000.000	7.69	**44.39**
World	1,025.260	40,682,316,800,000	4,852.11	4,852,109,000.000	8.38	**40.69**
OECD Total *without CHP*	367.040	14,564,147,200,000	2,079.55	2,079,550,000.000	7.00	**48.72**
OECD Total	475.500	18,867,840,000,000	2,631.10	2,631,100,000.000	7.17	**47.58**

OECD Americas *without CHP*	189.720	7,528,089,600,000	1,054.46	1,054,460,000.000	7.14	**47.79**
OECD Americas	232.480	9,224,806,400,000	1,277.37	1,277,370,000.000	7.22	**47.25**
OECD Asia Oceania *without CHP*	96.350	3,823,168,000,000	534.70	534,700,000.000	7.15	**47.72**
OECD Asia Oceania	103.500	4,106,880,000,000	567.59	567,590,000.000	7.24	**47.16**
OECD Europe *without CHP*	80.970	3,212,889,600,000	490.39	490,390,000.000	6.55	**52.08**
OECD Europe	139.530	5,536,550,400,000	786.14	786,140,000.000	7.04	**48.45**
IEA *without CHP*	333.890	13,248,755,200,000	1,889.80	1,889,800,000.000	7.01	**48.67**
IEA	442.180	17,545,702,400,000	2,440.62	2,440,620,000.000	7.19	**47.46**
Australia *without CHP*	9.110	361,484,800,000	41.93	41,930,000.000	8.62	**39.58**
Australia	10.790	428,147,200,000	49.66	49,660,000.000	8.62	**39.58**
Austria *without CHP*	1.000	39,680,000,000	6.43	6,430,000.000	6.17	**55.29**
Austria	2.280	90,470,400,000	12.40	12,400,000.000	7.30	**46.77**
Belgium *without CHP*	2.100	83,328,000,000	13.75	13,750,000.000	6.06	**56.30**
Belgium	4.040	160,307,200,000	25.43	25,430,000.000	6.30	**54.13**
Canada *without CHP*	10.820	429,337,600,000	51.13	51,130,000.000	8.40	**40.63**
Canada	13.290	527,347,200,000	62.11	62,110,000.000	8.49	**40.19**
Chile *without CHP*	2.410	95,628,800,000	13.72	13,720,000.000	6.97	**48.95**
Chile	2.410	95,628,800,000	13.72	13,720,000.000	6.97	**48.95**
Czech Republic *without CHP*	0.010	396,800,000	0.07	70,000.000	5.67	**60.19**
Czech Republic	0.460	18,252,800,000	1.17	1,170,000.000	15.60	**21.87**
Denmark *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Denmark	1.340	53,171,200,000	5.81	5,810,000.000	9.15	**37.28**
Estonia *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Estonia	0.070	2,777,600,000	0.25	250,000.000	11.11	**30.71**
Finland *without CHP*	0.040	1,587,200,000	0.20	200,000.000	7.94	**42.99**
Finland	1.720	68,249,600,000	9.45	9,450,000.000	7.22	**47.24**
France *without CHP*	3.860	153,164,800,000	13.12	13,120,000.000	11.67	**29.23**
France	7.870	312,281,600,000	26.76	26,760,000.000	11.67	**29.24**

Germany *without CHP*	5.220	207,129,600,000	32.28	32,280,000.000	6.42	**53.17**
Germany	16.080	638,054,400,000	83.63	83,630,000.000	7.63	**44.72**
Greece *without CHP*	2.220	88,089,600,000	12.39	12,390,000.000	7.11	**47.99**
Greece	2.390	94,835,200,000	13.94	13,940,000.000	6.80	**50.15**
Hungary *without CHP*	0.760	30,156,800,000	3.89	3,890,000.000	7.75	**44.01**
Hungary	2.290	90,867,200,000	10.74	10,740,000.000	8.46	**40.33**
Iceland *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Iceland	0.000	0	0.00	0	0.00	**0.00**
Ireland *without CHP*	2.250	89,280,000,000	13.02	13,020,000.000	6.86	**49.76**
Ireland	2.500	99,200,000,000	14.89	14,890,000.000	6.66	**51.21**
Israel *without CHP*	3.690	146,419,200,000	19.75	19,750,000.000	7.41	**46.02**
Israel	3.690	146,419,200,000	19.75	19,750,000.000	7.41	**46.02**
Italy *without CHP*	11.190	444,019,200,000	68.24	68,240,000.000	6.51	**52.44**
Italy	26.330	1,044,774,400,000	144.55	144,550,000.000	7.23	**47.21**
Japan *without CHP*	67.550	2,680,384,000,000	373.96	373,960,000.000	7.17	**47.60**
Japan	67.550	2,680,384,000,000	373.96	373,960,000.000	7.17	**47.60**
Korea *without CHP*	14.880	590,438,400,000	92.09	92,090,000.000	6.41	**53.22**
Korea	19.950	791,616,000,000	115.72	115,720,000.000	6.84	**49.88**
Luxembourg *without CHP*	0.310	12,300,800,000	1.95	1,950,000.000	6.31	**54.09**
Luxembourg	0.430	17,062,400,000	2.34	2,340,000.000	7.29	**46.79**
Mexico *without CHP*	27.060	1,073,740,800,000	156.28	156,280,000.000	6.87	**49.66**
Mexico	27.060	1,073,740,800,000	156.28	156,280,000.000	6.87	**49.66**
Netherlands *without CHP*	4.150	164,672,000,000	27.61	27,610,000.000	5.96	**57.21**
Netherlands	11.660	462,668,800,000	68.43	68,430,000.000	6.76	**50.46**
New Zealand *without CHP*	1.110	44,044,800,000	6.97	6,970,000.000	6.32	**53.99**
New Zealand	1.510	59,916,800,000	8.51	8,510,000.000	7.04	**48.46**
Norway *without CHP*	0.620	24,601,600,000	4.06	4,060,000.000	6.06	**56.31**
Norway	0.620	24,601,600,000	4.06	4,060,000.000	6.06	**56.31**

Poland *without CHP*	0.000	0	0.00	,0	0.00	**0.00**
Poland	1.120	44,441,600,000	5.82	5,820,000.000	7.64	**44.68**
Portugal *without CHP*	1.660	65,868,800,000	10.59	10,590,000.000	6.22	**54.86**
Portugal	2.750	109,120,000,000	14.92	14,920,000.000	7.31	**46.65**
Slovak Republic *without CHP*	0.220	8,729,600,000	1.28	1,280,000.000	6.82	**50.03**
Slovak Republic	0.660	26,188,800,000	3.16	3,160,000.000	8.29	**41.17**
Slovenia *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Slovenia	0.100	3,968,000,000	0.48	480,000.000	8.27	**41.27**
Spain *without CHP*	9.460	375,372,800,000	59.15	59,150,000.000	6.35	**53.77**
Spain	12.700	503,936,000,000	84.52	84,520,000.000	5.96	**57.23**
Sweden *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Sweden	0.470	18,649,600,000	1.55	1,550,000.000	12.03	**28.36**
Switzerland *without CHP*	0.000	0	0.00	0	0.00	**0.00**
Switzerland	0.140	5,555,200,000	0.99	990,000.000	5.61	**60.81**
Turkey *without CHP*	15.500	615,040,000,000	96.19	96,190,000.000	6.39	**53.36**
Turkey	17.760	704,716,800,000	104.05	104,050,000.000	6.77	**50.38**
United Kingdom *without CHP*	20.400	809,472,000,000	126.19	126,190,000.000	6.41	**53.19**
United Kingdom	23.770	943,193,600,000	146.81	146,810,000.000	6.42	**53.11**
United States *without CHP*	149.430	5,929,382,400,000	833.33	833,330,000.000	7.12	**47.95**
United States	189.720	7,528,089,600,000	1,045.26	1,045,260,000.000	7.20	**47.37**
Non-OECD Total *without CHP*	189.720	7,528,089,600,000	1,045.26	1,045,260,000.000	7.20	**47.37**
Non-OECD Total	344.240	13,659,443,200,000	1,592.00	1,591,997,000.000	8.58	**39.77**
Africa	49.460	1,962,572,800,000	228.88	228,877,000.000	8.57	**39.79**
Non-OECD Americas	34.940	1,386,419,200,000	158.74	158,737,000.000	8.73	**39.07**
Asia (excluding China)	106.190	4,213,619,200,000	546.11	546,113,000.000	7.72	**44.22**
China (P.R. of China and Hong Kong)	20.730	822,566,400,000	95.15	95,154,000.000	8.64	**39.47**
Non-OECD Europe and Eurasia	219.390	8,705,395,200,000	681.46	681,459,000.000	12.77	**26.71**
Middle East	119.060	4,724,300,800,000	510.67	510,669,000.000	9.25	**36.88**

Albania	0.000	0	0.00	0	0.00	**0.00**
Algeria	11.088	439,971,840,000	47.91	47,906,000.000	9.18	**37.15**
Angola	0.000	0	0.00	0	0.00	**0.00**
Argentina	13.847	549,448,960,000	66.64	66,638,000.000	8.25	**41.38**
Armenia	0.402	15,951,360,000	2.39	2,390,000.000	6.67	**51.12**
Azerbaijan	3.872	153,640,960,000	17.28	17,280,000.000	8.89	**38.37**
Bahrain	3.557	141,141,760,000	13.83	13,826,000.000	10.21	**33.42**
Bangladesh	9.264	367,595,520,000	40.31	40,308,000.000	9.12	**37.41**
Belarus	9.628	382,039,040,000	31.64	31,638,000.000	12.08	**28.26**
Benin	0.000	0	0.00	0	0.00	**0.00**
Bolivia	1.293	51,306,240,000	4.51	4,514,000.000	11.37	**30.02**
Bosnia and Herzegovina	0.015	595,200,000	0.05	49,000.000	12.15	**28.09**
Botswana	0.000	0	0.00	0	0.00	**0.00**
Brazil	4.950	196,416,000,000	25.10	25,095,000.000	7.83	**43.59**
Brunei Darussalam	1.129	44,798,720,000	3.69	3,686,000.000	12.15	**28.07**
Bulgaria	0.763	30,275,840,000	2.08	2,077,000.000	14.58	**23.41**
Cambodia	0.000	0	0.00	0	0.00	**0.00**
Cameroon	0.101	4,007,680,000	0.44	439,000.000	9.13	**37.37**
China, People's Republic of	18.571	736,897,280,000	84.02	84,022,000.000	8.77	**38.90**
Chinese Taipei	11.178	443,543,040,000	61.34	61,340,000.000	7.23	**47.19**
Colombia	1.640	65,075,200,000	8.26	8,255,000.000	7.88	**43.28**
Congo	0.123	4,880,640,000	0.49	493,000.000	9.90	**34.47**
Congo, Democratic Republic of	0.007	277,760,000	0.03	29,000.000	9.58	**35.62**
Costa Rica	0.000	0	0.00	0	0.00	**0.00**
Côte d'Ivoire	1.127	44,719,360,000	4.23	4,228,000.000	10.58	**32.26**
Croatia	0.610	24,204,800,000	2.62	2,621,000.000	9.23	**36.95**
Cuba	0.442	17,538,560,000	2.06	2,055,000.000	8.53	**39.98**
Cyprus	0.000	0	0.00	0	0.00	**0.00**

Dominican Republic	0.699	27,736,320,000	3.25	3,251,000.000	8.53	**39.99**
Ecuador	0.374	14,840,320,000	1.94	1,935,000.000	7.67	**44.49**
Egypt	24.545	973,945,600,000	117.02	117,018,000.000	8.32	**40.99**
El Salvador	0,000	0	0.00	0	0.00	**0.00**
Eritrea	0.000	0	0.00	0	0.00	**0.00**
Ethiopia	0.000	0	0.00	0	0.00	**0.00**
Gabon	0.126	4,999,680,000	0.58	584,000.000	8.56	**39.85**
Georgia	0.427	16,943,360,000	2.30	2,297,000.000	7.38	**46.26**
Ghana	0.692	27,458,560,000	2.72	2,724,000.000	10.08	**33.85**
Gibraltar	0.000	0	0.00	0	0.00	**0.00**
Guatemala	0.000	0	0.00	0	0.00	**0.00**
Haiti	0.000	0	0.00	0	0.00	**0.00**
Honduras	0.000	0	0.00	0	0.00	**0.00**
Hong Kong, China	2.161	85,748,480,000	11.13	11,132,000.000	7.70	**44.30**
India	18.782	745,269,760,000	108.53	108,534,000.000	6.87	**49.69**
Indonesia	8.251	327,399,680,000	37.09	37,090,000.000	8.83	**38.65**
Iran, Islamic Republic of	32.901	1,305,511,680,000	160.01	160,011,000.000	8.16	**41.82**
Iraq	4.767	189,154,560,000	33.68	33,675,000.000	5.62	**60.74**
Jamaica	0.000	0	0.00	0	0.00	**0.00**
Jordan	0.872	34,600,960,000	3.96	3,958,000.000	8.74	**39.03**
Kazakhstan	1.950	77,376,000,000	7.94	7,940,000.000	9.75	**35.01**
Kenya	0.000	0	0.00	0	0.00	**0.00**
Korea, Democratic People's Republic of	0.000	0	0.00	0	0.00	**0.00**
Kosovo	0.000	0	0.00	0	0.00	**0.00**
Kuwait	5.364	212,843,520,000	21.84	21,841,000.000	9.75	**35.01**
Kyrgyzstan	0.194	7,697,920,000	0.54	537,000.000	14.34	**23.80**
Latvia	0.692	27,458,560,000	3.01	3,014,000.000	9.11	**37.45**
Lebanon	3.718	147,530,240,000	15.56	15,560,000.000	9.48	**35.99**

Libya	3.518	139,594.,240,000	15.55	15,550,000.000	8.98	**38.01**
Lithuania	0.911	36,148,480,000	2.67	2,667,000.000	13.55	**25.17**
Former Yugoslav Republic of Macedonia	0.026	1,031,680,000	0.09	87,000.000	11.86	**28.77**
Malaysia	13.711	544,052,480,000	58.16	58,158,000.000	9.35	**36.47**
Malta	0.000	0	0.00	0	0.00	**0.00**
Moldova, Republic of	1.385	54,956,800,000	5.41	5,414,000.000	10.15	**33.61**
Mongolia	0.000	0	0.00	0	0.00	**0.00**
Montenegro	0.000	0	0.00	0	0.00	**0.00**
Morocco	0.662	26,268,160,000	4.05	4,051,000.000	6.48	**52.62**
Mozambique	0.007	277,760,000	0.02	20,000.000	13.89	**24.57**
Myanmar	0.493	19,562,240,000	1.59	1,588,000.000	12.32	**27.70**
Namibia	0.000	0	0.00	0	0.00	**0.00**
Nepal	0.000	0	0.00	0	0.00	**0.00**
Netherlands Antilles	0.000	0	0.00	0	0.00	**0.00**
Nicaragua	0.000	0	0.00	0	0.00	**0.00**
Nigeria	3.678	145,943,040,000	17.11	17,113,000.000	8.53	**40.01**
Oman	5.575	221,216,000,000	17.94	17,937,000.000	12.33	**27.67**
Pakistan	6.396	253,793,280,000	27.65	27,650,000.000	9.18	**37.17**
Panama	0.000	0	0.00	0	0.00	**0.00**
Paraguay	0.000	0	0.00	0	0.00	**0.00**
Peru	3.660	145,228,800,000	14.01	14,007,000.000	10.37	**32.91**
Philippines	3.132	124,277,760,000	20.59	20,591,000.000	6.04	**56.53**
Qatar	6.439	255,499,520,000	30.73	30,730,000.000	8.31	**41.04**
Romania	2.470	98,009,600,000	8.37	8,365,000.000	11.72	**29.12**
Russian Federation	169.260	6,716,236,800,000	519.20	519,202,000.000	12.94	**26.38**
Saudi Arabia	29.664	1,177,067,520,000	108.38	108,383,000.000	10.86	**31.42**
Senegal	0.015	595,200,000	0.05	53,000.000	11.23	**30.38**
Serbia	0.221	8,769,280,000	0.50	501,000.000	17.50	**19.49**

Singapore	6.823	270,736,640,000	35.88	35,879,000.000	7.55	**45.22**
South Africa	0.000	0	0.00	0	0.00	**0.00**
Sri Lanka	0.000	0	0.00	0	0.00	**0.00**
Sudan	0.000	0	0.00	0	0.00	**0.00**
Syrian Arab Republic	4.998	198,320,640,000	21.51	21,513,000.000	9.22	**37.01**
Tajikistan	0.181	7,182,080,000	0.19	192,000.000	37.41	**9.12**
Tanzania, United Republic of	0.606	24,046,080,000	2.59	2,586,000.000	9.30	**36.69**
Thailand	19.159	760,229,120,000	106.57	106,566,000.000	7.13	**47.83**
Togo	0.000	0	0.00	0	0.00	**0.00**
Trinidad and Tobago	1.909	75,749,120,000	8.84	8,843,000.000	8.57	**39.83**
Tunisia	3.140	124,595,200,000	15.96	15,957,000.000	7.81	**43.70**
Turkmenistan	7.467	296,290,560,000	17.22	17,220,000.000	17.21	**19.83**
Ukraine	6.859	272,165,120,000	18.45	18,451,000.000	14.75	**23.13**
United Arab Emirates	24.607	976,405,760,000	97.45	97,453,000.000	10.02	**34.05**
Uruguay	0.019	753,920,000	0.09	91,000.000	8.28	**41.18**
Uzbekistan	12.054	478,302,720,000	39.52	39,517,000.000	12.10	**28.19**
Venezuela	5.441	215,898,880,000	20.98	20,975,000.000	10.29	**33.15**
Vietnam	7.627	302,639,360,000	43.55	43,548,000.000	6.95	**49.10**
Yemen	0.317	12,578,560,000	1.34	1,342,000.000	9.37	**36.40**
Zambia	0.000	0	0.00	0	0.00	**0.00**
Zimbabwe	0.000	0	0.00	0	0.00	**0.00**

A3 Data sample

The following tables contain the data of the sample. Table 0-5 gives an overview of the employed country specific data, which is independent from the kind of fossil fuel used. Whereas the tables 0-6 to 0-9 show the country specific data that depends on the kind of fossil fuel used. The data values are set at '-', if the corresponding data does not exist, or is not available.

Table 0- 5: Data Sample Country Specific Data

OVERVIEW: country	**EPI**	**GDP (US$)**	**GNI per capita (US$)**	**FDI (US$)**	**interest rate (%)**	**Temperature (°C)**	**Capacity (Million kWh)**	**Technology**
Australia	56.61	1,386,889,147,177	40,070	65,432,448,213	4.69	21.4	48,800	5.11
Austria	69.92	415,984,217,115	42,600	23,675,873,461	1.26	7.9	5.377	5.40
Belgium	63.02	513,317,999,900	40,210	117,161,100,157	1.26	11.3	9.023	5.80
Canada	58.41	1,778,632,046,933	40,570	40,131,613,267	1.00	-4.2	43.386	5.40
Chile	55.34	251,162,316,598	19,040	23,443,915,104	4.64	8.6	10.871	4.26
Czech Republic	64.79	216,061,200,559	25,230	2,248,932,510	0.75	9.0	11.361	4.82
Denmark	63.61	333,743,578,564	42,960	13,555,949,082	1.25	8.9	8.311	6.20
Estonia	56.09	22,542,967,739	22,080	521,041,511	1.26	6.9	2.573	4.95
Finland	64.44	262,379,400,238	38,720	-6,008,146,394	1.26	3.6	8.720	5.75
France	69.00	2,782,210,861,683	37,040	40,832,023,979	1.26	12.4	30.461	5.63
Germany	66.91	3,628,110,015,053	41,910	44,678,217,260	1.26	10.0	74.595	5.61
Greece	60.04	289,886,951,188	26,260	1,091,980,638	1.26	15.6	10.960	4.21
Hungary	57.12	137,448,696,906	21,500	10,499,937,478	6.07	10.9	6.736	4.55
Iceland	66.28	14,042,801,904	32,790	1,107,000,000	4.75	2.8	0.12	6.21

Ireland	58.69	226,035,376,257	34,850	23,664,918,435	1.26	10.0	6.392	5.34
Israel	54.64	258,216,783,343	29,650	9,094,100,000	3.00	19.8	13.721	5.12
Italy	69.90	2,196,336,800,620	34,420	28,002,522,666	1.26	14.6	73.328	4.34
Japan	63.36	5,905,630,870,455	35,380	79,081,205	0.00	11.9	185.309	5.06
Luxembourg	69.20	58,009,863,403	61,140	18,116,198,692	1.26	10.7	0.491	6.00
Mexico	49.11	1,170,085,556,896	15,650	23,354,426,460	4.50	22.1	46.573	3.75
Netherlands	65.65	832,755,438,977	43,290	21,455,926,257	1.26	10.7	23.374	6.13
New Zealand	66.05	163,986,606,003	30,240	4,063,971,095	2.63	10.9	3.003	5.10
Norway	69.92	490,806,911,071	62,560	14,324,832,846	2.15	3.3	1.394	6.08
Poland	63.47	515,771,297,421	20,760	17,357,000,000	4.50	9.0	30.127	4.18
Portugal	57.64	237,888,302,256	24,890	11,878,396,627	1.26	16.0	9.323	5.31
Republic of Korea	57.20	1,202,463,655,510	31,510	9,773,000,000	3.06	11.8	58.056	5.33
Slovak Republic	66.62	95,877,536,836	24,620	3,658,300,079	1.26	7.7	3.183	4.54
Slovenia	62.25	50,250,208,507	27,780	816,502,676	1.26	10.5	1.212	4.76
Spain	60.31	1,454,534,452,554	31,090	34,098,152,765	1.26	14.7	48.729	4.95
Sweden	68.82	536,000,581,090	42,700	6,516,334,330	1.73	4.0	2.493	6.29
Switzerland	76.69	658,867,317,939	51,770	22,113,021,244	0.17	7.4	0.544	6.30
Turkey	44.80	774,754,155,294	17,820	16,171,000,000	6.08	11.1	33.805	3.95
United Kingdom	68.82	2,462,484.,285,580	35,270	36,243,797,828	0.50	9.6	68.013	6.08
United States	56.59	15,533,800,000,000	50,860	252,536,000,000	0.25	9.2	786.247	5.23
Albania	65.85	12,890,867,763	10,090	1,049,425,306	5.10	12.3	0.16	3.76
Algeria	48.65	199,070,864,638	12,480	2,571,293,681	4.00	23.6	11.145	2.83
Angola	47.57	104,115,863,405	6,430	-3,023,770,966	22.92	21.6	0.657	2.65
Azerbaijan	43.11	65,951,627,200	14,590	4,485,120,000	4.70	11.9	5.401	3.60
Bangladesh	42.55	111,905,616,039	2,460	1,184,776,059	22.50	25.3	6.093	2.82
Belarus	53.88	59,734,593,905	16,410	4,002,400,000	6.50	7.7	8.011	-
Benin	50.38	7,294,900,431	1,640	161,091,309	4.25	28.2	0.17	2.85
Bolivia	54.57	23,948,541,156	5,200	858,941,070	1.45	21.5	0.974	2.70

Bosnia and Herzegovina	36.76	18,252,896,439	9,310	468,733,719	7.40	11.4	2.187	3.62
Botswana	53.74	15,292,424,757	13,930	1,092,802,291	9.50	22.1	0.132	3.12
Brazil	60.90	2,476,694,763,271	14,030	71,538,657,409	11.80	25.6	22.368	3.98
Bulgaria	56.28	53,542,780,661	14,790	2,124,233,096	0.20	11.0	4.536	4.11
Cameroon	42.97	25,486,923,059	2,470	652,411,756	4.70	25.1	0.288	2.73
China, People's Republic of	42.24	7,321,891,954,613	9,940	331,591,710,742	6.35	7.5	0.766	3.57
Colombia	62.33	335,415,156,702	10,790	13,405,478,144	4.20	24.8	4.688	3.60
Congo	47.18	14,425,606,793	4,140	3,055,952,325	29.00	24.7	0.034	-
Costa Rica	69.03	41,237,296,807	12,510	2,176,110,879	5.70	25.4	0.862	3.94
Croatia	64.16	61,520,901,516	19,480	1,242,601,505	8.75	12.5	1.893	4.50
Cuba	56.48	68,233,900,000	18,520	-	2.25	25.5	6.165	-
Cyprus	57.15	24,851,264,943	31,540	2,078,721,742	1.20	19.0	0.965	4.36
Dominican Republic	52.44	55,433,248,935	10,340	2,197,500,000	6.50	24.2	2.473	3.65
Ecuador	60.55	76,769,729,000	9,420	640,527,359	8.35	21.7	0.299	3.10
Egypt	55.18	236,000,735,704	10,330	-482,700,000	8.35	23.0	24.447	3.31
El Salvador	52.08	23,139,000,000	5,050	122,500,004	1.75	25.3	0.801	3.37
Ethiopia	52.71	31,367,606,700	1,150	626,509,560	5.00	22.9	0.204	2.43
Gabon	57.91	18,796,191,833	15,410	696,000,000	4.00	25.4	0.245	-
Georgia	56.84	14,434,619,972	6,140	1,084,349,576	7.60	5.9	1.688	3.23
Ghana	47.50	39,564,970,070	3,340	3,222,240,000	12.95	27.8	1.000	2.97
Guatemala	51.88	47,654,789,735	6,720	1,139,659,133	4.95	24.2	1.570	3.50
Haiti	41.15	7,516,864,160	1,590	119,000,000	7.00	24.4	0.207	2.56
Honduras	52.54	17,710,325,578	4,110	1,042,571,021	4.70	24.2	1.089	3.37
India	36.23	1,880,100,141,185	4,840	36,498,654,598	7.50	24.2	171.098	3.36
Indonesia	52.29	845,931,645,339	8,190	19,241,252,762	6.60	26.1	34.717	3.33
Iraq	25.32	191,176.,927,521	13,620	2,082,000,000	6.00	22.1	14.439	-
Jamaica	54.36	14,433,926,129	8,170	172,757,165	6.60	24.7	0.846	3.63
Jordan	42.16	28,840,197,019	11,190	1,473,521,127	4.38	18.6	3.363	3.81

Kazakhstan	32.94	188,048,960,311	17,710	13,760,291,529	7.45	6.4	16.517	3.44
Kenya	49.28	34,313,315,840	2,110	335,249,880	8.50	25.7	0.784	3.26
Kuwait	35.54	160,600,006,232	88,170	3,259,067,552	2.50	26.7	13.500	3.69
Kyrgyzstan	46.33	6,179,766,119	2,670	693,528,000	13.60	2.5	0.795	2.60
Latvia	70.37	28,480,338,368	20,080	1,502,300,000	1.20	7.3	0.59	4.26
Lebanon	47.35	40,078,933,640	16,360	3,490,150,694	10.00	16.4	2.038	3.39
Lithuania	65.50	42,872,072,871	21,590	1,443,081,752	1.80	7.6	2.555	4.70
Macedonia	46.96	10,395,222,334	11,540	495,096,925	4.00	10.5	1.290	3.67
Malaysia	62.51	289,258,937,259	20,560	15,119,371,105	2.90	25.9	25.390	4.29
Malta	48.51	9,151,793,161	26,700	673,270,699	1.25	20.0	0.571	5.05
Moldova, Republic of	45.21	7,016,162,818	4,520	276,420,000	8.75	10.2	0.486	3.52
Mongolia	45.37	8,761,426,371	6,770	4,714,590,841	11.55	-0.2	0.832	3.10
Morocco	45.76	99,211,339,029	6,490	2,521,364,645	3.25	18.1	4.325	3.69
Mozambique	47.82	12,457,888,400	910	3,645,044,842	16.20	24.5	0.249	2.86
Namibia	50.68	12,451,760,766	8,460	968,867,335	6.00	20.6	0.144	3.25
Nepal	57.97	18,850,351,853	2,060	94,022,275	7.00	9.0	0.057	2.65
Nigeria	40.14	413,541,535,075	4,950	8,841,952,775	8.75	27.4	3.960	3.08
Oman	44.00	69,971,912,138	39,440	874,137,841	2.00	26.1	4.861	4.08
Pakistan	3956	213,685,918,599	4,450	1,308,770,000	13.50	21.2	15.454	2.94
Panama	57.94	3,270,500,000	15,290	4,375,300,000	0.30	25.7	1.040	4.44
Paraguay	52.40	25,071,193,102	6,820	447,766,667	7.85	23.8	6.000	2.99
Peru	50.29	170,563,949,736	9,950	8,232,636,979	4.05	19.6	5.103	3.65
Philippines	57.40	224,095,219,329	6,830	2,007,150725	4.35	26.1	10.772	3.47
Qatar	46.59	169,804,731,108	123,280	-86,758,242	4.95	28.5	7.830	4.74
Romania	48.34	182,610,666,616	16,830	2,557,000,000	6.25	9.5	12.610	3.76
Russian Federation	45.43	1,904,793,021,649	21,860	55,083,632,500	8.06	-3.4	159.400	3.66
Saudi Arabia	49.97	669,506.,666,667	49,940	16,308,280,000	2.00	25.6	51.148	4.33
Senegal	56.36	14,440,676,498	2,140	338,218,819	4.25	28.6	0.621	3.45

Singapore	56.36	274,065,043,016	73,520	50,367,876,463	0.03	27.2	10.215	5.90
South Africa	34.55	403,894,316,555	11,640	4,139,289,123	8.52	18.3	40.141	3.60
Sri Lanka	55.72	59,178,013,928	8,020	955,920,000	7.00	27.5	1.742	3.46
Sudan	46.00	67,320,812,663	3,210	2,313,694,286	9.85	28.0	0.718	-
Tajikistan	38.78	6,522,732,203	2,200	67,496,200	9.20	2.8	0.389	2.90
Tanzania, United Republic of	54.26	23,874,165,047	1,580	1,229,403,285	8.10	23.2	0.283	2.70
Thailand	59.98	345,672,232,116	12,340	3,867,529,586	2.95	26.2	44.065	3.47
Togo	48.66	3,756,023,048	1,080	171,038,614	4.25	27.6	0.018	-
Trinidad and Tobago	47.04	23,676,348,287	24,990	1,216,100,000	3.15	26.2	2.099	4.04
Tunisia	46.66	45,951,129,422	9,720	432,666,012	4.10	20.3	3.956	3.82
Ukraine	46.31	163,421,733,019	8,170	7,207,000,000	7.75	9.2	35.026	3.47
United Arab Emirates	59.01	348,594,945,288	56,390	7,678,692,988	1.00	28.0	26.132	4.88
Uruguay	57.06	47,236,710,623	17,040	2,690,094,197	7.60	17.7	1.126	4.18
Uzbekistan	32.24	45,324,319,955	4,590	1,651,000,000	12.00	12.6	10.619	-
Venezuela	55.62	316,482,176,579	16,580	3,889,000,000	17.75	25.8	10.017	3.36
Vietnam	50.64	135,539,487,317	4,510	7,430,000,000	13.50	24.3	11.992	3.51
Yemen	35.49	29,207,296,703	3,490	-517,842,928	20.00	24.4	1.533	2.41
Zimbabwe	52.76	10,956,226,611	1,490	387,000,000	11.20	21.7	1.220	2.69

Table 0- 6: Fuel Specific Data All Fuels

ALL FUELS: country	**Efficiency (%)**	**Production (Mtoe)**	**Total Primary Energy Supply (Mtoe)**	**Total Final Consumption (Mtoe)**	**TPES/TFC**
Australia	39.16	267.31	83.40	55.97	1.49
Austria	39.04	1.46	13.78	15.63	0.88
Belgium	42.98	0.00	11.30	31.74	0.36
Canada	35.87	166.01	94.96	149.04	0.64

Chile	40.72	1.49	15.79	15.18	1.04
Czech Republic	21.95	21.05	26.90	16.93	1.59
Denmark	36.09	6.23	10.67	3.32	3.21
Estonia	31.50	4.06	5.47	1.31	4.18
Finland	40.30	1.69	6.29	9.49	0.66
France	30.86	0.60	57.13	100.65	0.57
Germany	42.56	57.42	152.53	151.37	1.01
Greece	39.82	7.51	6.20	13.11	0.47
Hungary	38.49	3.76	11.11	12.46	0.89
Iceland	0.00	0.00	0.93	0.92	1.01
Ireland	43.30	1.04	9.29	7.98	1.16
Israel	36.35	3.55	9.80	8.76	1.12
Italy	37.14	6.98	57.62	91.90	0.63
Japan	44.46	320	233.22	229.14	1.02
Luxembourg	15.60	0.00	3.63	3.21	1.13
Mexico	40.77	49.58	85.11	89.31	0.95
Netherlands	39.87	57.73	10.92	42.91	0.25
New Zealand	27.89	6.37	5.24	7.73	0.68
Norway	30.23	87.19	-7.48	9.63	-0.78
Poland	40.40	59.61	67.88	45.35	1.50
Portugal	43.75	0.00	6.44	11.05	0.58
Republic of Korea	39.89	1.37	87.50	113.26	0.77
Slovak Republic	29.14	0.70	5.67	7.50	0.76
Slovenia	24.61	1.20	4.77	3.19	1.50
Spain	44.29	2.70	39.22	62.15	0.63
Sweden	30.43	0.22	-1.45	12.69	-0.11
Switzerland	34.60	0.00	8.20	12.60	0.65
Turkey	38.91	18.47	80.51	58.99	1.36

United Kingdom	42.02	51.62	82.74	95.43	0.87
United States	41.03	1,067.28	949.56	1,097.03	0.87
Albania	0.86	0.01	1.02	1.22	0.83
Algeria	36.58	69.59	5.59	24.56	0.23
Angola	19.99	0.61	2.77	4.00	0.69
Azerbaijan	38.43	13.72	5.66	6.25	0.91
Bangladesh	36.34	17.06	15.85	11.55	1.37
Belarus	28.25	0.87	-9.91	8.13	-1.22
Benin	36.54	0.00	1.57	1.54	1.02
Bolivia	29.97	13.40	3.10	3.95	0.79
Bosnia and Herzegovina	24.90	4.06	5.48	2.09	2.62
Botswana	18.71	0.49	1.45	1.27	1.14
Brazil	35.04	16.28	49.35	121.25	0.41
Bulgaria	31.94	5.00	6.98	4.87	1.43
Cameroon	32.00	0.24	-0.18	1.20	-0.15
China, People's Republic of	35.70	1,909.30	1,968.89	1,020.37	1.93
Colombia	39.38	64.93	7.21	17.42	0.41
Congo	34.26	0.12	0.19	0.60	0.32
Costa Rica	37.29	0.00	2.09	2.02	1.04
Croatia	38.07	2.01	3.20	4.70	0.68
Cuba	27.94	0.80	0.68	2.25	0.30
Cyprus	36.12	0.00	2.25	1.15	1.96
Dominican Republic	31.49	0.00	5.28	2.96	1.78
Ecuador	37.84	0.37	2.34	8.15	0.29
Egypt	42.03	49.89	46.38	39.05	1.19
El Salvador	38.55	0.00	1.29	1.55	0.83
Ethiopia	23.65	0.00	1.82	1.81	1.01
Gabon	33.11	0.16	-0.17	0.48	-0.35

Georgia	45.13	0.06	2.58	2.02	1.28
Ghana	33.85	0.69	2.42	2.75	0.88
Guatemala	34.76	0.00	3.28	2.60	1.26
Haiti	47.01	0.00	0.71	0.62	1.14
Honduras	42.28	0.00	2.45	1.63	1.50
India	29.77	290.64	323.17	253.49	1.27
Indonesia	34.07	277.91	88.93	90.58	0.98
Iraq	25.49	5.01	13.63	19.31	0.71
Jamaica	40.38	0.00	1.30	1.45	0.89
Jordan	39.32	0.13	3.50	3.42	1.02
Kazakhstan	32.13	76.29	58.76	30.81	1.91
Kenya	30.01	0.00	4.16	5.92	0.70
Kuwait	37.98	11.05	-19.98	11.34	-1.76
Kyrgyzstan	23.00	0.31	2.03	1.73	1.17
Latvia	36.75	0.00	2.78	1.87	1.49
Lebanon	35.99	0.00	6.07	2.35	2.58
Lithuania	25.81	0.01	-4.26	3.51	-1.21
Macedonia	34.28	1.46	1.84	1.07	1.73
Malaysia	36.00	49.24	44.97	33.94	1.33
Malta	31.68	0.00	0.81	0.20	4.03
Moldova, Republic of	33.38	0.00	3.15	1.62	1.94
Mongolia	21.05	18.81	3.44	1.47	2.34
Morocco	36.79	0.05	9.04	10.37	0.87
Mozambique	24.57	3.22	0.97	0.96	1.01
Namibia	24.84	0.00	1.05	1.31	0.80
Nepal	25.80	0.01	1.30	1.30	1.00
Nigeria	39.40	29.23	14.57	12.23	1.19
Oman	28.45	26.10	15.35	16.09	0.95

Pakistan	38.07	28.35	41.79	36.10	1.16
Panama	37.62	0.00	3.24	2.19	1.48
Paraguay	0.00	0.00	1.64	1.64	1.00
Peru	31.64	11.87	13.57	3.47	3.91
Philippines	41.91	6.92	15.26	13.39	1.14
Qatar	41.04	134.52	7.81	12.11	0.64
Romania	29.09	15.33	18.05	14.84	1.22
Russian Federation	25.75	732.77	398.64	269.80	1.48
Saudi Arabia	32.38	70.04	-26.48	70.25	-0.38
Senegal	34.80	0.02	1.11	1.14	0.97
Singapore	43,70	0.00	-26.22	20.73	-1.26
South Africa	36.02	143.86	102.84	42.63	2.41
Sri Lanka	36.19	0.00	2.89	3.15	0.92
Sudan	33.00	0.00	034	4.03	0.08
Tajikistan	9.12	0.14	1.00	0.84	1.19
Tanzania, United Republic of	36.27	0.67	2.07	1.49	1.38
Thailand	43.48	28.17	36.53	60.97	0.60
Togo	32.48	0.00	0.42	0.41	1.02
Trinidad and Tobago	39.84	35.86	12.26	14.75	0.83
Tunisia	43.68	2.60	7.05	4.74	1.49
Ukraine	28.47	55.87	91.69	50.83	1.80
United Arab Emirates	33.75	43.83	36.31	41.75	0.87
Uruguay	38.10	0.00	1.14	1.71	0.67
Uzbekistan	27.62	52.55	43.03	28.69	1.50
Venezuela	31.27	25.48	-5.41	39.65	-0.14
Vietnam	42.41	32.36	35.80	29.16	1.23
Yemen	40.49	8.60	3.79	5.00	0.76
Zimbabwe	24.05	2.06	2.63	1.75	1.50

Table 0- 7: Fuel Specific Data Coal & Peat

COAL & PEAT country	Efficiency (%)	Production (Mtoe)	Total Primary Energy Supply (Mtoe)	Total Final Consumption (Mtoe)	TPES /TFC
Australia	33.29	222.57	48.18	3.41	14.13
Austria	41.41	0.00	3.47	0.45	7.71
Belgium	39.20	0.00	2.91	0.73	3.99
Canada	37.24	33.66	19.60	3.12	6.28
Chile	35.22	0.25	5.35	0.35	15.29
Czech Republic	29.65	20.90	18.34	2.92	6.28
Denmark	38.75	0.00	3.23	0.16	20.19
Estonia	29.40	4.06	4.06	0.13	31.23
Finland	33.52	1.69	5.70	0.73	7.81
France	38.66	0.09	10.28	3.19	3.22
Germany	38.24	46.53	77.35	8.23	9.40
Greece	33.95	7.50	7.89	0.22	35.86
Hungary	32.15	1.65	2.76	0.42	6.57
Iceland	0.00	0.00	0.09	0.09	1.00
Ireland	42.56	0.76	2.03	0.55	3.69
Israel	39.45	0.03	7.75	0.00	-
Italy	38.12	0.06	15.91	2.34	6.80
Japan	41.35	0.00	107.42	26.46	4.06
Luxembourg	0.00	0.00	0.06	0.06	1.00
Mexico	35.49	7.79	10.01	1.72	5.82
Netherlands	42.61	0.00	7.47	0.81	9.22
New Zealand	35.21	2.89	1.44	0.23	6.26
Norway	34.40	0.93	0.85	0.61	1.39
Poland	34.39	55.76	54.62	11.88	4.60

Portugal	38.32	0.00	2.21	0.02	110.50
Republic of Korea	34.74	0.96	80.24	9.61	8.35
Slovak Republic	27.79	0.60	3.70	1.18	3.14
Slovenia	32.55	1.20	1.47	0.06	24.50
Spain	36.07	2.65	12.44	1.23	10.11
Sweden	26.74	0.22	2.49	0.89	2.80
Switzerland	0.00	0.00	0.14	0.14	1.00
Turkey	34.10	17.84	33.93	13.09	2.59
United Kingdom	36.67	10.87	30.66	2,54	12.07
United States	37.00	536.37	479.00	2458	19.49
Albania	0.00	0.00	0.07	0.07	1.00
Algeria	0.00	0.00	0.30	0.10	3.12
Angola	0.00	0.00	0.00	0.00	-
Azerbaijan	0.00	0.00	0.00	0.00	-
Bangladesh	32.72	0.45	0.91	0.70	1.31
Belarus	0.00	0.69	0.58	0.40	1.46
Benin	0.00	0.00	0.00	0.00	-
Bolivia	0.00	0.00	0.00	0.00	-
Bosnia and Herzegovina	24.86	4.06	4.75	0.40	12.02
Botswana	18.71	0.49	0.49	0.32	1.54
Brazil	30.17	2.12	15.43	8.30	1.86
Bulgaria	33.30	4.94	6.93	0.47	14.84
Cameroon	0.00	0.00	0.00	0.00	-
China, People's Republic of	35.63	1,823.39	1,858.66	550.91	3.37
Colombia	30.90	55.77	3.50	2.51	1.39
Congo	0.00	0.00	0.00	0.00	-
Costa Rica	0.00	0.00	0.06	0.04	1.78
Croatia	39.79	0.00	0.70	0.15	4.75

Cuba	0.00	0.00	0.03	0.03	1.15
Cyprus	0.00	0.00	0.01	0.01	1.00
Dominican Republic	35.03	0.00	0.62	0.07	8.66
Ecuador	0.00	0.00	0.00	0.00	-
Egypt	0.00	0.00	1.04	0.47	2.21
El Salvador	0.00	0.00	0.00	0.00	-
Ethiopia	0.00	0.00	0.00	0.00	-
Gabon	0.00	0.00	0.00	0.00	-
Georgia	0.00	0.06	0.06	0.06	1.00
Ghana	0.00	0.00	0.00	0.00	-
Guatemala	34.99	0.00	0.30	0.00	-
Haiti	0.00	0.00	0.00	0.00	-
Honduras	36.11	0.00	0.15	0.12	1.26
India	28.41	252.17	325.78	85.69	3.80
Indonesia	31.83	206.88	31.48	11.21	2.81
Iraq	0.00	0.00	0.00	0.00	-
Jamaica	0.00	0.00	0.04	0.04	1.00
Jordan	0.00	0.00	0.00	0.00	-
Kazakhstan	31.85	50.99	37.77	16.13	2.34
Kenya	0.00	0.00	0.23	0.23	1.00
Kuwait	0.00	0.00	0.00	0.00	-
Kyrgyzstan	22.16	0.29	0.72	0.54	1.35
Latvia	1.91	0.00	0.12	0.11	1.12
Lebanon	0.00	0.00	0.17	0.17	1.00
Lithuania	0.00	0.01	0.24	0.23	1.03
Macedonia	34.38	1.46	1.48	0.17	8.87
Malaysia	35.01	1.84	15.58	1.76	8.86
Malta	0.00	0.00	0.00	0.00	-

Moldova, Republic of	0.00	0.00	0.10	0.10	1.02
Mongolia	20.88	18.81	2.42	0.53	4.54
Morocco	33.96	0.00	2.98	0.02	198.47
Mozambique	0.00	0.41	0.02	0.01	1.23
Namibia	24.57	0.00	0.01	0.00	-
Nepal	0.00	0.01	0.29	0.29	1.00
Nigeria	0.00	0.02	0.02	0.02	1.00
Oman	0.00	0.00	0.00	0.00	-
Pakistan	13.53	1.42	4.09	3.92	1.04
Panama	30.04	0.00	0.20	0.05	3.75
Paraguay	0.00	0.00	0.00	0.00	-
Peru	25.96	0.11	0.67	0.63	1.07
Philippines	35.18	3.63	8.45	2.02	4.19
Qatar	0.00	0.00	0.00	0.00	-
Romania	27.12	6.66	8.10	0.67	12.06
Russian Federation	23.95	180.04	115.94	15.69	7.39
Saudi Arabia	0.00	0.00	0.00	0.00	-
Senegal	0.00	0.00	0.17	0.17	1.00
Singapore	0.00	0.00	0.00	0.00	-
South Africa	36.02	142.75	98.48	16.68	5.91
Sri Lanka	0.00	0.00	0.38	0.08	4.69
Sudan	0.00	0.00	0.00	0.00	-
Tajikistan	0.00	0.10	0.11	0.11	1.00
Tanzania, United Republic of	30.35	0.03	0.03	0.01	2.42
Thailand	34.15	6.19	18.25	9.38	1.95
Togo	0.00	0.00	0.00	0.00	-
Trinidad and Tobago	0.00	0.00	0.00	0.00	-
Tunisia	0.00	0.00	0.00	0.00	-

Ukraine	30.26	40.35	41.49	9.40	4.41
United Arab Emirates	0.00	0.00	1.25	1.25	1.00
Uruguay	0.00	0.00	0.00	0.00	1.00
Uzbekistan	19.77	1.35	1.37	0.42	3.24
Venezuela	0.00	1.53	0.21	0.21	1.00
Vietnam	35.00	24.92	15.54	10.40	1.49
Yemen	0.00	0.00	0.00	0.00	-
Zimbabwe	24.03	2.06	1.97	1.10	1.78

Table 0- 8: Fuel Specific Data Oil Products

OIL PRODUCTS: country	Efficiency (%)	production (Mtoe)	Total Primary Energy Supply (Mtoe)	Total Final Consumption (Mtoe)	TPES /TFC
Australia	44.63	0.00	8.20	39.56	0.21
Austria	28.95	0.00	2.56	10.46	0.24
Belgium	35.62	0.00	-6.73	20.07	-0.34
Canada	30.19	0.00	-8.21	90.01	-0.09
Chile	37.98	0.00	5.88	12.88	0.46
Czech Republic	14.33	0.00	1.35	8.33	0.16
Denmark	32.25	0.00	3.72	1.58	2.35
Estonia	34.40	0.00	0.91	0.98	0.93
Finland	40.13	0.00	-2.77	7.76	-0.36
France	19.46	0.00	9.82	69.85	0.14
Germany	44.74	0.00	5.60	91.97	0.06
Greece	35.35	0.00	-5.66	11.42	-0.50
Hungary	42.99	0.00	-1.00	5.84	-0.17
Iceland	0.00	0.00	0.84	0.83	1.01

Ireland	36.11	0.00	3.14	5.88	0.53
Israel	23.58	0.00	-2.05	8.64	-0.24
Italy	26.10	0.00	-22.09	53.61	-0.41
Japan	44.42	0.00	25.85	167.33	0.15
Luxembourg	0.00	0.00	2.54	2.54	1.00
Mexico	37.17	0.00	18.88	73.94	0.26
Netherlands	26.53	0.00	-30.74	21.60	-1.42
New Zealand	0.00	0.00	0.39	5.80	0.07
Norway	0.00	0.00	-13.27	8.17	-1.62
Poland	42.13	0.00	0.43	23.11	0.02
Portugal	46.26	0.00	-0.23	9.39	-0.02
Republic of Korea	35.05	0.00	-34.32	82.08	-0.42
Slovak Republic	18.47	0.00	-2.67	3.00	-0.89
Slovenia	0.00	0.00	2.56	2.55	1.00
Spain	39.57	0.00	-2.20	46.33	-0.05
Sweden	36.21	0.00	-5.10	11.14	-0.46
Switzerland	42.99	0.00	5.39	10.00	0.54
Turkey	32.25	0.00	9.80	28.23	0.35
United Kingdom	36.27	0.00	-18.10	54.14	-0.33
United States	38.70	0.00	-98.17	745.66	-0.13
Albania	0.09	0.00	0.93	1.15	0.82
Algeria	29.00	0.00	-19.49	14.66	-1.33
Angola	19.99	0.00	2.16	4.00	0.54
Azerbaijan	41.19	0.00	-2.65	3.04	-0.87
Bangladesh	24.06	0.00	3.32	3.96	0.84
Belarus	27.66	0.00	-11.06	7.33	-1.51
Benin	36.54	0.00	1.57	1.54	1.02
Bolivia	28.25	0.00	0.42	2.82	0.15

Bosnia and Herzegovina	36.31	0.00	0.50	1.53	0.33
Botswana	0.00	0.00	0.96	0.95	1.01
Brazil	27.57	0.00	11.04	100.21	0.11
Bulgaria	10.81	0.00	-2.25	3.15	-0.71
Cameroon	30.26	0.00	-0.42	1.20	-0.35
China, People's Republic of	37.53	0.00	2.48	398.00	0.01
Colombia	30.07	0.00	-3.87	11.16	-0.35
Congo	25.80	0.00	0.07	0.60	0.11
Costa Rica	37.29	0.00	2.03	1.98	1.03
Croatia	36.53	0.00	-0.10	2.95	-0.03
Cuba	25.86	0.00	-0.16	1.84	-0.08
Cyprus	36.12	0.00	2.24	1.14	1.96
Dominican Republic	27.51	0.00	3.89	2.89	1.34
Ecuador	36.25	0.00	1.97	8.15	0.24
Egypt	47.71	0.00	3.02	25.89	0.12
El Salvador	38.55	0.00	1.29	1.55	0.83
Ethiopia	23.65	0.00	1.82	1.81	1.01
Gabon	26.08	0.00	-0.33	0.48	-0.68
Georgia	5.02	0.00	1.01	1.00	1.01
Ghana	0.00	0.00	1.72	2.75	0.63
Guatemala	34.58	0.00	2.98	2.60	1.15
Haiti	47.01	0.00	0.71	0.62	1.14
Honduras	42.51	0.00	2.30	1.51	1.52
India	16.88	0.00	-52.99	141.45	-0.37
Indonesia	35.15	0.00	22.79	62.72	0.36
Iraq	6.70	0.00	8.63	19.07	0.45
Jamaica	40.38	0.00	1.26	1.42	0.89
Jordan	39.42	0.00	2.63	3.42	0.77

Kazakhstan	29.93	0.00	-3.42	10.74	-0.32
Kenya	30.01	0.00	1.97	2.84	0.69
Kuwait	40.06	0.00	-33.86	8.22	-4.12
Kyrgyzstan	0.00	0.00	1.03	1.11	0.92
Latvia	1.72	0.00	1.38	1.36	1.01
Lebanon	35.99	0.00	5.90	2.18	2.70
Lithuania	38.24	0.00	-7.22	1.71	-4.23
Macedonia	34.90	0.00	0.25	0.86	0.29
Malaysia	38.92	0.00	0.90	24.46	0.04
Malta	31.68	0.00	0.81	0.20	4.03
Moldova, Republic of	10.44	0.00	0.80	0.79	1.01
Mongolia	24.73	0.00	1.02	0.94	1.09
Morocco	35.46	0.00	5.35	10.31	0.52
Mozambique	0.00	0.00	0.83	0.82	1.00
Namibia	25.80	0.00	1.04	1.31	0.80
Nepal	25.80	0.00	1.01	1.01	1.00
Nigeria	37.13	0.00	6.53	10.86	0.60
Oman	32.65	0.00	-2.69	5.66	-0.48
Pakistan	39.05	0.00	10.76	12.45	0.86
Panama	39.18	0.00	3.04	2.14	1.42
Paraguay	0.00	0.00	1.64	1.64	1.00
Peru	26.91	0.00	6.45	1.42	4.53
Philippines	36.71	0.00	3.52	11.30	0.31
Qatar	0.00	0.00	-21.16	6.89	-3.07
Romania	17.92	0.00	-1.15	7.16	-0.16
Russian Federation	25.70	0.00	-108.51	116.16	-0.93
Saudi Arabia	34.10	0.00	-52.12	70.25	-0.74
Senegal	34.91	0.00	0.93	0.98	0.95

Singapore	38.27	0.00	-34.28	19.50	-1.76
South Africa	35.29	0.00	0.57	24.32	0.02
Sri Lanka	36.19	0.00	2.51	3.07	0.82
Sudan	33.00	0.00	0.34	4.03	0.08
Tajikistan	0.00	0.00	0.55	0.57	0.96
Tanzania, United Republic of	25.18	0.00	1.39	1.38	1.01
Thailand	40.30	0.00	-12.50	45.77	-0.27
Togo	32.48	0.00	0.42	0.41	1.02
Trinidad and Tobago	41.27	0.00	-7.10	1.25	-5.68
Tunisia	28.66	0.00	2.74	3.62	0.76
Ukraine	22.09	0.00	3.36	12.24	0.27
United Arab Emirates	22.18	0.00	-17.25	13.43	-1.28
Uruguay	38.01	0.00	1.07	1.66	0.64
Uzbekistan	30.12	0.00	-0.23	3.13	-0.07
Venezuela	29.27	0.00	-31.58	25.40	-1.24
Vietnam	32.26	0.00	12.81	18.32	0.70
Yemen	41.78	0.00	3.02	5.00	0.60
Zimbabwe	25.80	0.00	0.67	0.65	1.03

Table 0- 9: Fuel Specific Data Natural Gas

NATURAL GAS: country	Efficiency (%)	Production (Mtoe)	Total Primary Energy Supply (Mtoe)	Total Final Consumption (Mtoe)	TPES /TFC
Australia	39.58	44.74	27.02	13.00	2.08
Austria	46.77	1.46	7.75	4.72	1.64
Belgium	54.13	0.00	15.12	10.94	1.38
Canada	40.19	132.35	83.57	55.91	1.49

Chile	48.95	1.24	4.56	1.95	2.34
Czech Republic	21.87	0.15	7.21	5.68	1.27
Denmark	37.28	6.23	3.72	1.58	2.35
Estonia	30.71	0.00	0.50	0.20	2.50
Finland	47.24	0.00	3.36	1.00	3.36
France	29.24	0.51	37.03	27.61	1.34
Germany	44.72	10.89	69.58	51.17	1.36
Greece	50.15	0.01	3.97	1.47	2.70
Hungary	40.33	2.11	9.35	6.20	1.51
Iceland	0.00	0.00	0.00	0.00	-
Ireland	51.21	0.28	4.12	1.55	2.66
Israel	46.02	3.52	4.10	0.12	34.17
Italy	47.21	6.92	63.80	35.95	1.77
Japan	47.60	3.20	99.95	35.35	2.83
Luxembourg	46.79	0.00	1.03	0.61	1.69
Mexico	49.66	41.79	56.22	13.65	4.12
Netherlands	50.46	57.73	34.19	20.50	1.67
New Zealand	48.46	3.48	3.41	1.70	2.01
Norway	56.31	86.26	4.94	0.85	5.81
Poland	44.68	3.85	12.83	10.36	1.24
Portugal	46.65	0.00	4.46	1.64	2.72
Republic of Korea	49.88	0.41	41.58	21.57	1.93
Slovak Republic	41.17	0.10	4.64	3.32	1.40
Slovenia	41.27	0.00	0.74	0.58	1.28
Spain	57.23	0.05	28.98	14.59	1.99
Sweden	28.36	0.00	1.16	0.66	1.76
Switzerland	60.81	0.00	2.67	2.46	1.09
Turkey	50.38	0.63	36.78	17.67	2.08

United Kingdom	53.11	40.75	70.18	38.75	1.81
United States	47.37	530.91	568.73	326.79	1.74
Albania	0.00	0.01	0.01	0.00	6.00
Algeria	37.15	69.59	24.78	9.81	2.53
Angola	0.00	0.61	0.61	0.00	-
Azerbaijan	38.37	13.72	8.31	3.22	2.59
Bangladesh	37.41	16.61	11.61	6.89	1.69
Belarus	28.26	0.18	0.58	0.40	1.46
Benin	0.00	0.00	0.00	0.00	-
Bolivia	30.02	13.40	2.68	1.13	2.37
Bosnia and Herzegovina	28.09	0.00	0.23	0.16	1.38
Botswana	0.00	0.00	0.00	0.00	-
Brazil	43.59	14.16	22.89	12.74	1.80
Bulgaria	23.41	0.06	2.30	1.25	1.84
Cameroon	37.37	0.24	0.24	0.00	-
China, People's Republic of	38.90	85.91	107.75	71.46	1.51
Colombia	43.28	9.16	7.59	3.75	2.02
Congo	34.47	0.12	0.12	0.00	-
Costa Rica	0.00	0.00	0.00	0.00	-
Croatia	36.95	2.01	2.60	1.60	1.62
Cuba	39.98	0.80	0.80	0.39	2.07
Cyprus	0.00	0.00	0.00	0.00	-
Dominican Republic	39.99	0.00	0.78	0.00	-
Ecuador	44.49	0.37	0.37	0.00	-
Egypt	40.99	49.89	42.32	12.70	3.33
El Salvador	0.00	0.00	0.00	0.00	-
Ethiopia	0.00	0.00	0-00	0.00	-
Gabon	39.85	0.16	0.16	0.00	79.50

Georgia	46.26	0.00	1.51	0.96	1.58
Ghana	33.85	0.69	0.69	0.00	-
Guatemala	0.00	0.00	0.00	0,00	-
Haiti	0.00	0.00	0.00	0.00	-
Honduras	0.00	0.00	0.00	0.00	-
India	49.69	38.48	50.38	26.35	1.91
Indonesia	38.65	71.03	34.67	16.65	2.08
Iraq	60.74	5.01	5.01	0.24	21.03
Jamaica	0.00	0.00	0.00	0.00	-
Jordan	39.03	0.13	0.87	0.00	-
Kazakhstan	35.01	25.31	24.42	3.94	6.19
Kenya	0.00	0.00	1.97	2.84	0.69
Kuwait	35.01	11.05	13.88	3.12	4.45
Kyrgyzstan	23.80	0.02	0.28	0.08	3.31
Latvia	37.45	0.00	1.29	0.40	3.24
Lebanon	35.99	0.00	0.00	0.00	-
Lithuania	25.17	0.00	2.72	1.57	1.73
Macedonia	28.77	0.00	0.11	0.04	2.56
Malaysia	36.47	47.40	28.48	7.72	3.69
Malta	0.00	0.00	0.00	0.00	-
Moldova, Republic of	33.61	0.00	2.26	0.74	3.05
Mongolia	0.00	0.00	0.00	0.00	-
Morocco	52,62	0.05	0.71	0.05	14.24
Mozambique	24.57	2.81	0.13	0.12	1.06
Namibia	0.00	0.00	0.00	0.00	-
Nepal	0.00	0.00	0.00	0.00	-
Nigeria	40.01	29.21	8.03	1.35	5.94
Oman	27.67	26.10	18.04	10.43	1.73

Pakistan	37.17	26.94	26.94	19.73	1.37
Panama	0.00	0.00	0.00	0.00	-
Paraguay	0.00	0.00	0.00	0.00	-
Peru	32.91	11.76	6.45	1.42	4.53
Philippines	56.53	3.29	3.29	0.08	42.19
Qatar	41.04	134.52	28.96	5.21	5.56
Romania	29.12	8.66	11.10	7.02	1.58
Russian Federation	26.38	552.73	391.21	137.95	2.84
Saudi Arabia	31.42	70.04	25.64	0.00	-
Senegal	30.38	0.02	0.02	0.00	-
Singapore	45.22	0.00	8.06	1.24	6.52
South Africa	0.00	1.11	3.79	1.63	2.33
Sri Lanka	0.00	0.00	0.00	0.00	-
Sudan	0.00	0.00	0.00	0.00	-
Tajikistan	9.12	0.03	0.35	0.17	2.08
Tanzania, United Republic of	36.69	0.64	0.64	0.10	6.43
Thailand	47.83	21.99	30.78	5.82	5.29
Togo	0.00	0.00	0.00	0.00	-
Trinidad and Tobago	39.83	35.86	19.35	13.50	1.43
Tunisia	43.70	2.60	4.31	1.11	3.87
Ukraine	23.13	15.53	46.84	29.19	1.60
United Arab Emirates	34.05	43.83	52.31	27.07	1.93
Uruguay	41.18	0.00	0.07	0.05	1.42
Uzbekistan	28.19	51.19	41.89	25.13	1.67
Venezuela	33.15	23.95	25.96	14.04	1.85
Vietnam	49.10	7.45	7.45	0.45	16.51
Yemen	36.40	8.60	0.78	0.00	-
Zimbabwe	0.00	0.00	0.00	0.00	-

A4 World Bank Country Classification

The following classification by GNI per capita for the year 2011 is taken from the Homepage of the World Bank.

- Low income: $1,025 or less
- Lower middle income: $1,026 to $4,035
- Upper middle income: $4,036 to $12,475
- High income: $12,476 or more

Low- and middle-income economies are sometimes referred to as developing economies. The term is used for convenience; it is not intended to imply that all economies in the group are experiencing similar development or that other economies have reached a preferred or final stage of development. (World Bank 2012)

A5 OECD member countries in 2011

Australia	France	Korea	Slovenia
Austria	Germany	Luxembourg	Spain
Belgium	Greece	Mexico	Sweden
Canada	Hungary	Netherlands	Switzerland
Chile	Iceland	New Zealand	Turkey
Czech Republic	Ireland	Norway	United Kingdom
Denmark	Israel	Poland	United States
Estonia	Italy	Portugal	
Finland	Japan	Slovak Republic	

(OECD 2014a)

A6 Histograms by Transformation

The following Figures provide an overview of the possible transformations ***GDP*** (Figure 0-1) and ***GNI per capita*** (Figure 0-2) can undergo in order to increase normality of the data. In all the Figures, the transformation that creates the most normal distribution is the log transformation, displayed in the middle of the figures.

Figure 0-1: Histogram by Transformation GDP

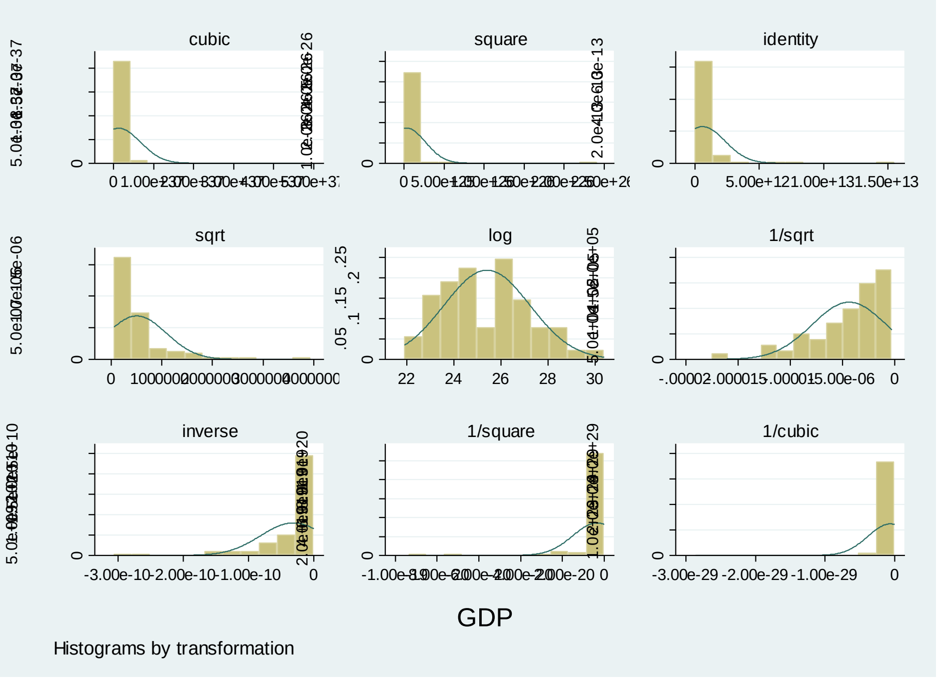
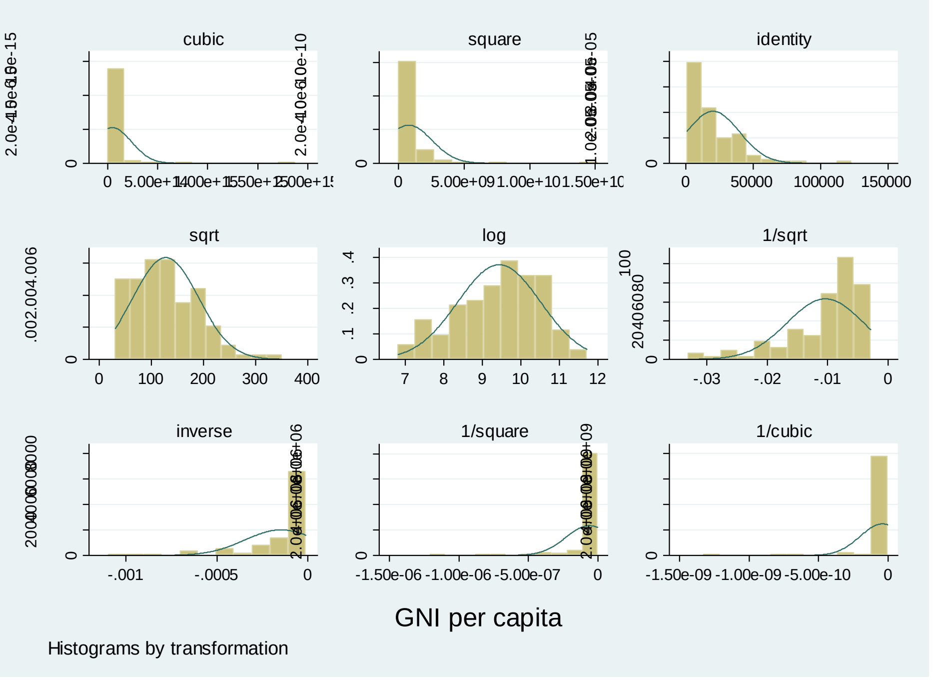


Figure 0-2: Histogram by Transformation GNI per capita



A7 Examining influential data

In the figures 0-3 till 0-6 that follow, no observations can be discovered that holds both, a high value for the leverage and high value for the residuals. Consequently the data samples do not contain observations that need further investigations, due to a superior influence on the data set.

Figure 0-3: Influential Data All Fuels

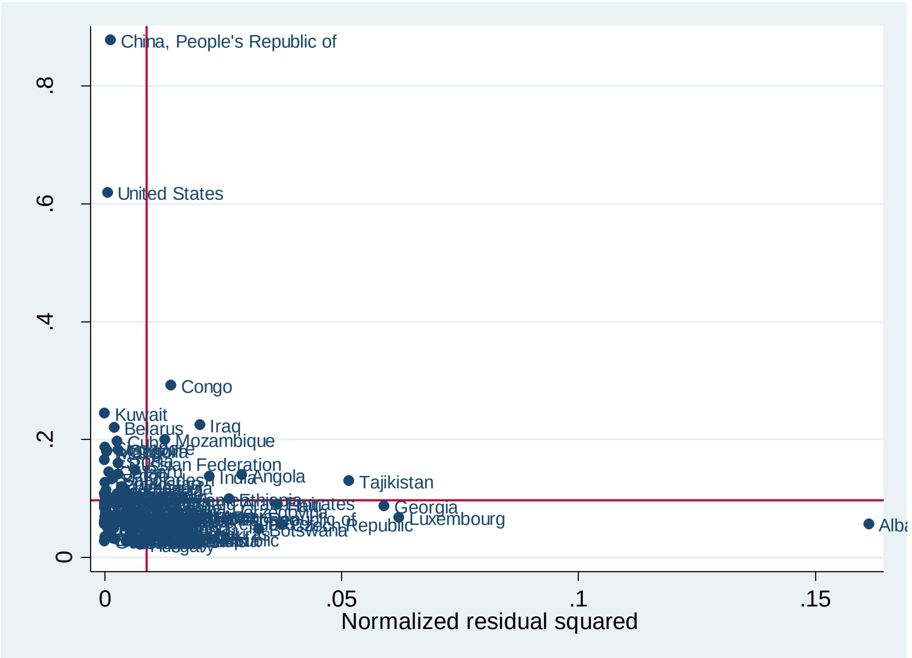


Figure 0-4: Influential Data Coal & Peat

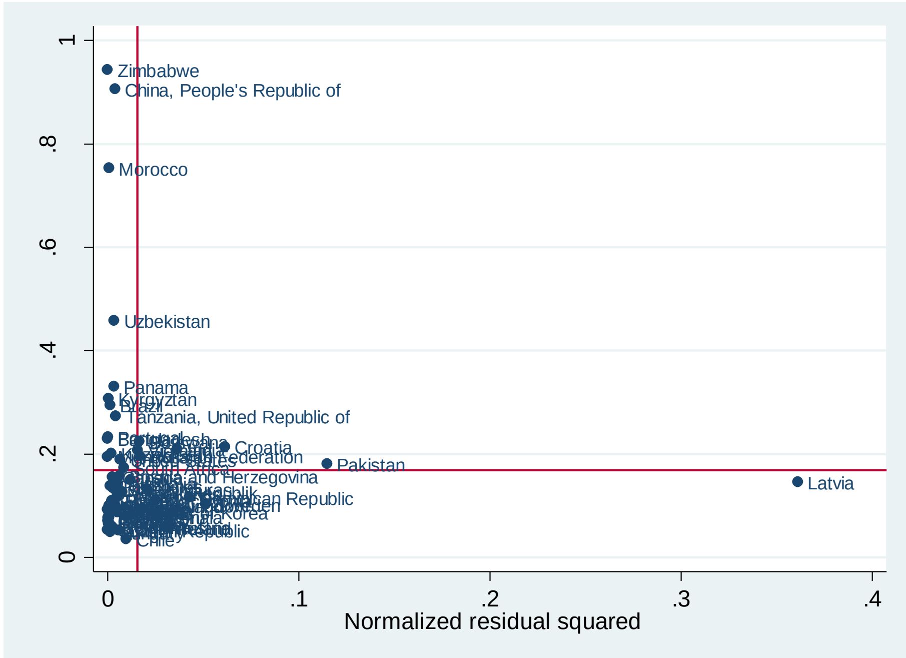


Figure 0-5: Influential Data Oil Products

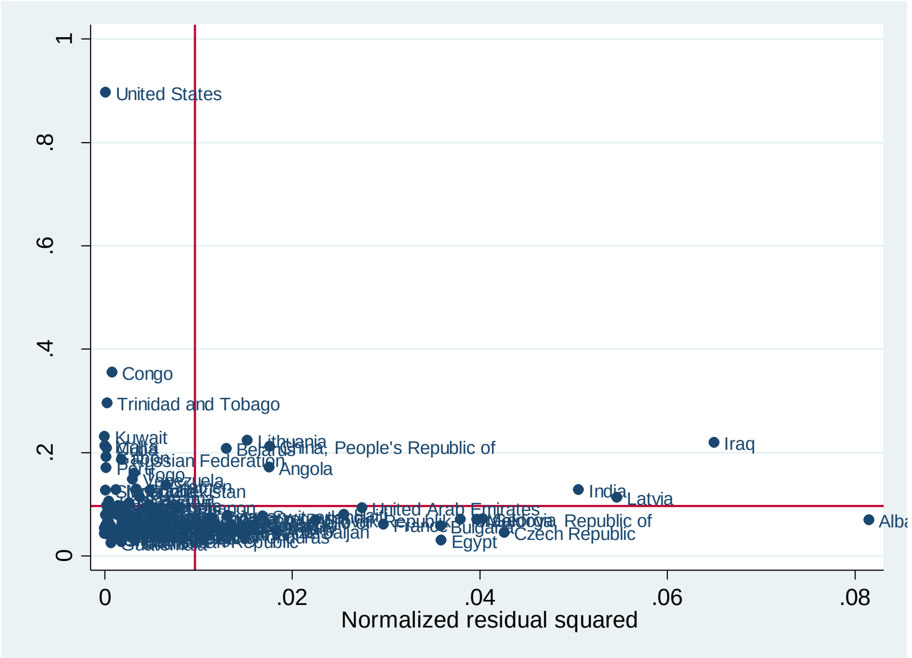
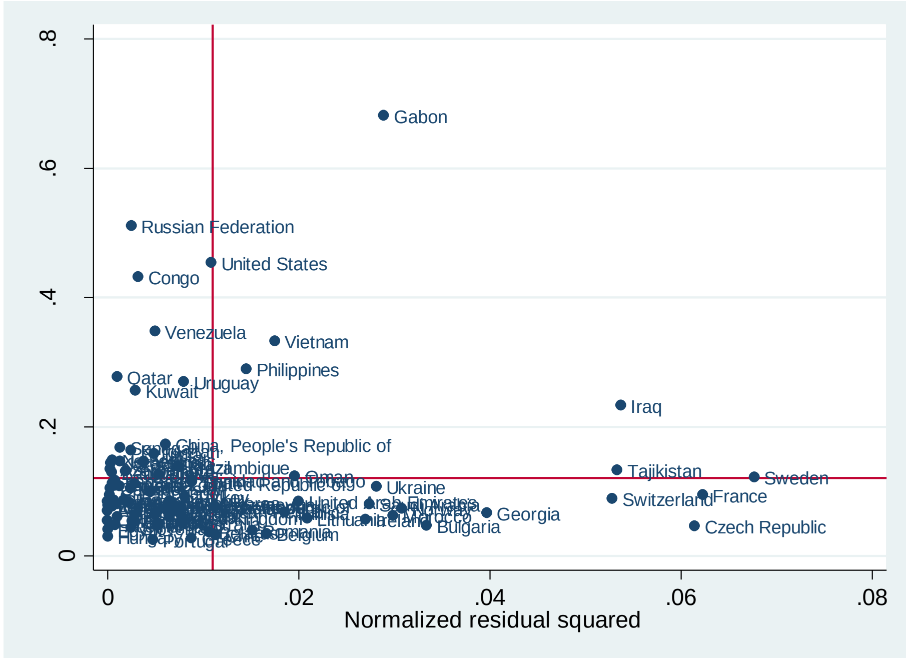


Figure 0-6: Influential Data Natural Gas



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Abstract

This thesis examines the power generation efficiency of fossil power plants among 116 countries, in order to identify country specific factors that do have an influence on efficiency. Thereby the fossil fuels are surveyed separately (coal & peat, oil products, and natural gas) and altogether (all fuels). First, a countries efficiency in electric power production is determined by the heat rate. Second, a multiple regression analysis is executed to discover the country specific factors that do have an influence on the efficiency. The results of the thesis indicate that if a power plant is using coal & peat, GDP and technology have a positive effect on efficiency. Moreover the fossil power plants that run with oil products, show that temperature, technology, and the OECD membership do have a positive effect on efficiency. In the case of natural gas as the fuel used for electric generation, only GDP has a positive effect on efficiency. Taking the fossil fuels used jointly into account, the result shows that GDP and temperature do have a positive effect on efficiency.

Abstract – German

Diese Arbeit untersucht den Einfluss von länderspezifischen Charakteristiken von insgesamt 116 Ländern auf die Effizienz von Fossilen Kraftwerken. Hierbei werden die Fossilen Energieträger Kohle & Torf, Erdölprodukte und Erdgas sowohl getrennt, als auch gemeinsam untersucht. Die Effizienz der Stromproduktion eines jeden Landes wird hierbei mithilfe der Heizleistung der fossilen Brennstoffe bestimmt. Diese fließt zusammen mit den länderspezifischen Charakteristiken eine multiple Regressionsanalyse ein, um so die Charakteristika zu bestimmen, welche einen direkten Einfluss auf die Effizienz der Stromerzeugung haben. Die Ergebnisse für Kohle & Torf zeigen, dass GDP und die Technologie einen positiven Einfluss auf die Effizienz haben. Bei Erdölprodukten zeigt sich, dass die Temperatur, die Technologie und die Mitgliedschaft in der OECD eine positive Auswirkung auf die Effizienz haben. Für Erdgas als fossilen Brennstoff zeigt sich jedoch, das lediglich GDP einen positiven Einfluss auf die Effizienz hat. Zuletzt zeigt sich, dass wenn man alle Fossilen Brennstoffe zusammen analysiert, GDP und die Temperatur einen positiven Einfluss auf die Effizienz haben.

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