ECONOMICS OF TOTAL ENERGY SCHEMES IN THE LIBERALISED EUROPEAN ENERGY MARKET

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A thesis submitted in partial fulfilment of the requirements of
Sheffield Hallam University
for the degree of
Doctor of Philosophy

November 2007

ABSTRACT

This thesis is concerned with the liberalisation of the European Energy markets and the affects this has had on total energy systems. The work concentrates on a number of case studies all of which are located in the area surrounding Gelsenkirchen – Bottrop - Gladbeck, the centre of the Ruhr region of Germany.

The thesis describes briefly how the legislation of the parliament of the extended European Union has been interpreted and enacted into German legislation and its affects on production, transport, sales and customers. Primarily the legislation has been enacted to reduce energy costs by having a competitive market while enabling security of supply. The legislation whose development has accelerated since 1999 can lead to negative effects and these have been highlighted for the case studies chosen.

The legislation and technological advances, each of them successful by themselves, do not provide the expected reduction of carbon dioxide emissions when applied to total energy system. The introduction of human behaviour as a missing link makes the problems evident and gives a theoretical basis to overcome these problems. The hypothesis is proven by eight detailed research projects and four concisely described ones.

The base of the research is the experience gained on approximately 1,000 operation years of the simplest total energy system, that of centralised heating. This experience is transferred to different solutions for total energy systems and their economics in combination with the changing legislation and observation of human behaviour.

The variety of topics of the case studies includes the production of heat by boiler, solar or combined heat and power and the use of fuel cells. Additionally the transfer of heat, at the place of demand is considered, either as an individual boiler in a building or as de-centralised district heating.

The various results of these projects come together in a final project which covers four different heating systems in identical buildings each with five apartments.

Based on the experience described a schematic of the energy system is developed demonstrating the interdependence of actors within energy systems, the energy system itself and the outer frame which includes legislation and the environment. In parallel a financial solution is proposed for a future carbon dioxide free heating and hot potable water supply.

To combine both systems a missing link that of human behaviour is introduced. This linkage requires changes of legislation which are described.

The solution proposed enables future energy consumption and in parallel the reduction of carbon dioxide emissions.

PREFACE

The work presented in this thesis was carried out between August 2001 and June 2007 at Sheffield Hallam University, School of Engineering/Faculty of Arts, Computing, Engineering and Sciences.

The work described is original to the best of my knowledge, excepted where reference has been made to others, and no part of it has been submitted for an award at any other College or University.

During the course of work, the following conference was attended:

- QRM 2002 4th International Conference on Quality, Reliability and Maintenance St Edmunds Hall University of Oxford, UK 21st – 22nd March 2002

During the course of work, the following presentations were given

- SHEFFIELD HALLAM UNIVERSITY, CITY WIDE ENERGY – GERMAN DEVELOPMENTS, SHEFFIELD, UK, 22ND OCTOBER 2002
- SHEFFIELD CO-OPERATIVE SOCIETY EDUCATION COUNCIL WEEKEND SCHOOL, LOW ENERGY HOUSES, TWO DIFFERENT EXAMPLES FROM GERMANY, WORTLEY HALL LABOUR COLLEGE, UK, 20TH OCTOBER 2002

The following paper relating to this work has been published

- Lampret, P. & Denman, M. 2002, 'Maintenance Starts with Planning', *Proceedings of* QRM 2002 4th International Conference on Quality, Reliability and Maintenance St Edmunds Hall University of Oxford, UK 21st – 22nd March 2002

ACKNOWLEDGEMENTS

First of all, I would like to thank my supervisors Dr. Malcolm J. Denman and Dr. Peter Foss for giving all the support required to write this thesis. Especially Dr. Denman's patience and creativity gave the chance to finish this thesis. He created insights into research projects and contacts which I never thought of before.

A special thanks is worth giving to Olive Denman who gave my family and myself the feeling of being welcome at any time. I like to state that my family and I found real friends.

Working fulltime, having a family with three children and writing a thesis can be achieved only with help and understanding of the team and the team spirit.

Together **E**verbody **A**chieves **M**ore

The destination of the holidays was fixed by the thesis. The sleeping room became a library and office. In the end the living room was also required and even when present I was absent for my family.

Thank you, Bärbel, Ricarda, Matthias and Verena for enabling me the chance to make a dream come true. I hope I can give a bit back to you what you gave to me.

Thanks to the team of School of Engineering and the understanding for a part time student.

Last but not least I would like to thank my parents who created the circumstances for this thesis by giving me the chance to attend grammar school and enabled my first degree at the university.

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NOMENCLATURE

Derivations of SI-Units

p	Density	kg/m³
H	Caloric Value	J/kgK
Q	Energy (Heat)	J
P	Power (mechanical or electrical)	W

Substances

C	Carbon
H_2	Hydrogen
CH_2	Methane
C_2H_6	Ethane
C_3H_8	Propane
O_2	Oxygen
CO_2	Carbon Dioxide
N_2	Nitrogen

Subscripts

0		Indication for Nominal Factor in Price Formulas
1, 2, …n		Amount of elements in substances
		Price Zone in Price Formulas
Basis		Indication for Nominal Factor in Price Formulas
el	electrical	in Combination with Capacity or Efficiency
th	thermal	in Combination with Capacity
total	total	in Combination with Efficiency
i	inferior	nett in Caloric Value
s	superior	gross in Caloric Value

Greek Symbols

Δ	delta	Symbol for Difference
η	eta	Efficiency

Currencies

£	British Pound
€	Euro
cent	Euro (€) cent (1/100 Euro)
DM	Deutsche Mark (German Mark) 1 € = 1.95583 DM

Abbreviations

AC	Alternating Current (mainly three-phase)
AP	**A**rbeits**p**reis = WP
CB	**C**ondensing **B**oiler
CH	**C**entralised **H**eating with Centralised Hot Water Supply, 4 pipe system
CHP	**C**ombined **H**eat and **P**ower
CHCP	**C**ombined **H**eat **C**old and **P**ower
CMM	**C**oal **M**ine **M**ethane
CP	Price for **C**apacity/**P**ower
CU	**C**entral **U**nit
DC	**D**irect **C**urrent
Delta N	Deviation of the Timely Year to Reference Heat Output
DF	**D**irect **F**ired Chiller
DSO	**D**istribution **S**ervice **O**peration (Company)
FC	**F**uel **C**ell
FOB	**F**ree **O**n **B**oard (prices for transportation)
FOP	**F**ree **O**ff **P**ower Station
GP	**G**rund**p**reis = CP
GTJ	**G**rad**t**agszahlen**J**ahr –Degree Days of Year
GVV	Regulation on general condition for the basic supply of household customers and substitute supply **V**erordnung über Allgemeine Bedingungen für die **G**rund**v**ersorgung von Haushaltskunden und die Ersatzversorgung (GVV)
H	Price for 1 hl **HEL**
HEL	Energy **H**eizöl **e**xtra **l**eicht (Light Fuel Oil) 1 hl HEL = 1,017 kWh H_i at 15°C
HM	**H**eat **M**eter
HT	**H**igh **T**ariff in Price Formulas
I	**I**nvestitionsgüterindex (Index for Investment Goods)
IF	**I**ndirect **F**ired Chiller
K	Price for 1 t SKE
L	**L**ohn = monthly salary
L 40	Name of Contract, Price for 1 kW_{el} = 40 DM
L 125	Name of Contract, Price for 1 kW_{el} = 125 DM
L 200	Name of Contract, Price for 1 kW_{el} = 200 DM
LM	**L**oad **M**anagement
LP	**L**eistungs**p**reis = CP
LPG	**L**iquid **P**etrol **G**as
LT	**L**ow **T**ariff in Price Formulas
LT	**L**ow **T**emperature **B**oiler
n	unspecified amount
NAV	Regulation on general condition for the connection to the grid and its use for electrical supply in low voltage **V**erordnung über Allgemeine Bedingungen für den Netz**a**nschluss und dessen Nutzung für die Elektrizitätsversorgung in **N**iederspannung (NAV)

NDAV	Regulation on general condition for the connection to the grid and its use for gas supply in low pressure **V**erordnung über Allgemeine Bedingungen für den **N**etzanschluss und dessen Nutzung für die Gasversorgung in **N**ieder**d**ruck
NEV	Regulation on fees for the access to grids **V**erordnung über die **E**ntgelte für den Zugang zu Versorgungs**n**etzen
NT	**N**ieder**t**arif = LT (Low Tariff)
NZV	Regulation on access to grids **V**erordnung über den Zugang zu **V**ersorgungs**n**etzen
OTC	**O**ver **t**he **C**ounter Business)
P	**P**rice for Capaity/Power = CP
P	**P**rice for Metering
PCS	**P**rocess **C**ontrol **S**ystem
PEC	**P**rime **E**nergy **C**onsumption
PEM	**P**olymer **M**embrane
QE	Input of Gas in H_s
QG	Output of Heat (overall)
QN	Standard Heat Output - Capacity
QWWB	Portion of Heat Output for Potable Water Supply
SKE	Energy **S**tein**K**ohle**E**inheit (StoneCoalUnit) 1 SKE = 8.141 MWh
ST	**S**atellite system, Centralised Heating, 2 Pipes with Separate Heat Exchangers
TOP	**T**ake **O**ver **P**oints
TP	**T**echnical **P**lanning Departmnet
TSO	**T**ransport **S**ervice **O**peration (Company)
VAT	**V**alue **A**dded **T**ax
VBS	**V**oll**b**enutzungs**s**tunden - Full Load Operation Time in Hours
VBS HZ	VBS for heating only
VP	**V**errechnungs**p**reis (Metering Price)
WE	**W**ohn**e**inheiten - Number of Apartments being supplied
WP	Price for Energy (**W**ork)
WWB	**W**arm**w**asser**b**ereitung - central potable water supply

1. Introduction

The year 1996 saw the start of liberalisation for the countries of the European Union (EU) with a new guideline which came into force in 1997. At that time energy was less expensive than today's, the border to East Europe had been open for almost ten years and the first war in the Gulf region almost forgotten. Most people were unsure of climate change and it was uncertain whether the Kyoto Protocol would be ratified.

New laws were discussed for developing new technologies to save energy, reducing the output of carbon dioxide and other gases which have negative impacts on the atmosphere and to enable the energy markets to increase competition.

As things developed the change of the climate became more obvious e.g. by flooding in the UK and in Germany in the world heritage landscape near Dresden[1], or at the German, Polish border (river Oder)[2]. Further extreme weather situations followed destroying the oil exploration on the US coast and the flooding of New Orleans. There were also unusual weather patterns such as the heavy snowfall in Ochtrop, Germany, which brought down the electricity pylons of the electrical supply network[3]. These have been indicators of climatic change but there is now a scientific consensus that the increase of greenhouse gases are leading to an overall increase of the average temperature of the world and an increase in extremes of weather.

As well as these changes there have also been changes in political circumstances, energy prices and economic development. In the OECD countries there is a dependence on energy imports. The dependency on energy imports and the effect on energy prices led to a political crisis, an example of this is the second Gulf War. Political changes in the developing nations, especially China and India have seen rapid industrialisation, expanding economic growth and an exponential rise in use of resources.

In 1999 European legislation opened the energy market for customers and suppliers. European guidelines had to be transferred into national law. The effect on the design of efficient plants such as combined heat, cold and power production (CHCP) and the plants themselves are part of the original aims of this thesis. The European Union extended, especially to the east and south east of Europe and these countries had to be accommodated. Many countries obtained exemptions to the guidelines. Additionally the number of Acts and guidelines which have an effect on energy prices, use of renewable energies such as solar, limitation of emissions were passed and changed in rapid succession.

The details of plants and the consumptions are taken from current laboratory and ongoing research projects. Research projects are known to have an influence on the behaviour of those taking part in the study. If this were to happen it would not be possible to transfer the results to comparable projects. To minimise these effects the users were informed of the project but not to the objectives.

The research objectives of this thesis are a study of operational CHP-, CHCP-plants; energy concepts for estates and shopping centres and energy supply for buildings.

Measurements are made with calibrated meters which are sufficient for billing according to German law. It is obvious these measurements cannot be as accurate as in a laboratory, but when it is sufficient and exact enough for billing it should be accurate enough to determine trends and to develop guidelines.

To enable international comparisons commercial calculations and prices are in Euro (€). The conversion rate from Euros to Pounds Sterling (£) used for calculations is:

1 € = £0.67734 £1 = 1.47636 €[4]

As a base topic it has to be proven that actions of the involved organisations, companies and individuals follow the way of least resistance as with electricity and water. This is the influence on the realisation of technical developments and concepts. Both supplier and customer have the same target, maximum profit but the effect is different. For suppliers maximum profit is achieved by high prices with minimum costs. This effect is strengthened by share holder value which became increasingly important. Annual dividend is the leading figure for the development of the value of shares for the company; on the other hand, the consumer is interested in minimum prices by which money can be saved for other purposes.

Last but not least, ways have to be found to reduce energy consumption to reduce the dependence on resources and to protect the environment.

This thesis elaborates on the effects of European legislation on national (German) legislation and the effect on the design of energy plants or the change of operation for existing ones. The effects are described, chronicled and proven by measurements. The objective is to develop proposals for changes in legislation in order to reduce carbon dioxide emissions and to elaborate ecological energy supply systems that will be acceptable to consumers.

We do not have the world as a heritage from our parents but we have borrowed it from our children.

CHAPTER 2

LEGISLATION IN GENERAL

2. Legislation in General

2.1 Introduction

This thesis is not a judicial one. The aim is to show how legislation is formulated, how it comes into force and to elaborate its influence onto other laws and Acts or to explain the interdependence. In a country different players are active. Legislation written for a specific purpose can have an effect on other areas even when no relationships in the regulations are obvious.

2.2 Europe

The European Parliament passes guidelines and resolutions. Apart from the aims these papers specify the date when the European guideline has to be changed into national law excluding exemptions negotiated by the member countries of the European Union (EU). The European guidelines and resolution can be taken from www.europe.eu, the official web site of the European Parliament. Referring to latest figures more than 84 % of German legislation is determined by European Guidelines and regulations.[5]

2.3 Germany

The basis of German legislation is the constitution (Grundgesetz) which came into force in May 1949. Since then 52 amendments have been passed and come into force, the latest one on 28th August 2006.

The constitution is divided into eleven chapters

1 Basic Rights
2 The Federation and the Länder
(11 until the reunification, 16 since then)
3 The Parliament
4 Federal Council
5 The President of the Federal Republic
6 The Government
7 The legislation of the Federation
8 The execution of Federal laws
9 The judgement
10 The financing area
11 Transition and concluding clauses

Table 2.1: The Chapters of the Constitution

An important amendment of the Constitution is amendment No. 50 dated 26th of July 2002. The protection of the necessary foundation for life became paragraph 20 a. The aim is to preserve resources for future generations. This new paragraph enables a strong argument for judgements to be used at court when the common interests are determined more important than individual ones.

In chapter 2 the influence that European legislation has on German law is described. Article 31, also part of chapter 2, states that the law of the Federal Republic breaks laws of the Länder countries (the provinces of Germany) which constitute the Federal Republic.

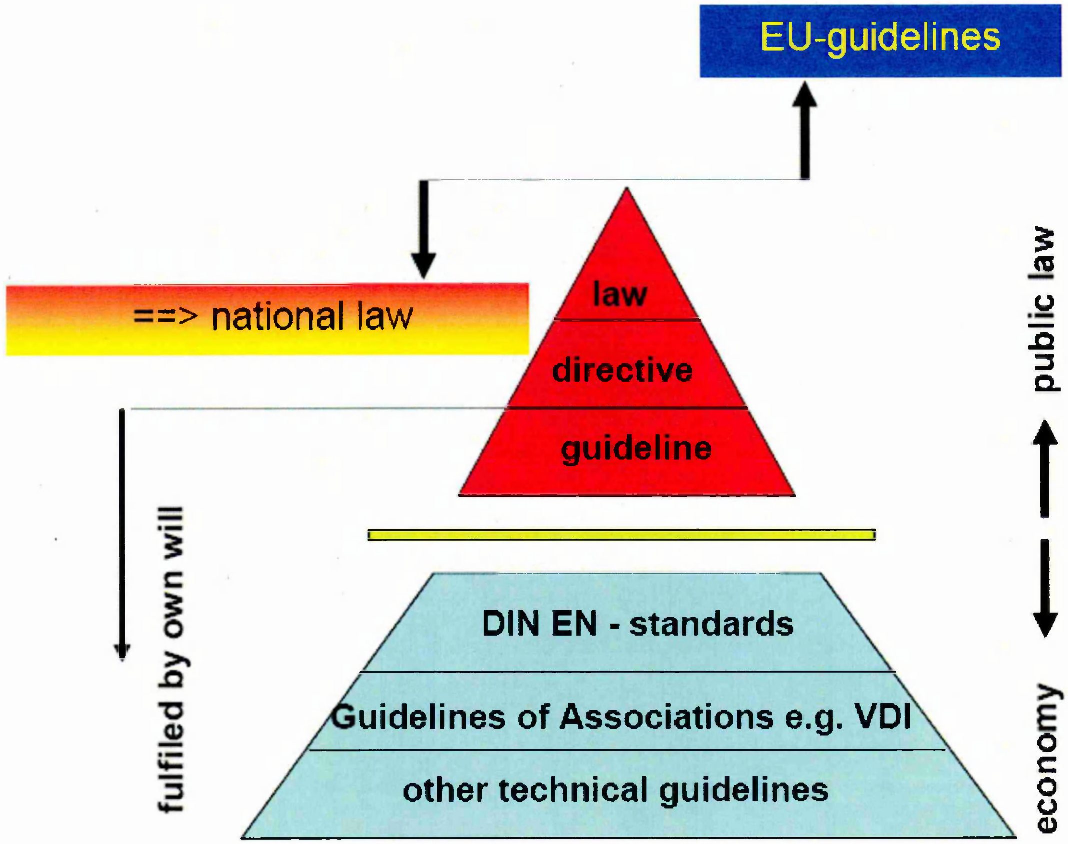
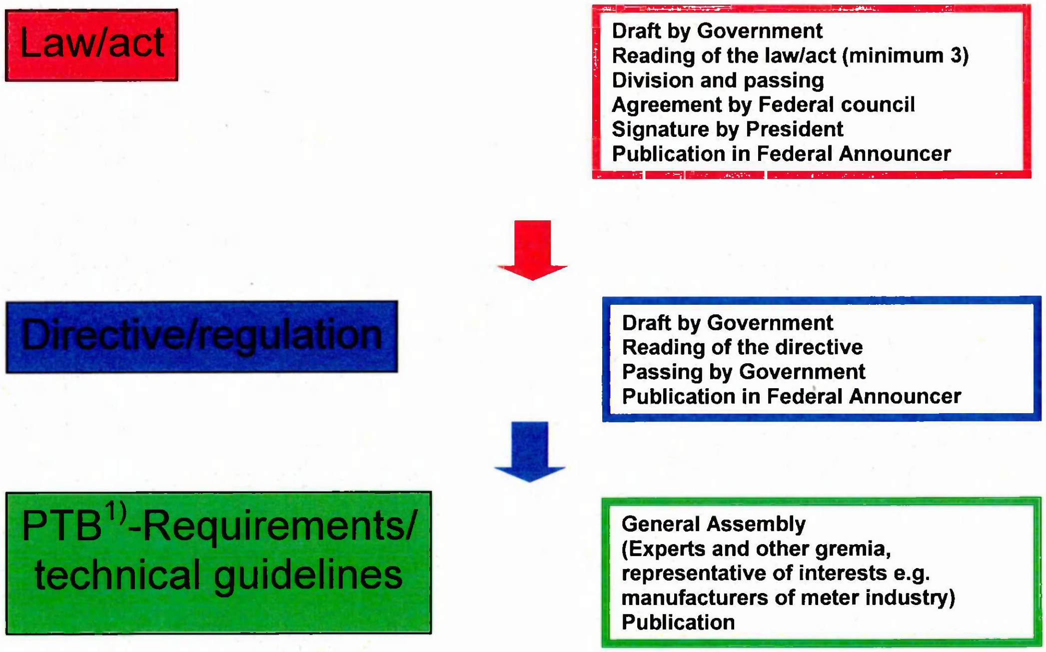


Figure 2.1: Hierarchical Structure of German Legislation

A simple model of German legislation is given in figure 2.1 which shows the hierarchical structure and the relationship between them. Figure 2.2 describes the method of law enactment as an example of how the Act is used. The project groups are formed to advise the permanent technical committees. Figure 2.3 shows the involvement in the legislation of one of the many associations (DVGW). The complete complex enforcement for legislation including readings in Parliament, negotiations between Parliament and the Länder, the signing off by the President of the Federal Republic is shown as a chart in the appendices (refer to electronic appendices 2.1 and 2.2). The following description shows the complex nature of the way laws are published.

Article 82 of the Constitution states that all laws have to be published in the Bundesgesetzblatt (Federal Law Gazette, Publication of federal laws and Acts). The name is also the internet address (www.bundesgesetzblatt.de). As a standard every law, Act etc. contains the date when it comes into force and if the date is not stated then it comes into force a fortnight after being published in the Bundesgesetzblatt.



[1] PTB **P**hysikalisch **T**echnische **B**undesanstalt
Federal Department for Physics and Technology

Figure 2.2: Calibration Act and its Way to Come into Force

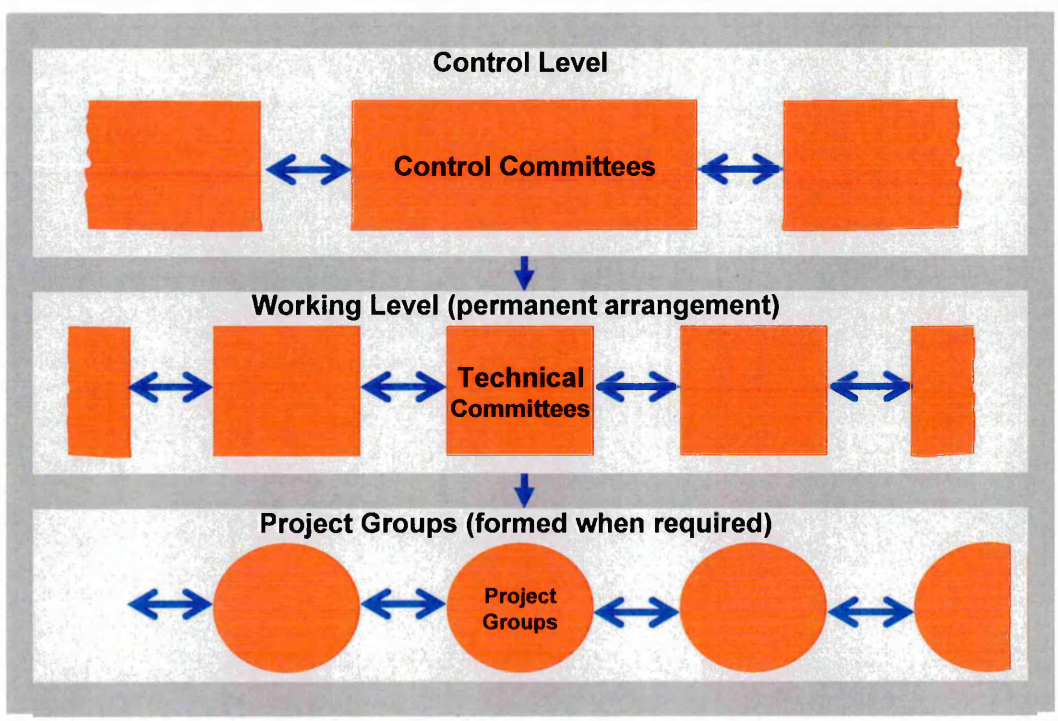


Figure 2.3: Structure of DVGW Committees

The advantage of the publication is that it contains the original text of the Act or regulation. A disadvantage is that only the amendments are published when a regulation is published and in force. Amendments are necessary even when only the responsibility for a law or even the name of a ministry has changed. The disadvantage of the Bundesgesetzblatt is obvious: Apart from the first publication a complete definitive regulation cannot be found in its entirety. This results in the Parliament having to support two internet addresses (www.staat-modern.de and www.Gesetzgebung.de) where the actual versions of regulations are published, but they do not give any guarantee of being free of mistakes. In addition to this the latest changes are not marked. As a consequence both sources are necessary for persons who have to deal with regulations.

As well as the Federal Laws each of the 16 Land can have its own legislation provided it is not in competition with the federal law. At a district level each town or village can pass directives or regulations. In consequence the working of a simple copy of a complex solution e.g. emergency power from one town into another town within one of the 16 Land is not guaranteed. It is even more difficult from Land to Land.

In accordance with the extended legislation a hierarchy of courts exists starting from a town and extending to districts and Länder. Even the themes of the courts are split; some will concentrate on work matters and others on administration etc. Gelsenkirchen, a town of approximately 270,000 residents has at the moment two courts for civil matters and another court for work matters.

The jurisdiction of these courts contributes to the legislation. It is to be borne in mind that in general the judgements of these lower courts are not transferable.

The main parties within the energy supply for estates referring to the legislation are the

- energy suppliers (production, transmission and sale)
- the owners of the supplied objects
- the users of the supplied objects

Laws, Acts and regulations control the actions within and between the groups.

CHAPTER 3

LEGISLATION ON ENERGY SUPPLY

3. Legislation on Energy supply

3.1 Introduction

The influence of the new legislation on energy supply can be split into the old, intermediate and new regimes. The old regime is the period between December 13th 1935 when the first Energy Industry Act ('Act for advancement of energy industry' in direct translation), in German Energiewirtschaftsgesetz (EnWG), came into force and remained almost unchanged until April 24th 1998 when the first change happened because of European legislation. The version of May 20th 2003 had just 19 articles to the amendments of 1998. The new regime started on July 7th 2005 with 118 articles (Electrical power and gas supply Act).

The different titles give the intention of the law. The law of 1935, the first Energy Industry Act, could be interpreted as either preparation for the impending war or as providing stabilisation for investments.

Article one of the latest Act describes the aims:

- priority given to safety and low price, friendly to consumers and the environment, with a grid connected supply for electricity and gas
- to ensure competition
- to fulfil European guidelines

3.2 The Old Regime

The old Act gave a monopoly for certain areas to one supplier. It was a vertical integrated energy supply as described in EnWG § 38. Production, transport and sales were in the hands of a single operator. Another Act controlled the use of public areas and streets for building a grid. A sole supplier had the rights for one kind of energy and by this the duty to connect all customers to this grid. The fees for the use of the public area were a function of the size of the town (number of inhabitants) and the amount of energy which was delivered to a customer. In large cities such as Munich, Berlin and Hamburg the fees were higher than in smaller towns or villages. Larger towns were more attractive to energy suppliers because the density of the grid was higher and by this the investment per kWh supplied into the grid was lower. In addition the fees for tariffs were higher than that of a negotiated supply. It is obvious that with such a kind of monopoly further Acts were required to protect the customers from the abuse of the monopoly holders. As a consequence, prices for tariffs had to be applied for from the authorities in the Länder.

The most important Acts relating to the old EnWG which are out of force now are given in Table 3.1 and the new ones in Table 3.2.

This vertical structure, see figure 3.1, enables a simple market and measuring structures. Contracts between the large national players e.g. RWE AG, VEBA AG and their supply city works were built up in the same way as the contracts between the city works and their customers which will be shown below in section 4.3.

Energy Industry Act ((1935, 2003 - 2005)
Energiewirtschaftsgesetz, EnWG
Regulation on General Conditions for the Supply of Electricity to General Customers
(1979 – 2006)
Verordnung über die Allgemeinen Bedingungen für die Elektrizitätsversorgung von Tarifkunden - AVBEltV
Regulation on General Conditions for the Supply of Gas to General Customers (1979 – 2006)
Verordnung über die Allgemeinen Bedingungen für die Gasversorgung von Tarifkunden - AVBGasV
Federal Regulation on Electricity Tariffs (19771, 1980, 1989, 2001-2005)
Bundestarifordnung Elektrizität, BTOElt
Agreement Among Associations on Third Party Access (2005)
Verbändevereinbarung

Table 3.1: Energy Industry Acts and Regulations out of Force.

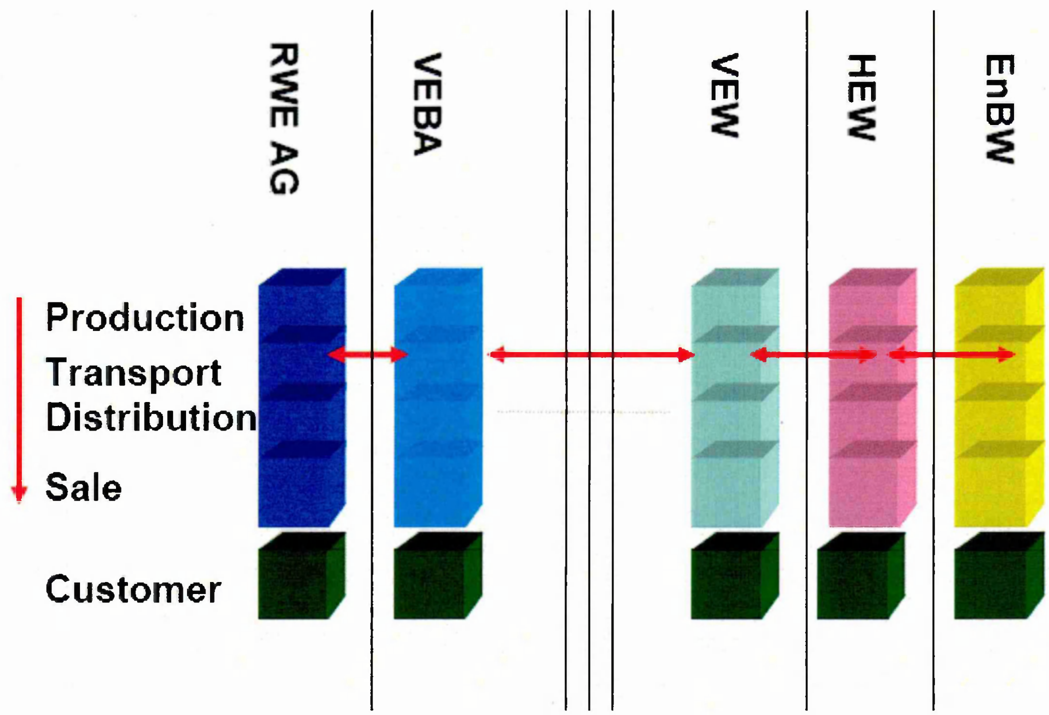


Figure 3.1: Vertical Structure of Energy Supply within the Old Regime

<u>3.3 The New Regime</u>

The new EnWG is divided into 10 parts. In consequence of the unbundling, the split into production, transport/distribution and sale, regulations had to be separated. Trusting to the success of competition the energy prices would not require regulation anymore. The grids are still a monopoly and in consequence a federal regulatory authority was founded.

The German Federal Net Agency was founded when telecommunication was liberalised in order to regulate the grid for telecommunication and mobile telecommunication. The experience and success with telecommunication and the reduction of fees was judged an advantage. This consideration led to an extension of the competence of the regulation authority when electricity and natural gas were later added. Further responsibilities are railway (tracks), mail, including electronic signature, and cable TV[6]. Water, waste water and district heating remained unregulated monopolies.

Energy Industry Act (2005)
Energiewirtschaftsgesetz, EnWG
Regulation on access to grids for supply with electrical power
Verordnung über den Zugang zu Elektrizitätsversorgungsnetzen (StromNZV)
Regulation on access to grids for supply with gas
Verordnung über den Zugang zu Gasversorgungsnetzen (GasNZV)
Regulation on fees for the access to grids for supply with electrical power
Verordnung über die Entgelte für den Zugang zu Elektrizitätsversorgungsnetzen (StromNEV)
Regulation on fees for the access to grids for supply with gas
Verordnung über die Entgelte für den Zugang zu Gasversorgungsnetzen (GasNEV)
Regulation on general condition for the connection to the grid and its use for electrical supply in low voltage
Verordnung über Allgemeine Bedingungen für den Netzanschluss und dessen Nutzung für die Elektrizitätsversorgung in Niederspannung (NAV)
Regulation on general condition for the connection to the grid and its use for gas supply in low pressure
Verordnung über Allgemeine Bedingungen für den Netzanschluss und dessen Nutzung für die Gasversorgung in Niederdruck (NDAV)
Regulation on general condition for the basic supply of household customers and substitute supply with electricity from the low voltage grid
Verordnung über Allgemeine Bedingungen für die Grundversorgung von Haushaltskunden und die Ersatzversorgung mit Elektrizität aus dem Niederspannungsnetz (StromGVV)
Regulation on general condition for the basic supply of household customers and substitute supply with gas from the low pressure grid
Verordnung über Allgemeine Bedingungen für die Grundversorgung von Haushaltskunden und die Ersatzversorgung mit Gas aus dem Niederdrucknetz (GasGVV)

Table 3.2: Energy Industry Acts and the Regulations in Force (2006)

1	Common Regulation	§§ 1 - 5
2	Unbundling	§§ 6 - 10
3	Regulation of operation of the grid	§§ 11 - 35
4	Energy supply to end consumer	§§ 36 - 42
5	Establishment for project procedure/ use of roads, streets etc.	§§ 43 - 48
6	Safety and reliability of energy supply	§§ 49 - 53
7	Authorities	§§ 54 - 64
8	Procedures	§§ 65 - 108
9	Further directions	§§ 109 - 111
10	Evaluation and final clauses	§§ 112 - 118

Table 3.3: Section Headings of EnWG

The regulations of the DVGW and VDE, the technical association for gas and electricity, are given in § 49 of the EnWG document. If they are fulfilled an energy plant will meet the technical requirements. These regulations are up-dated and improved regularly.

The old regulation on general conditions had to be split into sections for transmission and sales. AVB*Elt/Gas*V became NAV/NDAV for Distribution Service Operation (DSO) and *Strom/Gas*GVV for sales. The wording for the regulations was not complete when the EnWG document came into force. As a solution a transition period was defined for the change from old to new after the new regulations came into force (6 months).

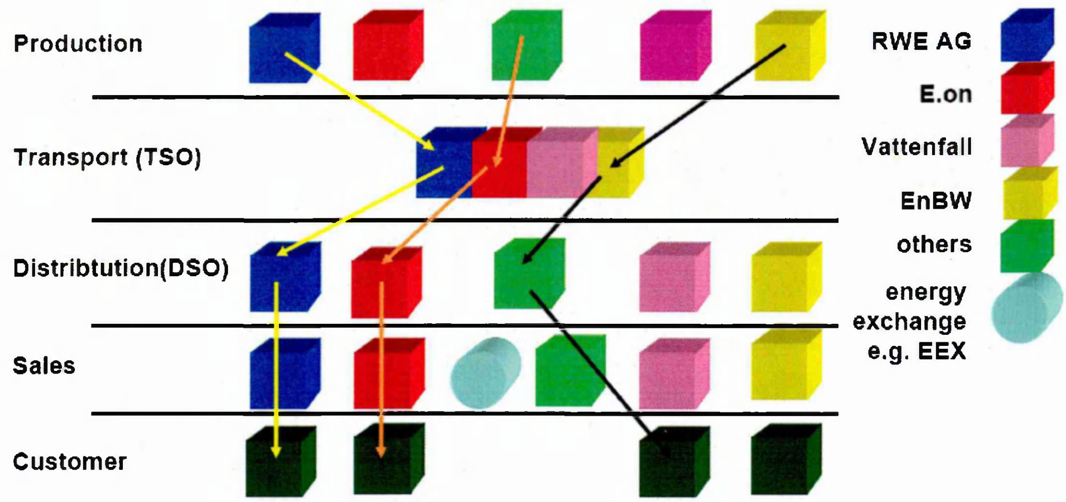


Figure 3.2: Horizontal Distribution New Regime - Physical Flow of Electricity

3.3.1 NAV/NDAV

Low pressure gas and low voltage electricity are not specified in the regulations. A small but important difference in wording can be found in the definition for the connection to the grids. For electricity the connection to the low voltage grid is determined. For gas the fact that the customer is supplied in low pressure is authoritative and not the pressure of the grid. An industrial customer being connected to the high pressure grid falls within the same regulation as a small customer like a household if the pressure control device reduces the pressure below 100 mbar at the take over point. Vis-a-vis: a small customer with a higher pressure than 100 mbar at the take over point loses the protection of the new legislation. In many cases the gas pressure reducer and metering station belongs to the supplier. In consequence almost all gas customers fall within the regulations which should protect small customers. Within the three towns supplied by ELE Emscher Lippe Energie GmbH with natural gas less then 10 customers are not within this regulation. The wording for the legislation on electricity excludes all large customers by their connection to the medium or high voltage grid.

The definition of tariff and Small and Medium Size Customers no longer exists.

The supplier liability became worse for the company in charge of distribution, service and operation of a grid (DSO). In the past the liability of the companies was limited to grossly negligent actions or mistakes of the employees by which the supply was interrupted or equipment of the customer was damaged. With the new legislation the companies are liable for careless actions or mistakes.

The DSO is in general responsible to the customer for the interruption of supply. Even when third parties not working for the supplier cause damage to the supplier's network destroying cables or pipes, the DSO is the company to be contacted by the customers and the company which has to pay the compensation. The DSO has to try to recover the payment for repair of the grid plus the extra money to compensate the damages to the customers. This is especially true when continuous production processes are interrupted, e.g. glass, paper or steel industry or research projects, where the compensation can be considerable. In the case of substantial damages, the companies responsible for causing the damages may resort to bankruptcy before they are taken to court. In this way they can inaugurate a new company. In cases such as this the TSO/DSO can carry the burden of the costs.

In the summer of 2004 an excavator destroyed a 110 kV main cable of the city of Gelsenkirchen which was switched off for maintenance. The cable was covered by concrete slabs and marked as a high voltage cable. Within seconds the substitute cable was also destroyed. Parts of the southern city were without electricity for 4 hours. The driver closed the hole and drove 500 m further on. He rejected all responsibility even when large copper burns were obvious on the shovel. Many claims for damages were made. One of them was the control of the large screen in the ArenaAufSchalke (Arena Gelsenkirchen during the football world championship 2006). The damage was 20,000 €.
The company which caused the damage resorted to bankruptcy within three months. In April 2007 the first sentence was delivered and the company, which does not exist anymore, was guilty.

Such cases were not foreseen by the new legislation and a revision is expected.

3.3.2 GVV

The headline of the regulation for gas may lead to a misunderstanding. The text of the headline determines the connection to the low pressure grid. To the contrary the paragraph is in accordance with NDAV: The customer is supplied with low pressure not the pressure of the grid but the pressure at the take over point is used.

For electricity this misunderstanding does not occur: The voltage at the connection to the grid is used.

A basic supplier for each grid of a DSO is defined. The basic supplier is automatically the supplier when energy is taken from the grid and no other supplier is named. In addition the basic supplier takes over the customers of bankrupted suppliers as long the consumers have no other supplier.

Compared to the old regulation the curtailment of supply is much more difficult. When a customer does not pay an outstanding bill a reminder is sent. In the past it depended on previous circumstances as to how long the supplier waited until the energy supply was cut or whether the customer received a second reminder. It was common practice to have a red list of customers who were unwilling to pay and they were disconnected from the grid in advance (no second reminder). In the new situation the reminder continued to be used. It had to give the customer a period of 4 weeks before disconnection. The customer had to be again notified before the disconnection was made. As a consequence there were additional charges on the outstanding money. Due to the unbundling of the DSO and sales the DSO has to be informed about the planned disconnection in parallel with the customer.

Parallel to NAV/NDAV the definition of tariff and small and medium size customers does not exist anymore. Customers for electricity are split into household and non household customers. The non-domestic customers are split into groups of less than 10,000 kWh per year and more than 10,000 kWh per year.

3.3.3 NEV/NZV

These four regulations, two each for electricity and natural gas, were not necessary in the past within the vertical integrated energy supply. Different grid operators and different suppliers are now possible and they need a legal framework to operate within. Points for discussion are the fee structure and the cost of connection to the grid when somebody wants to deliver energy into the grid, as in the case of electrical power from renewable energy plants such as photo voltaic or bio-methane into the gas grid.

Electricity is a synthetic product and has the advantage of having to meet stringent requirements such as voltage, frequency etc.

Natural gas is a product extracted from the earth's crust and is in competition with other energies in the heat market. As a natural product it is competitive with other fuels. Work sheet DVGW G 260 describes different gas groups; Work sheet DVGW G 262 contains regulations on gas from biomass. Work sheet DVGW G 685 requires that within a billing period the energy content (H_s) value may change only by a maximum of 2 % around the average value. The billing period for industrial customers can be one month, for domestic customers it is in general one year. In the case of large cities the billing year is rolling because all meters cannot be read within a month. The flow (consumption) of gas varies throughout the year.

A study of biogas published in January 2006 (see Electronic Appendices 3_02) coined the expression bio-methane. Under the precondition of constant flows for natural gas and bio-methane or constant mixing ratio for both gases with different, (but constant), energy contents then the requirement of G 685 would be fulfilled. Bio-methane plants produce a constant flow. The flow in the grid is varying during the day and throughout the year. In consequence the mixture of both gases is varying if the above preconditions are not fulfilled. To assure that the complete amount of bio-methane can be input into the grid the bio-methane has to meet the current values (energy content etc.) of natural gas otherwise the requirements for measuring and billing would not be met. Research is being undertaken by the GasWärmeInstitut (GWI) Essen, Germany to solve this problem.

In general the common production of electricity and input into the grid is the responsibility of the DSO while electricity from CHP-plants and renewable energy are input into the low or medium voltage grid. The take over points between DSO and TSO are sub stations. The DSO has to pay fees for the use of the TSO grid. These fees are incorporated into the fees of the DSO. The fees consist of a price for power and a price for the maximum peak. It can happen that at some sub station the flow of electricity is the opposite – from the medium to the high voltage grid. This can happen when the previously mentioned plants produce more electricity than the customers being connected to the grid consume. The StromNEV gives the Transport Service Operation (TSO) companies the opportunity to calculate the peak of electrical consumption in different ways. In the past the supplied area of a DSO was integrated and was treated like one take over point with one peak.

Now each take over point (sub-station) can be treated by itself. It is unlikely that the peaks at all sub-stations happen at the same time. In consequence the sum of the peak of the single sub-stations will be higher than the integrated peak.

The maximum load of the grid, in the past the integral plus the electricity produced in the grid area of each DSO, is reduced to a statistical figure that now has no relation to the payment.

This problem can be alleviated by the input of renewable energy into the grid which is demonstrated by an example with two sub-stations:

Time 1 (maximum at sub station 1):

Sub-station one:	flow high to low	10 MVA
Sub-station two:	flow low to high	5 MVA

Time 2 (at maximum load in the grid):

Sub-station one:	flow high to low	5 MVA
Sub-station two:	flow high to low	8 MVA

Time 3 (maximum at sub station 2):

Sub-station one:	flow high to low	3 MVA
Sub-station two:	flow low to high	9 MVA

Integrated peak:	13 MVA	(Time 2:	5 plus 8 MVA)
Single view:	19 MVA	(Times 1 and 3:	10 plus 9 MVA)

Apart from their own peak the peak in the grid of the TSO is used to determine the fees to be paid. This peak is not known to the DSO during the present year. It is calculated within the first months of the following year.

3.4 Further Acts Referring to Energy Matters

The EnWG provides the framework for unbundling of the energy market (Table 3.4). Taxation and pricing for energy as well as the energy changes with renewable energies such as solar, biomass or the technologies to develop them are described in further Acts, laws etc. Overall the common legislation with the Civil Code (Bürgerliches Gesetz-buch) and many other Acts provide a framework. The energy market is just a section with more regulations than exceptions.

Referring to Figure 3.2 the physical flow of electricity obeys the laws of nature. The artificial separation into different companies plus the additional responsibility for the different taxes and levies requires more administration. Administration is not free of charge. This is in contradiction with the intention of the New Energy Industry Act which was to enable lower prices. Figure 3.3 describes the various pathways for the flow of money from the customer to the producer. Figure 3.4 shows the flow for the various portions of the customer's price.

Act Against Restraints of Competition (2005)
Gesetz gegen Wettbewerbbeschränkung, GWB
Act Against Unfair Trade Practices
Gesetz gegen den unlauteren Wettbewerb, UWG
Rebate Act
Rabattgesetz
Regulation on General Conditions for the Supply of Heat to General Customers
Verordnung über die Allgemeinen Bedingungen für die Fernwärmeversorgung von Tarifkunden (AVBFernwärmeV)
Regulation on General Conditions for the Supply of Water to General Customers
Verordnung über die Allgemeinen Bedingungen für die Wasserversorgung von Tarifkunden (AVBWasserV)
Renewable Energy (Sources)Act
Gesetz für den Vorrang Erneuerbarer Energien (EEG)
Combined Heat and Power Act
Kraft-wärme-Kopplungsgesetz (KWK-G)
Electricity Tax Act
Stromsteuergesetz (StromStG)
Energy Tax Act
Energiesteuergesetz, EnStG (2006)
Act on Greenhouse Gas Emission Trading
Treibhausgas-Emissionshandelsgesetz (TEHG)
Allocation Act
Zuteilungsgesetz (ZuG)
Saving of Energy in Buildings Act
Gesetz zur Einsparung von Energie in Gebäuden (EnEG)
Act on start of ecological reformation of taxes
Gesetz zum einstieg in die ökologische Steuerreform
Civil Code
Bürgerliches Gesetzbuch

Table 3.4: Acts and Laws Referring to Energy Market

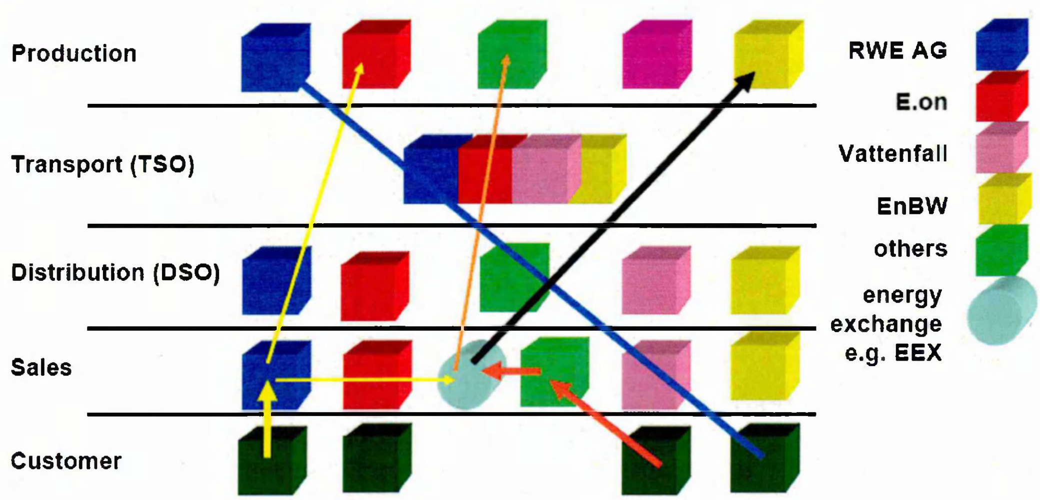


Figure 3.3: Horizontal Distribution New Regime - Flow of Money for Energy only (no Taxes, Levies or Fees)

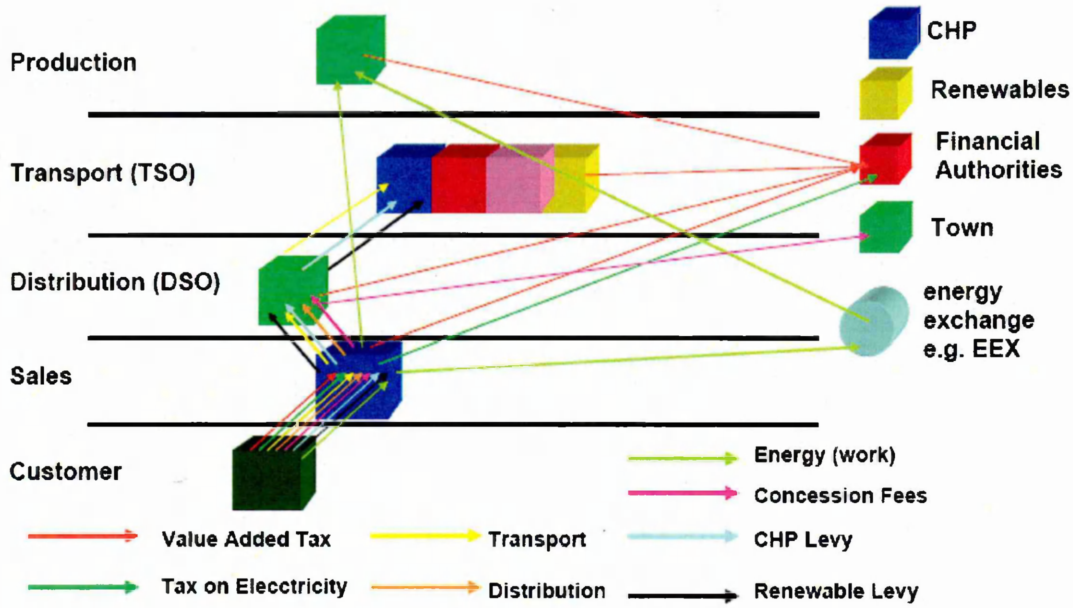


Figure 3.4: Horizontal Distribution New Regime – Distribution of Sales Price Including Taxes, Levies and Fees

3.5 Missing Links and Ambiguities

These legal regulations are the responsibility of different ministries. Even if the Acts are passed in the same Parliament sometimes nobody seems to notice that terms do not fit.

Example 1:
Combined Heat and Power Act in combination with other laws and Acts relating to CHP-plants.
Responsibility: Ministry of Economics and Technology (§ 10)

Purpose of the Act ref. to § 1 sentence 1

Reduction of CO_2 emissions
limited (in time) protection of CHP-process with the effects of modernisation of old plants,
more, smaller CHP-plants, to enable fuel cells to get into the market

The reduction of CO_2-emissions is also described in

Act on Greenhouse Gas Emission Trading
Renewable Energy (Sources) Act

which is both the responsibility of the Ministry for Environment, Nature Conservation and Nuclear Safety.

Application of the Act ref. to § 2

> The taking up and compensation from electrical power produced in CHP-plants naming the input energy and the disconnection to Renewable Energy Act (Electrical Power being paid in accordance to the Renewable Energy Act is excluded).

Definition of the Act ref. to § 3

> CHP is the change of energy input into electrical power and heat at the same time.
> The type of CHP processes are listed.

In § 4 of Renewable Energy Act a direct link to the Combined Heat and Power Act is given.

The former taxation Act of mineral oil which includes gas also had as a definition for CHP:

> CHP is the change of energy input into mechanical power and heat at the same time

This definition is used for the new Energy Taxation Act. The Ministry of Finance has responsibility for the old and new Acts.

The consequence is simply described.
ELE as an operator of a fuel cell filed an application with the authorities in charge, the customs authority in Dortmund. The application was rejected for the reason that a fuel cell is not a CHP-plant according to the Act. A response letter was written arguing that laws which are younger than the taxation Act for mineral oils have a new definition and should take effect. A proposal given by the responsible person: ELE could try to go to law. ELE contacted other operators of fuel cells and the association of fuel cell operators and learned that they had no problems with their local customs authorities. But ELE was requested not to go to law. As a solution letters were sent to the three responsible ministries of the aforementioned Acts

Ministry of Economics and Technology
Ministry for Environment, Nature Conservation and Nuclear Safety
Ministry of Finance

explaining the situation and asking for an unequivocal definition of CHP and a comment for ELE's situation. The result was:

- The two first mentioned ministries did not confirm the receipt of the letters (no reaction).
- The reaction of the Ministry of Finance was a telephone call to the secretary (without leaving a telephone number) and the oral advice to go to law and to contact the Federal Office for Public Control of Finance.

Time solved the problem: the responsible person at the customs retired early and the new responsible person gave the tax refund. The new Energy Taxation Act still has the definition with mechanical energy.

§ 5 names CHP-plants which do not receive a surcharge meaning extra money beside the price for electricity and saved fees for the grid. In the case when a new

CHP-plant supplies an estate or building which was supplied with district heating produced in CHP-process before the new plant receives no surcharge.

Another situation was when clerks of the responsible authorities had difficulties in understanding the Acts and laws or mixing them up.
The Federal Office for Economy and Supervision of Exports (**B**undes**a**mt **f**ür Wirtschaft und **A**usfuhrkontrolle (BAFA) is responsible for the application of CHP-plants. In 2006 the author contacted the BAFA by telephone because of the CHP-plant of the new ZOOM adventure world in Gelsenkirchen. The abbreviation for CHP-Act in Germany is KWK-G. The author was asked to contact the Ministry of Defence. Even when the function of the CHP-plant was described the clerk insisted on contacting the Ministry of Defence. Explaining that the ZOOM does not intend to export the CHP-plant gave some clearance. KWK-G is used in German legislation in the same federal office in two ways:

Kraft-**W**ärme-**K**opplungs-**G**esetz	(Combined Heat and Power Act)
Kriegs**w**affen-**K**ontroll-**G**esetz	(Supervision of Weapons for War Act)

In a hidden way the Act involves an association: Working Community for District Heating (AGFW Arbeitsgemeinschaft für Fernwärme e.V.). The Community belongs to the Association of Electrical Economy Verband der Elektrizitätswirtschaft e.V. The working sheet FW 308 is the basis for the calculation of the amount of electrical power being produced in a CHP-process.

The influence of the producers of electrical power can be estimated.

Example 2
Act on Greenhouse Gas Emission Trading, Allocation Act and their regulations

Responsibility:
Ministry for Environment, Nature Conservation and Nuclear Safety
German authority for emission trading (**D**eutsche **E**missions**h**andels**st**elle (DEHSt))
(www.dehst.de)

In Germany emission of greenhouse gas means the gases according to the Kyoto-protocol but in practice trading means CO_2-emission and is restricted to plants in which energy input is higher than 20 MW. These plants need a permit of operation in accordance with to the Federal Act on Protection from Immissions* (Bundesimmissionsschutzgesetz). All plants are listed.

Approximately 60 % of emissions are produced by the plants of 5 companies[7]. They are mainly power stations. Here the connection with liberalisation is made. The customer or consumer pays the price for the CO_2-emissions of the electricity produced.

The producer has to produce at least 60 % of the allocated emissions otherwise the certificates are taken away, especially if production is reduced. This does not happen in the case when efforts to reduce the emission are undertaken.

* In the German language there is a difference between emissions and immissions. Emissions is used to describe discharge from a stack, but immissions is used to describe the effect on the ground where they fall.

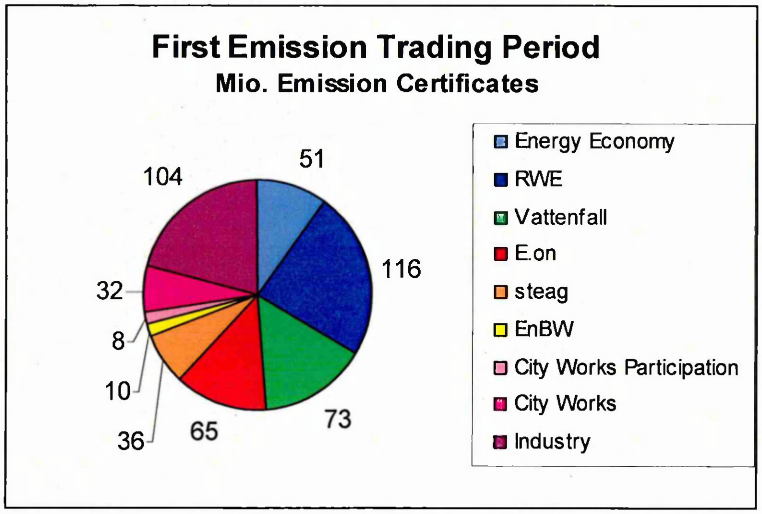


Figure 3.5: First Emission Period (2005 – 2007), Distribution of Certificates

In the papers for calculating the CO_2-emission the main fuel and their figures are given. Unfortunately today the figures for Norwegian natural gas which is number 2 after Russian Gas in Germany are still missing in the tables.

A monitoring report has to be established and every year a report has to be elaborated and certificated by an expert with legal approval.

ELE has a CHP-plant for supplying an estate with district heating. Since ELE is a supplier of electrical energy, the plant can be used to cut the peak for electricity with the target to reduce the fees for the grid. Because of this part of the heat which cannot be consumed by the customers is sent to the cooling towers. Since the price for electricity was low compared to the price of natural gas the production of electricity (peak shaving) was reduced. ELE sent a letter to DEHSt to clear the definition of production – heat or electricity. The answer was not unequivocal.

In consequence emissions were produced to make sure that certificates are not taken away (further details see chapter 7.6).

Example 3:
Saving of Energy in Buildings Act
Responsibility:

Ministry of Economics and Labour plus (now split into Ministry of Economics and Technology plus Ministry of Labour and Social Affairs)
Ministry of Transport, Building and Urban Development

This law was established at the end of the 1970s as a consequence of the first energy crisis when OPEC stopped their production and driving was prohibited in Germany on Sundays.

Several regulations passed Parliament with the Act as a basis.

The latest change passed Parliament in July 2007. Buildings need an energy certificate. The energy certificate gives a indication of the energy consumption of a building. It does not give the right to go to law in cases where the figures of the energy certificate do not meet the actual consumption.

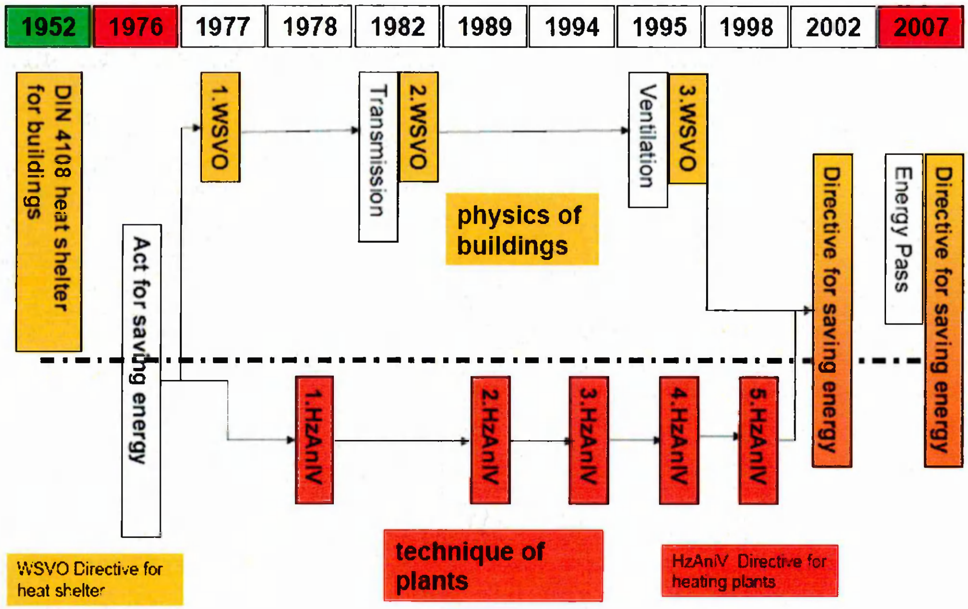


Figure 3.6: Development of Regulation on Saving Energy

Figure 3.4 describes the parallelism of two regulations until they were unified in one. In the past the structure of a building and its heating system were handled separately. With the Regulation on Energy Saving the architect or the constructor receives the chance to decide whether money is put into insulation or technology for heating e.g. solar device or CHP.

In 1989 the regulation concerning distribution of costs for heating and production of warm potable water came into in force and still remains unchanged. This distribution is required when a house has two or more apartments. In the case of just two, if the owner lives in one of them, the owner is relieved of this duty. The target was a saving of 18 % of energy. The costs consist of costs for energy, maintenance, operation, billing and with the permission of the tenants the rent for the distribution system. The costs of repair are not allowed to be included. Between 50 to 70 % is distributed in accordance with the consumption, the rest of 30 to 50 % in accordance with the heated housing space based on floor area or volume. In Germany 50 % of the surface of a balcony is included in the contracts as rented housing space. This space is not heated. The distribution is done by specialised companies. They sell their meters to the customers in combination with a contract for the reading of the meters and the distribution of the costs. In many cases the meters are rented by the owners of the houses. (In this case the tenants have to be informed about the amount of the rent and the right to refuse renting within 4 weeks. If more than 50 % of the tenants vote against renting within 4 weeks of being informed the owner of the house has to buy the meters.) The result of the distribution of costs is given to the owner of the building who will charge the tenants.

In cases where there are no meters for proportioning the energy into energy for heating and energy for warm water some method of measurement has to be installed. The simplest method is to have two separate heat counters behind the boiler. Heat counters have to be changed in accordance with German legislation every five years. In times of low energy costs this was too expensive. Warm water counters in the apartments is a legal alternative if the first method is impossible. The formula to calculate the amount of energy is given in the regulation. Another method is a warm water counter behind the storage tank. When there are separate circulation pipes this does not work. The last alternative for central measuring is a cold water counter on the entry side of the storage tank. In cases where no measurement device is installed 18% of the total energy costs are the legal limitation for the part of energy for warm water production. This figure has been unchanged since 1989 – even when the ministry in charge reduce the amount for heating.

In general the owners of buildings determine the energy and the heating system (see Civil Code). They cannot change the systems without permission of the tenants.
In contrast to central systems for decentralised or individual systems the billing is done by the supplier. In this case 100% of the consumption is charged. This is a deviation from central systems where a minimum 30 % has to be charged in accordance with the heated space.

In cases where a customer does not pay the bill, the connection to the grid can be interrupted by the supplier. This can be done by disassembling the meter or blocking and sealing the entry valve. The system has to be checked before it is connected to the grid again (installing a new meter or taking the seal away). This inspection will be charged for. If the customer is a tenant, the owner of the house cannot be informed by the supplier about the interruption. The reason is the Safety of Data Act. The interruption could cause damage to the property of the owner. It could be worse if this is done during wintertime as condensation and mould could cause damage to the walls.

3.6 Relationship between Owner and Tenant

Apart from the legislation which has a direct influence to transformation, transport and sale of energy there are additional Acts that can have an indirect influence. Table 3.5 shows relevant Acts and laws referring to the residential area. In the case when a law/Act/regulation is already mentioned above, it is written in capital letters.

Different ministries are involved in this legislation. A list of the present ministries is in the electronic appendices. The name and the responsibility can change depending on the government.

The Acts mentioned and regulations describe the relation between tenant and owner. Saving energy for heating houses has an impact on the operators of the grids. Fewer fees due to less transport but constant or even increasing costs because of inflation will lead to lower returns for the operators of the grid if they cannot raise the prices. Higher fees mean higher energy costs – a part of the rent. This seems to be a vicious circle for which the alternatives can be bankruptcy for the TSO and DSO, or both are nationalised in order for the grids to continue to operate.

Civil Code
Bürgerliches Gesetzbuch (BGB)
Book about civil Acts
Zivilgesetzbuch (ZGB)
Act on regulation on amount of rent Act
Gesetz zur Regelung der Miethöhe
Regulation for distribution of operating expenses costs onto tenants
Verordnung über die Umlage von Betriebskosten auf die Mieter (BetrKostUV)
Further simplifying of economics penal law Act
Gesetz zur weiteren Vereinfachung des Wirtschaftsstrafrechts
Second home-building Act – Home- building- and family home Act
Zweites Wohnungsbaugesetz - (Wohnungsbau- und Familienheimgesetz – II.WoBauG
Protection of purpose for social homes – Home Binding Act
Gesetz zur Sicherung der Zweckbestimmung von Sozialwohnungen (Wohnungsbindungsgesetz – WoBinG)
Regulation on Calculation of allowed rent for price limited apartments – Regulation on rent for New Buildings
Verordnung über die Ermittlung der zulässigen Miete für preisgebundene Wohnungen Neubaumietenverordnung (NMV)
Regulation on economic calculations for apartments – Second regulation of Calculation
Verordnung über wohnungswirtschaftliche Berechnungen –Zweite Berechnungsverordnung (II. BV)
Rent Act
Wohngeldgesetz (WoGG)
Regulation on rent
Wohngeldverordnung (WoGV)
Act on Constitution of Courts
Gerichtsverfassungsgesetz
Saving of Energy in Buildings Act and its regulations
Gesetz zur Einsparung von Energie in Gebäuden (EnEG)
Gesetz zur Regelung des Rechts der Allgemeinen Geschäftsbedingungen (AGB-Gesetz)
Country Regulation on Buildings
Landesbauordnung (BauONW)

Table 3.5: Regulation on Residential Buildings

CHAPTER 4

PRICES

4.0 Prices

4.1 Introduction

Fossil resources are limited and prices are a function of supply and demand. Figure 4.1 outlines the regions of strategic ellipse which contains approximately 70% of the world's resources. This area is a crisis area subject to political unrest and instability.

4.2 Prime Energy Prices

As well as a limitation in the resources available there is an increase in demand due to the exponential growth of world's population (figure 4.2). The maximum has not yet been reached. China managed to stop population growth in a long term strategy by adopting a stringent one child policy. The current growth in China is the result of rising the average age of the population. Taking the experience of Western countries into account, a decrease within the next 25 to 40 years can be expected. For example the population of Germany (and the UK and Italy) is increasing because of better health and longer life expectancy. Since the early sixties more people are dying than children are born. For Germany the loss is expected to be approximately 17 million within the next 25 years. This equals 20 to 25% of the present population, not including immigration. This is the complete population of the former German Democratic Republic.

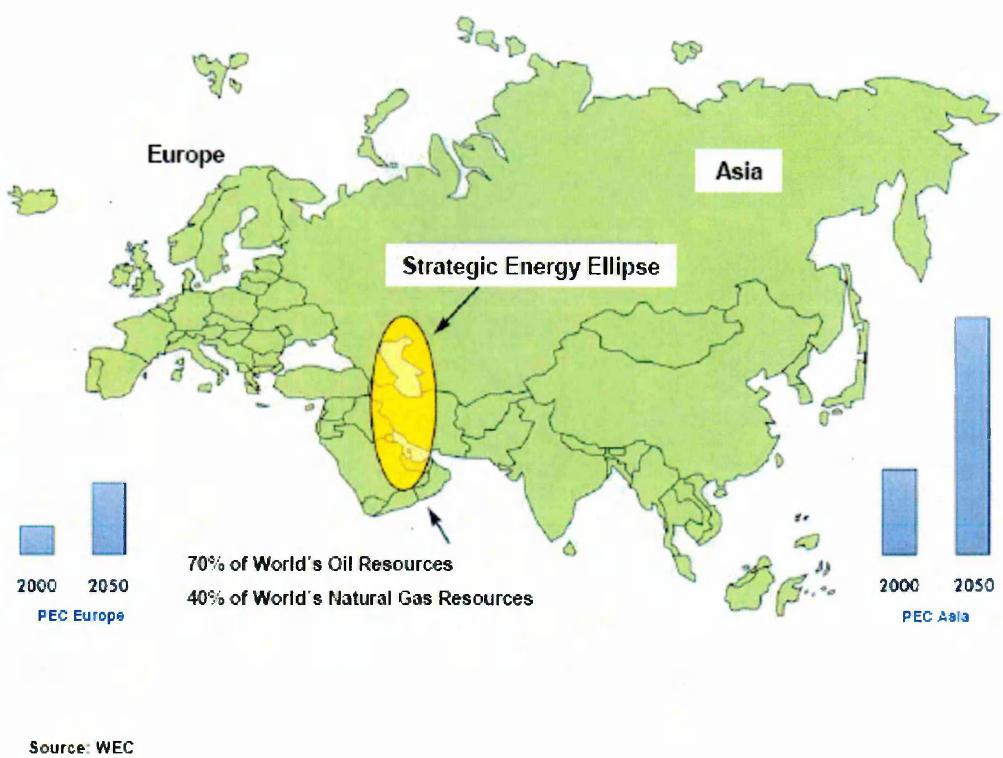


Figure 4.1: Strategic Energy Ellipse

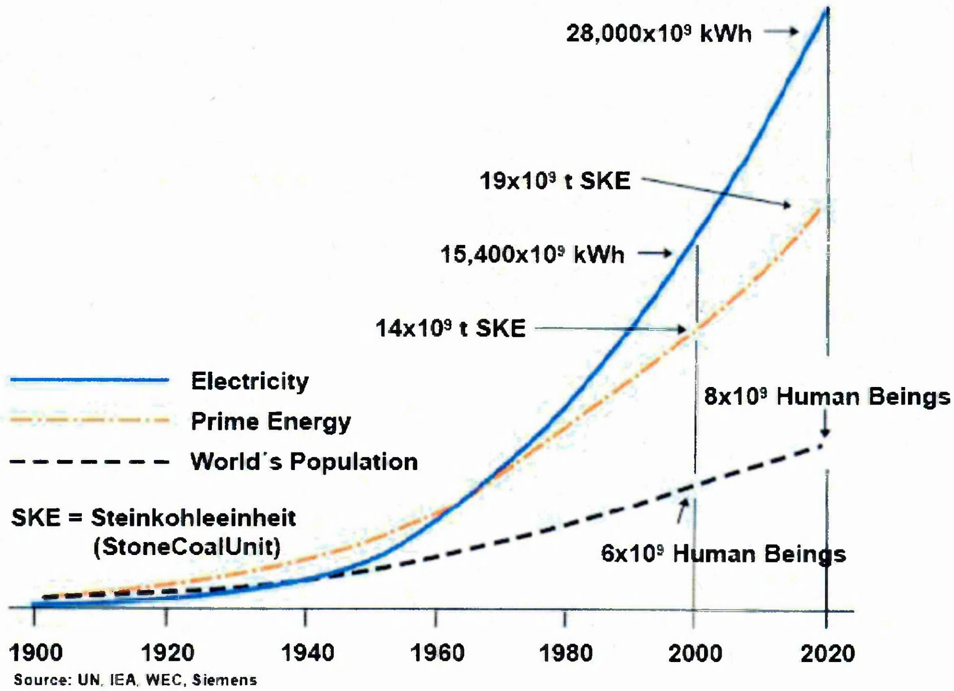
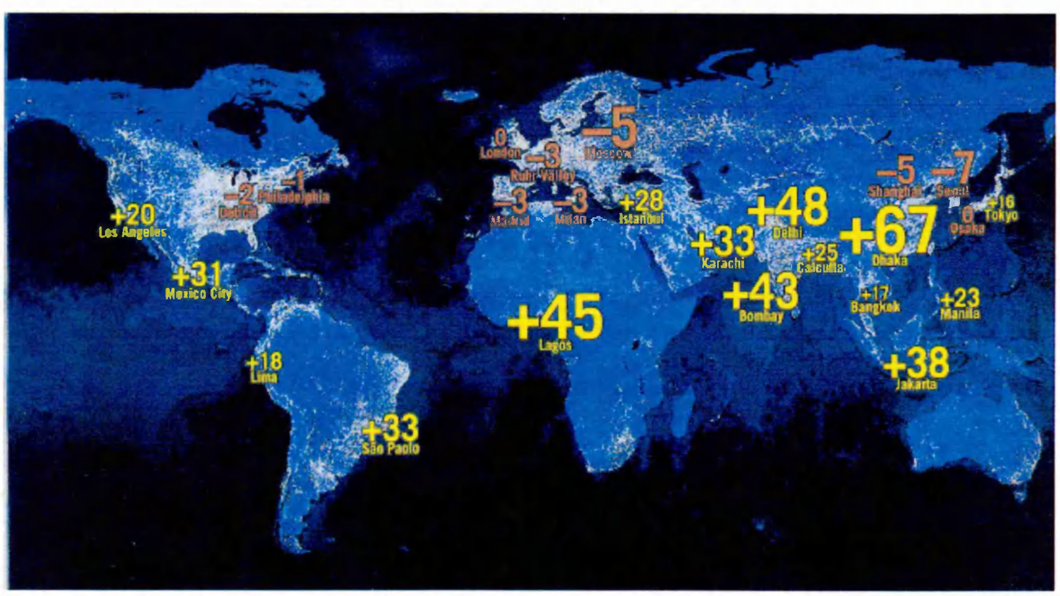


Figure 4.2: Development of World's Demand for Electricity and Population until 2020[8]

The result will be that in the future German (and European) market will be much smaller than today. The developing countries are and will continue to determine the demand.



Source: AMO

Figure 4.3: Net Change of Population per Hour[9] (2003)

The suppliers of energy in Europe are mainly traders because most of the resources are owned by a few companies. These companies now have the opportunity of opening the market to supply energy directly to final customers. They can deliver cheaper than the traders by leaving out one trading stage. Examples are Statoil from Norway or Gazprom from Russia.

The units in table 4.1 and figure 4.4 are t SKE (**S**tein**K**ohle**E**inheit (StoneCoalUnit)) for coal which equals 8.141 MWh and hl (=100 l) for oil which equals 10.17 kWh/l H_i at 15°C (=11.83 kWh/kg)[10].

Date	coal		oil	
	[€/t SKE]	[ct/kWh]	[€/100 l]	[ct/kWh]
1999-04-01	34.62	0.39	20.50	2.02
1999-07-01	34.71	0.39	16.71	1.64
1999-10-01	34.08	0.39	20.50	2.02
2000-01-01	33.91	0.38	26.86	2.64
2000-04-01	36.90	0.42	29.83	2.93
2000-07-01	39.22	0.44	31.42	3.09
2000-10-01	43.13	0.49	38.15	3.75
2001-01-01	47.76	0.54	39.82	3.92
2001-04-01	50.17	0.57	31.41	3.09
2001-07-01	54.08	0.61	33.60	3.30
2001-10-01	55.26	0.63	33.89	3.33
2002-01-01	53.47	0.60	28.19	2.77
2002-04-01	50.76	0.57	28.30	2.78
2002-07-01	47.33	0.54	30.31	2.98
2002-10-01	40.31	0.46	30.99	3.05
2003-01-01	39.41	0.45	30.99	3.05
2003-04-01	38.42	0.43	34.32	3.37
2003-07-01	37.83	0.43	28.17	2.77
2003-10-01	40.43	0.46	28.43	2.80
2004-01-01	42.27	0.48	29.71	2.92
2004-04-01	48.68	0.55	28.54	2.81
2004-07-01	55.44	0.63	31.80	3.13
2004-10-01	58.76	0.66	35.60	3.50
2005-01-01	61.81	0.70	39.39	3.87
2005-04-01	64.81	0.73	37.55	3.69
2005-07-01	64.01	0.72	42.08	4.14
2005-10-01	65.59	0.74	49.69	4.89
2006-01-01	65.80	0.74	49.31	4.85
2006-04-01	63.03	0.71	48.60	4.78
2006-07-01	61.61	0.70	51.95	5.11
2006-10-01	59.75	0.68	51.95	5.11
2007-01-01	62.54	0.71	46.86	4.61
2007-04-01	63.10	0.71	42.60	4.19

Table 4.1: Development of Prices for Coal and Light Fuel Oil

Both prices per unit approximately doubled. In absolute terms the price per kWh coal increased by just 0.3 to 0.4 ct/kWh, the oil prices by 3.1 ct/kWh which means a factor 10 in comparison to the price of coal.

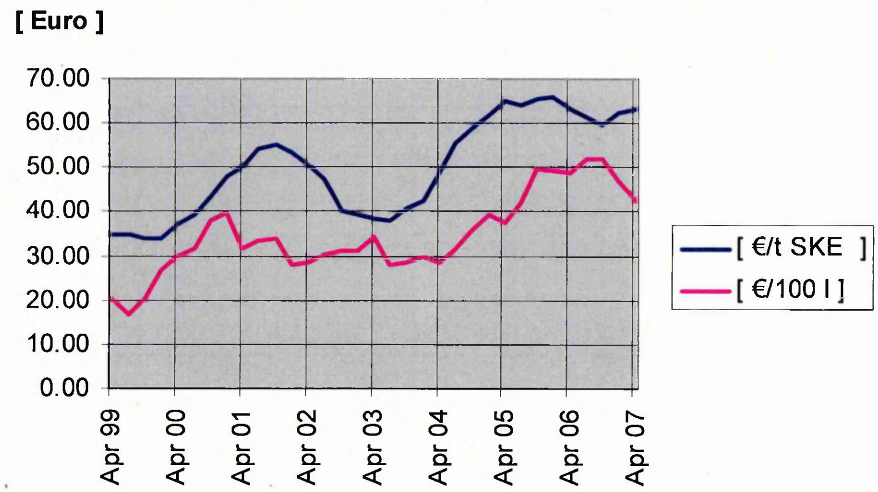


Figure 4.4: Development of Prices for Coal and Light Fuel Oil in Euro per Unit [11],[12]

In Germany the price for natural gas is linked to the oil price. The reasons are of a historical and practical nature. The main actors were Ruhrgas AG, today a part of E.on and many cityworks. Ruhrgas was founded approximately 80 years ago by a number of companies that were producing gas as a waste product from the coke making pro-cess in order to find a market. In the nineteen seventies the German policy was changed by Willy Brandt, Chancellor of Germany, who prepared the way for the opening up of the Eastern countries. Russia had natural gas and Germany pipe manufacturers such as Mannesmann AG which was bought by Vodaphone in the mid-nineties. A barter deal was the result: the pipes were paid with the delivery of natural gas[13]. This was the door opener for natural gas getting into in the heat market. At that time a price had to be found – it was the price of the competitor and market leader oil.

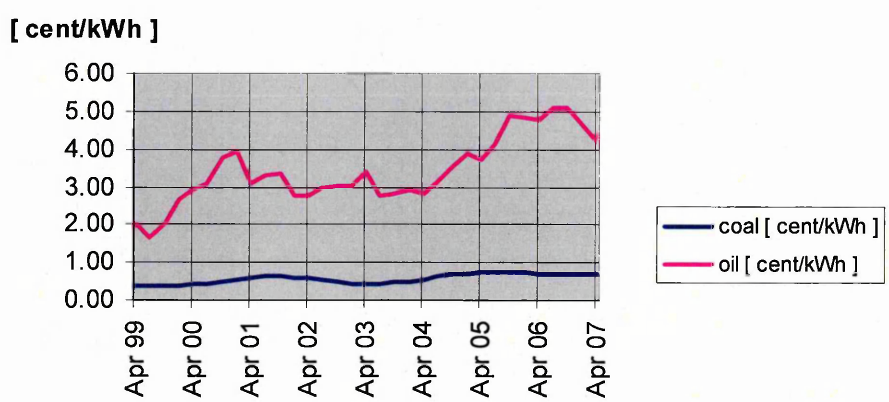


Figure 4.5: Development of Prices for Coal and Light Fuel Oil in cent per kWh

Because the main market was the heating market for housing, a time delay was included. During summertime both the demand and the prices are low. The home owners fill their tanks with oil in order to have enough oil during the high price wintertime. The same effect has the time delay for price increase of natural gas. In wintertime the low costs of the summer oil have to be paid. The advantages to the owners were no loss of space because of the oil storage tank, no check of tank filling or purchase of oil. Nowadays natural gas is the leading energy source for heating in Germany. Referring to the prime energy consumption, natural gas is number two with a portion of 22.8 % in 2006[14]. This situation is the main argument to disconnect the link between the price of natural gas from that of oil. Figure 4.7 shows the result of this in the UK.

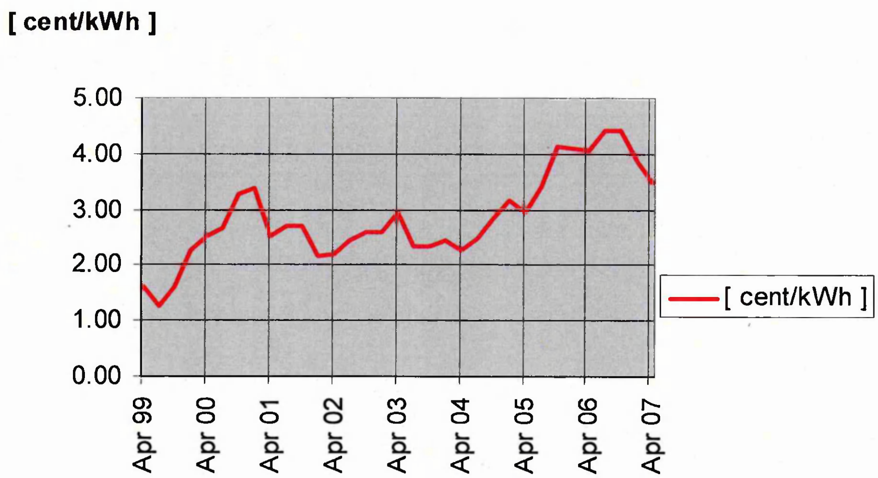


Figure 4.6: Development of Price Difference between Light Fuel Oil and Coal in cent per kWh

Another argument against oil price binding was published in 2005 in GWF[15]. The authors were sure that the market players would achieve a situation in which no oil price binding would be required in the future. History will show whether the German market will react differently from the liberalisation model adopted by the UK.

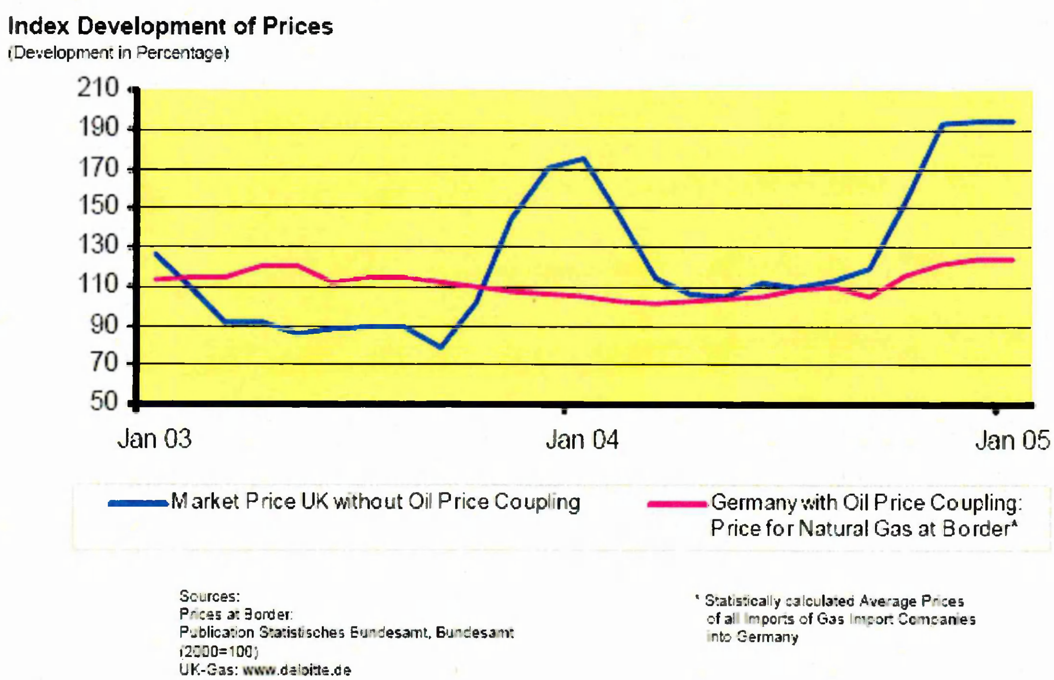


Figure 4.7: Development of Prices for Natural Gas with and without Coupling to Light Fuel Oil Prices

The Federal Ministry of Economics and Technology was worried about increasing oil prices and ordered a study by Prognos AG. The theme was "Effects of increasing Oil Prices on Energy Supply and Demand"[16]. The results predicted that consumption will decrease in all areas and resources whose exploration was too expensive will become economical viable. This will increase the supply and in consequence the price increase will decelerate. The loser in the market will be oil and natural gas and the winners will be coal and renewable energies.

A study of the consequences of increasing oil prices is given in the appendices.

4.3 Old Price System (Before Liberalisation)

In the past the structure of the price system for natural gas and electrical power were similar. Both consisted of

- a component for the peak
- a component for energy used
- a component for taxes, levy, etc included in the price for the energy used.

District heating as a competitor in the heat market had a fourth component, a metering price.

4.3.1 Price for electrical power

Customers were subdivided by their energy demand and the pattern of the consumption. Tariffs were offered according to these differences. The RWE system which was copied by city works being delivered from RWE had for customers with a low consumption L 40, medium sized customers L 125 and large customers L 200.

L is the abbreviation for Leistung (power). Figure 4.8 shows the price per kWh peak in DM at that time, e.g. L 125 means 125 DM/kWh peak. The definition of peak is:

The consumption over ¼ hour multiplied by 4.

In all three cases the price for energy used was split into high tariff and low tariff periods. These periods were different for summer and wintertime. Additionally for the L 125 and L 200 the price was split into different zones. The price decreased if the consumption was higher. Because the L 200 had a higher base price (price for the peak) the price for power was lower.

The formulas for price increase included wages and an index for the coal price.

The real price for the peak can be calculated if the differences in the zones are included. Figure 4.8 shows this for L 125. For the L 200 the real price for the peak was approximately 329 DM which equals 168 €.

The prices were total prices. They included fees for transportation and transformation between the different voltages (high, medium and low).

As an additional condition the L 125 and L 200 contained a minimum consumption of at least 70 % of the contracted volume.

Example L 125 (=125 DM/kW ≈ 64 €/kW)

CP_{Basis} = **125.00 DM/kW**

+ [330,000 x (0.1830 - 0.1430) WP_{HT1}

+ 1,200,000 x (0.1590 – 0.1430) WP_{HT2}

+ 330,000 x (0.1100 – 0.0860) WP_{LT1}

+ 1,200,000 x (0.0950 – 0.0860)] WP_{LT2}

x 1/125

= 329.00 DM/kW (≈ 168 €/kW)

WP_{HT3} **= 0.1430 [1/100 DM/kWh] for amount > 1,530,000 kWh/anno**

WP_{NT3} **= 0.0860 [1/100 DM/kWh] for amount > 1,530,000 kWh/anno**

CP: **Price for Capacity (LP** Leistungspreis)

WP: **Price for Energy (AP** Arbeitspreis)

HT: **High Tariff (HT** Hochtarif)

LT: **Low Tariff (NT** Niedertarif)

Figure 4.8: The Real Price for Capacity

4.3.2 The Price for Natural Gas

The main difference to the price for electrical power was the calculation for the peak and the linking to the oil price. Due to the competition in the heat market the price for the peak and the energy were negotiated within a framework but the structure of the price changing formulas were the same in all contracts.

For small consumers the peak was not measured. It was defined by the installed power of the installed equipment.

For industrial customers and city works the peak was defined as the total consumption within a day. Similar to the electrical power the peak was calculated as an average of two peaks. The peaks had to have a time difference of 14 days minimum and had to be in different months. The price was approximately 1.40 DM/kWh which equals 0.70 €/kWh and was lowered a small amount over the period. The formula for the calculation of the price for the peak contained a linking to the income of a worker to a basis of 1986. This income consisted of the wage of a defined worker (age plus qualification), the working week, holidays and extra payments for Christmas and holidays. The main factor was the almost yearly increase of the wage. This was increased additionally because of a reduction of the working week and an extension of holidays etc. In the end this increase was higher than inflation and had to be corrected to remain in competition.

The oil price linking for the price for energy had a doubling effect on the gas price when tax or levy was increased for energy. To compensate this effect Ruhrgas gave a price reduction. When the customer did not have to pay tax on natural gas this price reducing compensation was not given.

Similar to electricity the contracts contained a consumption of 70 % minimum and included the distribution charge.

4.3.3 The Price for District Heating

As mentioned above the price for district heating is built up in a similar manner to electricity and natural gas. In the case when the change of price was described by a formula the main price factors had to be included with their portion to the reference. This requirement occurs from the Regulation on General Conditions for the Supply of Heat to General Customers.

The price of energy supplied by the city works of Gelsenkirchen had, in 1989, a 100 % price linkage to coal because the main fuel was methane from the active mining and the price for the gas had a linkage to coal. When the supply of methane decreased and was substituted by natural gas, an oil portion was included. In 2000 the delivery of methane from the coal mines was stopped. The price formula was changed again and the coal portion taken out.

VEBA Fernheizung GmbH, now a subsidiary of E.on which supplies several towns in the Ruhr area and the north of Gelsenkirchen had the following formulas:

base price per month

$GP = GP_0 \times (0.31\ L/L_0 + 0.69\ I/I_0)$ [€/(m³/h)]

The price in €/(m³/h) cannot be compared directly with the prices for electricity or natural gas which are in €/kWh.
The standard temperature for district heating is 130°C, the design and contract temperature difference between the entry/exit of the heat exchanger equals 55 K

1 m³/h at 55 K is equivalent to a heat exchange rate of 64.16 kW

The ratio entry/exit has to be calculated for every design to enable the direct comparison of the prices in €/kWh

price for energy used

$AP = AP_0 \times (0.30\ L/IL_0 + 0.22\ K/K_0 + 0.16\ H/H_0 + 0.14\ I/I_0 + 0.18)$ [ct/kWh]

metering price

VP = constant price [€/month]

Steag, the supplier of the western Ruhr area and the south of Gelsenkirchen had the following formulas:

base price per year

$P = P_0 \times (0.45\ L/IL_0 + 0.55\ I/I_0)$ [€/kJ/s] = [€/kW]

price for heat

$P = 0.34$ €/GJ $+ P_0 \times (0.65\ K/K_0 + 0.20\ HEL/HEL_0 + 0.15\ I/I_0)$ [€/GJ]

metering price

$P = P_0 \times (0.35 + 0.65\ L/L_0)$ [€/month]

Explanation of the formulas (in the case of two abbreviations: E.on mentioned first, Steag second)

GP or P	price for power
AP or P	price for energy
VP or P	price for metering
L	income of a defined worker
I	price index for industrial goods
K	price per t SKE (stone coal unit) = 8.141 kWh
H or HEL	price per 100 l of light heating oil
Index $_0$	figure at starting point of formula

The methodology of both companies is slightly different. E.on tries to achieve the maximum price referring to the formulas. Steag uses a part of their possibility of pricing. Under the pre-condition that the prices for oil and coal rise in the same percentage, the Steag formula enables lower prices for heat. In times of low prices for oil it is the other way round.

4.4 Optimisation of Costs

Load management e.g. for start up of electrical drives or stopping production processes which had minor or no impact on the production was adopted by industry. Most customers had little chance to minimise their costs for energy. In the case of energy supply to housing, prices were tariff prices. The investments to make energy saving costs to reduce fabric losses, boiler, plant or processes had to be changed. The owner was and is not allowed to put the complete investment into the rent tenants had to pay.

The situation was slightly different for the city works. The contract with the main supplier would often prevent many of them from having common production of electricity. The advent of renewable energy, waste as fuel or CHP-plants opened the chance to influence costs. A change to another supplier was impossible. The advantage was that everybody in the grid area was a customer.

Load management, mainly identical with peak shaving was practiced in several ways.

4.4.1 Reduction of the Price for Electricity

As mentioned above, the cost effective peak was just a ¼ h figure and the price per kWh was approximately 150 €. As a comparison an electrical water heater has a power of 21 to 24 kW and it takes approximately 15 to 20 minutes to fill a bath tub. Filling one bath tub at peak time cost the City Works approximately 3,500 € which is much more than a household customer had to pay for a complete year.

The most simple way was to lower the voltage but keeping in mind that a minimum voltage had to be kept (230 AC / 400 V three phase current minus -10%)[17]. This can be achieved by transformers which can be switched into different voltage steps automatically. The fact that during this time less energy was sold can be neglected by the supplier. A rough calculation proves this:

> Price for power:
> 250 W within ¼ h equals 1 kW which previously cost 150 € and presently 55 € at medium voltage. 10% reduction saved 15 € or 5.5 € depending on whether previous or present values are used.

The prices per kWh electricity without taxes and levy which a customer has to pay is lower than 0.15 €. It has to be kept in mind that the figure is the sales price and not the profit between purchase and sales. The error in neglecting this is lower than 0.1% in the calculation for the profit which arises by peak shaving and can be neglected.

Many city works had CHP-plants being pioneers of virtual power plants. They were started or operated in overload during periods of high peaks. The heat had to be stored in tanks or the hot water supply system itself acted as additional storage.

According to German legislation emergency generators have to have a test run once per month minimum. It is obvious that these test runs were conducted during peak times.

Other simple actions without customers being involved were switching of lighting to a minimum or to switch off electrical boilers or heaters.

Some customers were able to do without with electricity for 0.5 to 1.0 hour or to switch off items of plant. Examples were the chillers for cold storage depots or ice rinks, and in some cases the wave machines in leisure centres.

4.4.2 Reduction of the Price for Natural Gas

The price for the peak was a price for 24h consumption. Industrial customer's especially had a dual fuel system so that they were able to be switched from gas to oil/lpg by demand. In this manner they saved a part of their costs for the peak. The remaining part was mainly a price to cover risk of the city works supplying the energy. The main risk for the city works was to lose the customer because the customer had a complete system for a competitive energy. In consequence the price for natural gas without peak portion had to be lower than the price for the substitute energy.

City works acted in a similar manner to industrial customers. Dual fuel systems were run on the substitute fuel, mainly oil, but in some cases LPG.

Another opportunity was to add a mixture of LPG and air into the grid. In this case DVGW work sheets G 260 (specification of gas) and G 685 (billing of gas) needed special attention. The figure which could not be kept was the methane figure. Lower methane figures have a negative impact on the maximum possible power of an engine. Suppliers which had such plants put a special clause into their contracts which allowed them to lower the methane figure or pointed out that during wintertime the lowest methane figure was possible. This process can be compared with the lowering of the voltage.

The city works of Gelsenkirchen did not have such a device. A similar effect happened when the gas quality was changed from Russian gas to Norwegian gas. Both belong to the H-group. Norwegian gas has apart from a different Nitrogen content, a higher content of C_2H_6 and C_3H_8. These longer carbon hydrogen chains increase the energy content and lower the methane figure.

Component		H_{Norway} [1]	$H_{Mixture}$ [2]	H_{Russia} [2]	$L_{Netherlands}$ [1]
Carbon Dioxide	CO_2	1.98	1.93	0.09	1.40
Nitrogen	N_2	0.94	1.42	0.82	11.05
Oxygen	O_2	<0.01	<0.01	<0.01	<0.01
Methane	CH_4	87.02	87.27	97.79	83.40
Ethane	C_2H_6	8.10	8.26	0.88	3.33
Propane	C_3H_8	1.59	0.92	0.29	0.54
Characteristics					
Cal. Value gross $H_{s\,k}$Wh/m³		11.784	11.589	11.120	10.136
Rel. Density ρ		0.639	0.632	0.568	0.640
Wobbe-Index kWh/m³		14.742	14.578	14.755	12.670
Methane Figure		77	80	92	89

[1] Gas Analysis ELE December Figures 2005
[2] Average Analysis e.on Ruhrgas

Figure 4.9: Components of Natural Gas

Another possibility was the operation of storage tanks. In this case it was necessary to ensure that it was possible to supply the natural gas in sufficient quantities to the distribution pipelines.

A further method to reduce the overall average price (defined as costs for peaks plus energy in Euro (€) divided by total consumption) was to increase the summer portion. Gas was sold to customers who only required energy during the warmer periods during the year such as tar producers for road repairs. As they had no effect on the peak which arose during the winter period the price for the capacity they had to pay to the city works was minimal. The advantage for the companies was lower handling costs in comparison to oil which needs tanks, more maintenance for burners and fulfilment of higher environmental restrictions etc.

Some city works had several energies, such as electricity and natural gas and sometimes district heating and potable water. The city works of Gelsenkirchen had electricity and natural gas and some district heating. This gave the chance to optimise the total system as described later on.

4.4.3 Technical Economical Combination, Nowadays Called Tax Combination

In the past many city works were owned 100 % or at least by the majority by the cities they supplied with energy. Like all enterprises they had to make profits and they had to pay tax. A part of the tax remains in the city, a part is paid to the Lander (one of the 16 in Germany) and a part is paid to the Federation.

The cities or the city councils had to run leisure centres or public transport. Both of these are in deficit. The idea was to combine energy sales with the operation of these loss producing enterprises. By this the profit of the city works was reduced and the tax being paid to the federation or the Länder was lowered. The city council saved some money for other projects. The city works of Gelsenkirchen had the leading role in Germany and it required much negotiation with the local tax authorities, the Ministry of Finance of North Rhine Westphalia and for the final decision with the Ministry of Finance of Germany.

The project: a new leisure centre with a CHP-plant opened in 1986. The object was to cut the peak from RWE supplying the city works. The heat was for the leisure centre and the electrical power for the grid. The authorities agreed after representation by the city works and because of this the profit was lowered by approximately 1,500,000 € per year. At that time the tax was about 49 % which meant 750,000 € remained in the town. Taxation of companies has since been lowered and is now under 40%.

Most city councils combined public transport with energy, especially in larger cities. Examples in the Ruhr area are Essen and Dortmund.

<u>4.5 The Price System in a Liberalised Market</u>

In the ideal world production; transport and sales is split into different independent companies. With the exception of industrial customers most consumers sign a contract with a supplier. This supplier signs the necessary contracts work with production, transport and local distribution companies. In such a case the bill of a customer contains:

Transport
- maximum peak (€/kWh for electricity ¼ h figure for gas 1 h figure)
- energy (€/kWh)

Distribution
- maximum peak (€/kWh for electricity ¼ h figure for gas 1 h figure)
- energy (€/kWh)
- (price for Transport is often included in distribution)

Customer consumption
- energy (€/kWh)
- includes the costs of the sales department

Taxes and levies
- fees for using public streets (in distribution)
- energy tax (sales department)
- CHP-levy (sales department)
- Renewable energy levy (sales department)

Metering

Base price

<u>4.5.1 Production</u>

In comparison to Free On Board (FOB) prices for transportation Free Off Power Station (FOP) prices could be defined for electricity. These prices include the plant (finance), the cost for energy input, carbon trading and, last but not least, operation and maintenance costs.

Most sales companies buy their supplies via direct contracts with the producers (over the counter (OTC) business). A smaller part is traded via stock exchanges such as the newly formed European Energy Exchange located in Leipzig or at an Energy Exchange in other countries. Figure 4.10 shows that even a previous customer of any supplier can buy directly from the producer. Additionally numerous independent traders appeared in the market.

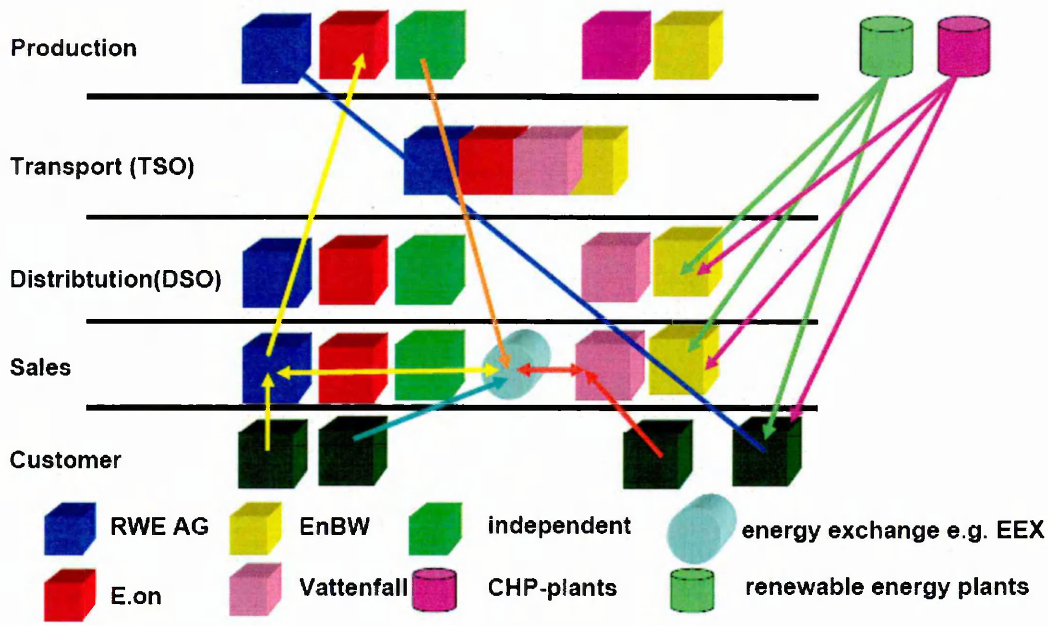


Figure 4.10: Trading Ways in New Regime

Natural gas is not an artificial product like electricity. Apart from exploration the production is mainly the cleaning and drying of the gas. This happens for North Sea Gas at the landing points and is less expensive than the production of electricity. At some places different gases are mixed to a compound gas e.g. in Werne by E.on Ruhrgas AG. In comparison to electricity trading points are the landing points for natural gas or locations where borders are crossed or virtual ones. City boundaries (in Germany called City Gates) are the next stage of the entry points into the distribution system.

4.5.2 Transport

The system for transport is almost the same as described for the old price system. In contrast to the old system large companies had the opportunity to opt out of the tariff system which all transport and distribution companies have to publish on the internet. They can ask for a separate calculated net entry. At the moment the common price system is for a complete year and is not split into summer e.g. 1st April to 30th September and winter 1st October to 31st March.

4.5.3 Energy Prices

The suppliers to customers buy their demand for electricity from one or more producers and in addition via Energy Exchanges such as the **E**uropean **E**nergy E**x**change (Leipzig) EEX, **A**msterdam **P**ower E**x**change (APX), Nord Pool Nordic Power Exchange, **E**nergy **Ex**change **A**ustria (EEXAA) etc. The prices are a function of the times of the day, the days itself and season. Even when only a small amount of Germany's demand is traded at EEX the development of prices is a price index for contracts. The importance of EEX is documented by the integration into the

CHP-Act. For small customers standard load profiles are defined. For medium sized customers and larger ones load profiles are important for the both parties, customer and supplier (sales).
At the moment such an exchange trading point does not exist for natural gas. Spot amounts on the market are sometimes directly offered by the suppliers and sometimes by customers or traders. These amounts can result for different reasons:

minimum consumption, very often 70 % of contracted amounts, which are not met but have to be paid either from supplier or customer,
over production from exploration,
full storages (salt caverns etc.).

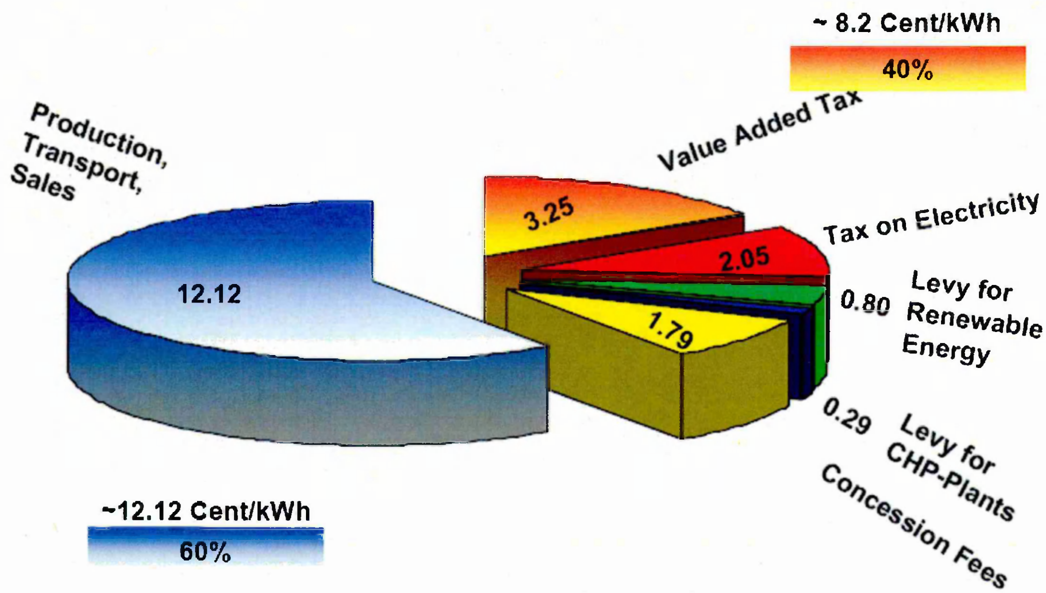


Figure 4.11: Proportions of Energy Costs for a Household Consisting of 4 Persons[18]

In consequence a similar exchange to electricity can be expected.

Figure 4.11 shows the distribution of costs for a household with four persons without electrical heating; figure 4.12 the development of the portion caused by new legislation.

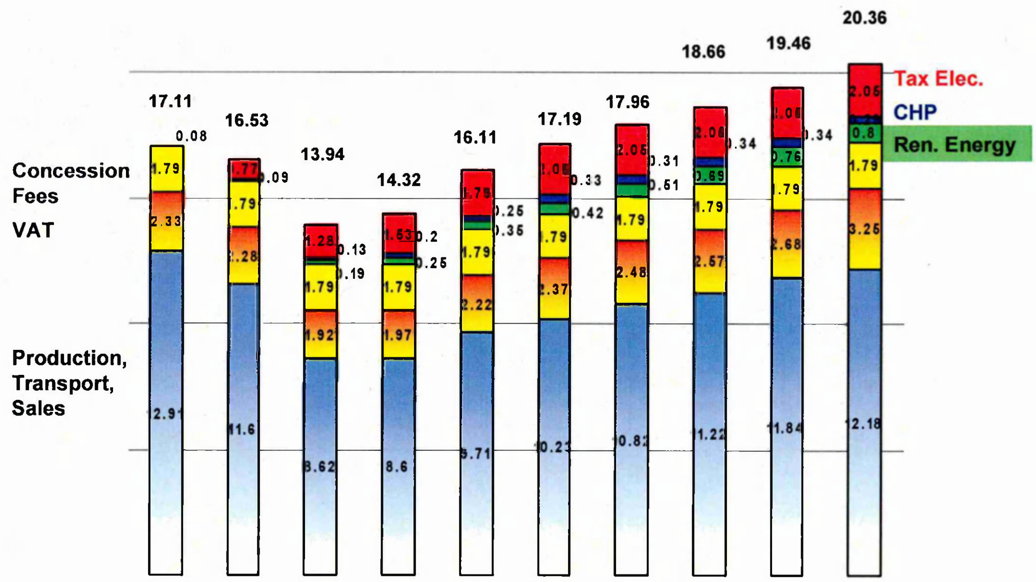


Figure 4.12: Development of Portion of Taxes and Levies[19]
(for a household load of 3,500 kWh/annum)

CHAPTER 5

HUMAN BEHAVIOUR

5. Human Behaviour

5.1 Introduction

The behaviour of human beings and the conduct of companies can generally be described as follows

The survival of the fittest (Darwinian theory)
Highest profit with least expenditure
The way of least resistance is preferred (hydrodynamic theory)

The liberalisation of the market can be interpreted as either a hazard or as an opportunity for change. The consequences can be predicted and can be foreseen.

5.2 Companies

Liberalisation in Germany started with local companies who had the benefit of sole grid operation and sales and 100% knowledge of its customers.

As a first step the market for electricity was opened. Integrated companies, delivering electricity, natural gas and maybe district heating, water supply, waste water were enabled to supply customers outside of their original closed market area. This opening of the market was done without division of the local companies. A sales department for customers outside of the original closed market had to be built up, e.g. Yello from EnBW or a completely new one had to be set up. Additionally foreign companies could deliver electricity to end customers. All companies but the local ones had the disadvantage of missing grids and customers data.

The closed market was opened and the danger of losing customers was a possibility. To obtain a strong position or to protect self interests some countries like France still have national companies like EdF or GdF. They receive legal protection as long as no European country goes to law.

The attempt of E.on to buy Endessa in Spain in spring 2007 was prevented by the Spanish government in cooperation with the Italians and their National company Eni.

Apart from the three basic statements mentioned above contact with customers is necessary to increase sales. In order to make contact the basic customer data required includes:

- name
- address
- telephone number or internet address
- status of family (married, divorced, children etc.)
- bank connection

Everybody needs electrical power and every customer has at least one meter. In the case of a housing block with several apartments, the tenants and the owner are known to the supplier because of the demand for electricity shared for the stairwell, elevator or central heating. This is a major advantage to electrical suppliers in comparison to gas companies. Gas is in competition with the heat market and not every house is supplied with gas. Water suppliers have the necessary contact data of all householders and company addresses.

To receive this data, taking the Act regarding protection of personal data into account, a simple solution is to purchase electrical or water companies. This was done by the market players. Ruhrgas AG not being a part of E.on at that time, bought Gelsenwasser AG, Europe's largest water supplier. When E.on bought Ruhrgas AG, Gelsenwasser had to be sold. A further example in the international market was the purchase of Thames Water by RWE AG.

An alternative method to gain influence on suppliers was to purchase parts of companies. According to German law all major consolidated companies have to publish their major consolidated companies and other major shareholdings. These data can be taken from the annual reports which are available as print or via the internet.

E.on AG
≈ 15 Subsidiaries in Germany
E.on Energie AG, E.on Bayern AG, E.on Kernkraft GmbH, E.on Kraftwerk AG...

E.on Energie AG
≈ 25 Subsidiaries in Germany
E.on Ruhrgas AG, REWAG, City Works Magdeburg GmbH...

E.on Ruhrgas AG
≈ 10 City Works or Regional Suppliers
thüga, N-Energie; Mainova....plus 4 Gas transport Companies plus Exploration

thüga
≈ 125 City works or regional suppliers (portion between 10 and 100 %) plus Gas Exploration

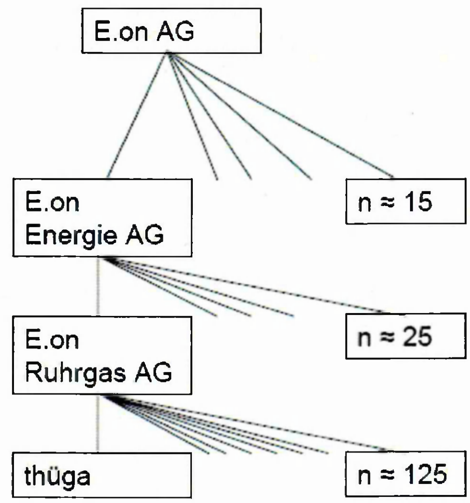


Figure 5.1: E.on and its Major Consolidated Companies:

The participation of Ruhrgas or Thüga at the lower levels is obvious. In a similar manner with the other three remaining market players in Germany almost all main local suppliers are partly owned by one of them.

In many cases companies were consolidated for a number of single energy supplier companies. One example is ELE Emscher Lippe Energy GmbH; another is the new company E.on Westfalen Weser AG were the former city works of Paderborn and the E.on company PESAG amalgamated.

5.3 Influence on the Internal Operation of Companies

In cases when two or more companies joined together all departments are doubled or tripled, including administration of purchasing, control, sales and operations. To reduce the costs the amount of personnel is reduced to the required number. The possibilities of initially achieving this are

Early retirement (additional payment from the company to compensate the gap in pension)
Offer of compensation, in the form of severance pay, to leave the company
Switch to another employer's association with lower tariffs negotiated by the trade unions (e.g. public service pays approximately 10 to 15 % less than private energy companies).
Cancelling social benefits for new employees
No new appointments, workforce reduced by natural wastage

No apprentices or no contract when time-served.
Part time jobs or life working time accounts (Overtime which is worked is not paid. The hours are accumulated and enable an earlier retirement without lose of pension)

These steps were realised by the major players and can be seen in the annual reports. The function between synergy effect by amalgamation and improvement of processes is not further researched in this thesis.

5.4 Influence on Generation

Up to 2007 liberalisation was almost entirely limited to electricity. The gas market could be neglected.
As a first step in many companies generation became a company in itself separated from sales, transmission and distribution.

With the appearance of foreign suppliers on the German market prices for electricity came under pressure. Many old or inefficient plants were run for peak times only or as standby plant when main stations were off-line for repair, refurbishment or maintenance. Savings were on capital costs and operation costs, mainly personnel (see 5.3)

The wages and social fees for employees in Germany are among the highest in Europe. To reduce the operation costs remaining plants were refurbished. In combination with carbon trading, wages and environmental and safety regulations the substitute of old plants or even complete new ones in eastern Europe (Poland, Ukraine, Czechoslovakia) is an alternative to the refurbishment of power stations in Germany.

Evidence that the producers of electricity have done their work effectively can be found in their annual reports.

5.5 Influence on Transmission and Distribution

In the old regime sales and technical consulting were in a separate department to planning for grids or technical equipment. Apart from standard operation work like installation of meters, laying of pipes, maintenance of equipment etc. the technicians had no contact with the customers and were not involved in price negotiations, contract maters or profit calculation.

The calculations for the offer of house service connection were made in the sales department. The calculation contained revenue (sales price multiplied by expected amount of energy) and costs such as administration (for sales, technical, purchase, and billing departments etc.), operation of the grid and the purchase of the energy. In the case of natural gas, which being in competition with oil, liquid gas, district heating, coal, wood, electricity or renewables, the offer for the house service connection was a combination of a long term (10 year) energy supply contract with the installation of the house service connection. The subvention of the energy sales price enabled a reduced price for the house service connection. In consequence customers paid less than the maximum that the regulations allowed (70% of the portion of grid they used plus 100% of the house service connection).

Electricity as a basic demand for the majority of users had less problems and in general the maximum costs were charged to the customer, meaning 100 % of the cost for the connection of the building to the grid plus 70 % of a proportion of the demand from the grid. (When the grid has a capacity of 1,000 kVA and the customer's demand is 100 kVA the charges are given by:

100/1,000 x 0.7 = 7 % of the cost for establishing the grid.
is paid by the customer.

This 70 % regulation has since been reduced to 50 %.

A special situation was foreseen for electricity. Additional to the reduction of the maximum cost of demand, the first 30 kW for a building/customer are free of charge and the transformer costs for high to medium to low voltage cannot be included in the calculation, as well as the costs for the high or medium voltage grid.

While suppliers can produce or sell electricity the grid appears to be a natural monopoly even when there were no grid operators. To protect customers from abuse of this regulation the previous price check and regulations for tariff prices are transferred to the fees for the grid. This is done by the same authority which regulates the telecommunication market, the Bundesnetzagentur, BNetzA, (Agency for Grids). The aim is to reduce the grid fees. In 2006 and 2007 the first regulation period reduced all fees for electricity, in some cases it was more than 30 % of the original charges.

To comply with the legislation and to reduce the costs summarised the following steps were necessary:

5.5.1 Separation of Operation and Sales (New Company)

In some cases the DSO consists of less than 10 people and the technical department remains in the holding company. In this case it is necessary to ensure that no information is given by the technical department to its own sales department (unbundling).

Additionally it is necessary to use a separate sales department for connection to the grid. As an alternative specific employees could be taught to meet this requirement. Natural gas remains competitive in the heat market. The price for the house service connection is a small part of the overall investment for a heating system. The decision of the customer can be interpreted as a long term decision. This enables the operator of the grid to function in a similar as the sales department did in the past. The profit from the sales price of energy which was partly used to reduce the price for the house service connection is substituted by the fees. The other difference to the old situation is that for the DSO it is not important who sells the energy. It is important to convince the customer to purchase the energy of the DSO.

In the case when district heating is within the same company the competition in the heat market (energy not sales) is reduced which allows the operator of the grid to charge higher prices for house service connections up to the maximum allowed by the regulations.

Several influences such as the actions of the BNetzA to reduce fees, legislation on energy saving or possible transfer of industrial production to other locations destroy the foundation for long term calculation. This leads to higher connection fees to the grid compared to those of the past. Higher fees increase the chances of competitive energies. Renewable energies, coal based district heating or efficient energy systems such as CHP require high investments. They have the advantage of lower costs for energy input compared to the energy output. If additionally there are increases in fees accelerated by increasing prices for oil or natural gas the high investment technologies become an alternative to the gas supply. Even heating with electricity e.g. heat pumps or night storage can become competitive.

The DSO has to analyse the market situation and then decide how the grid will be developed in the future.

5.5.2 New Cheaper Supply Concepts

The advantage of gas grids is the mesh of the grid. In this manner security of supply is simple to achieve apart from edge areas. The failure of one station does not compromise the rest of the grid.

Electrical grids are built as a beam or alternatively as a meshed grid (see figure 5.2). The input of energy into one level requires transformation from the higher or lower grid and the input from external plants such as CHP or renewable energy such as wind turbines.

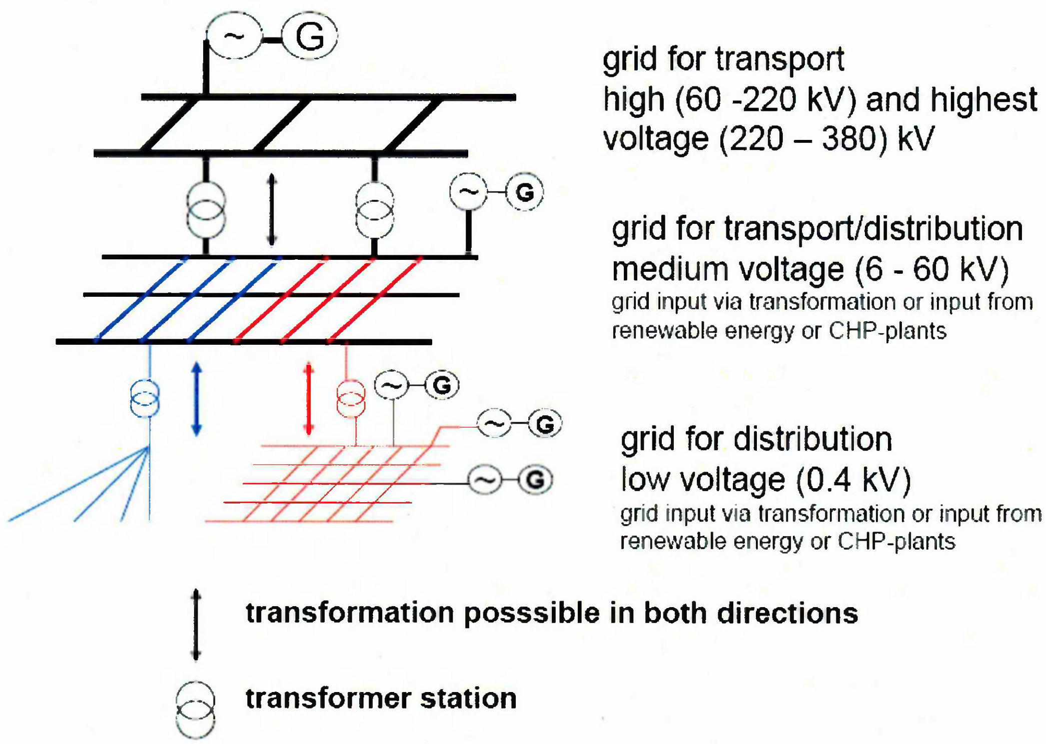


Figure 5.2: Schematic Structure of Grids for Electricity

Meshed grids give a high security for supply. In the case of failure or interruption due to maintenance the customer can be supplied via the other end of the gird. This grid requires higher investments because of the additional connection. In the future an increasing amount of beam grids can be expected. A failure at the front end of a beam causes interruptions to all customers supplied by the beam. The period of interruption is the time to repair the failure. Instead of one customer being disconnected from the grid for a time four or even more customers will be disconnected. Alternatively, if possible, an interconnector can be installed which would decrease the number of disconnected customers. Increasing the number of beam grids has as a consequence increasing times of interruption from the grid.

Customers requiring a second (loop) connection have to pay for the connection. At present higher fees are not charged for beam connection but in future additional charges can be expected.

Pylons are an economical method of grid construction. These are susceptible to damage from extreme weather conditions unlike the more expensive alternative of underground cabling.
Standardisation of technical equipment and processes will lead to lower costs especially when several companies merge. Bulk buying provides an opportunity to reduce the unit price or ordered items. Taking into account the rising influence of the large companies on to the smaller ones (chapter 5.1) will allow for standardisation which will result in reduced costs. In the long term the number of suppliers will be reduced which could result in increased prices.

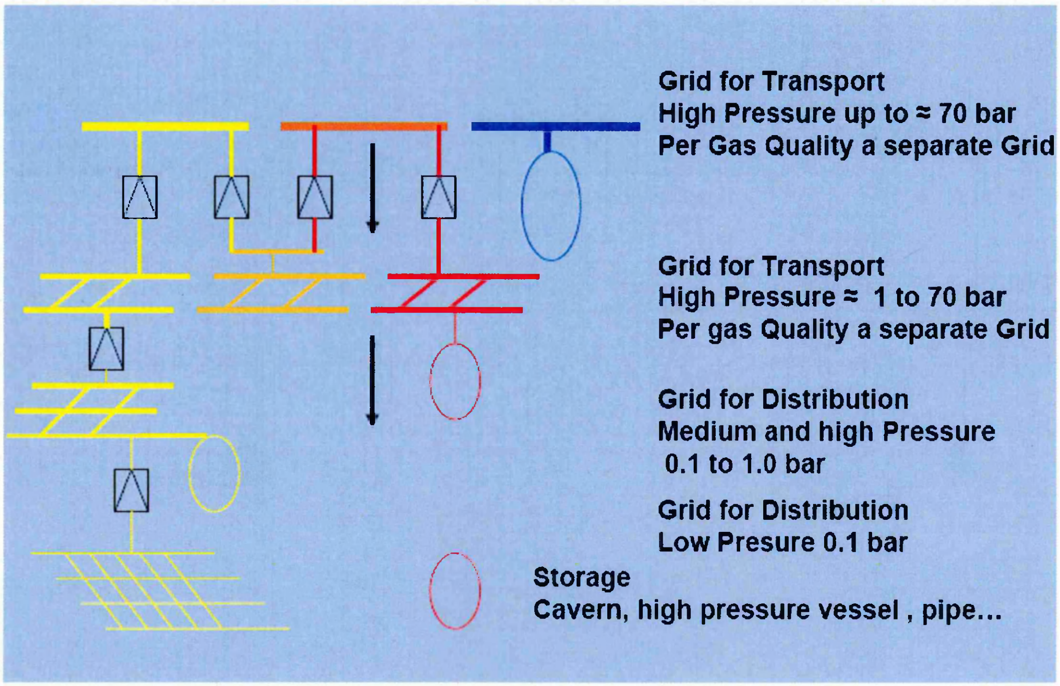


Figure 5.3: Schematic Structure of Grids for Natural gas

In the future the number of personnel will be reduced. For administration, purchase synergy effects can achieve reductions, mainly by tightening of work. System integration for installation or design using two different energies such as electricity and gas handled by one person is the alternative to the technical department. Instead of one person per energy only one person for both energies is required. This requires highly skilled personnel. The advantage of system integration is a decrease of contractual or sales matters which were not originally a part of the technical department. In the past the offer consisted of one letter which included the price for the house service connection. Current legislation demands at least one but up to a maximum of three contracts including attachments plus the letter. The contracts are

connection to the grid (compulsory for all customers)
utilization of the connection of the grid (compulsory for medium and high voltage/pressure customers and if required by low voltage/pressure customers)
utilization of the grid (mainly signed by sales companies or by customers who handle the management of fees by themselves)

Installation of electricity and natural gas was previously conducted in separate departments. A common trench would be used for the cables and pipes. Recent organisational changes require that installation of electrical and gas equipment is done by an individual who would require higher skill levels. Similarly for design – an individual has to design the trench together with the electrical and gas equipment.

In a future scenario individuals will be trained in sales negotiations, economic calculation, letters and contracts, design, coordination on-site and quantity surveying.

A final alternative is the outsourcing of work. This can be done for planning, installation or acquisition. An alternative for acquisition is to delegate the acquisition of tariff customers to an "outsourced" internal department, which Acts like an outsourced company but still remains within the company.

5.6 Influence on Sales

According to the guidelines on unbundling, sales departments are separated from the grid department (TSO / DSO). During the old regime all enquiries were given to the sales department. Within the new regime the addresses of the enquiries have to be checked. Variants are given in figure 5.4.

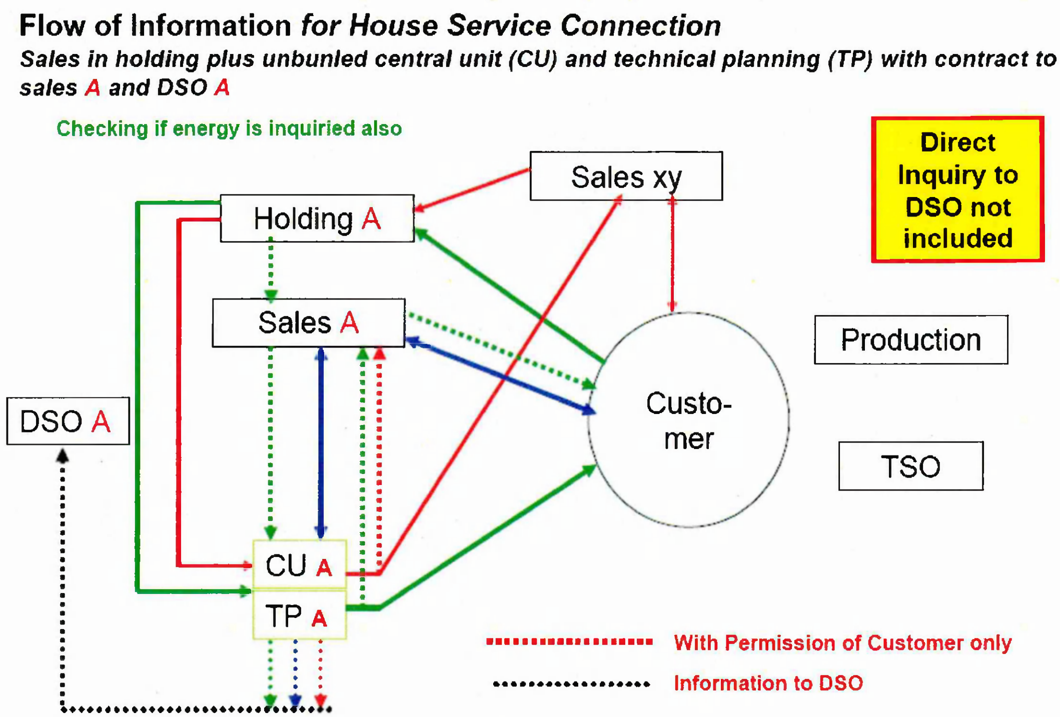


Figure 5.4: Check of Inquiries for Quotations

The customer data base has to be split into sales and grid. The grid database contains all data of the connected customers. The sales data base only has the supplied customers. To avoid double billing of sales and grid fees, systems are necessary to separate the billing and sales departments and to ensure that no information flows to sales department which is not allowed. By this structure, the billing department Acts like an outsourced company, with no additional personnel required.

Industrial customers need individual treatment. Small and medium sized customers as well as customers being supplied within tariff contracts are a mass business which can be outsourced. In this case a similar procedure can be chosen for sales as for acquisition of new customers for the grid. An outsourced company, even if it is an internal department, receives a contract with certain tasks. In this way customers do not notice the changes in the regulations. It is necessary to ensure that the same person does not offer a contract for connection to the grid and the supply of energy. Due to the low consumption (of small and medium companies) the profit per customer is low which has as a consequence that mainly only large companies are able to offer energy contracts for these types of customers. The most prominent in Germany is Yello, a subsidiary of EnBW. E.on and RWE have similar structures, e.g. E wie Einfach from E.on Ruhrgas AG to supply natural gas.

Further established solutions for the mass business are realized on the internet. These can contain information about legislation including links to relevant internet addresses. The use of the internet became established due to the reduction of personnel available to take enquiries, Simple structured programs which require minimal input of data were installed, Gebäudecheck (Check of buildings) which was developed by the author in cooperation with Ruhrgas AG. The required data were; year of construction, possible improvements of insulation or windows, the shape of the house as multiple choice, square metres, the annual energy consumption and the report from the gas maintenance engineer. The output was an indication (green as positive or red as negative). Additionally hints for methods of saving energy and money were given.

Programs to bind a customer to a (sales) company were developed e.g. customer cards (City Power invented by ELE is the most successful customer card in the energy market) or services out of the regulated market like heat or cold contracting, billing of heating costs are further possibilities.

Large customers remain in the sales department. Taking into account the human behaviour to receive simple and cheap solutions the supply of all kinds of energy has to be offered by one person. Again the synergy effect starts and reduces costs by reducing the amount of personnel.

Contrary to the long-term grid connection contracts energy contracts at the present are short time contracts with one to two years duration, with five years being an exception. Short duration contracts require a more intensive attention of the customers and as a consequence more personnel are required

The new legislation gives the opportunity to acquire customers all over Germany or Europe (with limitation to the opening of the market). Business cases paying attention to possible profit and taking into account personnel costs and risks have to show whether an engagement outside of the previous supply area is interesting or not. Very often different locations of one company are supplied by one contract.

The bankruptcy of Enron[20] can be understood as a warning example to check possible risks of future price development.

Uncertainty in the prediction of future electricity prices can be assumed as a reason for the shorter duration of contracts. The binding of prices for natural gas to oil prices is criticized and the duration cannot be predicted anymore.

5.7 Influence on Supplier of Technical Equipment and Services

As described in 5.4 standardisation will increase. The variety of equipment used will be reduced. This will reduce costs of the chosen deliverers and achieve lower costs for the operators for the grid. Discarded suppliers who can no longer sell their products may become insolvent. The effect on suppliers will be similar to that in the energy market; a concentration of companies can be expected. The attempts of the suppliers to survive can be predicted. It will be in analogy to the acting of energy suppliers and grid operators: Concentration by mergers of companies and using synergy effects such as smaller administration or design departments.

5.8 Influence on Associations of Energy Suppliers

In the past no association for grid operators was necessary. VDN, the Association of Grid Operators at VDEW (registered) was founded.

The energy market and the players within the market have changed. The number of grid operators has decreased. Parallel with this the number of sales companies has again decreased. Both groups were the main columns of the associations in the energy market. The associations have lost members by this concentration.

The dues to be an associate member is still a function of delivered or energy sales. The dues decrease in ct/kWh with increasing sales, the result being lower revenues. This has a negative effect on the work of the associations.

As in the past when the standard case was for one supplier for one kind of energy, each kind of energy still has its own association. Additionally separate association exist for contractual matters or legislation and technical matters. A list of associations is given in table 5.1.

VIK - Association of Industrial Energy- and Power Economy (registered)
VIK – Verband der Industriellen Energie- und Kraftwirtschaft e.V.
VDEW - Association of Power Economy (registered)
VDEW - Verband der Elektrizitätswirtschaft VDEW e.V.
VDN - Association of Grid Operators at VDEW (registered)
VDN – Verband der Netzbetreiber VDN e.V. beim VDEW
AGFW - Association for District Heating at VDEW (registered)
AGFW – Arbeitsgemeinschaft für Fernwärme AGFW e.V. beim VDEW
BGW - Association of German Gas and Water Economy (registered)
BGW – Bundesverband der deutschen Gas- und Wasserwirtschaft e.V.
DVGW – The German Technical and Scientific Association for Gas and Water (registered)
DVGW- Deutsche Vereinigung des Gas- und Wasserfaches e.V. – Technisch-wisenschaftlicher Verein
ASUE - Association for the Efficient and Environmentally Friendly Use of Energy
ASUE – Arbeitsgemeinschaft für sparsamen und umweltfreundlichen Energieverbrauch
VKU - Association of Local Utilities (registered)
VKU – Verband kommunaler Unternehmen e.V.
ASEW - Association for Rational Use of Energy- and Water at VKU
ASEW - Arbeitsgemeinschaft für sparsame Energie- und Wasserverwendung im VKU
VEA - Association of Energy Customers (registered)
VEA – Bundesverband der Energie-Abnehmer e.V.

Table 5.1: Associations of Energy Industries

e.V. is the abbreviation for eingetragener Verein which can be translated as "registered association" and which is not allowed to make a profit. Therefore they do not to have pay tax. The variety in German terms and the structure for members cannot easily be translated into English.

As described earlier energy companies unite, sell several kinds of energy and are very often influenced or are partly possessed by one of the big four.

Taking this development into account a unification of different association could be expected. In July 2007 unification of different associations was announced[21].

In combination with this concentration and the increasing pressure for companies to make profits fewer people will be sent to working groups. Considering the difficulties to release personnel for these tasks will mean that the influence of the big four will increase. Smaller companies cannot afford anymore to participate. The results of the working groups can be predicted.

5.9 Influence on Research Projects or New Technology

At the time of the old regime the quantity of suppliers was large and covered the complete chain starting with production via transport/transmission/distribution to sales. This allowed having research on total energy systems including the connection of customers. It also gave suppliers the opportunity to represent themselves as being responsible for the protection of the environment.

With unbundling and separation of the different processes to supply customers with energy a split of research in higher efficiency of production (power stations) or transport/transmission and distribution (less losses) can be expected. Each section will do research in the area of its own tasks and total energy systems will be out of focus.

Research on high efficiency of installations of the customers (CHP-plants, boilers, integration of solar panel into the heating systems of houses) could be within the focus of the sales department. For the regulated market all sales companies have the same commercial conditions for transport/transmission and distribution. Their profit consists of the difference between sales and purchases price and a good organisation. The gap in between is too small to have expenses on research projects.

Low consumption cannot be the aim of an operator of grids. The grid has to be operated anyway and costs are more or less fixed costs.

As a conclusion the suppliers of CHP-plants, boilers, solar panels etc. have to look for new sponsors. The single users do not have the required finance and as a consequence less research on this area can be expected.

CHAPTER 6

DEMOGRAPHIC CHANGE

6. Demographic Change

The growth of population has an effect on consumption, transmission/transport, a reduction of fossil resources and an increase in carbon dioxide emissions.

The world's population is increasing, especially in Asia (see figure 4.3). In many European countries the increase of population is primarily due to an increase in life expectancy. Since the early seventies of the last century the rate of birth in Germany is lower than the rate of death[22]. Without immigrants and their children and grandchildren Germany would lose 18 Million people within the next 40 years. This is more than the amount of the former German Democratic Republic. Almost all European countries have similar trends[23].

This development has led to a movement of population from developing countries to the rich countries in Europe.

The demographic changes are not consistent in all parts of the country which leads to areas where there are large changes of population which then has an influence on the energy supply in that region. The population itself is influenced by the availability of employment e.g. in heavy industries, future industries or services. The Ruhr especially will lose a large proportion of its population with the loss of employment in the energy intensive heavy industries (steel industry, coal mines, coke ovens)[24].

Other demographic changes affect housing. Even if the population decreases the number of flats will increase and by this the space per person. Possible reasons are more single households compared to the past or elderly people staying in their flats even when their children have left the flat.

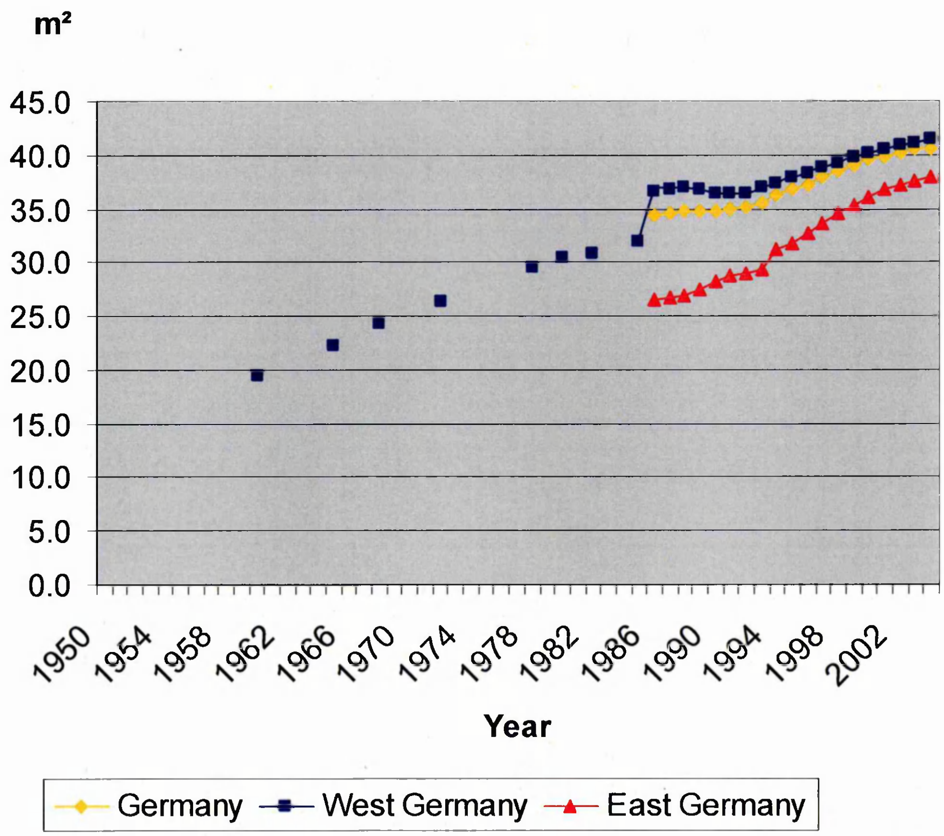


Figure 6.1: Living Space per Person in Germany[25]

The author of this thesis lives in a 5 person apartment of 120 m² which equals 24 m²/person. When the 3 children have left the figure will be 60 m²/person.

This example can be used to describe the energy consumption.

<u>Remaining consumption</u>
heating will be approximately the same when the children have left (one person permanent at home, not working)
main electrical installation like cooker, refrigerator or television (TV not representtative because just one TV in the household)
Cooling (not applicable at the moment)

<u>Decreasing consumption</u>
hot water supply down to 40 % (3 persons less).
stand-by equipment like computers with monitors and printers and radios (at the moment including laptop 4 systems)
illumination
washing machine down to 40 (less laundering)
dish washer (not applicable at the moment)
dryer for clothes (not applicable at the moment)

To extrapolate the consumption a further assumption has to be made for single households. In the case when a person leaves the flat for a longer period of time, e.g. for work, the temperature of heating is lowered. In consequence the function between running time of the boiler and consumption will change.

Taking the demographic trends above into account the decrease of energy will not be proportional to the decrease of population but will be less due to improvements of efficiency and a reduction in energy losses due to by better insulation of houses.

The current development of energy demand does follow this theoretical set-up. Figures of the "Statisches Bundesamt" prove that growth of Germany's population is negative (population decreases). The primary energy consumption in total and for households is increasing since the year 2000. The first effect with the reduction of industry activity caused by reunification of Germany is excluded.

This contradiction in logic is taken up in Chapter 8.

CHAPTER 7

RESEARCH PROJECTS

7. Research Projects

7.1 Introduction

The research described in this section is concerned with contracting projects, energy supply and additional services such as maintenance by Stadtwerke Gelsenkirchen GmbH (City Works of Gelsenkirchen). With the take over of municipal services such as waste, transport, public green plots and telecommunication the name was changed into GEW Gesellschaft für Energie und Wirtschaft mbH (Company for Energy and Economy). They are a 7 % owner of ELE Emscher Lippe Energie GmbH, the supplier for electricity and natural gas in the cities of Bottrop, Gelsenkirchen and Gladbeck (see appendices). The maintenance of boilers began in the nineteen-fifties while the first contracting plant for private customers started operation in September 1991.

A special consideration is given for district heating in Gelsenkirchen. District heating was established in the late nineteen-sixties. The contract was placed by the city of Gelsenkirchen to GEW with the condition that Steag AG would supply the south of Gelsenkirchen and E.on Fernwärme GmbH would supply the north. The geographical centre of the city, mainly without buildings, was given to GEW. This emptiness resulted from when the towns of Gelsenkirchen, Horst and Buer were united as Gelsenkirchen-Buer in 1928 and the former edges of the towns formed the new geographical centre. The district heating began in 1987 with a mobile boiler plant as a provisional arrangement. Steam was supplied to all customers without any differentiation between domestic or industrial users. In 1989 the power station started operation. The customers with domestic demand were changed to hot water, the industrial ones remained on steam.

The district heat supplier for Bottrop is Steag AG and for Gladbeck E.on Fernwärme GmbH. Both companies changed from direct supply to the building to an individual heat exchanger including pump and control. The customer is not concerned about the technique of delivery but is more interested in a system free of repairs and maintenance.

All the networks were designed to meet the heating demand, which are weather and temperature related. The three cities supplied by ELE with electricity and natural gas have Essen as a neighbour. Essen is the site of the nearest meteorological station. The degree days for the last two decades and their graphs since 2000 are given as a preface to the projects.

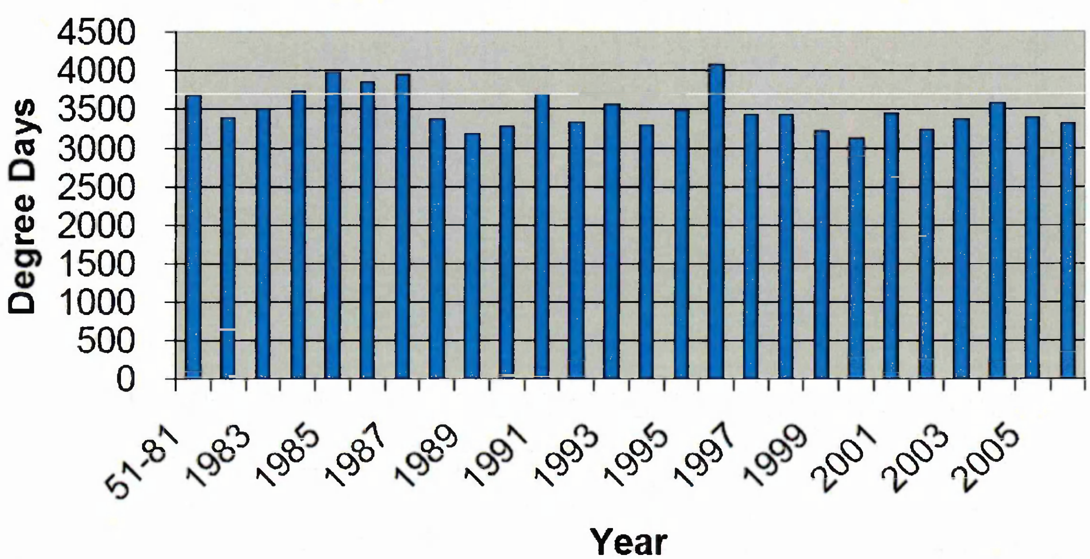


Figure 7.1: Degree Days 20°C, City of Essen

The average of the three decades 1951 to 1981 is defined as a standard year. The light grey line in figure 7.1 is the guideline to compare the current year with the standard year. Since 1989 all years except 1997 required less heat demand than the standard year.

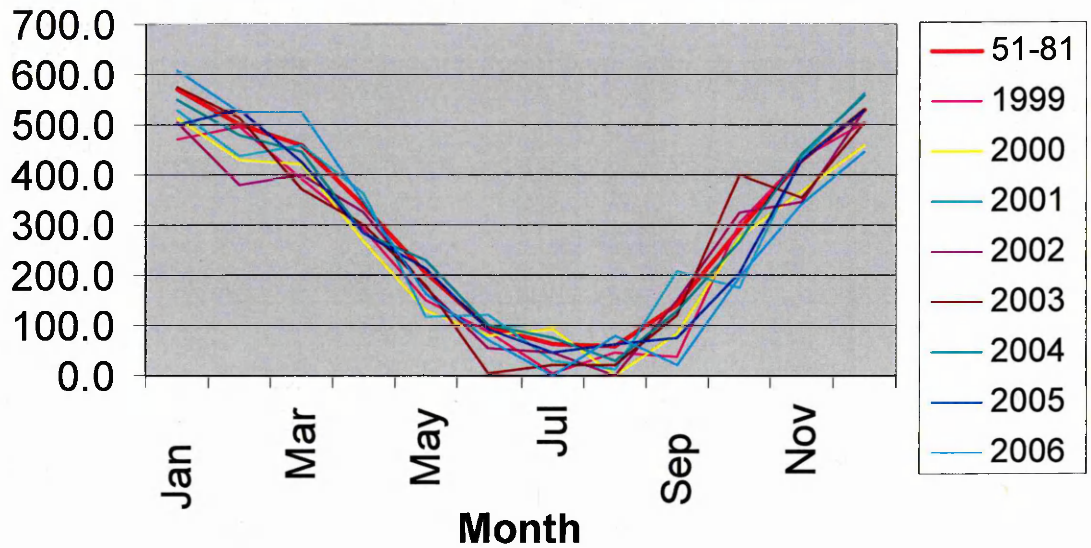


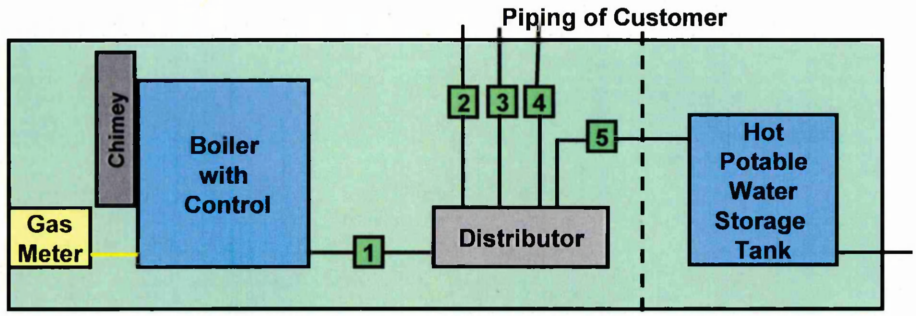
Figure 7.2: Monthly Degree Days 20°C, City of Essen, 1999 to 2006

The summary of the monthly data gives an indication to the development in general. The monthly curves create more detailed information. The standard year curve has reduced to a lower level within the last decade and the degree days have at times reached zero. The heating season is reduced and finishes by early June but the start in September remains the same.

If the extended hot period is not changed or strengthened by global warming it can still be used to extend heating with solar thermal panels.

7.2 Central Heating with Gas fired Boilers

The competitive service product offered was heat contracting:
The customer pays for the connection of his house to the natural gas supply like every other gas customer. GEW supplies the house internal gas pipe and the boiler including the controls. The heat meter is directly installed at the entry/exit of the house piping at the boiler. In the case of hot potable water supply, a second meter is installed in the circuit to the storage tank beside the main counter (refer to figure 7.3).



1 Heat meter for total heat production/input

2..n Heat meter for separate billing of customers (only possible when one circuit per appartment)

5 Heat meter for input preparation hot potable water

Heat for heating as Δ (HM 1 – HM 5) with HM = Heat meter

Efficiency of boiler: HM 1 / Gas Input (Gas input in Hi)

Loss by chimey: Measured by authorities at full load once per year (ELE plants in average 6 to 8 %)

Figure 7.3: Sketch of Heating System for Contracting with Metering Points

Table 7.1 shows as an example the evaluation for the year 1998 (J98) for the boilers being installed in 1994 (B94). This table is done for every installation and operational year.
B91-97J91-98. Tables and written analysis of data are given in the appendices (refer to electronic appendix 7)

Description to the table:

Column	A	Street (Straße)	
	B	Manufacturer of Boiler (Kessel, Fab.)	
	C	Type of Boiler (Typ)	
	D	QN	standard heat output capacity
	E	WWB	central potable water supply
	F	WE	number of apartments being supplied
	G	QG	output of heat
	H	QE	input of gas in H_s
	I	eta	efficiency *QG/QE/0.9*100* $H_i/H_s = 0.901\text{-}0.902$
	J	QWWB	portion of heat output for potable water supply
	K	VBS	full load operation time in hours *QG/QN*1,000*
	L	VBS HZ	full load operation time for heating only *(QG-QWWB)/QN*1,000*
	M	QGN	reference heat output corrected with degree days figures *IF(WWB="x";* *(QN*1500*GTJ/3680+WE*3000)/1000;* *(QN*1500*GTJ/3680)/1000)*

N	Delta N	deviation of the current year to reference heat output *(QG-QGN)/QGN*100*
O – AE		commercial data with investment, sales prices etc.

Sub table			
Column	A	Gradtagszahl 98	Degree days of current year here 1998
	BC		figure of degree days; *GTJ*
	Vollbenutzng. HZ		full load operation time for heating only *1500*GTJ/3680*

The capacity of the boilers is calculated in accordance with the DIN 4708[26], the German standard for calculation. The reference temperature is -10°C.

Referring to VDI 2067[27], the full load operation time for heating only is approximately 2,000 h. The set-up used for this project is 1,500 h. The main reasons for the reduction are:

not all rooms are heated in accordance with DIN 4708 (e.g. sleeping rooms)
in cases were the accommodation is unoccupied the temperature is reduced because of

holidays (30 days/year on average plus bank holidays and entitlement days)
time at work

Apart from these assumptions the full load operation time give some characteristics of the tenants:
high figures of full load operation time (>1.800 h):
heating costs are paid by the municipality (social welfare)
low figures of full load operation time:
< corrected reference value: working tenants
< 1,200 h: single households

With knowledge of the ethnicity of the tenants, correction factors can be included. The input of energy for hot potable water is neither in accordance with VDI 2067 nor with the regulations the billing of heating costs (18 % of total amount of energy input).

For the commercial evaluation, which is not part of this thesis, the set-up is 3,000 kWh/year per flat. Heat losses for the distribution are included. This figure equals 100 to 170 *l* per flat per day depending on heat losses between 0 and 40 % which are not measured. A calculation program which was developed for ASEW by the author is in the appendices. This corresponds 25 to 40 *l*/day per person.

Nahwärme BJ94J98

allg. Anlagendaten						Jahresdaten						Normabweichung	
Strasse/HsNr.	Kessel Fabr.	Kessel Typ	QN [kW]	WWB	WE	QG [MWh]	QE [MWh]	eta [%]	QWWB [MWh]	VBS [h]	VBSHZ [h]	QGN [MWh]	Delta N [%]
Auf der Hardt 111	Vai	VK 47-2	47		8	51.4	63.9	89.3		1,093	1,093	65.7	-21.9
Auf der Hardt 140	Vai	VK 47-2	47		8	58.7	74.2	88.0		1,249	1,249	65.7	-10.7
Bahnstraße 27	Wol	NG 3 E	31		6	51.4	64.4	88.6		1,659	1,659	43.4	18.6
Burgstraße 12	Bud	GE 405	190		43	254.7	321.1	88.1		1,341	1,341	265.8	-4.2
Grabenstraße 28	Vie	Paromat Tn	105		16	104.8	145.3	80.1		998	998	146.9	-28.7
Im Meldegang 1	Vai	VK 31-2	31	x	3	27.3	36.0	84.2	6.4	879	672	52.4	-48.0
Industriestraße 96	Vai	VK 36-2	36		6	45.9	56.2	90.8		1,275	1,275	50.4	-8.8
Josefinenstraße 37	Bud	GE 405	190	x	35	430.5	586.5	92.9	135.6	2,581	1,868	370.6	32.3
Katernberger Str. 14	Vai	VK 42-2	42		9	95.1	117.8	89.7		2,264	2,264	58.6	61.9
Katernberger Str. 22	Vai	VK42-2	42		10	115.1	144.8	88.3		2,740	2,740	58.6	95.8
Katernberger Str. 30	Vai	VK42-2	42		9	114.1	143.7	88.2		2,717	2,717	58.6	94.2
Katernberger Str. 32	Vai	Atmotec	20		6	59.3	78.5	83.9		2,965	2,965	28.0	111.9
Katernberger Str. 33	Vai	VK 47-2	47		15	94.1	121.1	88.3		2,002	2,002	65.7	43.1
Liebfrauenstraße 2	Vie	Vitola	40	x	5	48.6	59.5	90.7	13.5	1,214	877	71.0	-31.5
Parallelstraße 2	Bud	GE 405	165	x	38	358.6	517.5	83.4	110.1	2,355	1,685	344.8	12.7
Ringstraße 84	Vai	VK 47-2	47		9	49.0	67.5	80.6		1,042	1,042	65.7	-25.5
Röttgersweg 17	Vie	Atola	32		6	50.5	67.2	83.5		1,578	1,578	44.8	12.8
Sandstraße 44	Vai	VK 42-2	41		7	46.4	61.7	83.6		1,132	1,132	57.4	-19.1
Schaffrathstraße 99	Vie	Atola	64		12	59.5	78.6	84.0		929	929	89.5	-33.6
Summe			1,259		251	2,204.9	2,805.6	87.3	265.6	1,751	1,540	2,004.2	10.0

	Investition						Betriebs- und Kapitalkosten						Einnahme			Ergebnis	
Strasse/HsNr.	WEA [DM]	Plan. [DM]	WZ [DM]	Sonst. [DM]	Summe I [DM]	Spez. [DM/kW]	Annu. [DM]	KOAB [DM]	BSFN [DM]	Wart. [DM]	Repa. [DM]	Summe B [DM]	AP [DM]	GP [DM]	Summe E [DM]	Marge a [DM]	RM [%]
Auf der Hardt 111	7,161		823		7,984	169.87	913	2,674	87	202		3,875	3,424	2,193	5,617	1,742	21.8
Auf der Hardt 140	7,600		823		8,423	179.21	963	3,101	87	202		4,353	3,912	2,193	6,105	1,753	20.8
Bahnstraße 27	6,240		823		7,063	227.84	807	2,691	87	169		3,755	3,426	1,447	4,873	1,118	15.8
Burgstraße 12	34,711		1,665		36,376	191.45	4,158	13,429	87	492		18,166	16,975	8,867	25,842	7,677	21.1
Grabenstraße 28	16,758		1,042		17,800	169.52	2,035	6,077	87	320		8,518	6,983	4,900	11,883	3,365	18.9
Im Meldegang 1	10,450		823		11,273	363.65	1,289	1,504	87	169		3,049	1,816	1,447	3,263	214	1.9
Industriestraße 96	6,016		823		6,839	189.97	782	2,350	87	180		3,395	3,060	1,680	4,740	1,341	19.6
Josefinenstraße 37	36,000	4,197	2,526		42,723	224.86	4,883	24,528	87	492		29,990	32,682	8,867	41,549	11,559	27.1
Katernberger Str. 14	7,035	893	823		8,751	208.36	1,000	4,927	87	192		6,206	6,337	1,960	8,297	2,091	23.9
Katernberger Str. 22	7,035	893	823		8,751	208.36	1,000	6,056	87	192		7,335	7,687	1,960	9,626	2,292	26.2
Katernberger Str. 30	7,035	893	823		8,751	208.36	1,000	6,009	87	192		7,255	7,604	1,960	9,565	2,276	26.0
Katernberger Str. 32	5,170	656	823		6,649	332.45	760	3,265	87	147		4,279	3,951	933	4,885	606	9.1
Katernberger Str. 33	7,235	918	823		8,976	190.98	1,026	5,064	87	202		6,379	6,271	2,193	8,464	2,085	23.2
Liebfrauenstraße 2	13,589		1,648		15,237	380.93	1,742	2,489	87	188		4,505	3,237	1,867	5,103	599	3.9
Parallelstraße 2	23,622	3,180	2,707		29,509	178.84	3,373	21,643	87	441		25,544	25,898	7,701	33,598	8,054	27.3
Ringstraße 84	8,269		823		9,092	193.45	1,039	2,823	87	202		4,151	3,263	2,193	5,457	1,306	14.4
Röttgersweg 17	6,249		823		7,072	221.00	808	2,812	87	171		3,876	3,365	1,493	4,859	980	13.9
Sandstraße 44	8,331		823		9,154	223.27	1,046	2,580	87	190		3,903	3,092	1,913	5,006	1,103	12.0
Schaffrathstraße 99	9,769		823		10,592	165.50	1,211	3,289	87	236		4,823	3,962	2,987	6,949	2,125	20.1
Summe	228,275	11,630	21,110	0	261,015	207.32	29,834	117,330	1,653	4,579		153,396	148,925	58,758	205,683	52,287	20.0

Berechnungsgrundlagen		
Gradtagszahl 98	3,432	
NW-Arbeitspreis 98	66.636	DM/MWh
NW-Grundpreis 98	45.67	DM/kW
Erdgaspreis 98	4.182	Pf/kWh
WartungsGP 98	106.51	DM
WartungsAP 98	2.03	DM/kW
Vollbenutzng. HZ	1,399	

Kesselfabrikate	
Bud	Buderus
Jun	Junkers
Vai	Vaillant
Vie	Viessmann
Wei	Weishaupt
Wol	Wolf

Katernberger Str. xx versorgt über Stw Essen

der Gaseinsatz Katernberger Straße mit 11,4 kWh/m³ gerechnet

Der Erdgaspreis ist gemittelt anhand der Gradtagszahlen.	
Bis zum 01.10. galt ein Preis von 4.3 Pf/kWh, danach von 4.0 Pf/kWh	
Gradtagszahlen 01-09	2,053
Gradtagszahlen 10-12	1,349
Erdgaspreis	4.182 Pf/kWh

Der NW-Arbeitspreis ist gemittelt anhand der Gradtagszahlen.	
Bis zum 01.07. galt ein Preis von 68.26 DM/MWh, danach von 64.80 DM/MWh	
Gradtagszahlen 01-06	1,821
Gradtagszahlen 07-12	1,611
NW-Arbeitspreis	66.636 DM/MWh

Table 7.1: Energy Consumption and Efficiency of Boilers (installed in 1994, data 1998)

The summarized results are

1 - No boiler reached the efficiency quoted in their sales catalogue of boiler manufactures/German Standard
2 - The production of warm potable water does not have a negative effect on the efficiency of the boilers. The positive difference is not significant enough to state as a positive effect.
3 - In the case of boilers with two rows of atmospheric burners, fan burners or modulating fan supported burners the full load operating hours in the range between 1,100 and 2,000 hours have no significant influence on the efficiency of boilers
4 - Boilers with just 1 row of atmospheric burners are susceptible to low full load operation hours (- 15 % efficiency)
5 - A good correlation between degree days and consumption is given with the exception of extreme cold winters as in 1996 to 1997.
6 - Heat demand for the warming of potable water can be taken for first set-up as a constant (depending on the tenants of the building)

From the commercial part
1 - instead of an expected price decrease, a price increase can be seen for plants that are larger than 200 kW
2 - the costs for investment are 100 €/kW for plants without central preparation of warm potable water and 125 €/kW for plants with it. (40 to 100 kW)
3 - under 40 kW the portion of fixed costs (gas pipe in the house, assembly of boiler plus control) leads to higher cost per kW

These commercial figures are needed for decisions on energy concepts.

With the exception of Ellinghorst 37 and Brockskampsweg 17 and Brockskamp 99 heat measurement were made with WSC / WSD ultra sonic heat meters by Landis and Staefa. According to short and long period tests by AGFW[28] the errors in measurements are smaller than 1.5 %.

Many of the impeller heat meters fail the calibration specification (5 %) and the operational error limit (10 %) within 2 to 3 years. As a rule these measurements are usually low.

The Ellingorst 37 is equipped with an impeller type heat meter. Within the five years between 1991 and 1996 the efficiency calculated from the measurements (gas and heat meter) reduced from 91 % to 83.6 %. This decrease was not real but was due to drift in the calibration of the heat meter. Due to the low prices for energy at that time the heat meter was not regularly replaced. With today's prices for energy the meter would be replaced before the end of its calibration period. Each kWh which is not recorded is money lost to the supplier.

The Brockskamps plants were equipped with turbine-type heat meters. The efficiency remained constant. In 2001 the heat meters were changed to ultra sonic type meters.

7.3 Central Heat Supply for 13 Apartment Blocks

Figure 7.2 shows the initial design concept for a district heating system for an existing estate of multiple family dwellings. The blocks are divided into 41 sections arranged into 6 blocks of 4, 3 blocks of 3 and 4 blocks of 2 sections. The double blocks have two floors giving 4 apartments per block, the others have 3 floors giving 18 apartments and 24 apartments per block.

The heat demand was approximately 1,100 kW without the losses of the district heating grid. The concept envisaged the take over points (TOP) to the similar boiler plants at the entry/exit of the de-centralised heating described in 7.1. The size of the CHP plant was 250 – 300 kW_{el}. The hot potable water supply was achieved with electrical instantaneous water heaters. This reduced the operational time of the engine without interruption to the winter season (maximum 2,000 h/year) and the operational time with interruption during spring and autumn (together another 2,000 h/year as maximum). During summer the operational time of the CHP was assumed to be zero due to the replacement electrical heating of the potable water. This was the reason why the central supply from the CHP plant and boiler was not able to meet peak demand.

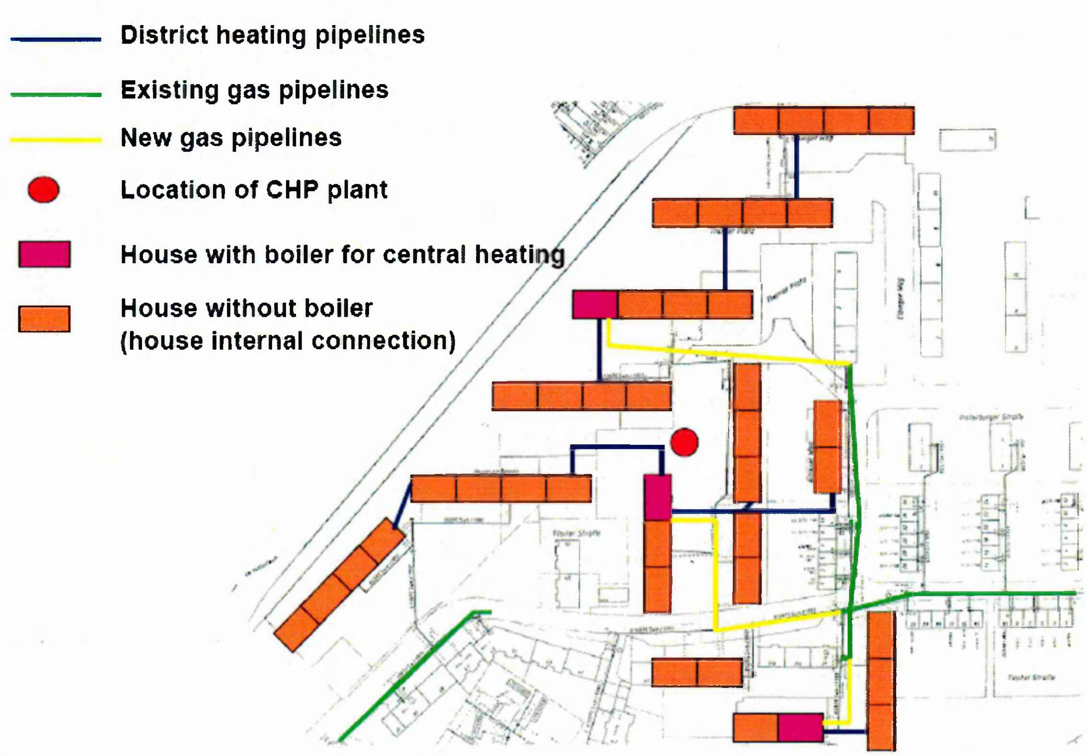


Figure 7.4: Initial Design of the Heat Supply Network

As an alternative a second concept shown in figure 7.4 was investigated. The results for this concept indicated very high capital expenditure. Within 6 weeks a final concept was elaborated and an order was placed. Figure 7.5 shows the realized concept; figure 7.6 shows the comparison of costs.

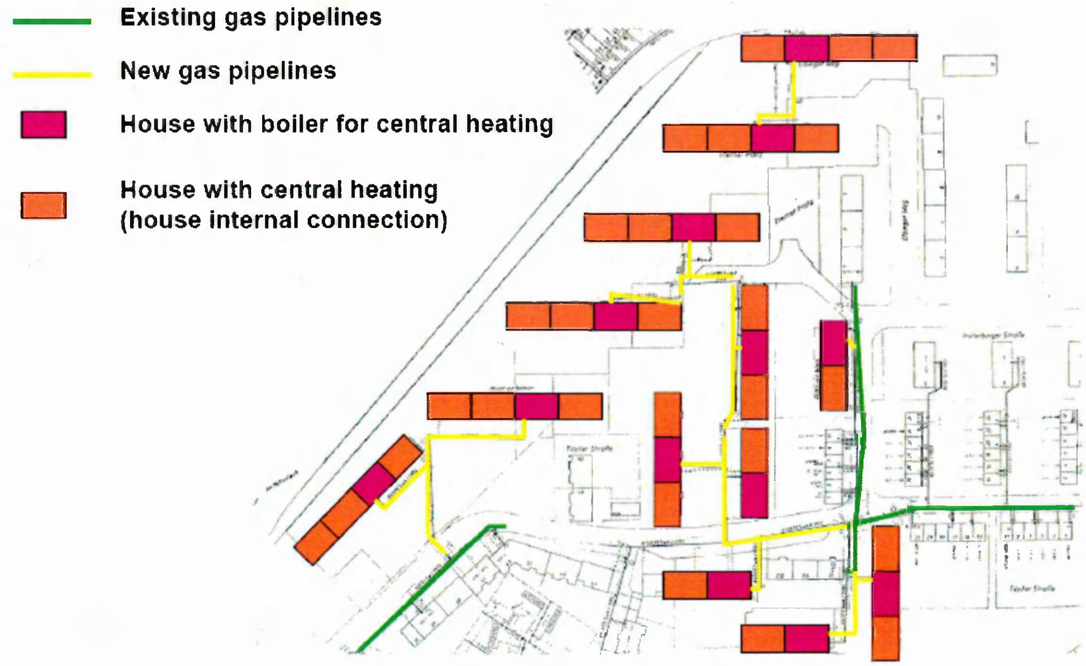


Figure 7.5: Realized Concept

Costs owner of estate	3 Centrals	13 Centrals
contribution network gas	0.0	58.5
district heating pipes	>150.0	0.0
chimneys	38.5	19.5
heating rooms	7.5	32.5
	>346.0	115.0
costs ELE		
laying of gas grid	31.5	57.5
contribution network gas	0.0	-58.5
heating centrals	147.5	108.5
heat meter	3.0	8.0
	182.0	105.5
savings owner of estate		235.0
savings ELE		75.0

All costs in 10^3 €

3 centrals
2 @ 450 kW (225 CB + 225 LT)
1 @ 225 kW (CB)

13 centrals as 1 boiler plant
6 @ 130 kW
1 @ 91 kW
2 @ 70 kW
4 @ 46 kW
(all in LT)

CB: Condensing boilers
LT: Low temperature boilers

Figure 7.6: Comparison of Costs

Energy input, costs per year can be found in the table of the years

1992 Bahnstr. 34 and 42
Tilsiter Str. 27, 33, 37, 38 and 44.
Pillauer Weg 15
1993 Elbinger Weg 15
Thorner Platz 2, 3, 8 and 11

The present costs (2007) for services trenches per metre[29] are given in Table 7.2. These costs are for smaller installations, larger ones are at a lower price. For gas pipes or electric cables a trench with a width of 0.3 m is sufficient. The smallest bore for district heating, 25 mm, has an outer diameter of 75 mm. Two pipes are required;

the distance between them is approximately 150 mm and the distance to the edge of the trench another 100 mm at each side. Taking these standard figures in account the trench has a minimum width of 0.5 m. District heating grids also require expansion bows and additional space for welding.

AGFW have undertaken a number of projects aimed at reducing the costs for establishing a grid. Limiting the flow temperature to 95 °C enables plastic pipes to be used. They can be laid without welding. Another alternative is to lay the pipes on top of each other with the return flow under the flow line, but this requires more depth. The flow line has the higher thermal load, expansion and because of this is more prone to damage. The less often case of repairs to the return line are more expensive than when they are laid side by side.

		Gas		Cable		Δ	Δ %
	Soil and Surface	Dimension	Price	Dimesion	Price		
Trench	Trench, ash, lawn, field	100; 50; 100	35.63	100; 30; 70	11.93	23.70	199
Trench	Banquet	100; 50; 100	46.29	100; 30; 70	25.17	21.12	84
Trench	Building area without surface	100; 50; 100	39.69	100; 30; 70	16.24	23.45	144
Trench	Building area 30 without surface	100; 50; 100	42.36	100; 30; 70	19.55	22.81	117
Trench	Bitumen pavement	100; 50; 100	92.49	100; 30; 70	61.93	30.56	49
Trench	Bitumen Street 1	100; 50; 100	116.5	100; 40; 90	102.01	14.49	14
Trench	Bitumen Street 2	100; 50; 100	132.52	100; 40; 90	116.67	15.85	14
Trench	Bitumen Street 3			100; 45 ;90	139.47		
Trench	Cobbled pavement	100; 50; 100	75.61	100; 30; 70	48.59	27.02	56
Assembly Hole	Trench, ash, lawn, field	140; 140;150	275.51	100; 100; 100	52.3	223.21	427
Assembly Hole	Banquet	140; 140;150	310.93	100; 100; 100	88.6	222.33	251
Assembly Hole	Building area without surface	140; 140;150	287.28	100; 100; 100	62.58	224.70	359
Assembly Hole	Building area 30 without surface	140; 140;150	296.13	100; 100; 100	71.76	224.37	313
Assembly Hole	Bitumen pavement	140; 140;150	428.65	100; 100; 100	150.83	277.82	184
Assembly Hole	Bitumen street 1	140; 140;150	512.68	100; 100; 100	213.41	299.27	140
Assembly Hole	Bitumen street 2	140; 140;150	570.14	100; 100; 100	248.77	321.37	129
Assembly Hole	Cobbled pavement	140; 140;150	409.86	100; 100; 100	148.96	260.90	175

Λ = price cable - price gas
Λ % = basis price for cable

Assembly holes gas: one per 12 m (service connection excluded)
Assembly holes cable: one per 100 to 500 m (service connections excluded)

30 cm trench is sufficient for 2 cables

Table 7.2: Prices for Trenches including Restoring Surface

7.4 Solar Estate (German Award for Natural Gas and Renewable Energies)

Planning for the estate started in 1998 when GEW and the former RWE Regional Supply Emscher Lippe were not then unified as ELE. The supplier for gas was GEW, for electricity RWE and for district heating in competition with natural gas Fernwärmeversorgung Gelsenkirchen GmbH, a subsidiary of Steag AG. In the immediate neighbourhood a school was connected to district heating with a quotation from GEW of guaranteed heat prices 10 % lower than those of district heating. The original design was a gas fired CHP plant, solar thermal panels for hot water plus a natural gas fired boiler to meet peak demand. The connection to the gas net was free of charge for the customer. A similar situation arose in 1997 with another estate and a free of charge gas connection was also made.

A revision of the original design was necessary in order to provide a more competitive technical and economical solution.

The demands for the houses were

55% CO_2-saving in comparison to standard houses (legislation),
40% of demand of electrical power by photo voltaic,
65% of demand of hot potable water by solar thermal panels.

At that time the EnEV, Regulation on Saving Energy, existed as two independent regulations on insulation and heating plants. To meet the aims of the regulators the system had to be viewed in total, to include the fabric of the building, the orientation, and the household appliances of the consumers, energy supply/production and the behaviour of users (requirement for an operational manual).

One half of the estate was designed as terraced houses with a central energy supply and the other half was designed as conventional buildings (brick built, no alignment of windows to the south and each house equipped with individual boiler and solar system).

The following description is limited to the terraced houses with a central system.

One section was erected as a wood-frame construction and another in limestone. The outer shell had to be insulated, the windows were fitted with heat protecting glass and the house had to be tight against wind. The alignment of the large windows was to the south while on the north side smaller windows were installed. The solar panels were designed in such a way that they provided shade to the large windows during summertime and allowed sun in during wintertime. Additionally the panels had to shade the openings of the controlled ventilation.

As a technical solution the items chosen were solar panels (thermal and photo voltaic), controlled ventilation, cooking with natural gas and connection of dish washer and washing machine to the hot water supply. Heating was supplied by a condensing boiler. From experience with a low energy house, heated by an electrical heat pump with controlled ventilation, the ventilation was switched off at outside air temperatures higher than 20 to 25 °C (depending on the adjustment of the owners) to keep heat out of the building.

The idea of a central "head" station was devised; a separate building (3 x 3 m) from which two rows of terraced houses could be supplied. The content is given in table 7.3.

A speciality is the billing of the gas for the gas cookers. The total amount of gas measured by the meter was divided by the amount of tenants cooking with gas. Instead of numerous single contracts with low base prices and high gas prices one contract with a higher base price and low gas prices was signed. The single higher base price was lower than the sum of the ten single lower priced ones. By this the owners saved money. A further motivation was the emission saving compared to cooking with electrical stoves.

The principle for the distribution of gain from the solar panels (photo voltaic and thermal ones) was similar to the cooking gas. The solar gain can be assumed as identical per house being supplied from the same head station.

1 connection to the electrical grid (entry)
2 connections for electrical supply for the terraced houses (two rows)
2 entry cables for electricity from photo voltaic panels
1 electric meter for consumption of installations in head station
1 electric meter for production of electricity from PV panels
2 entry pipes, hot water from solar thermal panels
2 exit pipes, cold water to solar thermal panels
1 heat exchanger to de-couple the storage tank from the solar thermal panels
1 solar storage tank (up to 2,000 *l*)
1 heat meter for solar thermal panels
1 expansion vessel, solar thermal panels
pumps, piping etc.
1 exit pipe for supply with gas for cooking
1 condensing boiler with stack and condensate piping
1 gas meter for consumption of condensing boiler
1 gas meter for supply of cookers
1 expansion vessel central heating
2 expansion vessels central hot water supply
2 heat meters (1 x heating, 1 x hot water)

Table 7.3: Content of Head Station

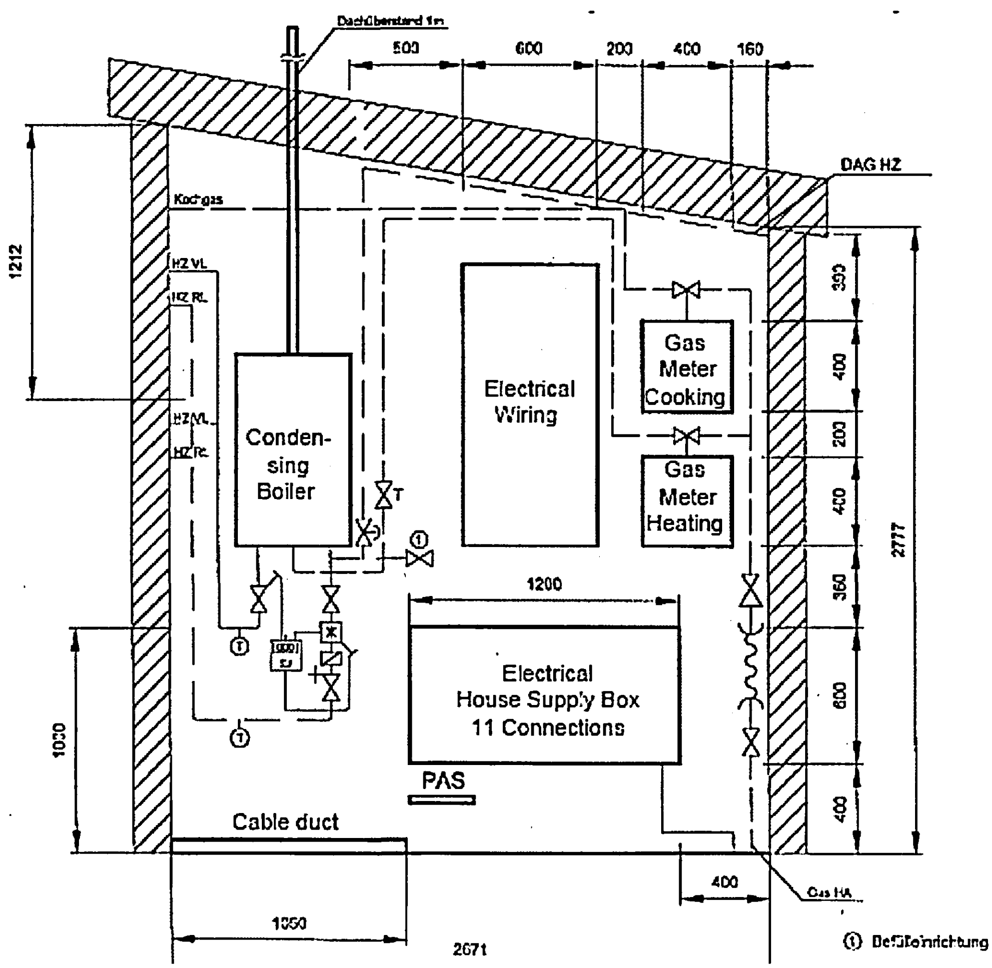


Figure 7.7: Sectional Diagram (View to the West Wall)

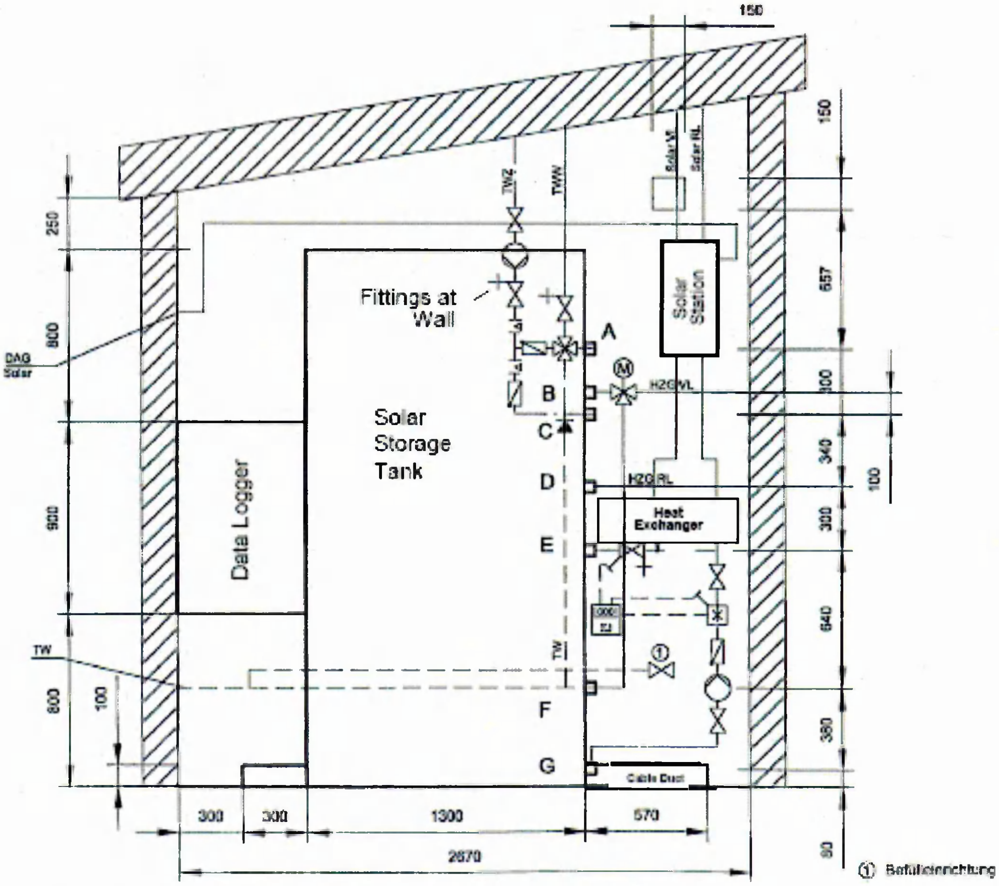


Figure 7.8: Sectional Diagram (View to the East Wall)

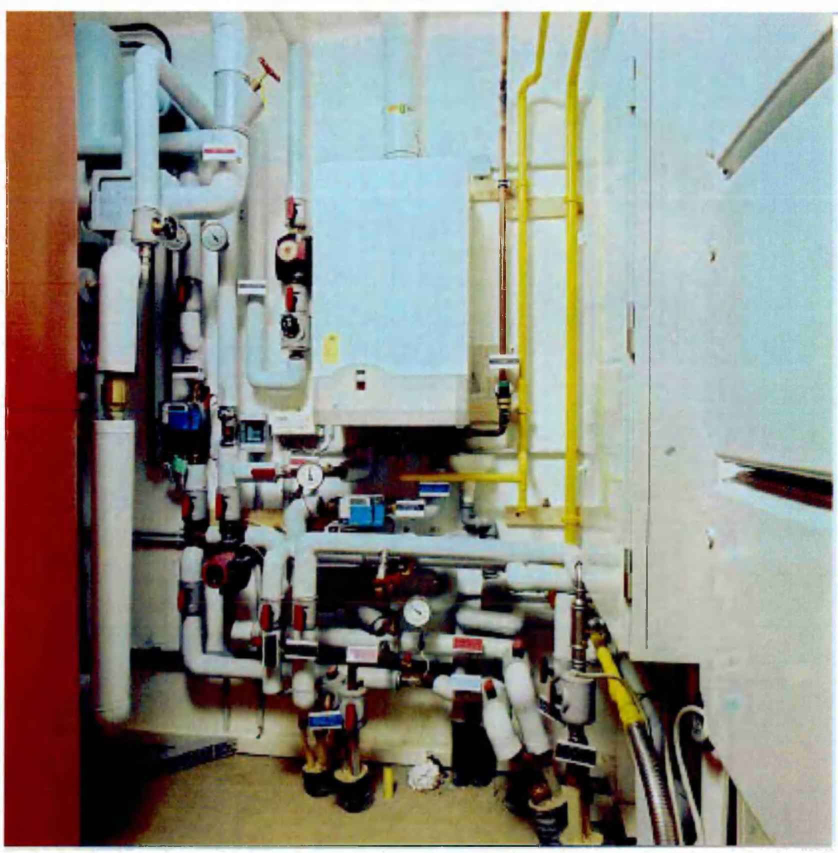


Figure 7.9: Photo of Interiors of Head Station

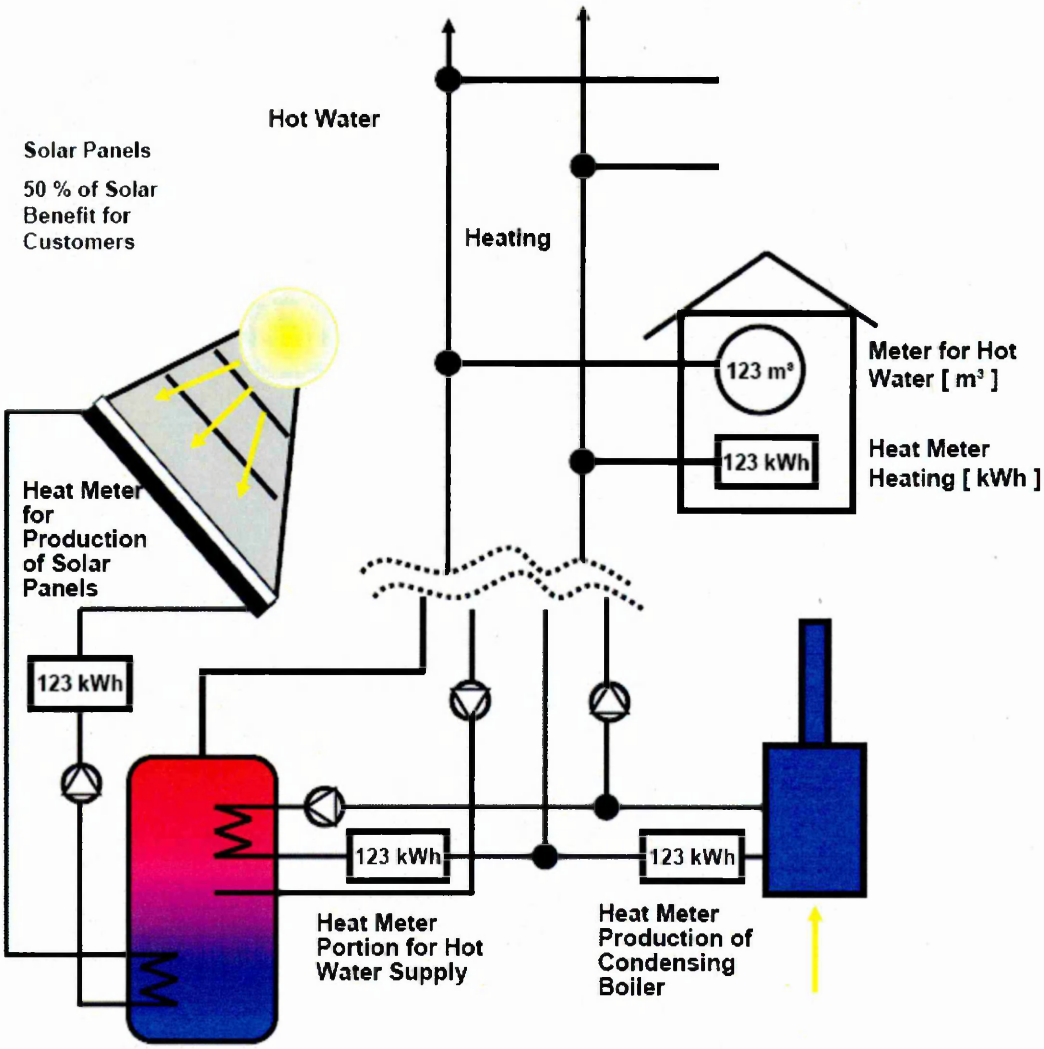


Figure 7.10: Simple Plant Schematic

The contract being signed included the same price for heat as for all contract plants (see 7.2). 50 % of the solar gain from the solar thermal panels was reimbursed to the owners within the yearly billing of heat as credit in MWh. The previous energy supplier, today the operator of the grid, had to pay for the input of electrical power produced by the photo voltaic panels. Two thirds of this payment had to be reimbursed to the owners of the properties. With the new Act coming into force on 1st of April 2000 the payment for the electrical energy was increased by a factor 5.

The service charges included in the price can be taken from table 7.4.

electrical power demand for pumps
payment of land tax
payment of gas maintenance engineer
operation, maintenance and repair of head station and solar panels
pre-payment to water supplier for potable water demand and distribution in accordance with the legislation
waste water (see above)

Table 7.4: Service Charges Included in the Price for Heat

	StrEG 2000 [ct/kWh]	EEG 2000 [ct/kWh]	EEG 2004 [ct/kWh]	
Water Power				
up to 500 kW	7.33	7.67	9.67	
portion 500 kW to 5 MW	5.96	6.65	6.65	
5 MW < plant < 120 MW	---	---	3,70 - 6,65	different portion from 500 kW (6,65) up to 50 MW (3,70)
% Degression per Year	---	---	1.00	
Purification and Depony Gas				
up to 500 kW	7.33	7.67	9.67	
portion 500 kW to 5 MW	5.96	6.65	6.65	
5 MW < plant	---	---	6.65	no portion with higher reimbursement
Add on for different technologies	---	---	2.00	no CHP efficiency required
% Degression per Year	---	---	1.50	
Gas (Methane) from Coal Mines				
up to 500 kW	---	7.67	9.67	
portion 500 kW to 5 MW	---	6.65	6.65	
5 MW < plant < 20 MW	---	6.65	6.65	no portion with higher reimbursement
Add on for different technologies	---	---	2.00	no CHP efficiency required
% Degression per Year	---	---		
Biomass				
up to 150 kW	7.33	10.23	11.50	
portion 150 kW to 500 kW	7.33	10.23	9.90	
portion 500 kW to 5 MW	5.96	9.21	8.80	
portion 5 MW bis 20 MW	---	8.70	8.40	
Add on I for CHP	---	---	2.00	no restriction to size
Add on II for CHP plus certain technology	---	---	2.00	restriction to plant size < 5 MW
Add on for certain bio mass up to 500 kW	---	---	6.00	
Add on for certain bio mass up to 5 MW	---	---	4.00	
% Degression per Year	---	1.00	1.50	
Photovoltaik				
Basic Reimbursement	8.25	50.62	45.70	
Add on I size Pel < 30 kW	---	---	11.70	
30 kW < Pel < 100 kW	---	---	8.90	
100 kW < Pel	---	---	8.30	
Add on II no roof	---	---	5.00	
% Degression per Year	---	5.00	5.00	
Wind Power				
inland plants				
Basic Reimbursement	8.25	6.19	5.50	
Add on first 5 years	---	3.43	3.20	Requirement 150 % of Reference Plant
off shore plants				
Basic Reimbursement	8.25	9.10	6.90	
Add on Erection before 2010	---	3.43	2.91	Requirement in act form 2000 different to 2004
% Degression per Year	---	1.50	2.00	
Geothermal Plants				
up to 5 MW	---	8.95	15.00	
portion 5 MW < Pel < 10 MW	---	8.95	14.00	
portion 10 MW < Pel < 20 MW	---	8.95	8.95	
20 MW < plant	---	7.16	7.16	
% Degression per Year	---	---	1.00	

Table 7.5: Reimbursement per kWh Electricity Produced with Renewable Energy

The results of a price comparison for heat (year 2000) are given in table 7.6.

solar with natural gas :	100 %
conventional natural gas:	102 %
district heating (Steag) plus solar:	150 %
conventional district heating (Steag):	181 %

Table 7.6: Comparison of Prices for Heat

For figures of CO_2-emissions see table 7.7:

CHP plus gas cooker:	58 %
solar with natural gas :	60 %
district heating plus solar:	61 %
conventional natural gas:	98 %
conventional district heating:	100 %

Table 7.7: Comparison of CO_2-Emissions

This solar estate was the first in Northrhine Westfalia. Landesinitiave für Zukunftsenergien[30], an institute of the Lander augmented this project with other studies. The project would not have been realised without the sponsorship of the Northrhine Westfalia Lander and the City of Gelsenkirchen. They enabled young families with children the chance to buy a house, but this support was given with some restrictions that the owners were obliged to meet.

The figures used in this study are taken from the project results. They proved that the set-ups were correct and the aims were reached with the exception of gas cookers. The owners all had electrical cookers at the onset of the project and they were obliged to change from electrical to gas cookers over a five year period. (This obligation was not controlled with the result that the energy supply for the cookers was not changed.)[31]

New regulations resulted in a change in the contracts in 2003. The compensation for solar produced electricity was increased to 66%.
The photo voltaic panels and the solar thermal panels were handed over to the owners of the houses together with complete responsibility for the operation, maintenance and repair.
After 15 years the head stations are to be handed over free of charge.

A complete description (power point slides) can be found in the appendices.

The calculations were based on the pre-condition that the solar produced electricity was consumed by the tenants and only surplus is fed into the grid. With the change of the renewable energy Act the owners with individual supplies of electrical power changed their electrical installations (electric meter) in such a manner that 100% of the solar produced electricity was fed into the grid and their demand was met via the grid with "polluted" electricity. As a consequence the target for CO_2-emissions is no longer met from the commercial point of view, but the overall net effect is the same.

Conversation with the owners about satisfaction with their plants gave the following results:
The terraced houses supplied via head stations have no major defects. The inverters had to be changed because they were damaged by lightning during a thunderstorm.

The houses supplied with single boilers have problems with the quality of the heating equipment. Insulation was defective, piping leaked and there were problems with their boilers.

The main difference between both of the solutions was the degree of inspection by the contractor during the construction phase and the selection of approved equipment, e.g. certain manufacturers of boilers, pumps etc.

7.5 WEKA (Combined Heat Cold Power Plant)

The WEKA, now called WEKA KARREE, is a departmental store built at the end of the 19th century. The building regulations of the city restricted the height of the roof. In order to provide more sales area the height of the floors was reduced, which allowed 5 floors instead of 4. This technique was used previously in Frankfurt[32].

Over the decades the heating system changed from coal to oil and district heating. Three chimneys were arranged close to the centre of the building. A 14,000 l oil tank approximately 5 years old was situated in one of the basement cellars.

Before the departmental store was refurbished in 1998 the obligatory emergency power was supplied by a Leonard Set (a row of accumulators with a DC-engine and a generator). Up to 1988 there was no air conditioning installed. During the refurbishment everything but the heritage façade was removed. Even the internal columns were reduced in cross section to the minimum requirements for static security.

The technical solution was developed under the old regime:

prices
High prices for peak of electricity (1/4 h-figure)
High price for peak of natural gas (24 h-figure)

air conditioning
due to low ceilings only small cross sectional ducting was possible.
the recirculated air had to be reduced and fresh air increased

emergency power
VDE 0108, the regulation on emergency generators, only allowed diesel as fuel in the past. This was changed and gas fired engines were allowed with the precondition that the gas grid supply to the emergency generator was independent from the failed electrical grid supply. The change of high pressure to the required low pressure has to be independent from electrically operated pressure control. Additionally a failure of electricity supply would affect the compression of the gas supply which is often required by larger gas engines. The engine has to start and produce the required power within 15 seconds. A gas-fired engine requires a ventilation of cylinders before it is filled with gas. This is an additional step which is not required by diesel engines. The electrical energy is supplied by the starter batteries.

number of possible fuel fired plants
three, because of three chimneys and the permission of new ones (historic façade)

The solution:
gas-fired CHP-plant, the engine is connected to the low pressure grid, at a maximum pressure of 22 mbar.
dual-fuel modulating boiler (oil and natural gas)

indirect fired chiller supplied alternatively with heat from the CHP-plant or boiler
dual-fuel modulating chiller enabling heating with a flow temperature of 80 °C.

The system adopted for the plant is a complex one. A heat, cold and emergency power supply contract was signed by the owner of the departmental store and GEW. The supply points were valves in the cellar. The contract specified that the customer had to meet maximum differences in temperature for the heating system and minimum temperature differences for the cooling system.

The standard operation envisaged was a CHP-plant led by heat. In the case of a peak in electricity the engine could be operated at full load. Possible surplus heat could be diverted to the cooler for emergency cases. For the periods when there were peaks in natural gas consumption for the supplier (GEW), the CHP-plant could be switched off and the heat and cold supply is secured by the oil fired boiler and direct heated chiller.
For the instances when there were simultaneous peaks in electricity and natural gas consumption, the CHP-plant is operated with full load and the remaining supply is achieved by the oil fired boiler and direct fired chiller. Due to the short time of the peak in electricity, the running time of the engine can be limited to just a few hours per day. After the peak in electricity the plant is operated in natural gas peak mode.

Detailed research was undertaken by M. Dorn from FH Gelsenkirchen. An assessment was made by Prof. Dr.-Ing. Braun and the author of this thesis. It is included in the appendices.

The efficiency was as follows:

boiler	85 to 95 % based on H_i
indirect heated chiller:	70 % based on heat input
direct fired chiller:	approx. 100 % based on H_i (catalogue figure of manufacturer)
CHP-plant:	η_{el} = max. 37.9 % based on H_i
	η_{total} = 86.09 % based on H_i

Legislation and prices for energy changed between 1999 and 2007. Additionally the three upper floors were changed from departmental sales space to office accommodation. The demands for air exchange and by this for heat and cold decreased. This caused changes in operation of the plant. As well as a monthly test the engine was operated in stand-by mode. Heat for the heating system and indirect heated chiller was supplied by the boiler only.

The separation of operator of the central equipment (heat and cold supply) and the de-centralised systems on the different floors caused difficulties for the cold supply. The demand of 6 K difference flow and exit for cooling could not be met.

Measuring points were:

customer:	heat meter input heating system
	cold meter input cooling system
CHP-plant:	gas meter
	heat meter
	electricity meter
boiler:	gas meter (together with direct fired chiller)
	oil meter
	heat meter
direct fired chiller:	gas meter (together with boiler)
	oil meter
	cold meter
indirect fired chiller:	heat meter (input)
	cold meter (output)

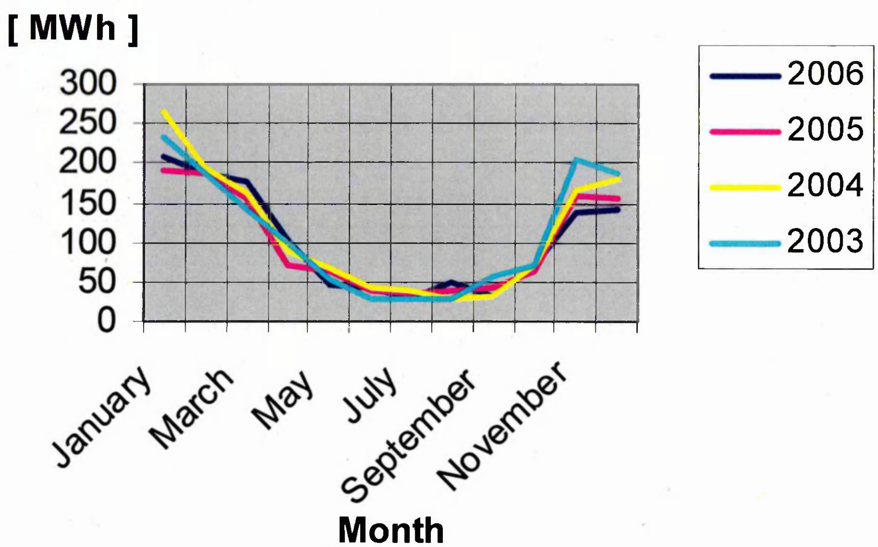


Figure 7.11: Heat Supply to Heating System

The figure shows that between April and October the heat demand is on a nominally constant minimal value. In total the demand is lower than calculated during the design phase. The main reason is the change from departmental store to offices. Additionally the winters during the research were warmer than the average year. This low heating period is longer than estimated by degree day figures (see figure 7.2) and is above zero. The reason is the air conditioning which requires heating for preparation of the air after cooling.

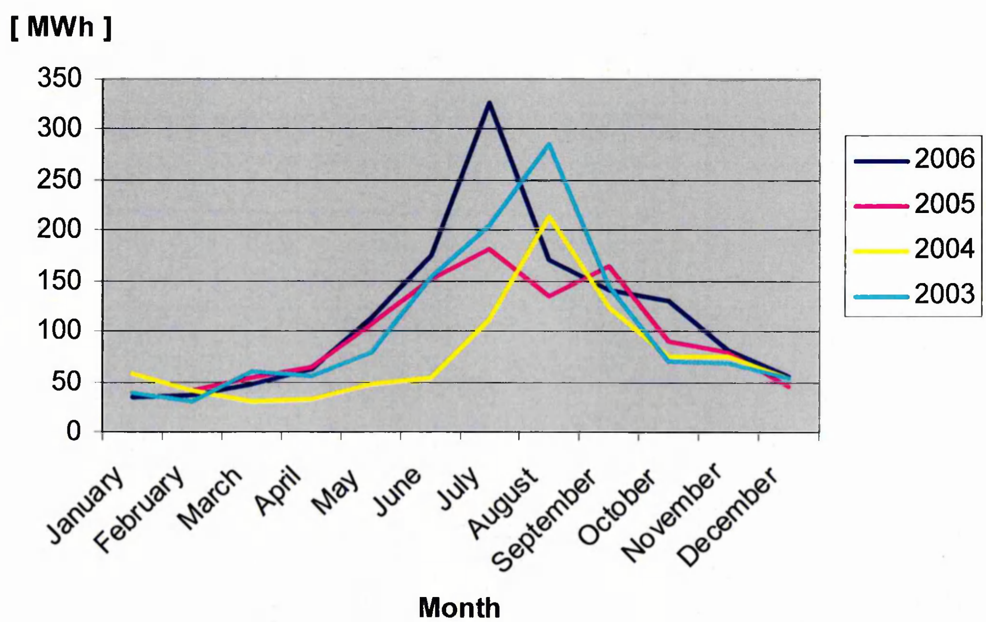


Figure 7.12: Cold Supply to Air Conditioning

The demand for cooling reaches the highest values during the summer time however, the peaks are not in accordance with the lowest heating degree figures. This effect can be explained by the heat capacity of buildings, especially old ones with thick walls and the chill nights during May and June compared to those of July and August. A comparison with the heat shows another effect:

The heat demand during spring time reaches the base demand before the demand for cold increases and the cold demand decreases to the base demand before heat demand increases.

This has an effect on the operation of the equipment to supply heat and cold.

During the transition period the demand for heat and cold is too low to run the CHP plant permanently.

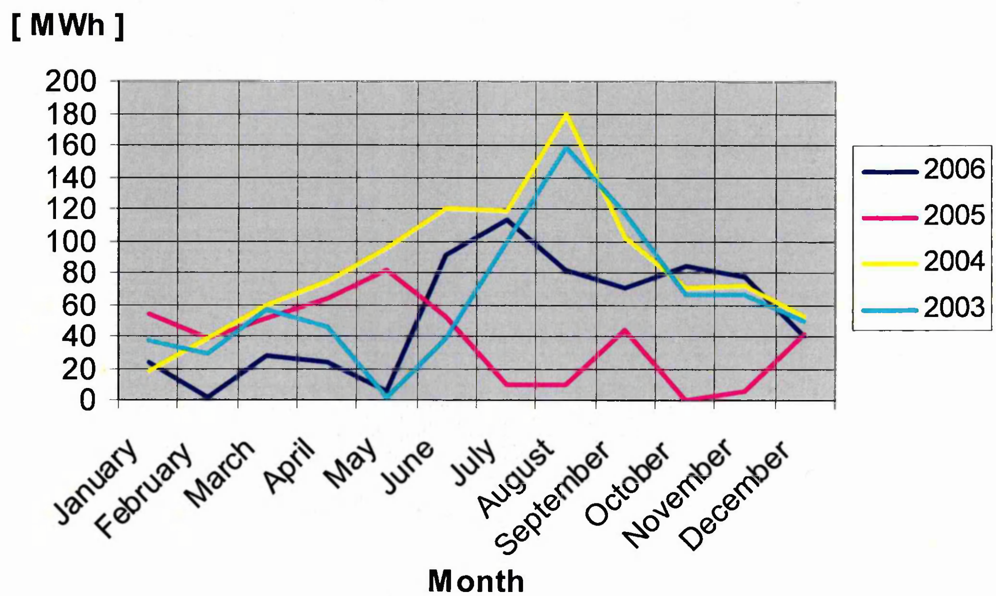


Figure 7.13: Cold Production Indirect Fired Chiller

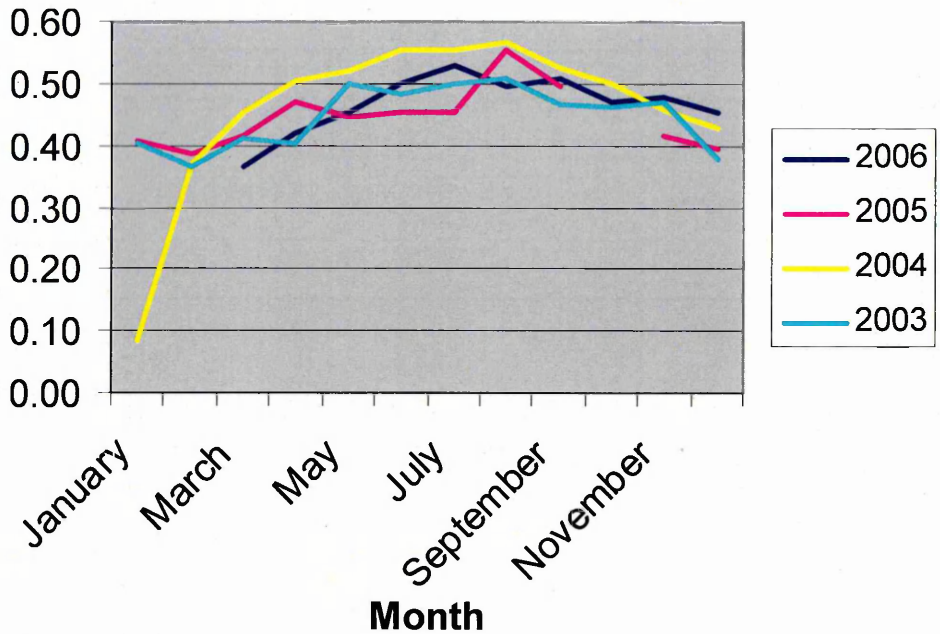


Figure 7.14: Efficiency Indirect Fired Chiller

The figures make clear that production per month has no significant influence on the efficiency of the chiller. The efficiency varies between 0.35 and 0.55.
The research of M. Dorn based on data from start-up phase and acceptance tests demonstrate an efficiency of 70%. The efficiency in practice varies between 50% and 75% of those from the previous tests.

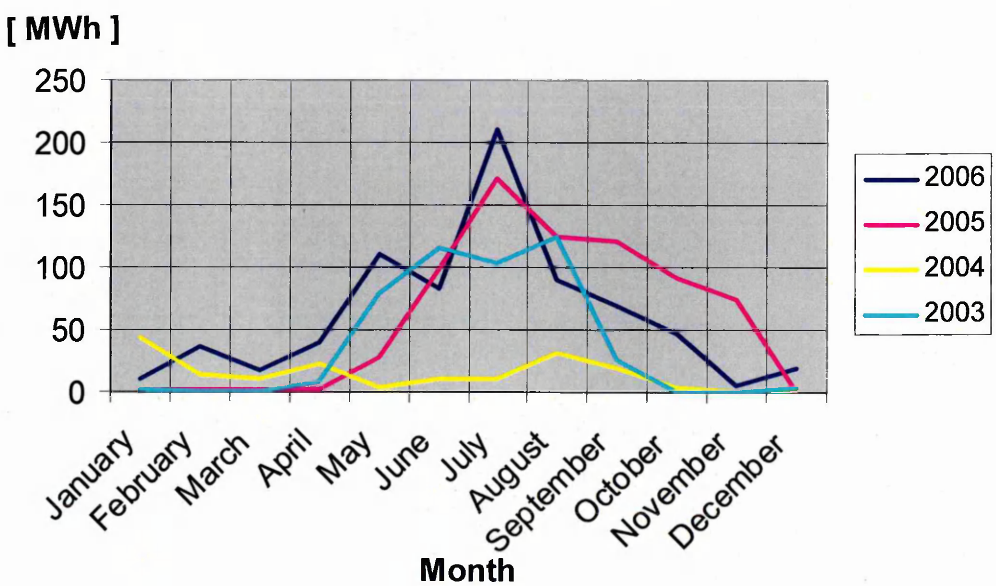


Figure 7.15: Cold Production DF Chiller

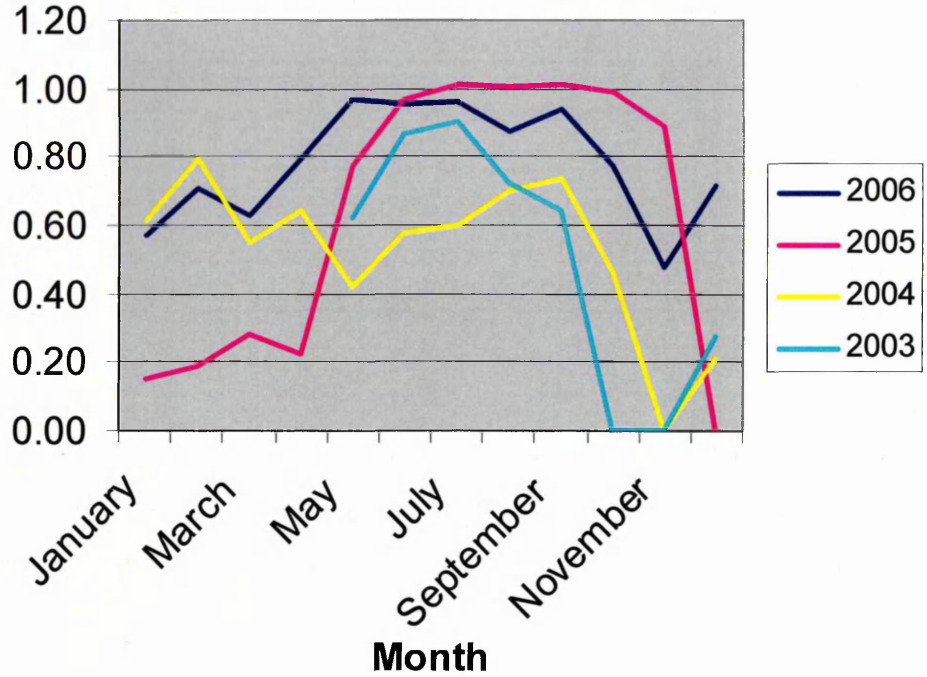


Figure 7.16: Efficiency DF Chiller

The direct fired chiller achieves higher efficiencies than that of the indirect fired chiller. The specifications of the manufacturer were met when there was sufficient full load for the hours per month.

The gas input for the boiler and the direct fired chiller was recorded by a single common meter. To separate the consumption it was assumed that the efficiency of the boiler is permanently 95 %. A value of 90 % would give negative gas input to the chiller for several months. The results of the contracting plants show that in reality the efficiency would vary. This would give higher gas input.

The gas input for the direct fired chiller equals

$gas_{input\ DF\ Chiller} = gas_{input\ total} - gas_{input\ boiler}$

$gas_{input\ DF\ Chiller} = gas_{input\ total} - heat_{out\ put\ boiler}/0.95$

The efficiency η is calculated in relation to H_i:

η_{boiler} = 0.95 = constant

$\eta_{DF\ Chiller}$ = cold production / $gas_{input\ DF\ Chiller}$

The assumption of a constant efficiency of the boiler of 95% leads to a lower value for the efficiency of the chiller than in practice.

The differences between design and testing phase to the research phase are:

change of legislation
change of use of building
operation of distribution and production under different control

The change of legislation had two effects:
Although a local energy supplier has to be separated into different companies for production, transport and sales the final result of the holding is the most important one. Due to unbundling the flow of information is stopped and because of this, economical (peak shaving) and ecological synergy effects. In the case of the operator of the plant being responsible for sales it is necessary to install a separate balance circuit to have the information on the overall demand.

The grid company has the information about the total energy in the grid – including daily curves and peaks. Peak shaving has a one time effect for the DSO only because the calculation of the fees which are checked by the authorities (BNetzA) is based on costs. When the costs are lower the fees will be lower too. In the case of missing the peak in the next year a gap will arise equalling the profit from the last year. This situation gives no incentive for the grid operator.

If somebody else does the peak shaving for the DSO the information about the daily curves has to be published for everybody due to the legislation on unbundling. Since every supplier has information on their own system they can estimate the energy and peak of the competitors.

The sales company could optimise the fees for their own interests. This leads to less income to the DSO. For the overall holding company these payments are a zero balance business as long as the peak of the grid company is not met (The turnover of both parties are added. The profit is shifted from grid operator to sales company and the sum remains constant). This causes an important economical effect to be lost.

The saving of the sales company results in a loss of profit for the DSO.

A customer or contractor has a single plant calculation and can include in the calculation the savings in fees, taxes and levies.

The second effect is the influence on the price for electricity. The prices for electricity remained on a constant level while the price for coal, lignite, oil and gas increased. The gap between prices for coal (stone and lignite) and oil (and natural gas) started in 1999 with 1.2 ct/kWh. This equals 3.6 ct/kWh for each kWh_{el}. In the past this gap could be closed by reduced investment for the plants and reduced operation costs. This gap increased to 4.5 ct/kWh or 13.5 ct/kWh_{el}. This present value can no longer be closed by reduced investment, reduced operation costs or higher efficiency.

In the cases where the BNetzA has successfully reduced the fees for the grid the existing advantage for non energy companies running CHP plants will be shortened.

The change of use has in consequence a change in energy demand. The illumination in a departmental store is very often realized using halogen spots which produce heat which has to be removed by the ventilation system. A second effect is that the occupancy per square metre a departmental store is higher than that for office accommodation. The heat input from shoppers is higher than that of sedentary workers. In a similar manner the input of humidity by customers is much higher e.g. by wet clothing caused by rain than that of persons working in an administration office. Another effect is that the opening times of a departmental store are longer than that for an office. The current opening times are Monday to Friday 9.30 – 19.30 and Saturday 9.30 to 16.00 during summer and 18.00 during the six weeks before

Christmas. This equals almost 60 hours per week not including times for the sales assistants for preparation and tidying up. The official working time for clerks in administration varies depending on the business. In average it is less than 40 hours/week plus a break of ½ to ¾ hour.

During the acceptance test phase only two floor levels were rented. To test the capacity and the efficiency of the plants cooling was simulated by direct heat input via the plants. The return flow temperature of the cooling system was 12 °C and the flow line one was 6 °C. These acceptance tests can be compared with the situation that responsibility for production and distribution (consumption) systems was executed within one company. This company had the interest to meet the targets – the design figures. Since 1999 when the supply started after the acceptance tests phase the return flow temperature was less than 12 °C. During periods of low demand the difference decreased to 2 K, one third of the design figure. This low temperature difference has a higher impact on the efficiency of the indirect fired chiller than on the direct fired chiller. All negotiations to achieve the temperatures fixed in the contract failed. As a local supplier ELE did not wish to challenge the fulfilment of the contract in court. This was a disadvantage to the contracting model because the customer was not charged for having a poor efficiency.

The charts show that the mode of operation changed. Currently the heat production by the boiler and the cooling produced by the direct fired chiller are the most economical.

If the plant was to be designed under present legislation and current prices, the emergency power would be provided by a diesel generator, a dual-fuel boiler would produce the heating, and cooling would be provided by electrically driven vapour compressor.

At present profits may be maximised but ecological components such as a restriction in CO_2-emissions is missing.

<u>7.6 MHKW (Trivalent Fuel CHP Plant with District Heating)</u>

Non technical description of the plant (analogous to § 4a section 1 No. 1 of 9th BImSchV)

The MHKW is designed for sensible utilization of coal mine methane (CMM) which arises at active mining sites. The system comprises of two large engines, each with a power output (P_{el}) of 5,250 kW, and a boiler for peak load operation. CHP is now an established technology. The heat produced is used for district heating (hot water and steam) of a quarter. To ensure reliability of heat supply, in the case when CMM is unavailable, alternative fuels and additional plant components are used. Possible fuels are CMM with varying concentrations of methane, natural gas and diesel oil and mixtures of them.

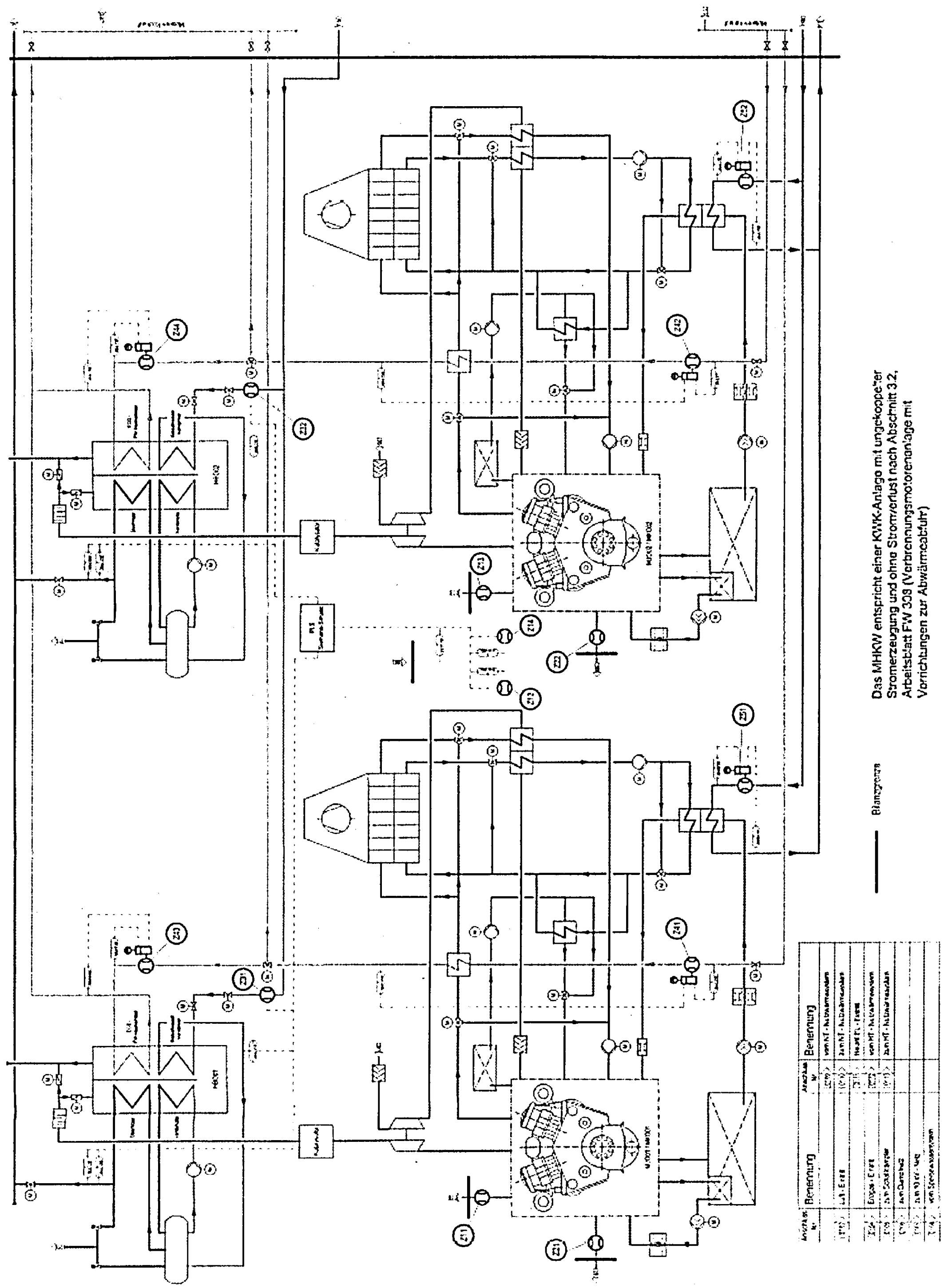


Figure 7.17: Plant Scheme of MHKW

The plant concept is to utilise in the engines all the available CMM from the coal mine even if the heat demand is lower than the heat output from the engines. This is the reason why both engines are equipped with a by-pass in the exhaust system and a dry cooling tower. These components enable an operation for optimisation of production of electrical power at peak times with coupled production of heat and power.

Beside the input of energy the output (electrical power and heat in form of hot water and steam) is recorded with calibrated meters.

The flow chart is taken from the certificate for an emission trading application. The origin of which is the CHP-application. For emission trading the central input of natural gas and diesel and their metering (Z1 and Z3 in the flow chart) is added to the chart. CHP-approval required a description of a sub plant (engines) only, the reason why corresponding central inputs are missing. The fuels reach the consumers directly where the fuel is fired for pure heat production (boiler) or for combined de-coupled heat and power production.

Size of plant, installed capacity referring to THG appendix 1:

34.6 MW referring to approval of application for emission trading
split into 13.2 MW per engine plus 8.2 MW boiler

The MHKW is classed as one plant for the approvals. From start of operation measurements were required. Since then measurements and reports were extended due to changing legislation such as CHP or emission trading.

Registration of Energy Data

The fuel consumptions (Energy Input) are registered by calibrated meters. The corresponding bills, containing invoice amounts, quantity and net calorific value are registered in SAP (the financial accounting system) and saved in accordance with legislation on trading and taxation. Due to confidential reasons prices are not given in the appendices.

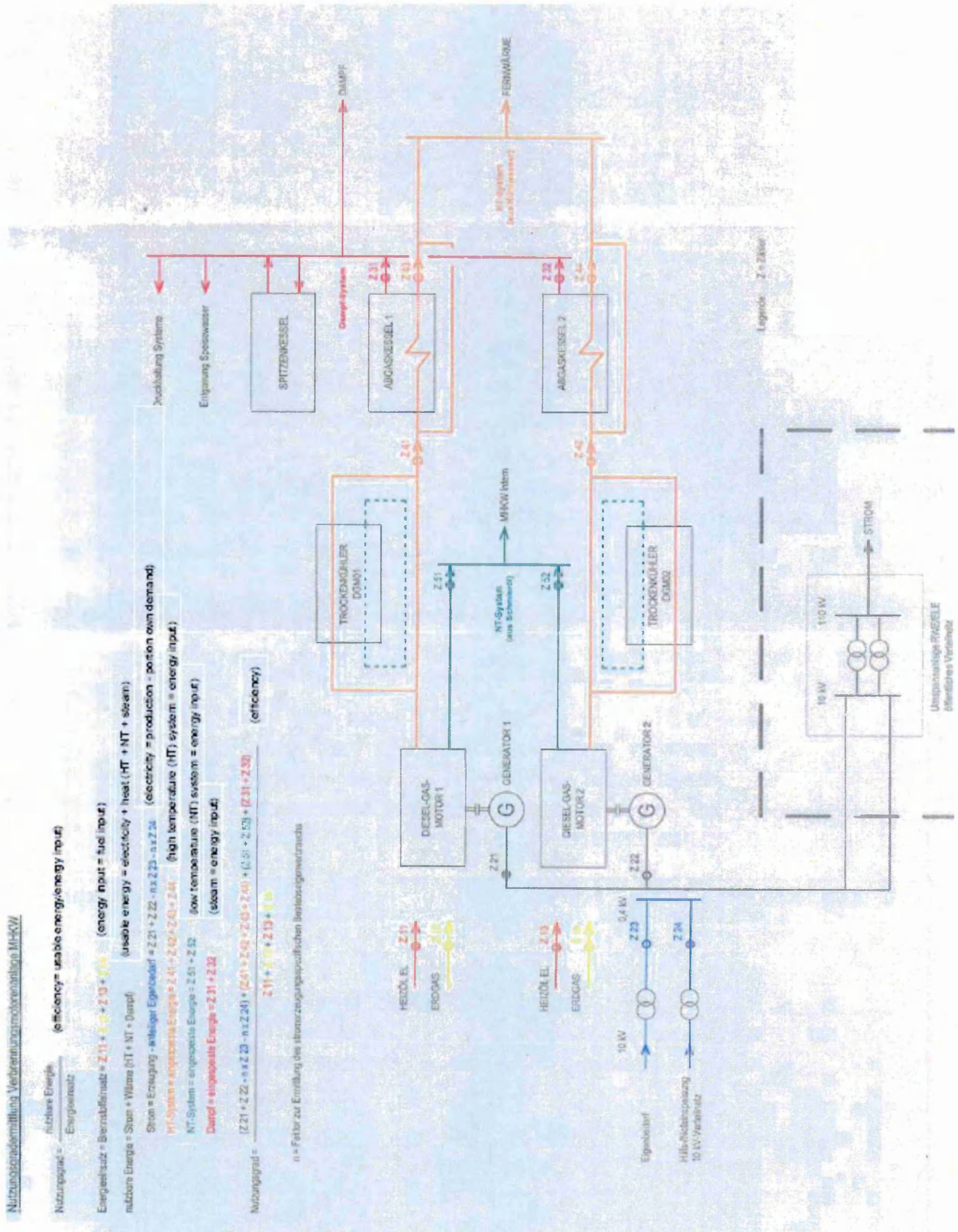


Figure 7.18: Simple Plant Scheme with Metering Points for Certification of CHP-Production and Emission Trading

Apart from these primary measurements non-calibrated metering is done to determine each aggregate. These data are recorded and registered in the Process Control System (PCS) of the plant. The values are checked monthly with the amounts given in the energy bill (calibrated metering) and corrected if necessary. The natural gas is analysed daily and given as a monthly average figure given in the bill.

The diesel input is recorded via calibrated meters of the supplier at delivery. A correction to the present amount is made by the PCS after every tank filing. No further analysis is taken for the diesel.

The PCS records the input of the fuels permanently and summarized in tables. For emission trading the accumulated amounts are compared with the amounts of the previous year on the same day. Based on these data a projection for the amount used for the year can be made.

1987	Purchase of existing district heating grid (steam)
1987- 1989	Operation with auxiliary boiler station
	Design and building of MHKW
1889	Start of production
1998	First Major Change of New Industry Energy Act
1999	Foundation of ELE Emscher Lippe Energie GmbH
2000	First Renewable Energy (Sources) Act
	First Combined Heat and Power Act
2003	Act on Greenhouse Gas Emission Trading
	Revision of Industry Energy Act
2005	Present Industry Energy Act
2006	Energy Tax Act

Table 7.8: Milestones which Influence Operation

When the MHKW was designed the GEW, at that time named Stadtwerke Gelsenkirchen GmbH, was the local supplier for electricity in Gelsenkirchen-Buer the northern part of Gelsenkirchen. Major industrial complexes were supplied by a subsidiary of RWE AG. The electricity had to be purchased from RWE AG. Production was only allowed if from renewable energy or waste. The maximum peak was 70 MVA. The amount of CMM from the surrounding coal mines allowed a maximum of 8,300 operation hours per year with 8,000 full load hours. For peak shaving the engines were run with 10% overload. Approximate 15% of the electricity sold by GEW was produced with the MHKW[33]. The offer of CMM from the active coal mines was higher than the capacity of the MHKW. CMM has to be extracted from the mines to avoid an explosive mixture of methane with air and was fired in the MHKW. Minimum power for operating the plant was not important during the design phase and was limited to 50 % of maximum power. A further restriction was the supply of steam (215°C, 14-15 bars) for a hospital laundry. The required high temperature cannot be achieved by the oil or the water cooling circuit. Only the exhaust gas has the necessary high temperature to enable the steam production. This is approximately 50% of the heat output. Both engines could be run with 110% load for 1 hour in order to reduce peaks in electrical demand of the grid (70 MVA). This overload period had to be followed by a lower load operation to cool down the equipment. Diesel could be used for up to 500 hours per year to reduce the peak in natural gas. CMM from the coal mine had to be fired and was free of a price for the peak. In the instances when the amount of this gas was higher than the capacity of the engines the remaining CMM was vented to atmosphere for low flows and combusted via a flare for higher flow rates.

The priority for safety in the coal mine had as a consequence, an overproduction of heat. During periods when no steam was demanded a by-pass in the exhaust system was activated. The heat output for engine cooling (oil and cooling water) was led to a dry cooling tower. An alternative which did not require electrical consumption for the drives of the cooling towers was to raise the temperature of the grid.

Considerations on the effects of the new Industry Energy Act, partly with the assistance of the Conenergy, led to the foundation of ELE in 1998, which was officially registered in 1999. The MHKW with its district heating remained at GEW. Lower prices for electricity were expected. A new price regulation had to be found because the GEW was no longer an energy supplier. Due to confidentiality the contract cannot be quoted. Instead different possibilities are listed.

Fixed rent independent of operation and production
    operation with ELE personnel to meet ELE requirements
    (GEW receives a rent comparable with the former profit. Investment and operational costs have to be met by ELE)
Price regulation as before with floating formulas
    operation with GEW personnel plus information about ELE requirements
Price regulation as before with floating formulas
    operation with ELE personnel
Operation by GEW personnel and payment to the existing Act on supply of Electricity

Table 7.9: Solution Caused by Milestones 1998/9

To meet the peaks of the new company a new control system had to be installed to ensure that the MHKW was running with full load at peak times. Sufficient supplies of CCM were available. CMM was waste so the Act on Taxation of Mineral Oil was not applicable for this case.

With the Renewable Energy (Sources) Act coming into force the reimbursement to be paid increased to more than 6.5 ct/kWh. Within one month after coming into force the delivery contract was cancelled 4 years before its end. One of the three fuels was missing that of CMM.

Parallel to the Renewable Energy (Sources) Act a first Combined Heat and Power Act came into force defining the reimbursement for electricity from CHP plants. All operators have to be treated in the same way when the contracts were the same. When the price situation described in Chapter 4 became applicable it meant that ELE does not have to pay a higher price for electricity to GEW and as long as the price for natural gas remained low in comparison to those for electricity then the economics of the plant remained stable. Additionally attention had to be paid to the plant efficiency. Natural gas is taxed at 0.55 ct/kWh. To receive a 100% rebate an efficiency of 70 % has to be reached. Between 60 and 70 % the rebate is 0.366 ct/kWh, below 60 % no rebate is paid.

The most important impact on plant operation at the beginning of unbundling was the increase of prices for natural gas and the decrease of prices for electricity.

The Act on CHP-plants gave the plant operator the possibility to sell the complete production of electricity to the grid operator or to sell the electricity to somebody else. In this case the grid operator had only to be reimbursed for the avoided cost for the high voltage grid. The price for energy was paid by the purchaser. In cases when the grid operating company was the purchaser the price was the base load price from EEX.

The contract from 1998 had to be split into two parts to achieve a solution which was similar to the origin contract:
The contract for reimbursement of the avoided costs for the high voltage grid had to be signed with the grid operator. The contract for the energy was signed with the sales company (department). The highest possible price for energy would be that which the sales company could sell to anybody else.

7.6.1 The Effects of Variations in Operation
The long term full load operation with CMM from the coal mines between 1989 and 2001 was not optimal.

In 2003 the operation was led by heat demand and a working control of the peak electrical demand. Experienced gained in the plant operation led in 2004 to a control strategy which required longer operational time. In 2003 and 2004 the emissions were just 11,000 tons.
Within these years the Act on greenhouse gas emission trading came into force. The Act in brief (see 7.6.4 emissions):

basic period for allocation:	2000 to 2002
1st trading period:	2005 -2007
allocation (standard):	the average emissions for the three years multiplied by a reducing factor which was unknown during the application (emission 2000 + 2000 +2001) / 3 x factor **X**
minimum emission:	60% (if no energy saving changes were made) decrease of production or shut down does not count as an energy saving change
consequence if below 60%:	reduction of future allowances

The production in 2005 started as in 2003 and 2004 until it was noticed that minimum emissions of 60% had to be produced. The written enquiry made to the authorities was to ask what had been the leading comparison figure (heat supply to the estate plus steam to the laundry or the production of electricity). This question was inadequately answered. A decision was made to keep the certificates – and to produce the minimum requirement of emissions. Approximately 4,500 tonnes CO_2-emissions had to be produced additionally compared to 2003 and 2004. This gave the opportunity for simpler peak shaving.

The allocation had to be applied for electronically. A program was supplied by DEHSt. The average annual production of emissions or the sum of the three years did not appear in the application program or in the allocation letter.

This led to a mistake being made for the target for CO_2 -emissions. Based on the 60% of the allowances it led to a target of 14,400 tonnes CO_2. The correct figure was 60% of the annual average emissions for the basic period (emissions from 2000 – 2002) which gave a target of 15,560 tonnes CO_2. This became the target for 2006 and 2007. 2003 and 2004 were years without emission trading and were not expected to become part of the basic period for the 2nd trading period 2008 - 2012. The expected CHP-production in 2006 was interrupted due to repair and maintenance work and heat production was substituted by the boiler. The boiler was installed as a back-up system for the engines. The engines had to produce more emissions in non CHP-production to reach the target. The by-pass in the exhaust system was used at low heat demands periods to dump heat.

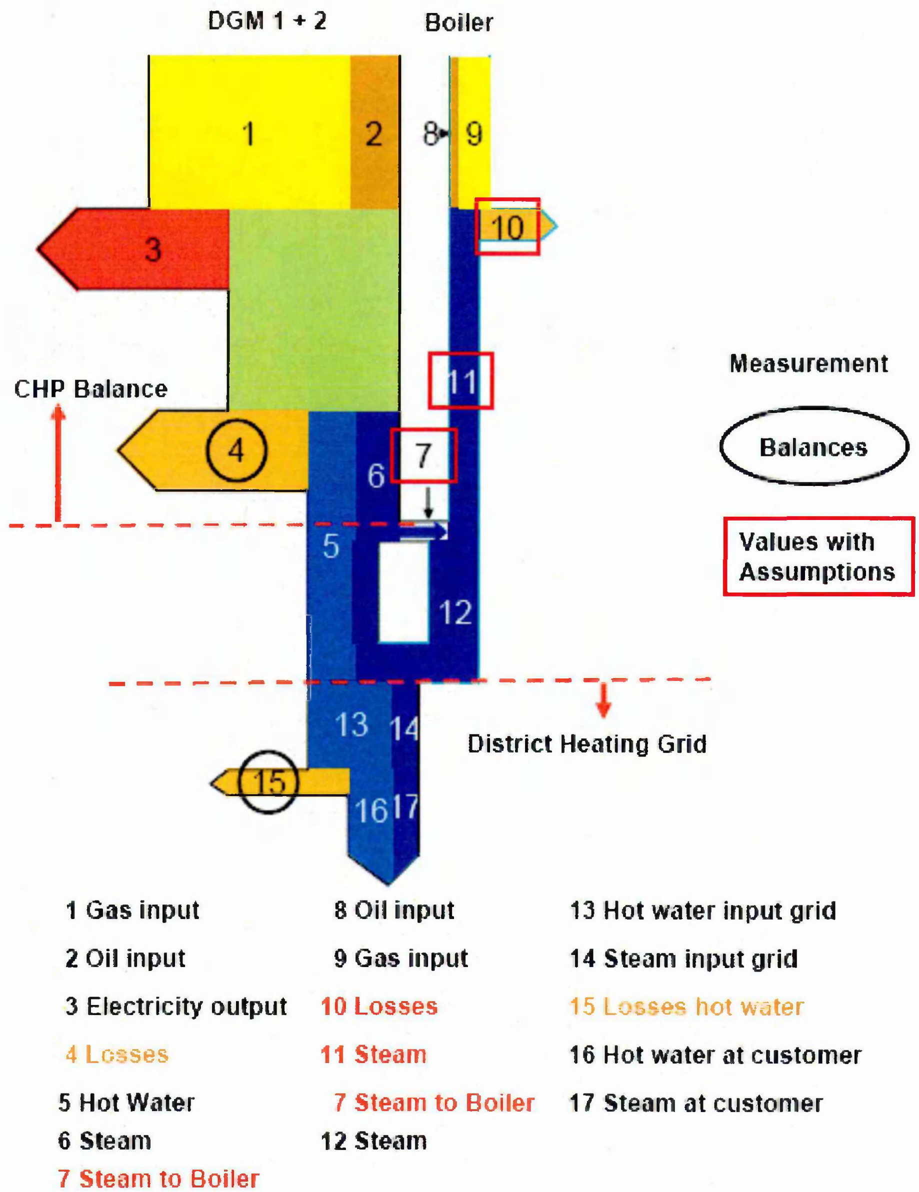


Figure 7.19: Energy Flow Chart MHKW

The boiler was in stand-by for the whole year, a second engine was run during the heating period (October to March). The necessary heat to keep the boiler at an operational temperature was delivered by the engines. This resulted in boiler efficiency apparently higher than 100 %.

The operation led by heat demand enabled an overall efficiency for the engines higher than 70 %. The operation led by emissions enabled an efficiency of 60 % with the consequence of a lower tax refund. The latest Energy Tax Act has foreseen a complete tax refund for the portion of production of electricity for plants with the size of the MHKW or larger. The description of the purpose of the plant can be changed in accordance with new legislation to maximise tax benefits.

The internal losses (see (4) in Figure 7.19) consist of exhaust gas including by-pass, heating the building, heating auxiliary equipment and the cooling tower (fans switched off).

Losses from the steam grid, approximate length 600 m, can be neglected for the compared years. The difference between input and output are within the accuracy of the heat meter.

The input into the hot water grid (6,600 m route) was in accordance with the degree days 2003 (3,370), 2004 (3,585) and 2006 (3,319). The consumption of the hot water customers was not in accordance with the degree days. 2006 had the lowest degree days and the highest consumption. The losses equalled 44 to 48 % of the input into the hot water grid.

This decreased the efficiency for the total system from 60 to 70 % and after the engines to less than 50 %.

No.		2003 [GWh]	2003 [%]	2004 [GWh]	2004 [%]	2006 [GWh]	2006 [%]
	input total	**49.8**		**53.7**		**76.2**	
	input DGM	**40.4**		**47.7**		**70.7**	
1	natural gas	36.6	90.6	44.1	92.5	63.1	89.2
2	Oil	3.8	9.4	3.6	7.5	7.6	10.8
3	output electricity	14.4	35.6	17.1	35.8	27.5	38.9
4	Losses	11.7	29	14	29.4	27.3	38.6
5	hot water	5.5	13.6	6.7	14	6.2	8.7
6	Steam	8.8	21.8	9.9	20.8	9.7	13.8
7	steam to boiler	4.3	10.7	2.4	5	2.7	3.8
	input boiler	**9.4**		**6**		**5.5**	
8	Oil	0.2	2.2	0	0.4	0.1	1.2
9	natural gas	9.2	97.8	6	99.6	5.4	98.8
10	Losses	1.8	19.6	1.2	19.9	1.1	19.8
11	Steam	7.4	78.2	4.8	79.7	4.3	79.1
7	steam to boiler	4.3	46.1	2.4	39.8	2.7	48.4
12	Steam	11.7	124.3	7.2	119.5	7	127.4
	input grid	**19.3**		**19**		**16.7**	
13	hot water	12.8	66.3	13.2	69.5	12.5	75.2
14	Steam	6.5	33.7	5.8	30.5	4.1	24.8
15	losses hot water	6.2	32.2	6.4	33.8	5.5	33.2
16	hot water at customer	6.6	34.1	6.8	35.7	7	42
17	steam at customer	6.2	32.1	5.7	29.9	4.6	27.5
	difference steam	-0.3	-1.6	-0.1	-0.6	0.5	2.7

Table 7.10: Energy Input and Output MHKW

7.6.2 Price Variations

In this analysis only prices for energy plus tax were varied. Maintenance, operational costs, price for capacity and losses of the grid were out of focus. The Base year was 2004 which resulted with the following data:

Efficiency for electricity		38	%
Efficiency for heat		32	%
Price for electricity	($Price_{el}$)	34	€/MWh
Price for Natural Gas	($Price_{Gas}$)	26	€/MWh
Price for Heat	($Price_{th}$)	46	€/MWh
Tax Refund		5.5	€/MWh (efficiency > 70 %)
Tax Refund		3.66	€/MWh (60 % < η < 70 %)

At the basis point (point without variations in percentage) the balance was negative without a tax refund.

Conclusions of the analysis are:
Increasing prices for heat and electricity had the same effect.
The reduction of internal losses (= higher efficiency) has a better effect on the economics than an increase of prices for electricity or heat, especially within the variation 0 to 30%.
In the case when the prices for natural gas and electricity have the same percentage variation a CHP process becomes uneconomic.
High electrical efficiency is necessary when the price for electricity is high. In the case when there are equal or lower prices in comparison with the price for heat a low electrical efficiency is more economic.

In 2006 the price for natural gas and electricity increased by 20 %. In 2007 the gas price remained constant and the price for electricity increased by 40 % which improved the economic situation.

The interpretation of the results depends on the point of view – grid operator, sales company or customer.
The grid operator reduces the fees for the higher voltage grids. The costs for the own grid remain unchanged. For this group the price per kWh of electricity must be higher than the price per kWh of heat for profitable operation of CHP plants.

Sales departments save the complete fees for the grids. The situation for them is more profitable.

Customers save additionally levies for renewable energies and CHP plants, the overall fees for the different grids including concessional fees plus a tax on electricity. The aim is that the off-price for electricity to be higher than the off-price for heat. This can be achieved simply because of the savings made by not paying the additional components charged for electricity. There is a precondition; all of electricity consumed must be used by the customer himself, otherwise the situation is similar to that of the sales company.

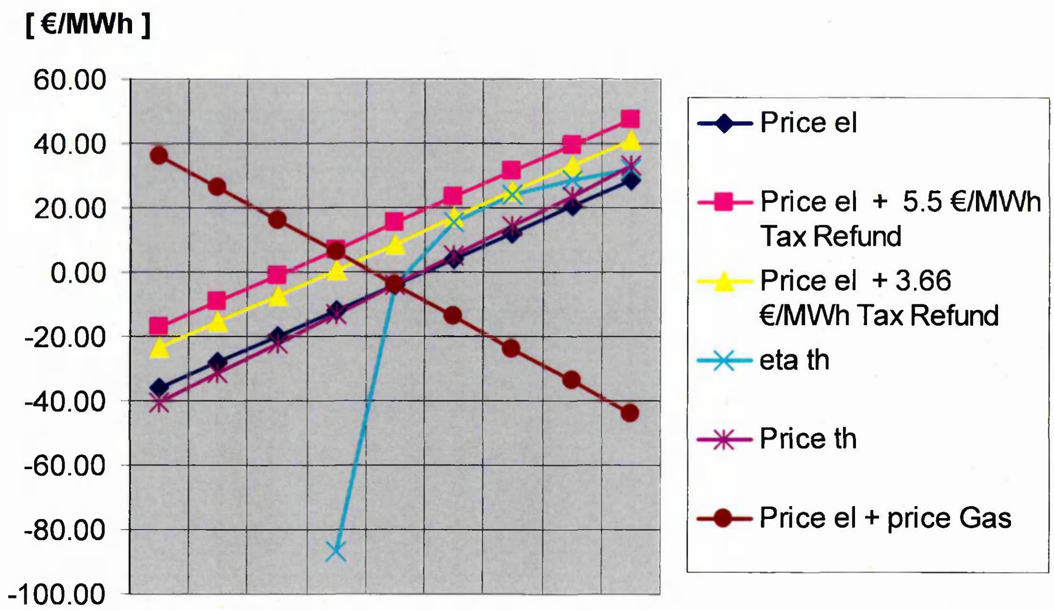


Figure 7.20: Sensitivity Analysis for MHKW

7.6.3 Peaks

The BNetzA required(s) the costs of the fees for the use of the grid. These costs are the basis for the permitted regulated fees of every grid operator. In common the permitted fees are lower than the demanded fees mentioned in the application. The purpose of a company is to make a profit. To minimize the risk and to receive high fees the load management (LM) was switched off and the fees from the high voltage grid increased. The permission was granted for several years while the higher costs were for one year only. By predicting the peak time exactly the operation time to meet the peak can be reduced. This was important because it was assumed that the operation time was not completely during CHP production. The return flow of money for the energy produced was lower and the CHP efficiency decreased which meant lower compensation for the produced electrical power. 10,000 kW equals 400,000 € when the correct ¼ hour load management period was met.

This had the effect that the operation time of the MHKW had to be defined in a different way.

Night storage loading time was taken out of focus because this could be controlled by radio signals. A second argument: Night storage was heating and as such was a function of the temperature.

As a first step the influencing figures which describe the load from the high voltage grid had to be defined.

Night storage was taken out. Only a few houses had an additional loading time during the afternoon. They could be described as a function of temperature. From experience it had a delay of one day. The reason was the heat capacity of the buildings (walls).
Street lighting was also taken out. Lighting is a function of time of the year (sunset and sunrise) and the weather conditions (rain, fog, snowfall). The lighting can be controlled by radio signals.
CHP-plants (during wintertime the electricity is used by the customers themselves)

Renewable energies

- photovoltaics (can be neglected during winter time)
- wind turbines (only a low capacity and predicted by weather forecast)
- bio mass plants (just one plant and not relevant to ELE peak)
- CMM (mainly from mines out of production)

Tables 7.11 and 7.12 show that the CMM from coal mines plants had a large influence on the peak and they were not predictable. The operator switched them off without any warning. During winter times the maximum input was 18,000 kW, during summer times the capacity increased to 30,000 kW which is 8 % of ELE´s winter peak. In winter the percentage was 5 %. The capacity cost 700,000 €.

Date	Day	Time	[kW total]	[kW CMM]
2003-12-10	Wed	18:45-19:00	345.974	17.338
2003-12-22	Mon	18:15-18:30	344.124	14.990
2003-12-22	Mon	18:45-19:00	344.090	15.003
2003-12-22	Mon	18:30-18:45	343.866	14.997
2003-12-10	Wed	18:30-18:45	343.246	16.316
2003-01-28	Tue	18:45-19:00	343.008	800
2003-12-14	Sun	18:15-18:30	342.690	17.562
2003-12-10	Wed	19:00-19:15	342.460	17.817
2003-12-10	Wed	18:15-18:30	342.310	15.276
2003-12-07	Sun	18:15-18:30	341.830	15.292
2003-01-06	Mon	18:45-19:00	341.648	1.850
2003-12-15	Mon	18:15-18:30	341.594	16.520
2003-02-10	Mon	18:45-19:00	341.396	790
2003-12-09	Tue	18:45-19:00	341.380	17.156
2003-12-16	Tue	18:15-18:30	341.150	16.437
2003-12-22	Mon	19:00-19:15	341.050	14.995
2003-12-09	Tue	18:15-18:30	341.024	17.138
2003-12-09	Tue	19:00-19:15	340.960	17.151
2003-12-14	Sun	18:30-18:45	340.900	17.547
2003-12-11	Thu	18:15-18:30	340.490	16.530
2003-12-24	Wed	18:15-18:30	340.420	14.173
2003-11-30	Sun	18:30-18:45	340.294	15.886
2003-02-10	Mon	19:00-19:15	339.960	790
2003-01-06	Mon	19:00-19:15	339.848	1.850
2003-12-24	Wed	18:30-18:45	339.690	14.164

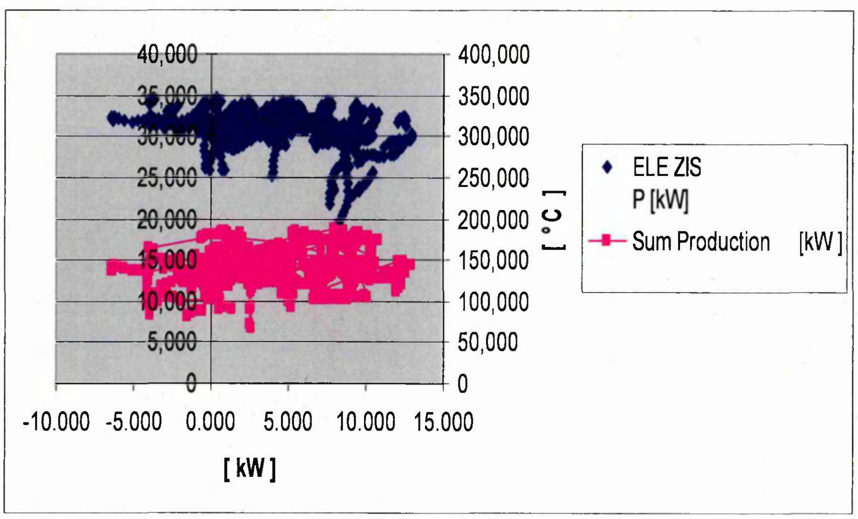
Date	Day	Time	[kW total]	[kW CMM]
2003-01-21	Tue	18:45-19:00	339.662	1.620
2003-12-01	Mon	18:45-19:00	339.650	16.084
2003-12-24	Wed	18:45-19:00	339.570	14.174
2003-12-09	Tue	18:30-18:45	339.536	17.138
2003-01-06	Mon	18:15-18:30	339.462	1.850
2003-12-15	Mon	18:45-19:00	339.440	16.497
2003-01-06	Mon	18:30-18:45	339.288	1.850
2003-01-29	Wed	18:15-18:30	339.172	790
2003-12-14	Sun	18:45-19:00	338.920	17.549
2003-01-14	Tue	18:15-18:30	338.848	1.700
2003-12-22	Mon	19:15-19:30	338.830	14.972
2003-12-03	Wed	18:45-19:00	338.760	15.542
2003-02-25	Tue	18:45-19:00	338.436	1.150
2003-12-08	Mon	18:45-19:00	338.390	14.769
2003-12-15	Mon	19:00-19:15	338.326	16.509
2003-02-10	Mon	18:30-18:45	338.204	790
2003-12-03	Wed	18:30-18:45	338.194	15.548
2003-12-23	Tue	18:45-19:00	338.180	16.071
2003-12-21	Sun	18:15-18:30	338.150	15.158
2003-12-15	Mon	18:30-18:45	338.130	16.498
2003-02-26	Wed	19:00-19:15	338.120	1.160
2003-01-21	Tue	18:15-18:30	338.092	1.620
2003-01-28	Tue	18:30-18:45	338.092	800
2003-12-10	Wed	19:15-19:30	337.956	17.921
2003-01-28	Tue	19:00-19:15	337.932	790

Table 7.11: TOP 50 Peaks in 2003 – Influence of CMM from Coal Mines Marked Red

Date	Day	Time	[kW total]	[kW CMM]
2004-12-09	Thu	18:45-19:00	345.974	8.453
2004-12-21	Tue	18:15-18:30	344.124	13.680
2004-12-21	Tue	18:45-19:00	344.090	13.882
2004-12-21	Tue	18:30-18:45	343.866	13.883
2004-12-09	Thu	18:30-18:45	343.246	8.459
2004-01-28	Wed	18:45-19:00	343.008	14.665
2004-12-13	Mon	18:15-18:30	342.690	12.119
2004-12-09	Thu	19:00-19:15	342.460	8.435
2004-12-09	Thu	18:15-18:30	342.310	8.451
2004-12-06	Mon	18:15-18:30	341.830	11.793
2004-01-06	Tue	18:45-19:00	341.648	14.423
2004-12-14	Tue	18:15-18:30	341.594	10.564
2004-02-10	Tue	18:45-19:00	341.396	14.196
2004-12-08	Wed	18:45-19:00	341.380	13.201
2004-12-15	Wed	18:15-18:30	341.150	12.557
2004-12-21	Tue	19:00-19:15	341.050	13.869
2004-12-08	Wed	18:15-18:30	341.024	13.192
2004-12-08	Wed	19:00-19:15	340.960	13.182
2004-12-13	Mon	18:30-18:45	340.900	12.112
2004-12-10	Fri	18:15-18:30	340.490	10.916
2004-12-23	Thu	18:15-18:30	340.420	12.445
2004-11-29	Mon	18:30-18:45	340.294	12.072
2004-02-10	Tue	19:00-19:15	339.960	14.198
2004-01-06	Tue	19:00-19:15	339.848	14.428
2004-12-23	Thu	18:30-18:45	339,690	12,450

Date	Day	Time	[kW total]	[kW CMM]
2004-01-21	Wed	18:45-19:00	339.652	14.822
2004-11-30	Tue	18:45-19:00	339.650	13.847
2004-12-23	Thu	18:45-19:00	339.570	12.443
2004-12-08	Wed	18:30-18:45	339.536	13.204
2004-01-06	Tue	18:15-18:30	339.452	14.430
2004-12-14	Tue	18:45-19:00	339.440	10.817
2004-01-06	Tue	18:30-18:45	339.288	14.423
2004-01-29	Thu	18:15-18:30	339.172	16.494
2004-12-13	Mon	18:45-19:00	338.920	12.117
2004-01-14	Wed	18:15-18:30	338.848	14.845
2004-12-21	Tue	19:15-19:30	338.830	13.881
2004-12-02	Thu	18:45-19:00	338.760	13.725
2004-02-25	Wed	18:45-19:00	338.436	17.268
2004-12-07	Tue	18:45-19:00	338.390	11.308
2004-12-14	Tue	19:00-19:15	338.326	11.567
2004-02-10	Tue	18:30-18:45	338.204	14.212
2004-12-02	Thu	18:30-18:45	338.194	13.736
2004-12-22	Wed	18:45-19:00	338.180	12.454
2004-12-20	Mon	18:15-18:30	338.150	12.786
2004-12-14	Tue	18:30-18:45	338.130	10.562
2004-02-26	Thu	19:00-19:15	338.120	17.626
2004-01-21	Wed	18:15-18:30	338.092	14.823
2004-01-28	Wed	18:30-18:45	338.092	14.702
2004-12-09	Thu	19:15-19:30	337.956	8.427
2004-01-28	Wed	19:00-19:15	337,932	14,682

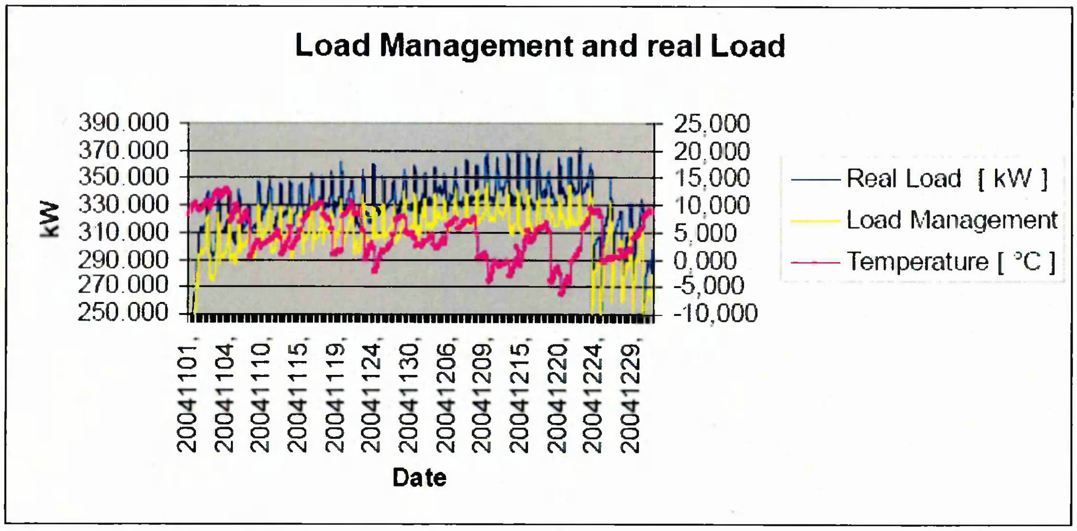
Table 7.12: TOP 50 Peaks in 2004 – Influence of CMM form Coal Mines Marked Red



The production in the ELE-grid varies between 6,600 and 18,600 kW.

Figure 7.21: Load Distribution and Production Nov. and Dec. 2004, 8.00 – 12.00 and 18.15 – 19.30

Figure 7.21 shows that no obvious relationship exists.



The peaks are always between

18.15 and 19.30.

Figure 7.22: Load Management, Real Load and Temperature 2004 Nov. and Dec., 8.00 – 12.00 and 18.15 – 19.30

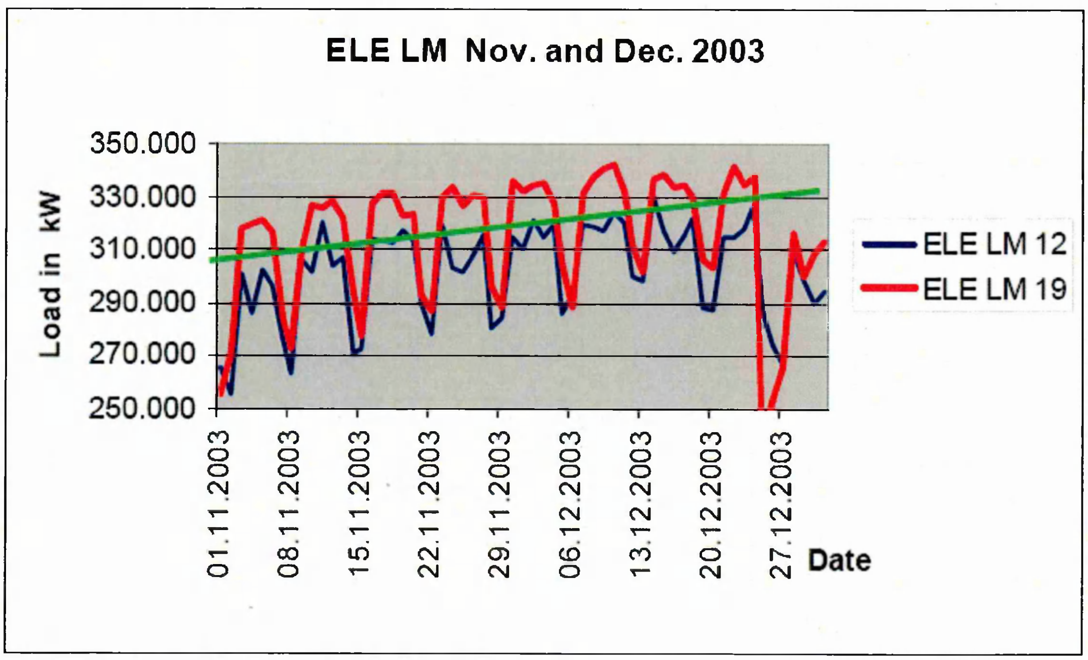


Figure 7.23: Load Management, Real Load and Temperature 2003 Nov. and Dec., 8.00 – 12.00 and 18.15 – 19.30

Figures 7.19 and 7.20 show the development of the peak. Reasons for this are unknown. During the period immediately before Christmas the peak increases. The 1200 hour values (LM 12) are a good indication for the higher 1900 hour values. Realizing this allows the additional operational time to be restricted to 2 hours per day. To ensure that the peak consumption was met it was done every week from Monday to Friday from December to February.

The losses for these 200 additional operation hours were lower than the additional 400,000 € for the peak.

7.6.4 Emission

As described in 7.5.1 – 3 the operation and the main purpose of the plant changed. The decision as to whether the plant is within the emission trading legislation depends on the permit granted when the plant was erected or when major changes on the equipment were executed. The operational time per year is out of focus (refer to chapter 7.6.1) for the permit or duty.

	natural gas [tonnes]	light heating oil [tonnes]	CMM [tonnes]	total [tonnes]
2000	23,189	3,596	4,933	31,718
2001	28,671	2,258	0,000	30,929
2002	13,715	1,427	0,000	15,142
2003	9,202	1,054	0,000	10,256
2004	9,741	0,955	0,000	10,696
2005	13,598	1,130	0,000	14,728
2006	13,560	2,002	0,000	15,562

Table 7.13: Emissions of CO_2 for MHKW in Tonnes per Year

The changes in legislation which affected the energy input had a direct correlation with the emissions.

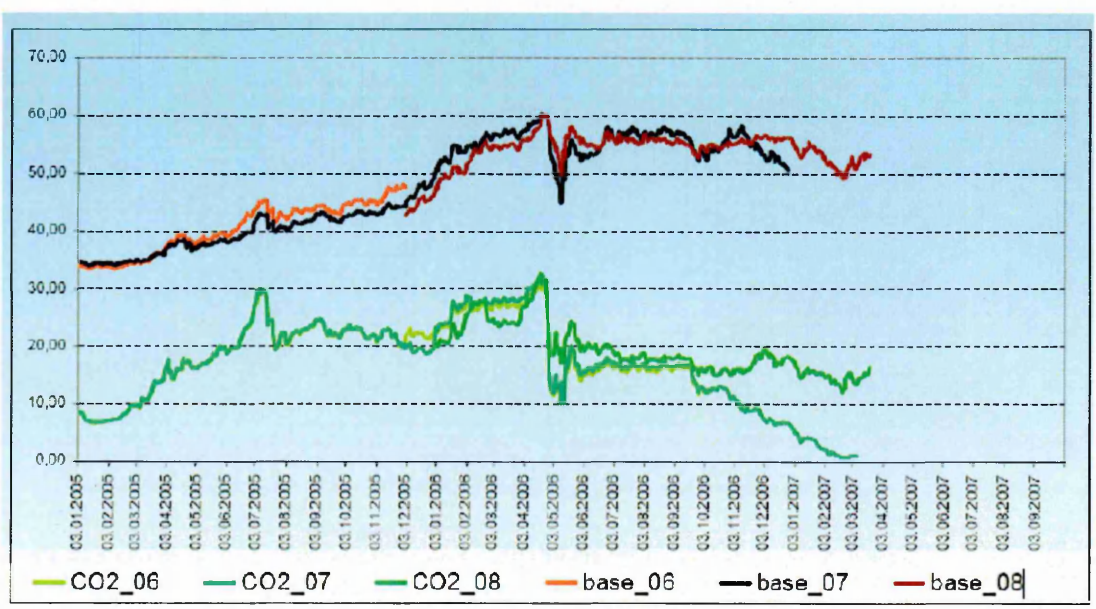


Figure 7.24: Correlation of CO_2-Allowances and Base Load Prices for Electricity[34]

For the first trading period the authoritative average output for the years 2000 – 2002 was 25,900 tons per year. This figure was revised down by DEHSt to 24,013[35].

The 60 % minimum emissions are related to the emissions of the basic period and not to the given value of 24,000. The price stated by the authorities is zero. In reality the price was 2,750 € per year plus the costs for the yearly charge of an expert who certificated information for the DEHSt (1,500 to 3,500 € depending on the expert) plus the internal costs of ELE. At maximum the value of the allowances equals 750,000 € (24.013 × 31 €/tonne). Referring to the minimum production of 60 % the value of the allowances available for sale was 300,000 €. The present figures are 0.10 €/ton which equals 2,400 € which is less than the costs of it.

The effect on the prices for electricity from the MHKW in the case when the allowances had to be bought:

Maximum price for allowances: 0.015 €/kWh

Minimum price for allowances: 0.00005 €/kWh (negligible)

(η_{el} = 38 %, 200 g CO_2 per kWh input of natural gas; the CO_2-emission output per kWh_{el} was approximately 500 g)

The decrease of the prices for the allowances had a negative effect on the current economics of the plant. To ensure that the minimum production of 60 % emission was reached electrical power had to be produced without heat demand. This production is not economic over a wide range (see the sensitivity analysis). The allocation for the second trading period was announced with the first two years of emission trading (2005 and 6) as the basis. A decision had to be made assuming that there would be higher prices for emission allowances in the second trading period (2008 – 2012). The Act which came into force in July 2007 defined the time from 1^{st} of January 2000 until 31^{st} of December 2005 as the basis period for plants of the first trading period. The unforeseen years 2003 and 2004 became part of the basis period. All efforts made within the period of emission trading to receive more allowances were to no avail.

Extraction back-pressure and extraction condensing turbines are alternatives to engine driven CHP plants. The author in discussion with politicians who were involved in legislating for CHP plant realised that they were unaware of such systems.

Emission factors for lignite are 0.093 – 0.111, for coal 0.093 – 0.097 and for natural gas 0.055 – 0.056 tons/GJ[36]. The $efficiency_{el}$ for the three mentioned systems are in the same range. In consequence, coal or lignite fired power stations emit 80 – 100 % more CO_2 than a gas fired engine.

Improving the relative efficiency of coal or lignite fired power stations by 20% , which is less than 10% in absolute efficiency (e.g. from 36% to 44%) has a worse effect on the decrease of CO_2-emissions than the change of the fuel to gas or renewable energy.

A mistake arises if differences in CHP-processes are ignored or unknown. In general engine CHP-plants have a heat output without an additional energy input. Steam turbines require an additional energy input for heat production when the electrical efficiency has to be kept on a constant level (Heat production without additional energy input decreases the electrical efficiency).

District heating from coal-fired extraction back-pressure and extraction condensing turbines is CO_2 loaded. Depending on the type of turbine an additional 0.4 – 0.6 kWh energy input per kWh of heat output is necessary. These emissions are almost identical to those of a gas fired boiler which can be located much closer to the consumers. Assuming similar levels of insulation then shorter grids have fewer losses and are to be preferred.

7.6.5 Fees for the Grid

As described in chapters 3 and 4 the payment for the energy transported on the grid systems changed completely. The common price for electricity as well as the price for natural gas consisting of energy supplied plus the peak load was split into two parts each. The plant was designed to cut both peaks. This was achieved for gas by the change from natural gas as the fuel to fuel oil and the engines ran with full load or 10% overload.

The liberalisation of the gas market was less developed than the market for electricity. Additionally the input of bio methane into the grid started just at the time as electricity from renewable energies reached a worthwhile value.

The BNetA - Federal Network Agency – cut the fees.[37]. This reduction was different for medium (2.63 €/kW) and low voltage (21.44 €/kW).

(medium voltage
01.01.2005: 57.73 €/kW[38]; 01.06.2007: 55.10 €/kW[39])

low voltage
01.01.2005: 79.11 €/kW; 01.06.2007: 57.67 €/kW)

The above figures include the costs for the grid and the transformers. The avoided costs are the costs for the grid minus the transformer's portion (21.€/kW).

The main problem was to fix the best time for the peak, which was difficult without a load management system and required longer operational times in accordance with the statistical data mentioned above. The maximum rebate obtained for the second engine was 190,000 € from 2002 to 2007. The costs for an hours operational time for one engine (15,000 kWh input per hour) were 500 to 750 € depending on the fuel. At 0% heat input to the grid this equated to 250 to 275 operational hours based on 2007 prices.

At the time when the peaks were between 1800 to 1900 hours it was a risk which could be calculated. This possibility was lost with the increase in the input of renewables as their load could suddenly be reduced. The consequence is the reinstallation of a load management system which includes an online metering of the main renewable energy plus the CHP plants. A second consequence was that the second engine has to be in stand-by to start up at short notice. The start of a stand-by engine to maximum load was achieved within 5 minutes which means the development of the peaks had to be watched.

Load management for natural gas with a 24 h peak was done until 2006 and could be achieved simply because of the close function between the peak and the outside temperature. The load management included high pressure storage vessels, the purchase of spot amounts of gas and the switch of fuel at large industrial plants. A change from 24 to one hour peaks would make the situation similar to electricity.

A correspondence with Mr. Conrady of BAFA on September 10th 2007 underlined the situation of CHP plants operating within the current legislation. Many old plants being outside of the CHP laws (start of operation before 1990) were closed down or used only during period of high peak demand.

In most cases since 2002 district heating with natural gas has lost to the competition with coal fired plants, independent of whether it was a boiler or a CHP-plant[40]. E.on and Steag the two other suppliers of district heating in Gelsenkirchen have coal as the main fuel. The energy portion in their price formulas is lower than that of ELE. Additionally the increase of the coal price was lower in percentage terms than that of crude oil. This allowed them to keep the price increase at a low level. Customers e.g. estate companies have buildings all over the town and their tenants can move to an area of lower charges. The effect is that due to competition the prices for the gas fired district heating could not be increased.

Several Acts and laws were in contradiction with each other: The requirement to reduce CO_2-emission (climate change) and the requirement to reduce prices for energy, mainly interpreted as electricity (see chapter 4 prices). The discrepancy between the price for coal and natural gas/fuel oil is not compensated by the better efficiency of the CHP plant.. The system must become cheaper which also means simpler. If CO_2 reduction is to remain the primary objective it will be necessary to modify the legislation.

7.7 Experience with 4.5 kW_{el} Fuel Cells

Natural gas is a limited resource. In the literature, hydrogen and the hydrogen economy was described as the system of the future. Gelsenkirchen was the last large city in the former West Germany which made the switch from coal gas to natural gas. The conversion was completed in 1989[41]. The coal gas consisted mainly of hydrogen with carbon monoxide, a mixture of hydrocarbons, carbon dioxide and hydrogen sulphide. A change back could be interpreted as a step into the past.

Fuel cells were mentioned as the technique for this future age. Support for this type of CHP development was reflected in the CHP Act which allowed higher reimbursements (see table 7.14).

ELE was the local energy supplier which was chosen to install the first fuel cell fabricated by Vaillant for residential buildings. The companies involved in this apart from ELE were

Vaillant GmbH, Remscheid (D)
Ruhrgas AG (Essen (D)
E.on Engineering GmbH, Gelsenkirchen (D)
EUS – Company for innovative change and storage of energy, Gelsenkirchen (D), current located in Dortmund (D)
EUS – Gesellschaft für innovative Energieumwandlung und –speicherung GmbH, Land North Rhine Westfalia (NRW)
Bundesland Nordrhein-Westalen

Size of Plant

§ 1 cipher 1	CHP-plant:	simultaneous change of energy input into electricity plus heat
§ 3 cipher 3	small CHP:	P_{el} < 2,000 kW (exception of fuel cells)
§ 7 cipher 4	CHP with $P_{el} \leq 50$ kW:	special regulation
§ 7 cipher 4	Fuel Cell:	special regulation
Existing Plants		
§ 5 cipher 1	old:	start of permanent operation before 31st December 1989
§ 7 cipher 4	new.	start of permanent operation between 1st January 1990 and 31st March 2002 or plants revamped within this period
§ 5 cipher 1	revamped:	old existing plant revamped beteeewn 1st April 2002 and 31 st December 2005

Year	Existing Plants				New Plants	New Plants[1]	Fuel Cells[2]
	old	new	revamped		> 50 kW	< 50 kW	
2002	1.53	1.53	1.74		2.56	5.11	5.11
2003	1.53	1.53	1.74		2.56	5.11	5.11
2004	1.38	1.38	1.74		2.40	5.11	5.11
2005	1.38	1.38	1.69		2.40	5.11	5.11
2006	0.97	1.23	1.69		2.25	5.11	5.11
2007	0.00	1.23	1.64		2.25	5.11	5.11
2008	0.00	0.82	1.64		2.10	5.11	5.11
2009	0.00	0.56	1.59		2.10	5.11	5.11
2010	0.00	0.00	1.59		1.94	5.11	5.11
						all figures in ct/kWh	

1) 10 years - from start of permanent operation; start of permanent operation before 31st December 2005

2) 10 years - from start of permanent operation

Table 7.14: Definitions and Reimbursements for CHP-Plants

The aims of the research project were:

reduction of the size and weight of the fuel cell heating device,
development of a sophisticated control system called "energy manager",
collection of experience on the integration of control, electrical and natural gas grid.

The best location of the fuel cell had to be selected. It was to be installed in a building with 4 - 6 apartments. The specification being:
30 to 35 kW heating capacity,
centralised hot potable water supply,
enough space for the equipment (fuel, boiler, controls, storage tanks),
suitable access fresh air supply,
two stacks.

Two fuel cells were envisaged for the installation in the building and a third unit would be used for research in the laboratory (operation with different gases, loads and electrical equipment).

The technical data of the fuel cell was

P_{el}	2.5 – 4.0 kW
Q_{th}	5.2 – 9.6 kW
η_{el}	maximum 25%
η_{total}	maximum 88%
mass	550 kg
size in m	1.7 x 0.94 x 1.65

Table 7.15: Technical Data of Fuel Cell NRW project

Basis for the selection of possible candidates were the figures described in chapter 7.2.

After measurements on two different sites Bergmannstraße was chosen, a building with more than 4,000 full load operational hours per year. The reason for the high demand was that the tenants were former Russian emigrants with German ancestors and their energy bill was paid for by social welfare (further residential buildings can be identified from the appendixes 7.1. They can be recognised due to the high amount of full load hours which are higher than 2,000 h per year). Later on at other properties two further premises were included in the study. Another reason for the high demand was the number of tenants: officially 36, thus giving more than 5 persons per flat.

December 2001	Installation and start of operation in Bergmannstraße, Gelsenkirchen (7 apartments) Start of laboratory tests (gas) at Ruhrgas AG
January 2002	Installation in Röckenstraße, Essen (6 apartments).
Feb. to March 2002	Interruption of testing because of modification to the inverter
April 2002	Start of operation in Röckenstraße.
June 2002	End of laboratory test (E.on Engineering, electrical equipment) Installation of the laboratory fuel cell in a brewery (Im Füchschen) in Düsseldorf (D)
July 2002	Start of operation in Düsseldorf Fuel cells in Gelsenkirchen is switched off due to low heat demand (July only)
July to Sept. 2002	Fuel cells in Essen is switched off due to low heat demand
December 2002	final switch off in Bergmannstraße (31-12-2002)
January 2003	final switch off in Röckenstraße (31-01-2003)
March 2003	final switch off in Im Füchsen (31-03-2002)
June	Final research report to Land North Rhine Westfalia[42]

Table 7.16: Time Table of the NRW project

The focus of the research was on technical development. Some parts, especially the reformation process from methane to hydrogen, were confidential.

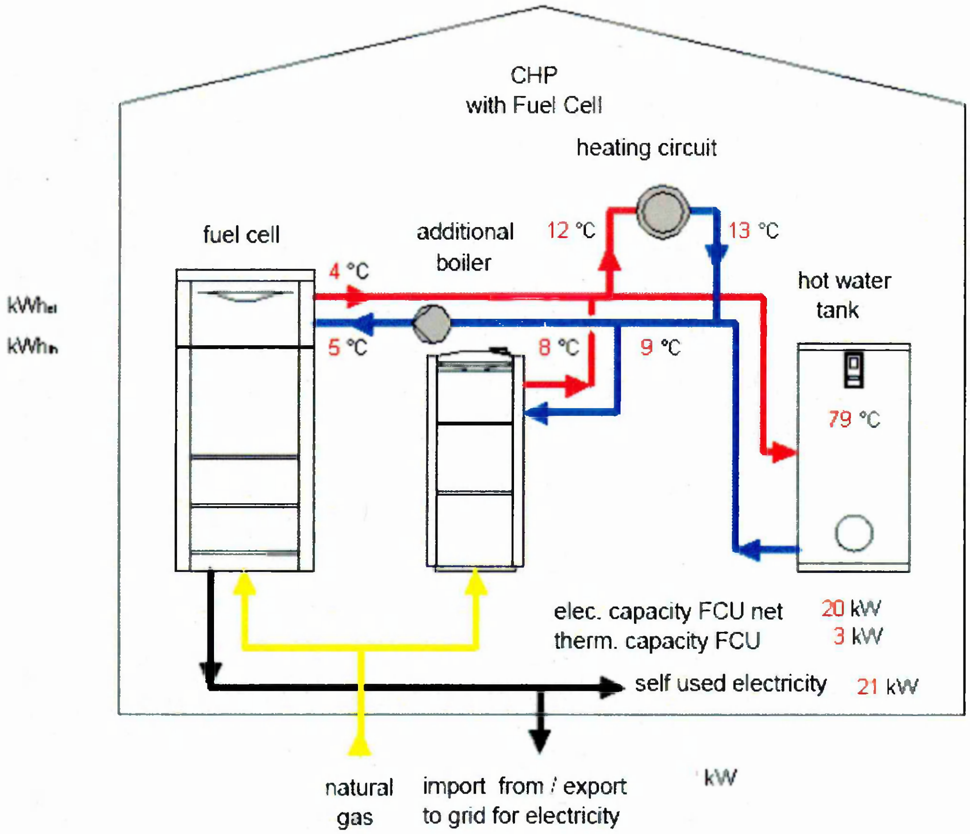


Figure 7.25: Plant Scheme NRW Fuel Cell

The structure of the plant was simple. The fuel cell, condensing boiler and storage tank (potable water) were supplied by Vaillant. The fuel cell was of the Polymer Membrane-type (PEM). The maximum return flow temperature was limited to 60°C. In consequence the temperature of 60°C in the complete hot water system to avoid legionella could be reached by operation of the boiler only. Not shown is the integration of the use of the heat of the inverter which is part of the fuel cell.

The difficulty of operating a CHP-plant, whether it is a fuel cell or another application, arises at low demand periods. For buildings, this is late spring, summertime and early autumn. The dominating demand is hot water supply.

A rough calculation for heat with half load of the fuel cell demonstrates the problem:

5 kW heat capacity produces 120 kWh within 24 h per day requires
1 kWh will provide approximately 8.5 *l* of water heated from 10 to 60°C or 12 *l* from 10 to 45°C (specific heat capacity 4.18 kJ/kgK).
120 kWh gives approximately 1,000 *l* at 60°C or 1,500 *l* at 45°C. The evaluation of the contracting plants used an average figure of 25 *l*/persons at 45°C.

The minimum number of people supplied by a fuel cell is 60. With the assumption of three persons per apartment the building requires a minimum of 20 apartments.
The heating portion of the boiler to assure the killing of legionella is neglected in this calculation.

The economical result of a CHP-plant is dependent on the simultaneous demand of heat and electricity. Peak shaving as described in section 7.5 for the MHKW and is for tariff customers in common not economic due to the missing price to be paid for capacity. An analogy is valid for feeding electricity into the grid. The reimbursement paid by the DSO is lower than the price for electricity from the grid. Figures 7.25 and 7.26 illustrate this situation.

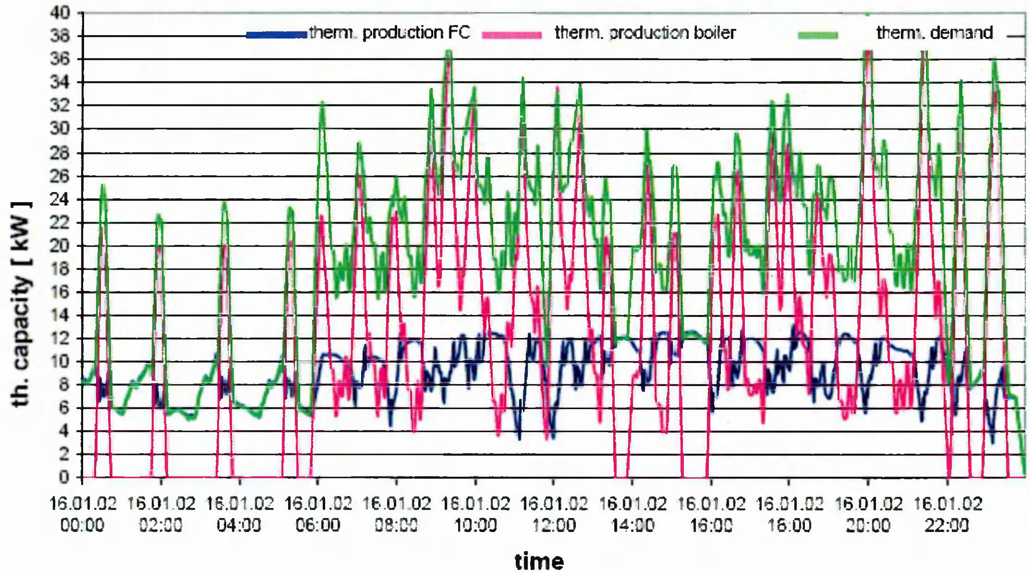


Figure 7.26: Heat Production on 16-01-2002

To avoid or to minimise the input of electricity into the grid the fuel cell is operated at minimum load during night-time, even in winter. The boiler had to assist the fuel cell to meet the additional requirements for heat.

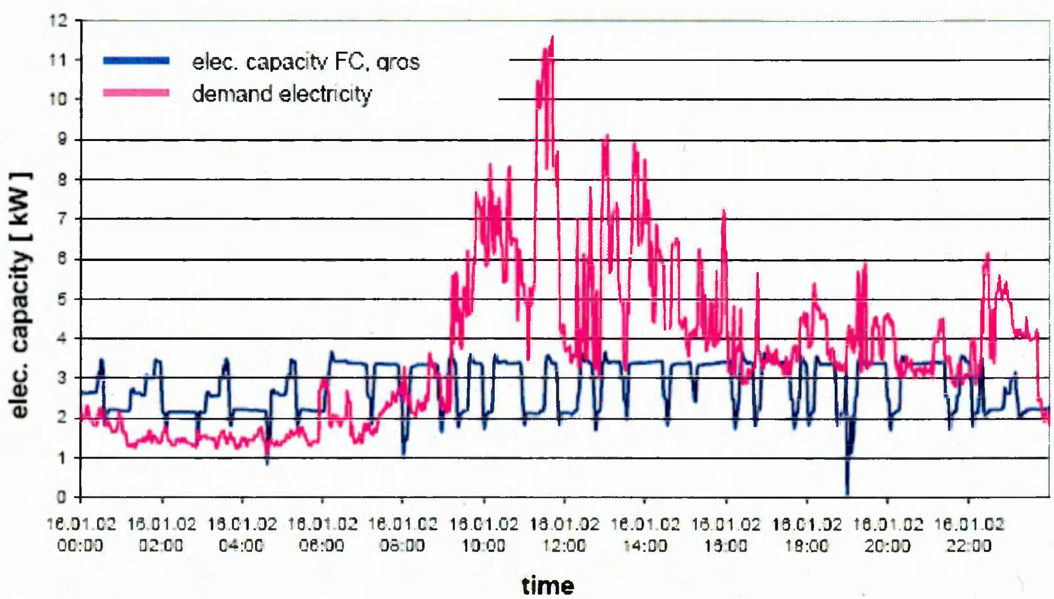


Figure 7.27: Production and Demand Electricity on 16-01-2002

The maximum average demand with less than 2 kW was in discrepancy to the installed capacity of the electrical equipment such as cookers, refrigerators, TV, radio, lightning etc. The first 30 kW of capacity for the building's electrical service connection are free of charge according to current NAV. This value is exceeded with 4 flats according to DIN 18015[43].

Further results of the first project were:

The minimum capacity of the fuel cell had to be decreased to 1 kW_{el} or lower if the foreseen market was not given up.

The hydraulic design had to be altered to enable the storage of heat for heating.

The maximum temperature of the return flow to the fuel cell needs to be increased. This was not possible for these tests due to the material of the membranes. The consequence would have been a complete new design of the stack and possibly the replacement auxiliary equipment (The author proposed another polymer membrane developed by Celanese which enables higher temperatures to be used.).

The next research project on fuel cells was the EURO 2 research which was supported by the EU. For this stage 31 fuel cells were installed in Germany, Netherlands, Spain and Portugal. The EU project covered 11 official partners which are named in figure 7.28.

Figure 7.28: Project Partners Euro 2 Fuel Cell

ELE decided to be involved in this project as a partner of E.on Ruhrgas AG. The idea was to continue the research in Bergmannstraße and to gain the opportunity to compare data without a fuel cell, the NRW fuel cell and the expected improvement by the Euro 2 fuel cell.

The Euro 2 fuel cells were scheduled to be the last prototypes before the precom-mecial start. The expected price is 30,000 € without auxiliaries.

The ELE plant was the first to be installed for this series (November 2003), the last set to come into operation was in February 2006, this being the only one with varying capacity. The hydraulic circuit had to be altered. The condensing boiler, which was less than three years old, was replaced by a new type. The new design is shown in figure 7.28

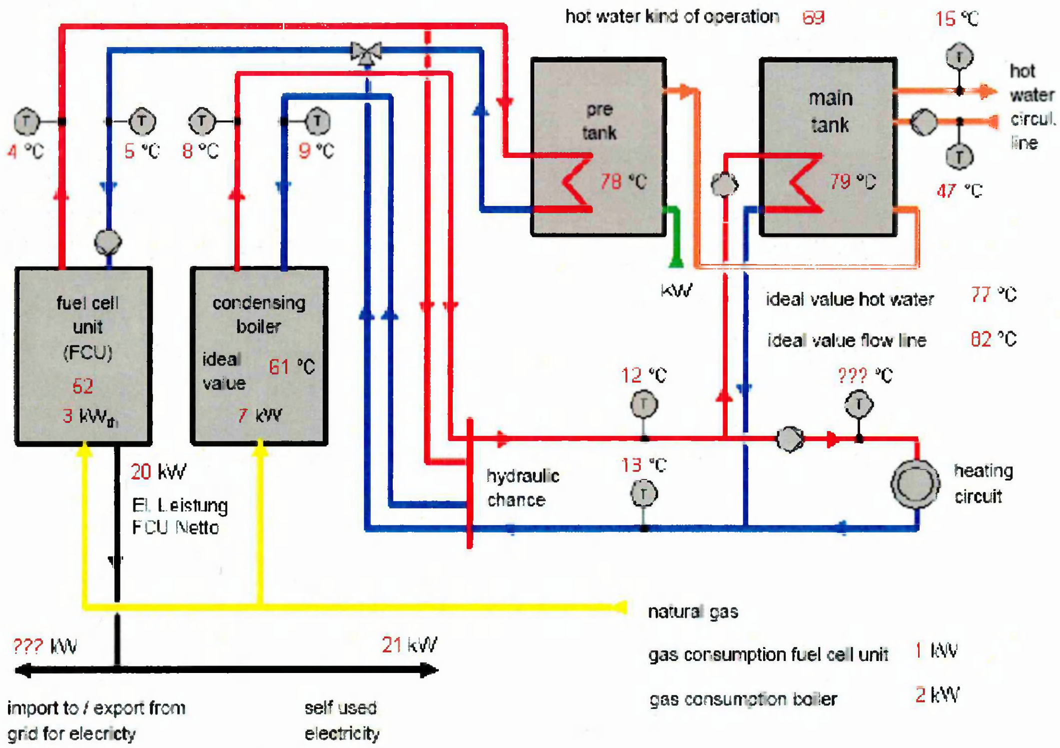


Figure 7.29: Plant Scheme Euro 2 Fuel Cell

The main changes in the hydraulic circuit compared to the NRW project were:

two solar tanks, each 500 *l*, one as a pre-tank,
hydraulic change,
the inverter is taken out of the heating circuit,

The hydraulic scheme results in the space requirement for the equipment to be high and was a limitation on possible markets for the system. A two tank solution was chosen because Vaillant did not have a larger solar tank. Additionally the ceiling in the cellar was limited in height.

The electrical efficiency was within the range of other small size CHP applications (see figure 7.30).

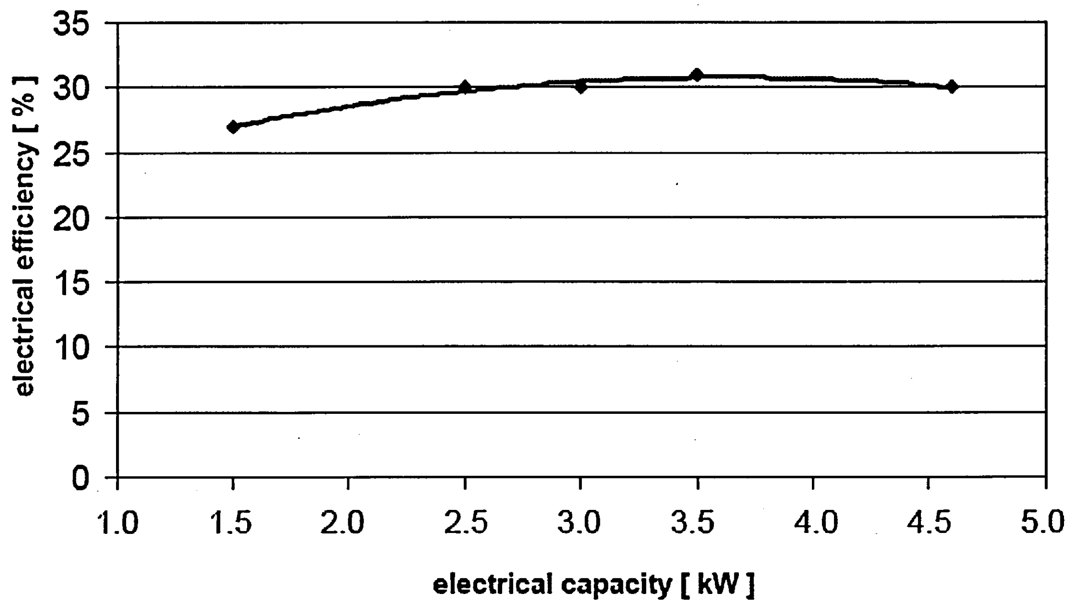


Figure 7.30: Electrical Efficiency as Function of Load

The advantage of the Bergmannstraße building was the high heat demand, as shown in tables 7.17 and 7.18.

	total	average	Bergmannstr.	unit
operation hours	23,413	4,683	5,962	[h]
gas input	341,786	68,357	82,771	[kWh]
prod. electricity	64,982	12,996	17,681	[kWh]
prod. heat	162,355	32,471	42,762	[kWh]

Table 7.17: Comparison of Euro 2 plants in 2004

	2003	2004	2005	2006
operation time[1)]	6 weeks	52 weeks	52 weeks	6 weeks
gas input	15,708	82,771	70,443	3,498
prod. electricity	7,568	17,681	11,974	481

[1)] including stand still periods

Table 7.18: kWh Gas Input and kWh Production of Electricity in the Bergmannstraße Building

The plant was dismantled in May 2006. The problem with the limitation of a 60°C return flow temperature to the fuel cell was not solved. Vaillant stopped production and has, the author is informed, changed the material of the stack and intends to develop a new fuel cell. Gas Wärme Institut in Essen which undertakes research on the optimisation of the control of small fuel cells produced three presentations which are given in the bibliography.

The main problem was and still is the behaviour of the users. The conclusions of these two research projects have similarities with other CHP projects using different technologies.

7.8 Individual Heating

The regulation on saving energy is based on European legislation. From the first moment of publication a discussion arose about the responsibility, cost and handling of the legislation. Every dwelling needs an energy pass. The energy pass is an official document issued by an expert. It describes briefly the dwelling, states its energy consumption (refer to figure 7.33) and the procedure how it is calculated. Some contain additionally advice on energy saving methods. By this every owner was and is involved. This led to pressure groups who tried to influence the regulations before Parliament passed the Act and it came into force.

Three main groups were:

owners,
tenant and
experts issuing the pass.

The concerns of each group were different. Owners wanted a cheap solution. Tenants preferred consideration with the right to go to court if the consumption deviated from the figures of the energy pass. Each group of experts (different kind of engineers, technicians, foremen, plumbers, gas maintenance engineers etc.) demanded exclusive rights to issue a pass. They also preferred an expensive solution.

Two kinds of energy pass were considered and were integrated into the regulation, those based a theoretical calculation (demand orientated) and those based real consumption (consumption orientated).

In 2004 the author of the thesis was asked to take part in the group for the home owners, namely the GdW Bundesverband deutscher Wohnungs- und immobilienunterbnehmen e.V., Berlin (Federal Association of German Economy for Housings and Immovable's (Estates). Further partners included Gasag, the Berlin gas supplier and E.on Ruhrgas AG.

The object of interest was the establishing of a cheap energy pass for buildings in which every apartment had their own boiler and including those who also produced hot water for heating hot potable water. The solution would be presented to a committee which was involved formulating the regulations.

Following data was required:
data from the owner of each apartment:

name of tenant, location of the house (street, street number), location of the apartment in the building, living space in square metres, type of potable hot water production, type of boiler, periods of unoccupancy

data from the energy supplier

location of the house (street, street number), name of the customer, number of meter, billing period, consumption, data for change of meters

The author collaborated with an estate company (Bauverein Selbsthilfe e.G.). Due to the Act on Protection of Data an agreement on confidentiality of data had to be signed. The data are attached in the appendices for chapter 7.6. This data can only be used for research purposes and the names of the tenants have been deleted.

The majority of the work was clerical and the cross check of the data bases (list of tenants with apartments and square metre living space, list of energy customers with consumptions and number of meters, list of boilers with manufacturer, type and owner of maintenance contract. E.on Ruhrgas AG and ELE placed an order with a small engineering company to do this work.

The collation of the data created difficulties. Apart from street and street number the only common data expected was the name of the tenants. The location of the apartment was in the list of the association but not in the energy supplier list.

The evaluators discovered that in several cases the names of the tenants did not appear in the list of the energy customers. In some cases the end or start of energy contract was not in the same name as the contract for rent. Having the correct name was important to calculate the correct energy consumption. A further difficulty arose when tenants moved from one apartment to another or rented an additional one.

Figure 7.31: Plan of Site (Section)

The excel table “Block1” consists of sub blocks

A Pfefferackerstr. 24 – 34
B Pfefferackerstr. 36 – 46
C Lindenstr. 24 – 26
D Lindenstr. 29 - 31
E Lindenstr. 33

These buildings were gas-fired. Additionally the excel table contains Block F. This is not described as it was connected to district heating.

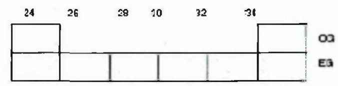
The street number was taken for further sub division e.g. “A 24” means Pfefferackerstr. 24. The tenants received anonymous names such as “A 24-1”. They can be recognized when the red triangle is clicked. The billing period (year), the amount of days the bill covered and the consumption within this period were listed. The consumption was split into three portions such as gas for cooking, gas for hot potable water and the heating. The portion for gas was defined in accordance with the regulation on distribution heat – 18 % of the total amount. The experience described in chapter 7.1 demonstrated that this figure was too low. In consequence the consumption calculated for heating was too high and the real figures were better than identified in the energy pass.

The next step was to settle the current year to the standard year. This was done for each apartment/tenant by degree days. (refer to sheets Kennwert (A) to (E) in the excel calculation). The structure of these is similar to the one described above and shown in figure 7.32.

Wohnungsunternehmen: Bauverein "Selbsthilfe" e.G., Lindenstraße 62, 45894 Gelsenkirchen

Liegenschaft: Block 1
A Pfefferackerstr. 24 & 26 & 28 & 30 & 32 & 34, 45894 Gelsenkirchen
B Pfefferackerstr. 36 & 38 & 40 & 42 & 44 & 46, 45894 Gelsenkirchen
C Lindenstraße 24 & 26, 45894 Gelsenkirchen
D Lindenstraße 29 & 31, 45894 Gelsenkirchen
E Lindenstraße 33, 45894 Gelsenkirchen
F Am Spritzenhaus 17, 45894 Gelsenkirchen

sketch front view



Pfefferackerstraße 24 & 26 & 28 & 30 & 32 & 34 (Block 1)

Objekt Block 1	Wohneinheit WE	Geschoss	Mieter	Wohnfläche m²	Abrechnungs-Jahr	Verbrauchs-tage	Verbrauch kWh	Anteil Kochgas kWh	Anteil WW kWh	Anteil HZG kWh
A 24	1	EG	A 24-1	75,50	2004	24	296	0	54	244
						346	19.471	0	3.505	15.965
A 24	1	OG	A 24-2	75,58	2004	363	12.706	0	2.287	10.419
A 26	1	EG	A 26-1	82,38	2004	1	0	0	0	0
						366	29.368	0	5.376	24.492
A 28	1	EG	A 28-1	82,38	2004	289	14.590	0	2.626	11.964
A 30	1	EG	A 30-1	82,38	2004	289	14.590	0	2.626	11.964
A 32	1	EG	A 32-1	98,45	2004	176	12.204	0	2.197	10.007
A 34	1	EG	A 34-1	62,90	2004	14	23	0	4	19
						346	7.639	0	1.375	6.264
A 34	1	OG	A 34-2	62,90	2004	22	11	0	2	[illegible]
						345	8.110	0	1.460	6.650
								0	21.512	97.998
Summe	8			622,55			119.510	119.510		
apartment		floor level EG basement OG 1st floor	tenant	living space	billing period	consumption days	consumption	portion gas for cooking	portion gas for hot water supply	portion gas for heating

Figure 7.32: Table of Consumption (Verbrauchswerte)

Based on the evaluation described an energy pass was issued for every building. A graphic (see figure 7.33) shows the situation of the building in comparison to non-refurbished or partly refurbished buildings built at the same time.

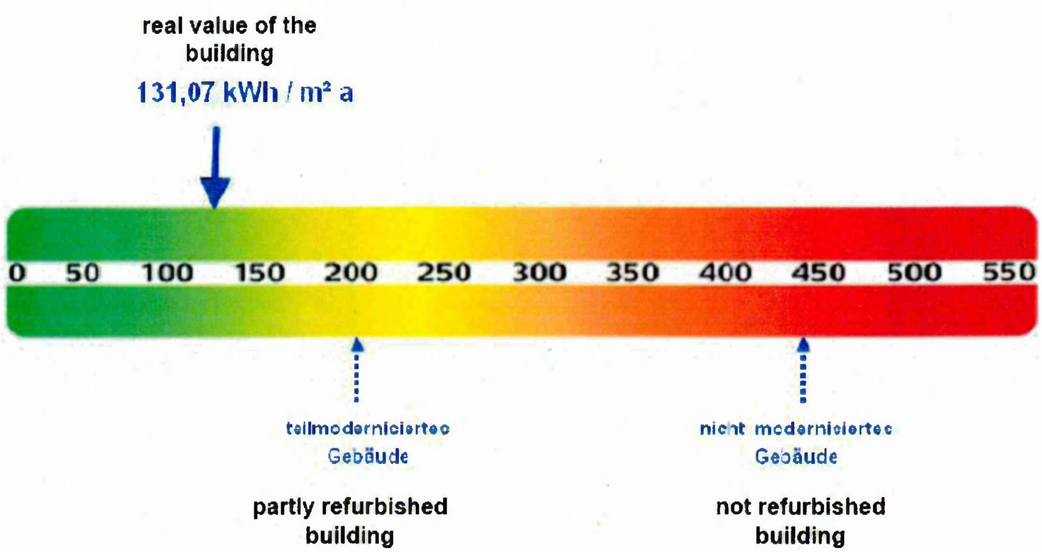


Figure 7.33: Energy Pass (Section with Comparison Graphic)
The results for block 1 were:

Block A	226 kWh/m²
Block B:	164 kWh/m²
Block C:	170 kWh/m²
Block D:	104 kWh/m²
Block E:	131 kWh/m²

Similar results for the other 22 blocks are given in the appendices referring to this chapter.

Two important facts are explained:

the low consumption in general and
the difference in consumption for similar buildings

The estate company was a co-operative. Each tenant was member of the co-operative. Owners have a different relationship with the building than ordinary tenants. They had to pay the rent and heating costs by themselves. It was not paid by social welfare.

Another reason could be the system itself. The difference between central heating and single boilers per apartment were heat losses arising in the distribution system between boiler and the apartments (see chapter 7.8).

The difference in consumption between the blocks can be explained by the heating behaviour of the tenants. Differences of 20 to 30% have been determined (see chapter 7.2).

The figures demonstrate the problem of energy passes. A pass based on a theoretical calculation can be proven wrong by the heating behaviour of the tenants or defects in insulation. Increasing the incidence of court action is a logical conclusion.

The consumption based energy pass contains individual heating behaviour. Individual behaviour can be observed when they are compared with the other tenants.

The data for the 23 blocks underline that individual behaviour has a large affect on energy consumption.

7.9 Comparison of Four Heating Systems

The projects described allow comparisons to be made between the energy supplied for centralised and de-centralised heating systems. Centralised systems give the opportunity to install larger systems with synergy effects on the price per kW of installed capacity. Research was undertaken on centralized heating systems (see chapter 7.2) and de-centralised ones[44,45,46]. The tests were not conducted on the different systems in the same buildings simultaneously. Project partners were sought who would have an interest in the results of a comparison of centralised and de-centralised systems.

In Germany the supply of new buildings is small, less that 1% of the housing stock is replaced each year. The older buildings have been built to a lower specification and so have the highest energy consumption and the highest demand for refurbishment. Comparing the refurbishment of existing building's heating systems would allow informed decisions to be made as to which systems to install in the future.

For the study it was necessary to source equivalent buildings with de-centralised heating systems which required replacement boilers. The number of comparable systems depended on the number of equivalent buildings.

The local estate company Gemeinnützige Wohnungsbaugesellschaft Gladbeck mbH, GWG, had a maintenance contract for their boilers with ELE. GWG agreed to participate in the study but it limited the funding to that of one replacement boiler. GWG offered four buildings for the study; Münsterländer Straße 17, 19, 21 and 23, each had five apartments:

2 x 50.5 m² in the floor level
2 x 53.1 m² in the 1st floor
1 x 42.5 m² in the roof
total: 249.7 m²

The four selected systems for the replacement boilers were installations of

one low temperature boiler per apartment (see figure 7.34)
one condensing boiler per apartment (see figure 7.35)
condensing boiler with conventional hot potable water supply, 4 pipe system, (see figure 7.36) and
condensing boiler with 2 pipe system, separate heat exchanger per apartment (see figure 7.37)

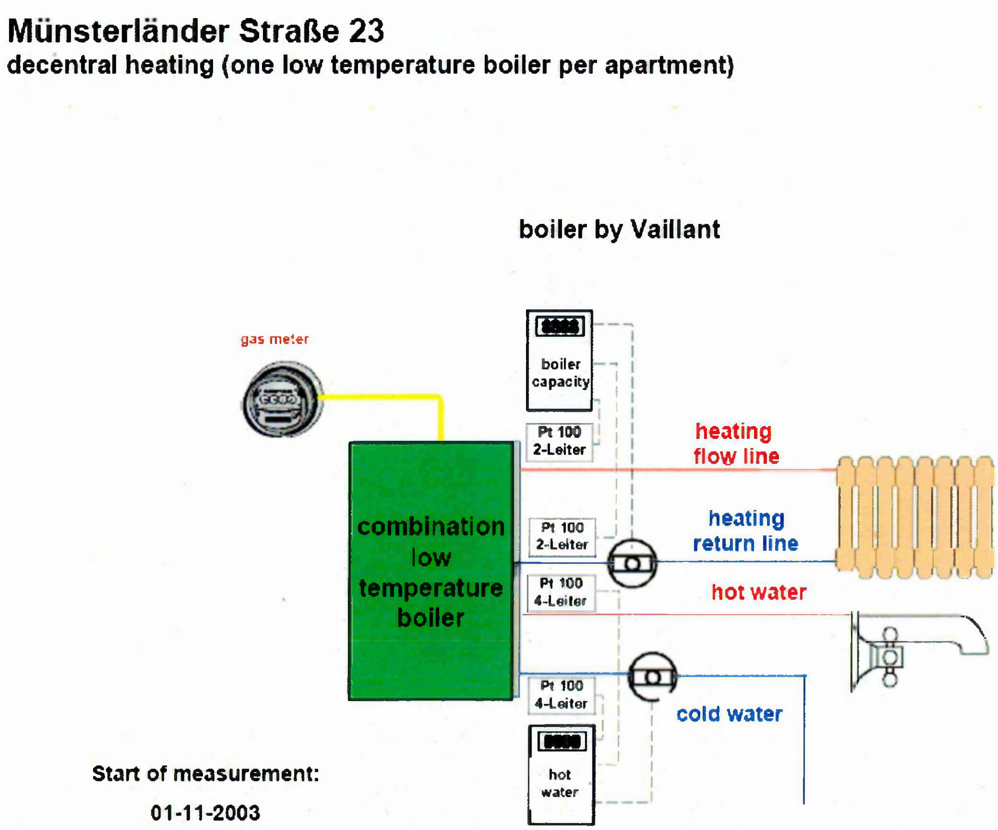


Figure 7.34: Schematic Diagram Münsterländer Str. 23 with Measuring Points

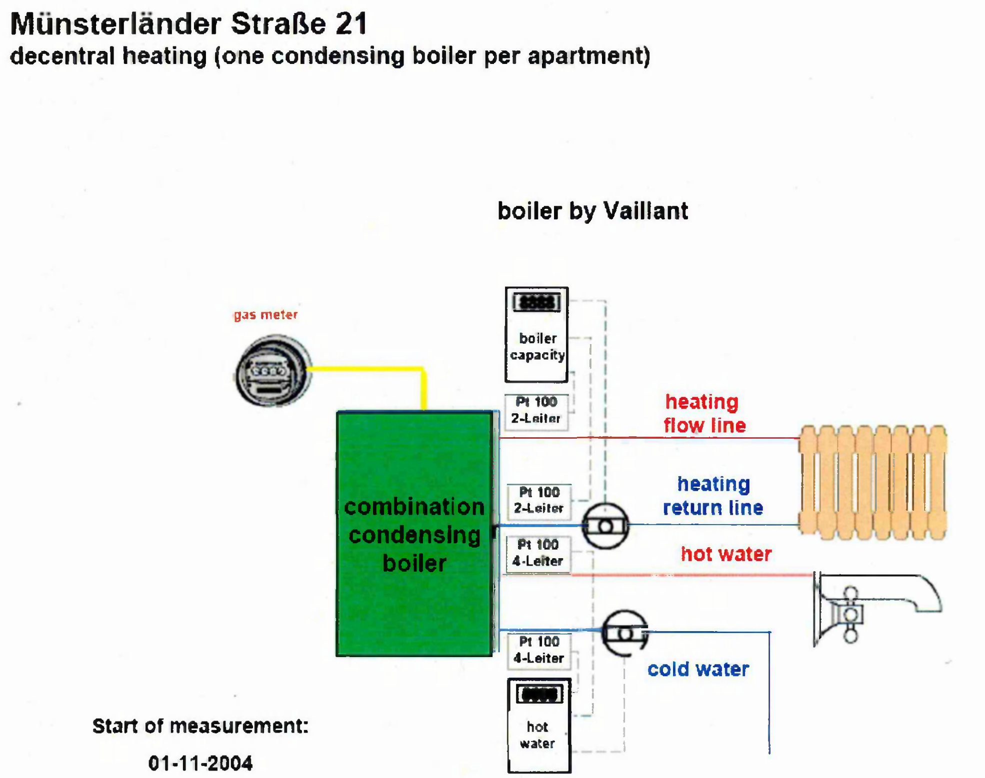


Figure 7.35: Schematic Diagram Münsterländer Str. 21with Measuring Points

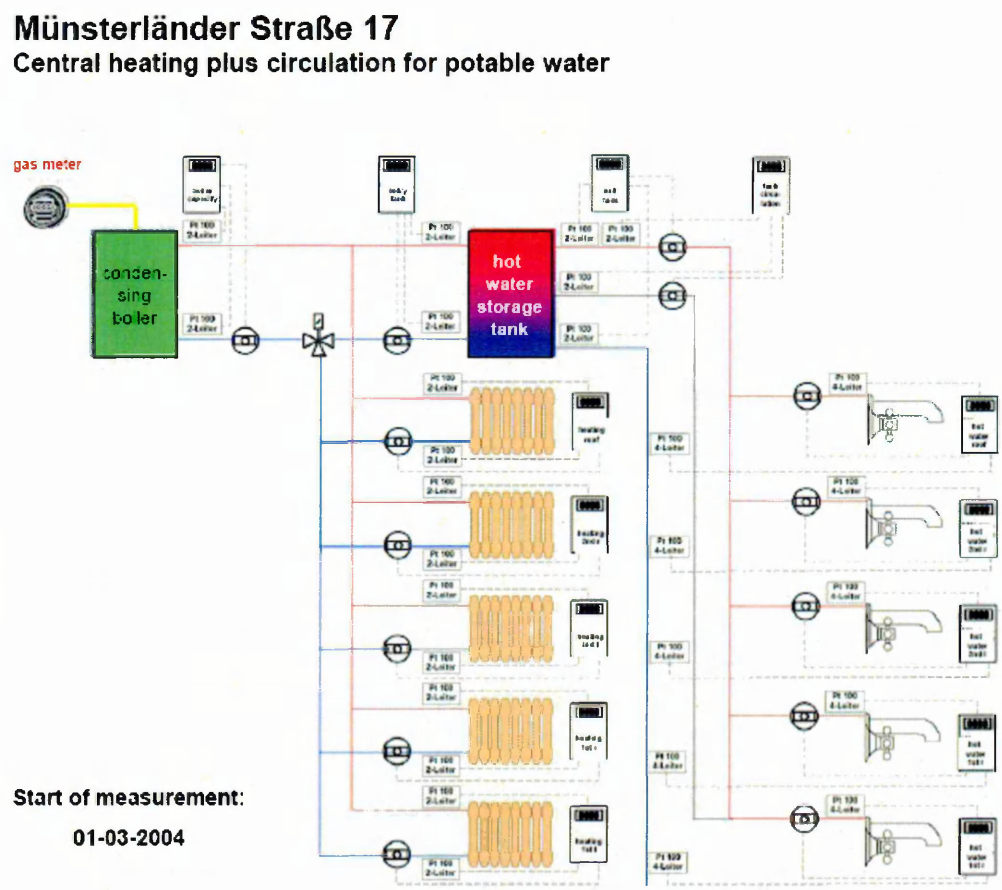


Figure 7.36: Schematic Diagram Münsterländer Str. 17 with Measuring Points

Münsterländer Straße 19
Central heating plus satellite system (two pipe system with seperate heat exchangers)

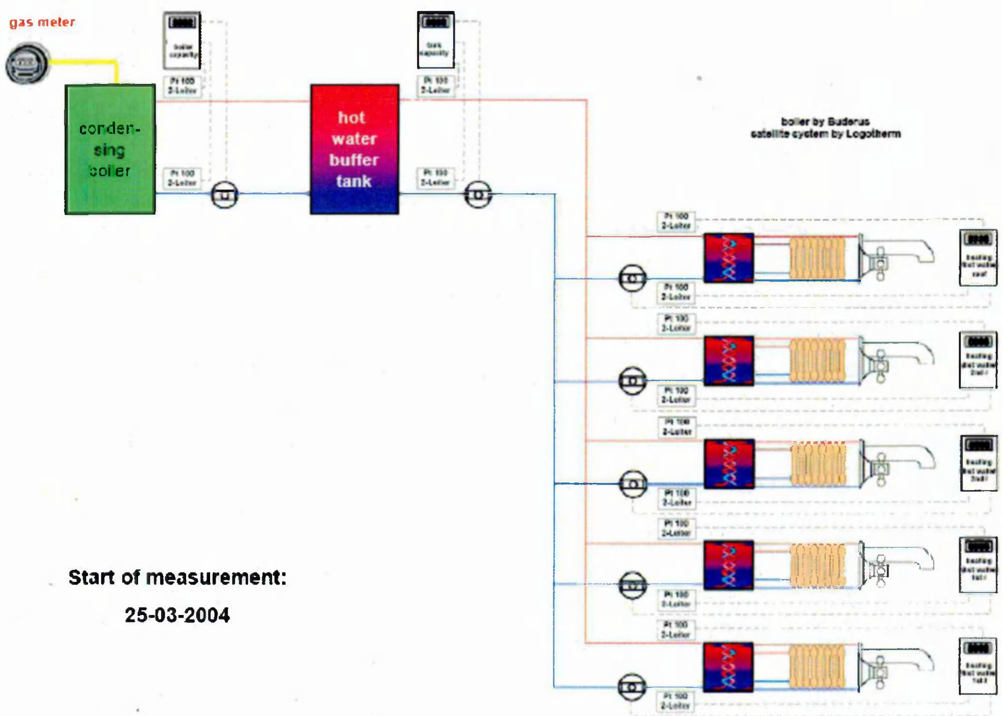


Figure 7.37: Schematic Diagram Münsterländer Str. 19 with Measuring Points

The boiler manufacturers, Buderus and Vaillant joined the project as well as Logotherm for the satellite system (two pipe system with separate heat exchangers) and E.on Ruhrgas AG as the main sponsor.

The project plan was in 2001 when the contract between GWG, E.on and ELE was signed:

Consumption data from the past three years supplied by ELE
Scrutiny by an independent consulting company
Installation of the new heating systems including measuring system by a local company
Measuring the improvement of the energy consumption by the new heating systems
Insulation of the housing according to German legislation (new windows, 12 cm insulation of the outer shell plus insulation of the ceilings in the cellar and the roof)
Comparison of costs (maintenance, administration, effects on rent etc)

The supervision of the installation was given to GWG to determine the final prices and time schedule.

German regulation on low interest rate credits (Kreditanstalt für Wiederaufbau, credit association for re building) required a refurbishment in one stage. The aim to elaborate the effect of insulation and new heating systems had to be deleted.

The quoted prices of the cheapest competitor and the final costs after installation can be taken from tables 7.19 and 7.20.

	combined condensing boilers		low temperature boilers	
	House 21 (plan)	House 21 (real)	House 23 (plan)	House 23 (real)
Boiler plus equipment	12,035 €	15,854 €	9,261 €	13,193 €
Piping and equipment				
Hot water supply and equipment				
Insulation				
Gas pipe and equipment				
Dismouting	105 €	72 €	131 €	38 €
Refurbishment of stack			3,441 €	
Administration costs	327 €	3,796 €	341 €	2,430 €
Total without VAT	12,468 €	19,722 €	13,173 €	15,661 €
price increase		7,254 €		2,488 €
price increase in %, basis: plan		58%		19%

Table 7.19: Comparison of Plan and Real Costs - De-centralised Boilers

	4 pipe system		satellite system	
	House 17 (plan)	House 17 (real)	House 19 (plan)	House 19 (real)
Boiler plus equipment	3,172 €	3,298 €	10,442 €	11,856 €
Piping and equipment	3,781 €	4,434 €	2,574 €	3,292 €
Hot water supply and euipment	2,643 €	3,073 €	398 €	268 €
Insulation	851 €	682 €	476 €	315 €
Gas pipe and equipment	604 €	348 €	604 €	369 €
Dismouting	293 €	52 €	226 €	35 €
Refurbishment of stack				
Administration costs	311 €	4,967 €	379 €	4,659 €
Total without VAT	11,655 €	16,855 €	15,099 €	20,794 €
price increase		5,200 €		5,695 €
price increase in %, basis: plan		45%		38%

Table 7.20: Comparison of Plan and Real Costs - Centralised Boilers

The ranking based on the quotations before installation was

1st Condensing boilers (CD)
2nd Low temperature boiler (LTB)
3rd Centralised heating with centralised hot water supply, 4 pipe system (CH)
4th Satellite system, centralised heating, 2 pipes with separate heat exchangers (ST)

The price difference between the cheapest and the most expensive system was approximate 4,000 € equalling 30% or 800 € per apartment. The control on site was given to the estate company. The work on site was not checked and extra bills for unforeseen works were written into the tables and included in the administration costs. The result was a price increase between 19 and 58% which changed the ranking to

1st Low temperature boiler (LTB)
2nd Centralised heating with centralised hot water supply, 4 pipe system (CH)
3rd Condensing boilers (CD)
4th Satellite system, centralised heating, 2 pipes with separate heat exchangers (ST)

The price difference remained at 30%, and in real costs it increased to 6,000 € or 1,200 € per apartment.

During the study the tenants had to pay the energy and the maintenance costs. Centralised heating requires heat costs allocations (see chapter 3.4) and a system to measure the energy consumption for hot water supply. Single boilers have additional costs due to extra maintenance. The costs are summarized in table 7.21, costs and prices were current ELE costs for energy and services such as heat distribution which was including in the billing.

	House 17 CH	House 19 ST	House 21 CB	House 23 LTB	Remarks
Base price energy	318	318	600	600	in Gelsenkirchen 144 €for CH and ST
Chimney cleaner	50	37	100	100	for condensing boiler measuring every two years
Maintenance boiler	99	99	396	396	price of association of maintenance quality
Maintenance tank	25	0	0	0	
intermediate sum	492	454	1,096	1,096	
distribution of heat costs					
base price	65	65	0	0	
heat costs allocator					4 radiators per appartment
rent	228	228	0	0	
billling	240	240	0	0	
hot water meter					1 hot water meter per appartment
rent	57	57	0	0	
billling	60	60	0	0	
intermediate sum	650	650	0	0	
total	1,142	1,104	1,096	1,096	

Table 7.21: Consumption Independent Energy Costs for the Different Systems

The base price for gas supply for centralised heating in Gladbeck and Bottrop is different to that in Gelsenkirchen. The reasons are historical ones and arise from the merger of different gas suppliers to the current ELE. Referring to the real prices (Gladbeck) the prices difference between the systems is less than 5%, in Gelsenkirchen the centralised heating and the satellite system would be less than15% or 1.50 € per apartment and month. It can be assumed that this small difference would not have a detrimental affect on the renting of the apartment.

In the case of buildings with more than 5 apartments the difference will increase because the basis for the distribution of heat costs and for the servicing engineer are independent of number of apartments, but are dependent of the capacity of the boiler. Additionally the maintenance price for larger boilers will not increase proportional to the increase of capacity.

Before the start of the research project the buildings had the same standards of insulation and heat preparation. They were standing in a row of separate buildings. To enable comparisons between the energy consumption for the different years the figures were normalized to the standard year. All years surveyed in the project were warmer than the standard year which can be taken from the factor to calculate the figure (see table 7.22)

Before the refurbishment the normalized energy consumption varied between 52,397 and 64,546 kWh per year (approximately 20% difference). After the refurbishment the energy consumption decreased to 39,347 at the lowest and 46,320 kWh at highest (approximately 15% difference). The savings made were between 22.4 and 28.0 per cent. The best saving was achieved in the building with the low temperature boilers which had the highest consumption before the refurbishment.

The detailed energy result can be taken from table 7.23.

Year	House 17 CH		House 19 ST		House 21 CB		House 23 LTB		factor standard year
	real	normalized	real	normalized	real	normalized	real	normalized	
2000	51526	61161	64191	76195	54533	64731	61197	72641	1.187
2001	51786	55463	55645	59596	68495	73358	61463	65827	1.071
2002	45253	51362	60567	68744	52362	59431	55199	62651	1.135
2003	49385	52397	60134	63802	51163	54284	60835	64546	1.061
average	**49488**	**55096**	**60134**	**67084**	**56638**	**62951**	**59674**	**66416**	
2004	40292	42830	54368	57793	51628	54881	48048	51075	1.063
2005	36602	39347	43088	46320	40149	43160	41498	44610	1.075
Saving in %	**22.3**	**25.4**	**19.0**	**22.4**	**19.0**	**22.1**	**25.0**	**28.0**	

Table 7.22: Energy Consumption Before and After Refurbishment

The efficiency of the boilers was in accordance with the figure from chapter 7.1. Only the condensing boiler of the satellite system reached the figures given in the catalogue. The satellite system requires a constant temperature of 60°C in the complete distribution system including the buffer tank. Due to this high temperature it was not be expected that the boiler would operate in the condensing mode for 100% of the time. An advantage due the low entry temperature for the storage tank was expected for the four pipe system compared to the satellite system. This advantage is not obvious from the results. The reason could be 17% higher heat production for house number19.

Both centralised systems were better than the single systems. This effect is as expected and results from the longer operation times and the storage capacity of the buffer tanks (potable water in the 4 pipe and heating water in the two pipe or satellite system). The losses for cycling of the system are lower.

Low temperature boiler (LTB)	81.4%
Condensing boilers (CD)	90.5%
Condensing boiler centralised heating, 4 pipe system (CH)	93.8%
Condensing boiler centralised heating, satellite system (ST)	94.2%

Table 7.23: Energy Efficiency of the Boilers

Centralised heating has distribution losses (heat radiation). The gas pipes to the single boilers (de-centralised heating system) have to be gas-tight. Leaky pipes are recognised because of the odour of a trace substance added to the gas. The installation procedure is dictated by technical guide lines (see chapter 3). This fact and the reduced losses due to not having heat distribution pipes between the levels of a house are an efficiency advantage of de-centralised heating systems. The boiler is in the apartment and possibly heat losses (radiation) are a bonus effect for the room which requires in consequence less heating. The same argument can be used for the insulated piping for the distribution system in the apartment.

The differences between the centralised and de-centralised systems are the additional distribution piping between the boiler and the apartment, and the possible additional piping for hot potable water supply. The boiler for centralised heating is within the shell of the building but in general not in an apartment. The results for the heat which reached the apartment were 63.8% for the 4 pipe and 73% for the satellite system.

The daily figures for the efficiency of the total system had a larger variation than those of the boiler (see figure 7.38). The low values in February corresponded with low heat production. This relationship appeared especially during summertime when the heat production was reduced to potable water supply only.

The satellite system has a better hydraulic control than the standard four pipe system. The system reacts on small deviations in temperature and pressure. It requires a small amount of by-pass to achieve this measurement.

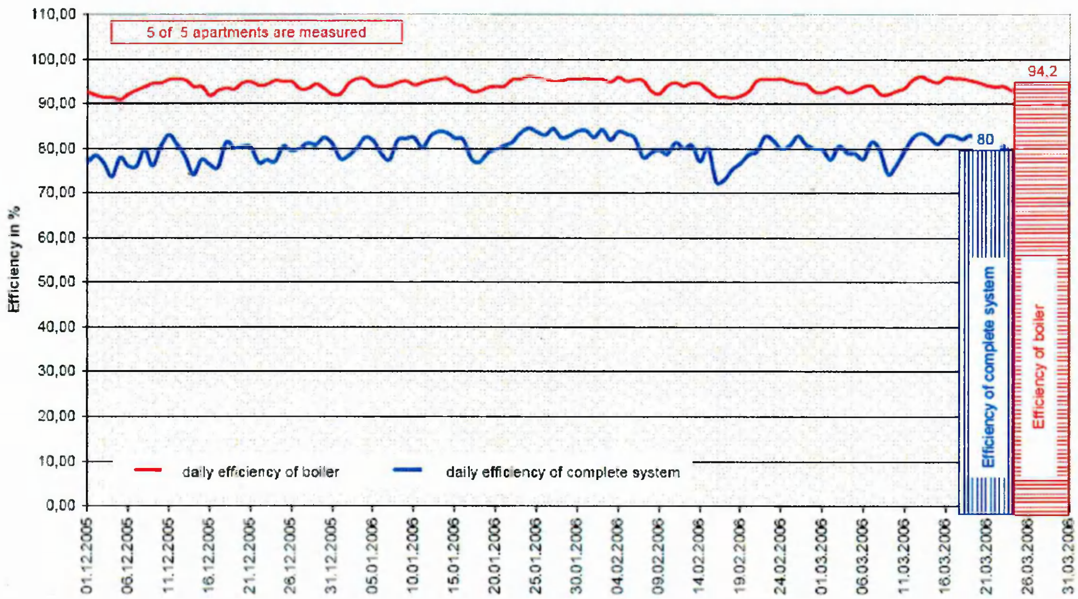


Figure 7.38: Efficiency of Complete System – Satellite

The poor performance resulted in E.on to ask for the results not to be published. It would severely affect the competitiveness for gas-fired centralised heating.

Further conclusions by the author:
Heat consumption is dependent on the consumers (individual behaviour). Otherwise the different consumptions cannot be explained.
The projects proves that every heat transport results in significant heat losses even if the insulation is in accordance with the latest regulation equalling highest current standard (compare chapter 7.5 MHKW district heating).
Consumers should be able to adjust the heat control centrally and not by thermostatic valves only. This requires ring pipes per apartment.
Heat distribution must be simpler and cheaper.
The satellite system has the advantage that legionella are reduced to a minimum or even avoided. The potable hot water is produced with 60°C and the distance to the tap is short.
The buffer tank could be connected to solar panels. Compared to standard systems the heat exchanger between solar panels and the storage tank (see chapter 7.4) can be made redundant (The buffer tank is heating water and not potable water).
The boiler of the buffer satellite system can be substituted by a CHP plant (compare chapter 7.7).

7.10 Further projects

Suppliers of energy have the advantage of knowing the energy consumption of their customers. This process has existed since the 19th century with the first energy supply companies. They know the effects of the change of technologies on consumption. This experience is used for contracting projects nowadays. Energy suppliers expand their range of offers in the regulated market. They are in competition with engineering and consulting companies. Additionally manufacturers of equipment e.g. boilers or transformer stations, have entered the service market.

Electronic Appendix 7.9.1 has a presentation on a low energy house heated by a heat pump (water/water with a ground heat source). The house was completed in 1999. Hot potable water was produced by solar panels and, if required, during cooler periods by an electric boiler which works with preheated water. A ventilation system without heat recovery was also installed. A control which switches the fan off at higher outside temperatures e.g. higher than 25°C was later installed in order to keep the warm air outside. This improvement was made with the agreement of the tenant.

The German Federal Garden Exhibition took place in Gelsenkirchen in 1997. The area a former coal mine was redeveloped with a combination of new houses in the outer area and new office premises which included low emission CHP plant. The old administration buildings were refurbished as offices and a restaurant. District heating was used for the heat supply. The final heat demand was calculated to be 10 MW in accordance with the house-building plan. A CHP-plant of reasonable capacity, defined by 500 kW_{el} minimum, was foreseen to meet the heat demand. The grid had to be laid before opening of the garden exhibition. The overall design was based on a house-building plan published by the city of Gelsenkirchen. The design incorporated a load management controller in order to restrict the heat capacity of condensing boilers to approximately 5 MW. The boilers required a return flow temperature in the grid of less than 55°C. Two grids, east and west, were designed. The east grid had to be in operation before the opening of the garden exhibition. The operation of the west grid depended of the construction of the buildings.

The situation in 2007 was:
The expected number of buildings was not reached.
A planned hotel was not built.
The arrangement of the dwelling houses differed from the house-building plan.
Each the terraced houses received a heat exchanger station instead of a central station per row. Due to this de-centralised supply the return flow temperature increased because each house had an individual controlled production of hot potable water. The condensing effect was lost.
The eight commercial buildings were substituted by a single building for one company. This caused an unforeseen load on the west grid. When the company went bankrupt the use and the demand changed.

CMM of suitable methane concentration could be drained from the closed coal mine. A CHP-plant capable of being fired with this gas was installed and was run even when the heat output was higher than the heat demand. When the engine was installed the methane concentration decreased to below 25% and it became impossible to run the engine with this gas. It was also not possible to fire the engine with natural gas as an alternative. The acceptance test with methane was not possible which delayed the acceptance test and the operation for more than two years. An agreement (payment of the complete price, surety by a bank for failing of acceptance test, acceptance within 5 years or cancellation) was made between the

supplier and operator and the engine started permanent operation in 2006 with natural gas.
A brief presentation is in electronic appendices 7.9.2

Another current project is the supply of heat, cold and electricity to Arena AufSchalke for the football world championships in 2006 (electronic appendices 7.9.3). The arena in Gelsenkirchen, opened in 2001 as Arena AufSchalke, the name of the club and renamed into Veltins Arena in 2006.

Due to the experience with the WEKA emergency power was produced with a diesel fired engine. As at the time the price for electricity was low the chillers used were electrically driven vapour-compression. The capacity (heat, cold, electrical power and emergency power) were designed in accordance with the consulting company which was responsible for the internal supply of energy. The experience of the former city works with the football world championship in 1974 at the arena Parkstadion was not acknowledged. The consultants envisaged 50 events per year, while the average figure since opening is 25).

A district heating grid was designed for the arena. An education centre, demanding 3.6 MW, and a leisure centre with existing dual-fuel boilers (2 x 1.0 MW), an existing CHP-plant (500 kW electrical capacity el) and a Diesel fired emergency generator were connected to the grid. The specified heat demand for the arena was 8.7 MW.

The heat capacity of the new boilers was 11.1 MW (3 boilers with 3.7 MW each). The simultaneous capacity was restricted to 10.0 MW input of natural gas equalling approximately 8.5 MW heat.

The experience since 2001 has been:
One of the two boilers was installed as a substitute in case the engine or one boiler failed. This equipment was sufficient to supply the customers connected to the grid from spring to the autumn. One of the three boilers had to be started during wintertime, mainly to supply the education centre.

The grid was extended. A hotel (0.9 MW), a medical centre (0.95 MW) and the heating of the 11,000 m² training pitch (2.5 MW) in total 4.35 MW were connected without extending the capacity of the heat producing equipment. It still has extra capacity for further customers.

Another project which will be finished in 2009 is the energy of the Zoom Adventures World in Gelsenkirchen. When the project started in 2002 the expected completion date was 2007. The Zoom is a modern zoo separated into the continents North America, represented by Alaska, Africa, Asia and a Westfalian farm house with native animals. Each continent has an energy intensive attraction such as an aircraft-type simulator used for an adventurous trip on an iceberg or a water fall (300 kW pump capacity) or a boat trip with "African Queen" passing among the animals.

For the above mentioned projects the heat demand of 1.595 MW was satisfied by a district heating system with 1.2 MW for the central and main consumers and single boilers (0.4 MW) for the distant consumers. The district heating is fed by a dual-fuel boiler (720 kW) and a CHP-plant (480 kW heat). The heat demand was supplied by contracting plants specified by ELE.

The architect team required in total a capacity of 2,500 kW for the electrical equipment from which 220 kW were for safety. Approximately 1,775 kW were specified for the supplied parts of the Zoom being realised (Asia will be added in

2009). The highest peak up to July 2007 was less than 570 kW. Assuming that the CHP-plant was in operation during the peak then 350 kW have to be added to give a value of 920 kW (570 plus 350) as the current maximum peak. This corresponds to 55% of the requested demand of 1,775 kW. A publication by the author in GWI – Gas Heat International from 1/2007 is given in electronic appendices 7.9.4

CHAPTER 8

DISCUSSION AND RECOMMENDATIONS

8 Discussion and Recommendations

8.1 Discussion

Today's society is built on a carboniferous economy that arises from the benefits of burning fossil fuels. Unfortunately it is a double-edged sword; it has provided humanity with the high standard of living but its legacy could be climatic change brought about by carbon dioxide emissions, air pollution from acidic emissions and the problem of meeting future expectations from a diminishing finite resource.

This thesis has described the changes that have been made to liberalise the energy market in Germany and it has highlighted the changes in the laws that are necessary to control CO_2 emissions. The case studies have shown that the two can be and are often in conflict.

This has recently been brought to the forefront at the highest level by Juergen Grossmann[47] the CEO of RWE AG who has called for "An Energy Pact for Germany", which in his view "it is high time for such an agreement".

The author's studies presented in this thesis allow him to present solutions to this debate.

Ruth C. Cohn, a psychologist, undertook research on interaction between human beings. A part of her theory Themenzentrierte Interaktion (TZI - theme orientated interaction)[48] results in the statement:

Good teamwork only happens in an equilateral triangle.

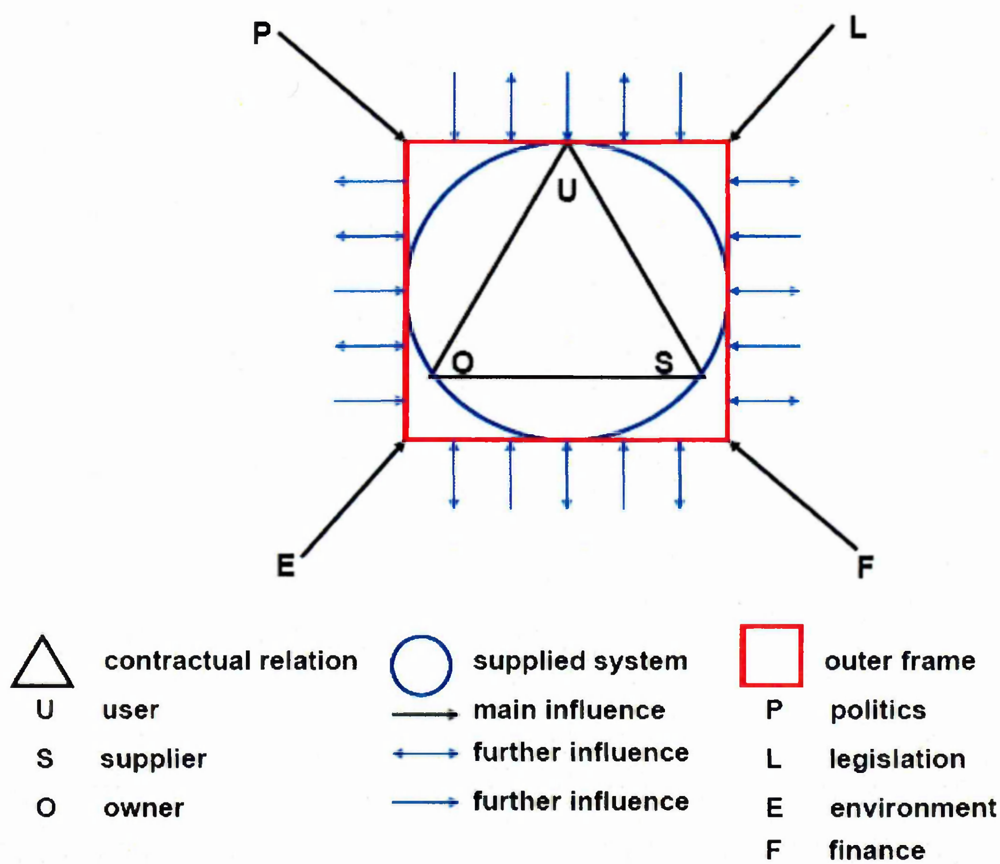


Figure 8.1: Schematic of the Energy System

In the case of the energy market her triangle interaction can be transferred to the team responsible for the energy supply of a building. The scheme is extended by the author to include a surrounding circle and a surrounding square (see Figure 8.1).

Actors on the outer frame are politics, legislation, finance and environment. The actors on the inner system are user (or tenant), owner and supplier of the system (engineering plant, factories, building or households). In-between the square and the triangle are the supplied systems shown as a circle or bubble. Whenever one of the actors pulls or pushes at any place on the system, the complete system will be deformed or change. The bubble is a symbol of the vulnerability of the system which allows a certain amount of flexibility but can burst easily and suddenly.

The energy system itself is designed at the current situation and with estimates or assumptions on future prices and possible future legislation. In general housing has an energy supply which will remain the same for decades. The only part which will be changed earlier is the method of energy production. The situation for business premises is different due to higher rents and other influences. Referring to figure 8.1 the economics changes the influence of the outer frame.

The action of all involved, except the environment, is based on money or profit and is the only invariant. Action and reaction can happen anywhere. These actions can be divergent especially concerning the energy supply and market. The interference of the system is explained by some examples:

<u>Liberalisation versus energy saving</u>

The European energy market for grid related energy is liberalised (Figure 8.1 outer frame legislation) with the hope for more competition and as a consequence lower energy prices. This liberalisation is thought to be for the protection of the customers. Energy suppliers are divided into several companies.

A customer could sign three contracts per energy type without receiving any kWh energy. This is extended into four since 1st of November 2007 when the market for metering was liberalised. The handling will be more complex but simple and cheap for the customers.

Low energy prices do not give any incitement to the user to save energy (refer to triangle, the inner system). Not saving energy has an impact on the environment e.g. the increasing greenhouse effect.

<u>Energy saving in buildings</u>

The inner circle requires money for energy saving measures. The money has to be spent by the owner. The tenant benefits from the measures taken and saves money by saving energy. The investment of the owner is not completely covered by the increase of the rent. This increase is limited by legislation. The motivation for the owner to invest money for energy saving measures is diminished.

The environment located at the outer frame receives a negative impact.

<u>Protection of customers versus behaviour of users</u>

The user (voter) has to be protected. The policy creates legislation which gives the impression that the user does not have to take care of anything. Legislation on renewable energies guarantees environmentally friendly energy. The price of electricity is increased. At the same time politicians criticise the high energy prices.[49]

This action leads to an uncertainty for the owners of the systems and the energy suppliers. Nobody will want to invest money without the chance of additional profit.

The building is an energy saving one – documented by an energy-certificate. The user has to pay but gets no chance to decide or influence the system. The energy certificate has to be paid for by the owner. At the same time the legislation on heat costs have remained unchanged since 1989. It is predicted that a minimum of 30% of energy costs for heating will be for the hot potable water supply.

<u>European legislation on liberalisation and enactment</u>
European legislation is officially valid all over Europe. But not all countries change their national laws in accordance with European legislation. Energy suppliers with a protected home market such as France with EdF and GdF can use the safety of their home market, without competition, to buy companies in other countries. This will lead to a reduction of energy companies and less competition. Less competition means higher energy prices which the user has to pay.

The final situation could be similar to that of petrol stations: The price is dominated by a tax or levy portion. Real competition does not happen because of missing competitors. An agreement on prices between the few is possible but will be hard to prove. At the moment the grid related energy suppliers are blamed by politicians. The oil or petrol industry receives less criticism. In general the energy consumption for a car is higher than that for heating an apartment (15,000 km/anno with 7.0 l/100 km equals 1,050 l/annum or 12,000 kWh/annum). Kerosene for aeroplanes is tax free. A single flight from Europe to North America requires approximately 300 *l*/passenger; basis: fully booked aircraft, 5 l/100 km per person).

<u>Energy saving and cost for the grids</u>
Energy can be saved by behaviour (user in triangle) or the change of the supply system. Less energy is equivalent to less income for the grid operators. The costs to maintain the grid are largely independent of energy being transported. The consequence is the increase of fees as a part of the energy costs. Politics and legislation will react.

These few examples demonstrate the flexibility of the system and the possibility of prediction. The environment and nature will react to the detriment of the human race. One actor, the user, has at the moment little chance to influence the system – all decisions come via the outer frame or are put on by the supplier or owner. The supplier decides what prime energy will be used in power stations – in order to maximise the profit at lowest sales prices. The user wants to save money and that does not automatically include decisions to reduce greenhouse gases. A system has to be found which enables the user to decide and to determine his/her actions.

Conclusion from the described research projects:

<u>Change of the demand</u>
Hot potable water supply will be the major energy demand in the future. Even for buildings erected before the latest two parliamentary amendments on energy saving in buildings the hot water portion reached up to 40%. The energy consumption is a function of the tenants whose actions are the reason for the differences between the consumption in identical buildings with identical boilers.

Centralised heating
District heating requires higher investment for the distribution system than single boilers. District heating has additional heat losses compared to single boilers. The heat production has to be cheap and friendly to the environment to compensate this disadvantage (refer to 7.3 and 7.6). Smaller system can be an alternative (refer 7.4 solar estate).

The conversion of primary energy into useful energy on the site of the demand has the lowest losses. The research projects prove that the transport of heat is loaded with heat losses especially as described in chapter 7.9 even when the insulation of the pipes was in accordance with the latest legislation.

Energy Efficiency
CHP-plants for de-centralised require high investment. The systems are susceptible to changes of efficiency due to implementation or operation (refer to 7.5 and 7.7). Design of the complete system (heat production and heat distribution) should be the responsibility of a single entity.

Individual Responsibility
Systems which give the user a simple chance to influence the control have lower energy consumption than central controlled systems with shared costs (refer to 7.8 and 7.9).

Carbon Dioxide Emissions
A ranking of fuels with emissions per kWh of energy exists and is known (lignite, coal, oil, gas, renewable energy). The chosen technology and fuel determines the emissions. More priority should be given to energy savings – which is the cheapest, the cleanest, and the safest and most reliable source of energy.

8.2 Recommendation for Heating and Hot Potable Water Supply Systems

Any future solution involving the burning of fossil fuels on the site of the demand is impossible in the long term due to the finite resources of fossil energy.

The two pipe system consisting of

central heat production
storage tank for heating water
central heat exchanger per apartment with a ring main
separate control per apartment (ring pipe with all radiators or floor heating and hot potable water connected to it) to allow central control of the flow line temperature of the apartment
additionally individual room control by thermostatic valves

can be the system of the future. Electrical heating of dish washers or washing machines have to be replaced by a connection to the hot water system. Devices of this sort are currently available.

The hot water storage tank can be fed by solar panels. Any top-up heat required during periods of low solar insolation can be achieved by

a fossil fuel fired boiler as a least favourable solution or
a energy efficiency solution such as CHP-plants (engine or fuel cell etc.) or
a wood chip fired boiler are other systems with renewables or
district heating (using waste energy from processes like power stations or steel production etc).

The system is independent of the heat producing system. Electrical heating could be possible too. The precondition is using renewable sources for the production of electricity.

Heat can be stored simpler than electricity. Currently radio controls exist for night storage heaters. The same system can be extended and used for loading the central storage tanks.

The research on virtual power stations requires a system which simplifies the control. The storage tanks create the possibility of flattening the demand and give the chance to store energy from peak periods.

Hot water is always required. The described solution gives the customer the chance to influence

the heating individually
the input of energy (and by this the production)
the bill for energy (carbon dioxide portion of the price)

8.3 Recommendation for Changes of Legislation

The weakest link is the customer at the end of the line. He/she has to pay the bill with the taxes, levies and has no chance to influence the technology (see chapters 2 to 4). The number of competitors is decreasing. The content of the energy box is almost the same. Referring to behaviour it is the price which influences the decision. The customer will look for cheaper energy – since 2001 this has been coal or lignite. The energy suppliers will follow this development and build new coal fired power stations. Even if the efficiency is improved from 30 to 50% the carbon dioxide emission will be higher than that of a gas fired plant. Renewable energy, for example wind energy, would be free of emissions.

The pressure from outside in the described system needs a relief valve from the inside. This could be a limited carbon dioxide allocation per person.

Each person (in a country) receives the same amount of carbon dioxide for heating, and hot water plus electricity for cooling, lighting and other electrical equipment.

The calculation of the first allocation can be simply made:

<u>Heating</u>
average living space per person (e.g. 40 m²)
the average requirement for heating (e.g. 120 kWh/m²)
energy mix for heating (e.g. 50% natural gas plus 40% oil etc.) including the efficiency of the systems

This equals approximate 1,500 kg/person if heating is done 100% by gas fired boilers.

<u>Hot water</u>
The same calculation can be done for hot potable water. The living space is substituted by the amount of hot water per person and day. The figure of 40 *l*/day from the past has to be adjusted to the new behaviour (referring to the figures of chapter 7.2 and the relating appendices to 25 *l*/day).

Electricity

The amount of electrical equipment is increasing. Many devices need power in stand-by mode. The calculation can be done in a similar manner to calculations above. (where? chapter section)

The consequence of this system is that the user has to balance the decision making. It is necessary to buy carbon dioxide emission allowances as well as energy. Carbon dioxide allowances are limited. Money cannot create new allowances in this system. Any increase of energy consumption can only be achieved by an increase in efficiency or renewable energy.

The limitation of allowances is the first step; reduction is the second.

If 20% carbon dioxide reductions are requested within 20 years the annual allowances will be reduced by 1% per year.

This system includes a social component. Larger families receive allowances proportional to their size. They can decide whether they want to sell their allowances.

Single households will have to decide on the size of their apartments and their energy input. Heating with electricity, direct heating or with night storage heaters, is highly taxed in Germany by current legislation, but switching to this form of supply could be positive for the environment if the electricity is from renewable energy which is carbon dioxide free.

Allowances will need to be made to accommodate changes in the weather and changes in personal circumstances such as the death of the partner. To avoid cases of hardship allowances could be collected for ten years. The death of the partner should not result in having to move from your home.

This saving of allowances without any reduction over time would have a saving of emission for the first years but could increase future emissions. To avoid this additional adjusting regulation need to be created. As a proposal: Only 90% of the unused allowances can be transferred to the next year. This reduction decreases the speculation on increasing prices for allowances, e.g. persons with a high demand for allowances due to their behaviour and (enough money) could bank allowances.

This proposed system requires that the energy bill includes a component for the delivered energy as well as a component for the carbon dioxide produced.

A similar balancing system already exists. Banks reduce the interest returns from savings and sales of shares by 25% and transfer this to the local financial authorities. The final taxation is done with the annual tax declaration.

The transfer of the system:
Each customer has a CO_2-account. This can be a single person or family account. The account is filled up every year with the new allowances. The customer has to transfer sufficient allowances to the energy supplier. In instances when there are no allowances the energy supply will be stopped.

Together with the annual tax declaration an emission declaration has to be made. The amount of allowances which the customer wants to transfer into the next year has to be stated in the declaration. Only 90% can be transferred according to the proposal described.

The circle will be closed with the transfer of the allowances to the producers.

The positive effect will be that energy from renewables can be sold at a higher price because they need no CO_2-allowances. A similar affect can be achieved with high efficient plant like CHP.

The levy system for renewable energy or CHP-plants will no longer be required.

The customer has the chance to influence the development of high efficient plants by his/her behaviour.

The economics can be described from different points of view. The protection of the environment and the preservation of the earth for future generations has to be considered higher than the economic success. Disputes with high administrative costs are not acceptable. The players involved in the system have to adapt in order to survive.

The total energy system when applied to buildings is dependant on the original purpose and the capability to adapt to new situations. The simplest system is a house or bungalow used by the owner while more complex systems are departmental stores.

The majority of buildings are old ones. The focus has to be on the refurbishment of these existing buildings. Insulation and heat recovery are solutions implemented by the owners in order to keep the tenants. The remaining demand will be the hot water supply. The future heating system will be a hot water preparation system which will be able to cover the secondary task of heating.

The customer will change his/her consciousness because he/she is forced to think about the energy consumption and the related emissions.

The emissions will be limited and can be reduced simply.
The system requires no complicated technology.
The financial demand is approximately on the same level as current conventional systems.
The system is open to future changes in energy supply.

Improvement of energy efficiency is very often combined with complex technology. This corresponds with high prices and carries the danger that the system is not accepted.

The described solution gives the chance of considerable savings in emissions by small changes of the individual; once started this will be difficult to stop.

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1 Legislation

European Legislation
www.europe.eu.int

German Legislation

Modern Country
Staat-modern
www.staat-modern.de

Acts and Regulations in Internet
Gesetze im Interner
www.gesetze-im-internet.de

juris GmbH
www.juris.de

Federal Law Gazette
Bundesgesetzblatt
www.bundesgesetzblatt.de

2 Involved German Deciders on Legislation

Federal Government
Bundesregierung
www.bundesregierung.de

Parliament
Bundestag
www.bundestag.de

Federal Council (Proper Name, no official translation)
Bundesrat
www.bundesrat.de

President of the Federal Republic of Germany
Bundespräsident
www.bundespraesident.de

3 German Ministries

Federal Ministry of Labour and Social Affairs
Bundesministerium für Arbeit und Soziales
www.bmas.de
poststelle@bmas.bund.de

Federal Ministry of Foreign Affairs
Auswärtiges Amt
www.auswaertiges-amt.de
poststelle@auswaertiges-amt.de

Federal Ministry of the Interior
Bundesministerium des Innern
www.bmi.bund.de
poststelle@mbi.bund.de

Federal Ministry of Justice
Bundesministerium der Justiz
www.bmj.bund.de
poststelle@bmj.bund.de

Federal Ministry of Finance
Bundesministerium der Finanzen
www.bundesfinanzministerium.de
poststelle@bmf.bund.de

Federal Ministry of Economics and Technology
Bundesministerium für Wirtschaft und Technologie
www.bmwi.bund.de
info@bmwi.bund.de

Federal Ministry of Food, Agriculture and Consumer Protection
Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz
www.bmelv.de
poststelle@bmelv.bund.de

Federal Ministry of Defence
Bundesministerium der Verteidigung
www.bmvg.de
poststelle@bmvg.bund400.de

Federal Ministry of Family Affairs, Senior Citizens, Woman and Youth
Bundesministerium für Familie, Senioren, Frauen und Jugend
www.bmfsfj.de
poststelle@bmfsfj.bund.de

Federal Ministry of Health
Bundesministerium für Gesundheit
www.bmg.bund.de
poststelle@bmg.bund.de

Federal Ministry of Transport, Building and Urban Development
Bundesministerium für Verkehr, Bau und Stadtentwicklung
www.bmvbs.de
buergerinfo@bmvbs.bund.de

Federal Ministry for Environment, Nature Conservation and Nuclear Safety
Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit
www.bmu.de
service@mbu.bund.de

Federal Ministry of Education and Research
Bundesministerium für Bildung und Forschung
www.bmbf.de
bmbf@bmbf.bund.de

Federal Ministry of Economic Cooperation and Development
Bundesministerium für wirtschaftliche Zusammenarbeit
www.bmz.de
poststelle@bmz.bund.de

4 German Authorities involved in Energy Supply

BNetzA – Fedral Network Agency
BNetzA - Bundesnetzagentur
www.BNetzA.de
poststelle@BNetzA.de

BAFA – Federal Office of Economics and Export Control
BAFA – Bundesamt für Wirtschaft und Ausfuhrkontrolle
www.bafa.de
contact via form sheet from homepage

DEHSt – Federal Office for Environment – German Emission Trading Office
DEHSt – Umweltbundesamt – Deutsche Emissionshandelsstelle
www.desth.de
contact via form sheet from homepage

Federal Office against Cartels (Proper Name, no official translation)
Bundeskartellamt
www.bundeskartellamt.de
info@bundeskartellamt.de

5 German Association for Technical Guidelines

DVGW – The German Technical and Scientific Association for Gas and Water (registered)
DVGW- Deutsche Vereinigung des Gas- und Wasserfaches e.V. – Technisch-wisenschaftlicher Verein
www.dvgw.de
info@dvgw.de

VDE – Association for Electrical Electronic & Information Technologies (registered
VDE – Verband der Elektrotechnik Elektronik Informationstechnik e.V.
www.vde.com
contact via form sheet from homepage

TÜV – Technical Control Association
TÜV – Technischer Überwachungsverein
www.tuv.com
press@de.tuv.com

DIN – German Institute for Standardisation (registered)
(Proper Name, no official translation)
DIN – Deutsche Institut für Normung e.V.
www.din.de
contact via form sheet from homepage

further international guideline (organisations only)
ISO – International Organisation for Standardization
IEC – International Electrotechnical Commission
CEN – European Committee for Standardization
CENELEC – European Committee for Electrotechnical Standardization
ETSI – European Telecommunication Standards Institute

6 Statistical Data

EDNA – Initiative Energy Data, Norms & Automation
www.edna-initiative.de
contact via form sheet from homepage

Federal Statistical Office
Statistisches Bundesamt
www.destatis.de

7 German Transport Service Operation (TSO)

EnBW – Energieversorgung Baden-Würtemberg (*Electricity*)
www.EnBW.com

E.on (*Electricity plus natural gas*)
www.eon.com

RWE AG (*Electricit plus natural gas)*)
www.rwe.com

Vattenfall (*Electricity*)
www.vattenfall.de

VNG – Verbundgas AG (*Natural gas)*
www.vng.de

wintershal (*Natural gas)*
www.winterhal.de

8 German Associations on Energy Supply supplied via Grid

BDEW – Federal Association of Energy- and Water Economics (registered)
BDEW – Bundesverband der Energie- und Wasserwirtschaft e.V.
www.bdew.de
contact via form sheet from home page

BDEW comprises former associations
BGW - Association of German Gas and Water Economy (registered)
BGW – Bundesverband der deutschen Gas- und Wasserwirtschaft e.V.
www.bgw.de

VDEW - Association of Power Economy (registered)
VDEW - Verband der Elektrizitätswirtschaft VDEW e.V.
www.strom.de
contact via form sheet from homepage

VDN - Association of Grid Operators at VDEW (registered)
VDN – Verband der Netzbetreiber VDN e.V. beim VDEW
www.vdn-berlin.de
contact via form sheet

VRE – Association of Connected Enterprises and Regional Energy Suppliers (registered)
VRE – Verband der Verbundunternehmen und regionaler Energieversorger e.V.
www.vre-online.de
postmaster@vre-online.de

former VDEW related Associations
AGFW - Association for District Heating at VDEW (registered)
AGFW – Arbeitsgemeinschaft für Fernwärme AGFW e.V. beim VDEW
www.agfw.de

HEA – Craft Union for Energy Marketing and Application at VDEW (registered)
HEA - Fachverband für Energie-Marketing und Anwendung e.V. beim VDEW
www.hea.de
hea@hea.de

no direct relation to BDEW or VDEW
VKU - Association of Local Utilities (registered)
VKU – Verband kommunaler Unternehmen e.V.
www.vku.de
contact via form sheet from homepage

VIK - Association of Industrial Energy- and Power Economy (registered)
VIK – Verband der Industriellen Energie- und Kraftwirtschaft e.V.
www.vik.de

9 German Associations on Energy Supply without Grid
DVG – German Association Liquid Gas (registered)
DVG - Deutscher Verband Flüssiggas e.V.
www.dvfg.de
info@dvgw.de

IWO – Institute for Economic Oil Heating (registered)
IWO – Institut für wirtschaftliche Ölheizung e.V.
www.iwo.de
contact via form sheet

10 German Associations for Energy Efficiency
ASEW - Association for Rational Use of Energy- and Water at VKU
ASEW - Arbeitsgemeinschaft für sparsame Energie- und Wasserverwendung im VKU
www.asew.de
info@asew.de

ASUE - Association for the Efficient and Environmentally Friendly Use of Energy
ASUE – Arbeitsgemeinschaft für sparsamen und umweltfreundlichen Energieverbrauch
www.asue.de
info@asue.de

German Renewable Energy Federation (registered)
BEE – Bundesverband erneuerbarer Energien e.V:
www.bee-ev.de
info@bee-ev.de

B.KWK –Federal Association for Combined Heat and Power (registered)
B.KWK – Bundesverband Kraft-Wärme-Kopplung e.V.
www.bkwk.de
info@bkwk.de

Forum for Future Energies
Forum für Zukunftsenergien
www.zukunftsenergien.de
info@zukunftsenergien.de

11 Price Comparison or customer Interests
verivox GmbH
www.verivox.de
strom@verivox.de
gas@verivox.de

VEA - Association of Energy Customers (registered)
VEA – Bundesverband der Energie-Abnehmer e.V.
www.vea.de
www.vea-online.de
info@vea.de

12 Energy Exchanges
Nord Pool - Nordic Power Exchange
www.nordpool.no

EEX - European Energy Exchange
www.eex.com
www.eex.de

APX - Amsterdam Power Exchange
www.apx.nl

EXAA – Energy Exchange Austria
www.exaa.at

PolPX, Poland Power Exchange
www.polpx.pl

GME or IPEX, Italy
www.mercatoelecttrico.org

REN – Portugal
www.ren.de

Powernext, France
www.powernext.fr

Omel, Spain
www.omel.es

13 Further Internet Addresses

BDI - Federal Association of German Industry (registered)
BDI - Bundesverband der Deutschen Industrie e.V.
www.bdi.eu

GdW – Federal Association of German Estate- and Apartment Enterprises (registered)
GdW – Bundesverband der deutschen Wohnungs- und Immobilienunternehmen e.V.
www.gdw.de
mailqw.de

German Weather Service
Deutscher Wetterdienst
www.dwd.de

WEC – World Energy Council
www.worldenergy.org

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7.2	Centralised Heating with Gas fired Boilers
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07_02_02	FIGURES (Main File)
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7.3	Central Heat Supply for 13 Apartment Blocks
7.4	Solar Estate (German Award for Natural Gas and Renewable Energies)
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7.5	WEKA (Combined Heat Cold Power Plant)
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7.6	MHKW (Trivalent Fuel CHP Plant with District Heating)
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07_06_03	CALCULATION_CHP-ELECTRICITY_MHKW_2003.pdf
07_06_04	CALCULATION_CHP-ELECTRICITY_MHKW_2004.pdf
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7.8	<u>Individual Heating</u>
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7_10_5	ZOOM_SLIDES_AND_FIGURES.pdf

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