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Energy Efficiency in the Netherlands

Dutch contribution to the project ‘Cross country comparison on energy efficiency’

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Preface

This study has been carried out in the framework of the SAVE project ‘Cross-country Comparison on Energy Efficiency Indicators - Phase 3’. This project is co-ordinated by the French agency ADEME. The project was financed to a large extent by the Dutch Ministry of Economic Affairs, together with the EU SAVE program under contract number 97 10 050. The ECN project number was 7.7120.

Abstract

The study uses energy efficiency indicators to present and review the energy efficiency situation in the Netherlands in the last decades. The indicators are calculated along a common methodology, using the ODYSSEE database and national data. Also, a short account is given of energy efficiency and environmental policy initiatives in the Netherlands in 1996 and 1997.

The improvement of the national final energy intensity since 1982 was 16%. The main factors explaining the intensities at macro level are the fuel prices, the sectoral structure (influenced by economic growth), and the effort and funds devoted to energy conservation policy.

In industry, the energy intensity of all branches has decreased between 1987 and 1994 with 1 to 2% annually. After 1990, the relatively large growth of value added of the chemical industry compared to total manufacturing has made the structure of the economy more energy intensive. Relatively high growth in food, basic metals and paper industries also contributed to this effect.

In the residential sector, energy efficiency has increased in the period from 1980 to 1990, mainly due to improved insulation and ‘good housekeeping’. After 1990, the rise in electricity use per household and the stabilisation of the use of natural gas per dwelling have lead to a decrease in energy efficiency in the household sector.

Both for freight transport and passenger transport, an increase in the number of vehicles and the distance travelled per year, combined with a decrease in the energy consumption per vehicle (improved efficiency) has resulted in an overall increase in the energy consumption.

The total energy intensity in the service sector has decreased about 20% in the period 1980 - 1994. The rise in energy intensity of electricity is compensated by improvements in labour productivity and building insulation.

CONTENTS

SUMMARY

The study uses energy efficiency indicators to present and review the energy efficiency situation in the Netherlands in the last decades. The indicators are calculated along a common methodology, using the ODYSSEE database and national data. In addition, a short account is given of energy efficiency and environmental policy initiatives in the Netherlands in 1996 and 1997.

One problem encountered with regard to the data collection is the disruption in Dutch statistics as a result of the adoption of the NACE code since 1993. Although in principle this should improve the comparability with other countries, it is a major undertaking to achieve consistency with the years before 1993. In the years 1993-1994, data are available along both classifications and therefore the pre-1993 classification is still used in this project.

In the period 1982-1994, total final demand has increased with 14%. This increase was a result of growth of the energy consumption in all sectors except households. There were no remarkable shifts in the fuel mix.

The improvement of the final energy intensity since 1982 was 16%. The main factors influencing the intensities at macro level are the fuel prices, the sectoral structure (influenced by economic growth), and the effort and funds devoted to energy conservation policy. The developments with regard to these factors in the Netherlands explain to a certain extent the development of the final energy intensity.

In industry, the energy intensity of all branches has decreased between 1987 and 1994 with 1 to 2% annually. After 1990, the relatively large growth of value added of the chemical industry compared to total manufacturing has made the structure of the economy more energy intensive. Relatively high growth in food, basic metals and paper industries also contributed to this effect. The recent high growth of the energy intensive industry has offset its energy efficiency improvements.

In the residential sector, the energy efficiency has increased in the period from 1980 to about 1990, mainly due to improved insulation and 'good housekeeping'. After 1990, the rise in electricity use per household and the stabilisation of the use of natural gas per dwelling have lead to a decrease in energy efficiency in the household sector.

Both for freight transport and passenger transport, an increase in the number of vehicles and the distance travelled per year, combined with a decrease in the energy consumption per vehicle (improved efficiency) has resulted in an overall increase in the energy consumption.

The total energy intensity in the service sector has decreased about 20% in the period 1980 - 1994. The electricity intensity however, has increased with 35% in the same period. The rise in energy intensity of electricity is compensated by improvements in labour productivity and building insulation.

With regard to the transformation sector, there are a few counterbalancing trends. The efficiency of electricity generation has increased in the eighties. However, the number of coal plants has also increased, and more electricity is imported, causing the average efficiency to remain more or less stable. The consumption of oil in refineries and the consumption of natural gas in gas production have increased.

DUTCH SUMMARY

In dit rapport worden energie efficiëntie indicatoren gebruikt om de ontwikkelingen in de laatste 15 jaar met betrekking tot energiebesparing in Nederland te analyseren. Deze indicatoren zijn berekend volgens een gemeenschappelijke methode, ontwikkeld in het kader van het SAVE-project 'Cross country comparison of energy efficiency indicators' waarbij alle EU landen betrokken zijn.

In de database ODYSSEE worden energieverbruiksgegevens, aangeleverd door de landen zelf, gebruikt om deze indicatoren op een vergelijkbare manier te berekenen. Hoewel de sectorindeling van de Nederlandse statistieken na de herziening in 1993 goed aansluit bij internationale conventies, is in dit project de indeling van vóór 1993 gebruikt, omdat consistente tijdreeksen over een langere periode (1980-1995) volgens de nieuwe indeling niet beschikbaar zijn.

Het rapport geeft ook een kort overzicht van de belangrijkste beleidsmaatregelen op het gebied van energiebesparing in Nederland in 1996 en 1997.

In de periode 1982-1994 is het finale energieverbruik gegroeid met 14%, en de finale energie-intensiteit met 16% gedaald. Deze energie-intensiteit wordt op macro-niveau beïnvloed door brandstofprijzen, de sectorstructuur, en de intensiteit van het besparingsbeleid. In de beschouwde periode kunnen ontwikkelingen in deze factoren het verloop van de intensiteit min of meer verklaren.

In de industrie is de finale energie-intensiteit van alle bedrijfstakken tussen 1987 en 1994 met 1 à 2% gedaald. Na 1990 is de structuur van de economie meer energie-intensief geworden, door groei van de toegevoegde waarde in de chemie en basismetaal, en in mindere mate in de voedingsmiddelen- en papierindustrie. De laatste jaren heeft de groei van de energie-intensieve industrie de effecten van genomen besparingsmaatregelen gecompenseerd.

In de huishoudens is de meeste besparing gerealiseerd tussen 1980 en 1990, met name door isolatiemaatregelen en gedragsverandering. Na 1990 treedt een stabilisatie op in het verbruik van aardgas, terwijl het toegenomen bezit en gebruik van elektrische apparaten een groei in het elektriciteitsverbruik veroorzaakt.

De voortgaande groei van het energieverbruik in de transportsector wordt vooral veroorzaakt door groei in het wegverkeer. Het aantal voertuigen en de afgelegde afstand per jaar nemen nog steeds toe, en compenseren zo technische verbeteringen.

In de dienstensector is de energie-intensiteit sinds 1980 met ongeveer 20% afgenomen. De intensiteit van het elektriciteitsverbruik is in dezelfde periode met 35% gegroeid, maar wordt gecompenseerd door verbeteringen in arbeidsproductiviteit en isolatie van gebouwen.

1. INTRODUCTION

This national report for the Netherlands is one in a series of national reports for the SAVE project 'Cross-country Comparison on Energy Efficiency Indicators - Phase 3'. This project is co-ordinated by the French agency ADEME. The project was financed to a large extent by national contributions, together with the EU SAVE program under contract number 97 10 050.

The aim of the project is to calculate energy efficiency indicators for all EU countries, based on national data, which, harmonised to a common format, are stored in one database 'ODYSSEE'.

Energy efficiency indicators are used for various purposes, such as:
- to support policy makers in answering different types of questions related to energy efficiency, for the evaluation of programmes and policies, for target monitoring, or for the definition of research programmes,
- to compare energy efficiency levels, both within a country through time (monitoring) and between countries,
- to provide a source of data for forecasting models.

This report uses energy efficiency indicators to present and review the energy efficiency situation in the Netherlands in the last decades. To facilitate the comparison between countries, all national reports have been set up along a common structure. First, in Chapter 2, the general context with regard to data collection, macro-economic developments, and recent energy efficiency and environmental policy in the Netherlands is described. Chapter 3 gives an overall assessment of energy efficiency trends on national level. In Chapters 4 to 7, the development of energy efficiency and savings in the main end-use sectors is analysed. Chapter 8 gives a short account of some developments in the transformation sector.

Unless indicated otherwise, the source of data for the figures and tables in this report is the ODYSSEE database, for the Netherlands mainly based on data from the energy database NEEDIS.

2. GENERAL CONTEXT

This chapter provides a general background to national and sectoral information presented in the other chapters. It starts with an overview of data sources and obstacles encountered in the collection of the data submitted to the ODYSSEE database. After that, the economic trends and energy consumption trends are reviewed. The remainder of the chapter consists of a description of energy efficiency and environmental policy initiatives in the Netherlands in 1996 and 1997.

2.1 Review of data collection

One of the most important sources of energy data for the Netherlands is the Dutch energy database NEEDIS (National Energy and Efficiency Data Information System), operated by ECN Policy Studies [1]. This database has been set up with the aim of providing a consistent framework for collecting data with regard to energy consumption and energy conservation. NEEDIS contains both energy data and some sectoral economical data. Important sources of data are the Dutch Energy Statistics (*Nederlandse Energie Huishouding* - NEH), and the Production Statistics. Other publications of Statistics Netherlands are also used regularly. At the moment, data are generally available for the years 1983-1995/1996, and updates are carried out each year.

NEEDIS contains data for the main end-use sectors, i.e. households, industry, transport, other energy consumers, and for the transformation sectors. In the industry sector, a further desaggregation into branches is supported. For each industrial branch or main sector, and for each energy carrier, final consumption (for energy and non-energy purposes), purchased energy, fuel input for cogeneration and other transformations are available. For these sectors/branches the value of production, value added and number of employees is also covered in NEEDIS.

One major problem with regard to the data collection is the disruption in Dutch statistics as a result of the adoption of the NACE code since 1993. Although in principle this should improve the comparability with other countries, it is a major undertaking to achieve consistency with the years before 1993. In the years 1993-1994, data are available along both classifications. Therefore it was decided to stick to the previous classification in this phase of the project, and reconsider the issue next year. Table 2.1 gives an overview of corresponding sectors in both classifications. An important difference, not visible in the table, is that in the SBI-'74 classification all companies employing less than 10 persons were included in the category 'Other energy consumers', whereas these companies have been included in their respective branches in the SBI-'93 classification. It must also be noted that the SBI-'74 classification was revised in 1982, causing disruptions in a few time series in 1982 as well.

One difference between the Dutch energy statistics and economic statistics that should be mentioned here, is that energy consumption by branch is given for all companies that have over 10 employees, while value added is given for companies with more than 20 employees.

Table 2.A *Sector classifications in the Netherlands compared, before and after 1993 [1].*

Former classification 'SBI-'74'	Code[1]	New classification 'SBI-'93'	Code
Food, beverages and tobacco	20, 21	Food, beverages and tobacco	15, 16
Textile	22	Textile, clothes, leather and leather products	17, 18, 19
Paper	26	Paper, paper products, publishing and printing	21, 22
Fertilisers	29.1	Fertilisers	2415
Other chemical industry	29.1-9, 30	Organical chemical industry	24141, 24142
		Inorganic chemical industry	2413
		Other basic chemical industry	rest 241, 247
		Chemical products	rest 24
Building materials, ceramics and glass industry	32	Building materials	26
Basic metal industry	33	Basic metal - iron and steel	271-273 (partly), 2751, 2752
		Basic metal - non-ferrous	274, 2753, 2754
Other metal industry	34, 35, 36, 37	Metal products industry	28-32, 34-36
Other industry	23, 24, 25, 31, 38, 39	Rubber and plastic products, instruments, other industry	20, 25, 33, 37
Transport	-	Transport	-
Households	-	Households	-
Other energy consumers (mainly agriculture and services, transport companies excl. motor fuels, also construction and mining)	0, 1, 5, 6, 7, 8, 9	Other energy consumers (mainly services, transport companies excl. motor fuels)	01-05, 14, 45, 5, 6, 7, 9 (partly)

The services sector includes:

- trade, repairs, restaurants
- dedicated transportation, storage, telecommunication
- financial services
- private services
- public administration
- education
- health care

[1] In this report, the SBI-'74 classification has been used.

- culture, recreation.

For all sectors, the consumption of motor fuels has been accounted for in the transportation sector.

Apart from NEEDIS, other sources from which data for ODYSSEE were collected are the Dutch monitoring tool MONIT [8] and various publications from Statistics Netherlands and the Dutch utilities [12,15].

2.2 Economic context

Figure 2.1 presents the trends in the main macro-economic indicators between 1970 and 1994. The Dutch GDP has grown by 2.4% annually on average, with a recession in the beginning of the eighties. Around 1990, there was a boost with growth figures of over 4% per year.

The average growth in value added in the industry sector is 1.4% per year. The recession between 1980 and 1983 is visible in the value added in the industry as well as in the private consumption. The average growth in private consumption is almost equal to GDP growth.

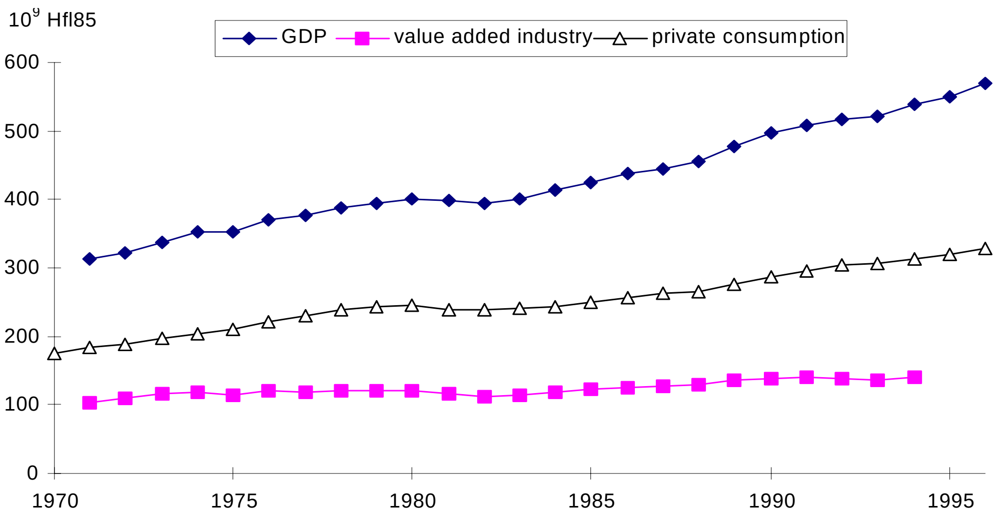


Figure 2.A *Macro-economic developments in the Netherlands*

2.3 Energy consumption trends

In this section, the focus is on final consumption, because the purpose of the project is to monitor and analyse energy efficiency mainly at the end-use level, where most policy is addressed at.

2.3.1 Definitions

In this section, a short overview is given of the definitions used in ODYSSEE, and thus also in this report. For CHP, the conventions used for the Netherlands are different from the international accounting method.

In ODYSSEE, the final consumption corresponds to the energy used by final consumers for energy purposes, including non conventional fuels [2]. Excluded from the final consumption are:

- non energy uses,
- fuels used for electricity generation (autoproducers),
- the energy consumption of energy industries, including gas and oil piping,
- the oil products used for international maritime transport (bunkers) and international air transport.

With regard to the accounting of self generation, in principle the conventions in IEA/EUROSTAT statistics are followed in ODYSSEE. This means that, as stated above, the fuel inputs for self-generation of electricity appear in the transformation sector for autoproducers. For CHP however, the Dutch statistics use a definition different from IEA/EUROSTAT, and therefore an exception is made in ODYSSEE for the Netherlands. All fuels input to cogeneration are part of the transformation sector, and the heat output is part of the supply to final users. In international conventions, only the part corresponding to the electricity generation is included in transformations; the part of fuels corresponding to the heat produced appears in the final consumption. This difference is important to note when comparing different countries, because it has consequences for the values of energy efficiency indicators.

Whenever climatic corrections have been imposed on the final consumption data, it is explicitly stated (see also Section 3.2). Climatic corrections are made only for space heating in the residential and tertiary sectors.

2.3.2 Final consumption trends

Total final energy demand has increased in the Netherlands with 14% between 1982 and 1994. In the beginning of the eighties, final demand for fossil fuels dropped drastically, due to the high prices of the second oil shock. In the period 1982-1990, total final consumption remained more or less stable around 40 Mtoe, after 1990 there was an increase to 44-45 Mtoe.

In the final consumption by energy carrier is presented. The increase in electricity consumption is relatively large; 31% between 1985 and 1994. The consumption of natural gas has returned to the 1985 level in 1994. The fluctuations in gas consumption can partly be explained by climatic influences, as natural gas is the main fuel used for space heating in the Netherlands. The demand for crude oil and oil products has increased with 9%. Solid fuels are the only energy carrier for which the demand has been decreasing steadily since 1985. Solids are mainly used in industry (steel production).

There have not been any remarkable shifts in the fuel mix recently. The fuel mix is dominated by natural gas, due to the domestic supply of this energy carrier, and oil products. In 1994, natural gas had a share of 47% in final demand, followed by crude oil and oil products (28%). The share of electricity is increasing, from 12% in 1985 to 14% in 1994. Compared to other EU countries, the electricity consumption is relatively low in the Netherlands. On the contrary, the share of heat of 8% is relatively high in the Netherlands. This is due to the large contribution of cogeneration in the Dutch industry sector, and the mode of accounting for CHP (see Section 2.3.1).

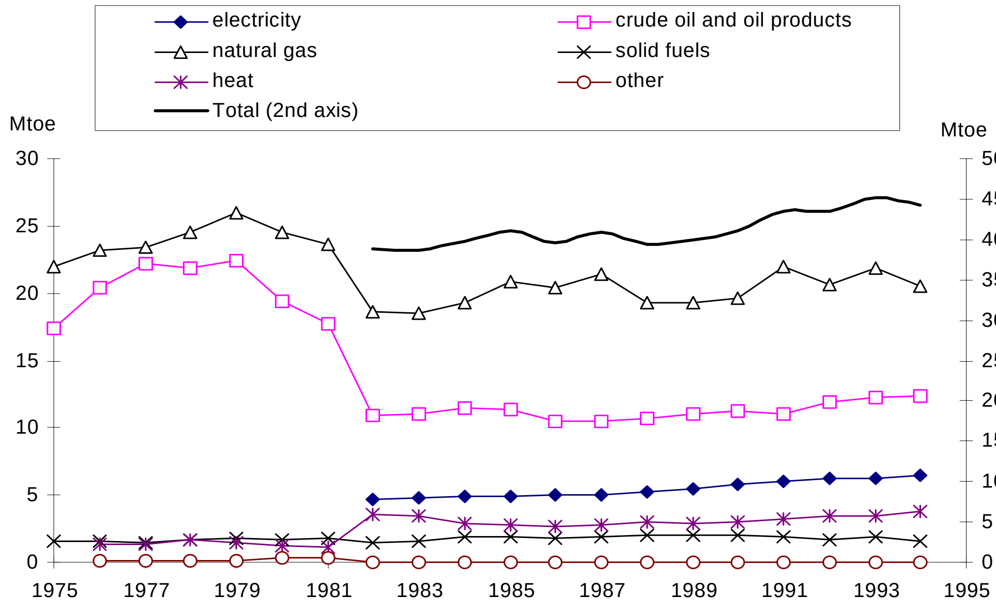
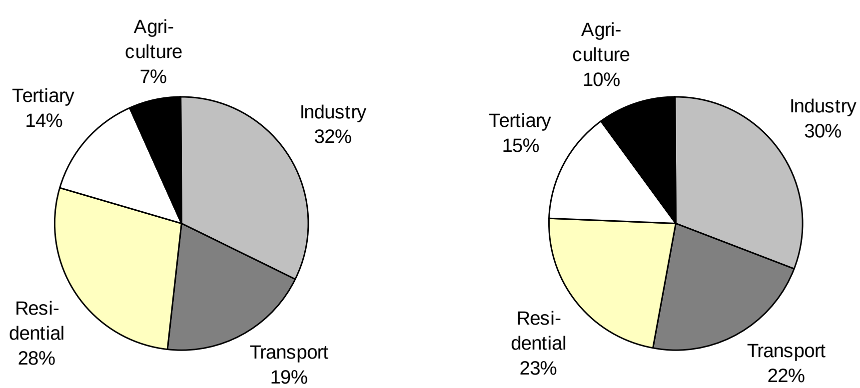


Figure 2.B *Final energy consumption by energy carrier in the Netherlands (conventional equivalence, excluding non-energy uses)*

Figure 2.3 shows the final energy consumption by sector for the years 1984 and 1994. In this period, total final demand has increased with 12% from 39.6 Mtoe to 44.3 Mtoe (excluding non-energy uses). This increase was a result of growth of the energy consumption in all sectors except households.



1984 1994

Figure 2.C *Shares of sectors in final energy consumption in the Netherlands in 1984 and 1994*

Energy demand in the transport sector has grown steadily, and has increased with 25% since 1980. It mainly concerns road transport, and although there have been efficiency improvements, the annual distance travelled has increased. Energy demand in the agricultural sector has also grown significantly, from 2.7 to 4.4 Mtoe between 1984 and 1994. Greenhouse horticulture is the main energy consuming sector within agriculture (80% of final demand) and the increase is both due to growth of the subsector, and to the use of more energy intensive cultivation methods.

The Netherlands has a large energy intensive industry, which accounts for 30% of the total final consumption (excluding non-energy uses). Although the share of the sector has decreased (Figure 2.3), energy consumption has increased in absolute terms. Since 1984 the energy consumption in the industry sector has grown with 7% partly as a result of growth of the energy intensive subsectors.

Final demand in the residential sector decreased with 9% from 11 to 10 Mtoe. This reduction is mainly due to improved insulation in dwellings and behavioural savings (good housekeeping). In recent years, electricity demand in households is increasing because of a growing penetration of electrical appliances and changes in lifestyle. This trend will probably counterbalance the decrease in energy required for space heating.

2.4 Recent energy efficiency and environmental policy

2.4.1 Institutions

In the Netherlands, the national government has the main responsibility for energy matters, in particular the Directorate-General for Energy in the Ministry of Economic Affairs. The Ministry of Environment also has an important influence, having the responsibility for climate policy and air quality. In 1996-1997, there have not been any institutional changes related to energy efficiency.

2.4.2 National programmes

There is no single energy efficiency law in the Netherlands. The energy policy framework has been formed since the first oil crisis in several White Papers and Environmental Policy Plans. The foundation for the current energy policy has been laid down in the Third White Paper on Energy Policy, submitted to Parliament in December 1995.

Most measures and targets identified in the Second Memorandum on Energy Conservation (1993), have been replaced by the energy policy as outlined in the White Paper. Only the target set in this Paper of reducing emissions of CO_2 by 3-5% in the year 2000, relative to the level of 1989/1990, still holds. Currently, no CO_2 reduction targets, except stabilisation, are in effect for the Netherlands after the year 2000. The new Dutch reduction target as part of the EU reduction targets resulting from the negotiations in Kyoto is not decided yet.

In the Third White Paper on Energy Policy, the two general objectives of the Dutch energy policy are outlined. The first objective is to attain a *sustainable energy supply* by:

- improving energy efficiency by one-third in the next 25 years, which means an improvement of 1.5% annually,
- increasing the share of renewables in primary energy supply to 10% by 2020.

Secondly, the White Paper strives towards *market liberalisation* both with regard to electricity and natural gas.

For achieving a sustainable energy economy, a number of measures are proposed, some of which will be described more extensively in the next sections. Energy efficiency is to be improved by Long Term Agreements in industry, introduction of standards and an energy tax (preferably on EU-level), fiscal instruments, and efficiency improvements in the transportation sector. In March 1997, the 'Renewable Energy Action Plan' was sent to Parliament. This plan is a further elaboration of concrete measures to achieve the goal set in the White Paper of 10% renewables in the primary energy supply. The plan focuses on improvement of the price-performance ratio of renewables, stimulating market penetration, eliminating administrative barriers, to a large extent to be achieved by fiscal measures, see below. A large share of the 10%-goal will be reached by the generation of electricity from renewable sources.

With regard to market liberalisation, the White Paper formulates a number of steps. Gradually, all customers will be enabled to select their own supplier of electricity and natural gas, starting with the largest (industrial) energy consumers. This will be made possible by further separation of management of the grid, production and distribution, non-discriminatory free access to the grid and independent supervision of the grid functions. The government will ensure protection of captive customers when the market is liberalised.

For implementation of the policy objectives, tasks have been given to municipalities, counties, agencies, and ‘target groups’. This illustrates the general observation that the Dutch energy policy is more based on co-operation than on regulation.

2.4.3 Budget

After substantial cuts in the energy policy budget in 1994, the budget was increased again in 1996 as a result of the White Paper and within the framework of climate policy. Cuts were mainly made in investment subsidies for energy conservation, and also in specific R&D subsidies (nuclear, fuel cells). One of the measures compensating for the cuts in subsidies for energy conservation and pollution control is the ‘Energy Regulatory Tax’ discussed further below. The White Paper proposes increases in R&D budgets, demonstration and market introduction of technologies, and fiscal measures.

Total government expenditure in energy policy was 519 million guilders in 1993, and rises to 531 million guilders in 1998. Within the budget, an important shift in expenditure has occurred from subsidies to fiscal measures, and to research and demonstration.

In addition, a CO_2 reduction plan involving a one time expenditure of 750 million guilders (375 million ECU) was agreed upon by the government in the 1997 budget. Half of this budget will be used for projects that improve the flexibility of the energy infrastructure in buildings, greenhouse horticulture, and industry, such as heatpumps and cold storage. Approximately 25% of the budget will be spent on the development of renewable energy sources, and the remaining 25% will be used for support of ‘break-through technologies’.

2.4.4 Utilities

Since 1990, the Dutch energy distribution sector has been contributing to the national energy efficiency policy, by implementing Environmental Action Plans (MAPs). The utilities have agreed on a number of energy conservation and emission reduction goals with the national government. The measures used to achieve these goals are financed by a ‘MAP-levy’ on the tariffs for electricity and natural gas. Measures for end-users include subsidies for insulation in dwellings and energy efficient lighting. On the supply side, CHP and renewable energy supply is stimulated. In addition, the market introduction of technologies such as heat pumps, high efficiency boilers, and CFLs is supported.

The legal framework for these Environmental Action Plans has been improved in 1996, in the Energy Distribution Law. The law requires utilities to justify their expenditures for energy conservation on the basis of the revenues of the MAP-levy. It also prevents unfair competition by utilities that have started commercial activities in recent years, both in not energy-related activities such as cable TV or waste handling, and in offering energy services.

In January 1997, the utilities have established a fund based on revenues of the MAP-levy, that enables Small and Medium sized Enterprises to finance investments in energy efficiency with a reduced discount rate. A recent phenomenon is ‘green electricity’ supplied by utilities. Some consumers are willing to pay more (voluntarily) for electricity that is generated from renewable sources. The revenues are used for investments in renewable energy.

2.4.5 Prices

The prices for domestic fuel use in the Netherlands (mainly natural gas and electricity) are relatively low compared to most other European countries. After several attempts to propose a EU-wide carbon/energy tax, the Dutch government has decided to introduce an energy tax unilaterally, to achieve the national CO_2 emissions target in an economy that is growing faster than expected (also causing the emissions to rise faster than expected). The tax is limited to small and medium users only, thus preventing undesirable effects on the international competitiveness of the Dutch manufacturing sector.

From January 1st, 1996, the ‘Energy Regulatory Tax’ has been introduced. The tax is levied on the use of natural gas, light fuel oil, heating oil, LPG and electricity by households and small and medium sized firms. The tax is introduced in three steps, with an annual increase. As the objective of the tax is stimulating energy efficiency, it is supposed to be revenue neutral, and the revenues are returned through reduction of direct taxes paid by households and firms. Tax rates are based on the proposed EU directive for a carbon/energy tax, and are given in Table 2.2. In order to exempt large energy users from the tax, a ceiling applies of 170,000 m^3/year of natural gas and 50,000 kWh of electricity. In addition, consumption of the first 800 m^3/year of natural gas and 800 kWh of electricity is free of taxation, as a protection of low income groups.

Table 2.B *Rates small user carbon/energy tax in the Netherlands in cents (excl. VAT) [6]*

	1996	1997	1998
Electricity per kWh	2.95	2.95	2.95
Natural gas per m^3	3.20	6.40	9.53
Light fuel oil per litre	2.82	5.64	8.46
Heating oil per litre	2.84	5.68	8.53
LPG per kg	3.36	6.72	10.09

The tax encourages renewable energy in the following way. Electricity produced from renewable sources (wind, solar, hydro, biomass) is levied when used, however, the proceeds are returned to the producer instead of the tax payer. The tax is expected to lead to a 1.5% reduction of total CO_2 emissions.

2.4.6 Efficiency standards

The Energy Performance Standard (EPS) for new dwellings came into effect in December 1995 as part of the Building Act. The EPS does not only take into account the energy required for space heating, but also for hot water use, ventilation, cooling and lighting. It is an integrated calculation, and the maximum value of 1.4 is equivalent to a total energy use in new dwellings of 1400 m^3 natural gas equivalent in 1996 The standard is to be tightened to 1.2 in 1998 and to 1 in the year 2000. A comparable standard is operational for new buildings in the tertiary sector. A distinction in the tightness of the standard is being made along the type of building, e.g. offices, hospitals, schools, shops etc. An Energy Performance Standard for Locations (EPL) for new districts is currently being developed, and will take into account the design of the local energy infrastructure.

A EU directive on minimum efficiency standards for refrigerators and freezers was established in 1996, and included in the Dutch Energy Saving Appliances Act in 1997. On the basis of an EU directive, energy labels for washing machines and tumble dryers have been introduced in the Netherlands in April 1996. A similar label had already been implemented for refrigerators, freezers and hot water boilers in 1995.

2.4.7 Other regulation

As mentioned before, the Dutch energy efficiency policy is mainly based on co-operation instead of regulation. However there are many regulations applying to emissions, in particular of SO_2 and NO_x, in the transport, manufacturing and electricity production sectors.

In the Netherlands, covenants or Long Term Agreements (LTA's) are used as an alternative to imposing regulation to large industrial energy consumers. Environmental permits are regarded as a supplement for those firms not participating in LTA's, or a safety net for firms failing to meet their LTA-obligations.

Covenants containing energy efficiency targets are formed between the Minister of Economic Affairs, a sector organisation, and Novem, the government agency that monitors the long term agreement. The target is stated in terms of efficiency improvement (energy consumption by unit production), and has been formulated in a negotiation process preceding the agreement. Individual companies draw an 'energy savings plan' to implement the agreement. They receive support from Novem in identifying saving measures, and the requirements of the Environmental Protection Act are assumed to be met.

There are now 29 LTA's in the industrial sector, and 9 with other sectors, including health care, freight transport and greenhouse horticulture. Small and Medium-sized Enterprises are difficult to reach because of the lack of sector organisations.

2.4.8 Fiscal or economic incentives

Fiscal measures for energy conservation are increasingly important in the Netherlands, mainly replacing subsidies. Advantages of fiscal incentives are that they are equally available for all investors and make better use of the market mechanism. Recent measures are the following.

The Accelerated Depreciation of Environmental Investments programme (VAMIL), gives a corporate tax advantage to companies that invest in specific energy saving measures or environmentally friendly technologies. This measure only applies however, to those companies obliged to pay corporate taxes, excluding for instance hospitals.

The interest offered by 'green' investment funds or saving accounts is not subject to income taxation, compensating for the fact that the interest rate usually is lower than that offered by other accounts. This enables investors in renewable sources, district heating etc. to borrow money at a lower interest rate.

The Energy Investment Allowance offers a lower corporate tax in the first year by deducting 30-40% of the investment sum from the profit in that year. This is equivalent to a subsidy of 14-18%. The investment must concern energy saving technologies or renewables, and again only applies to those companies obliged to pay corporate taxes.

An economic incentive for the development of CHP, wind, water and photovoltaic systems is the obligation for utilities to buy any surplus electricity produced privately, at prices reflecting avoided costs. In the process of liberalisation of the electricity market, this obligation will be limited to electricity generated by captive consumers.

3. OVERALL ASSESSMENT OF ENERGY EFFICIENCY TRENDS

3.1 Primary and final energy intensity

Three general indicators have been selected for characterising overall energy efficiency trends [2]. The first one is the primary energy intensity, that relates the total amount of energy used in a country to the GDP in constant prices. This indicator includes both efficiency changes in the energy transformation sector and efficiency changes at the level of final consumers.

The second indicator concentrates on final consumers only: the final energy intensity. This is the ratio of final energy consumption over GDP. Since energy efficiency policy often focuses on final consumers, this indicator is suitable for monitoring the overall development of end-use energy efficiency. The third indicator is the ratio of the previous ones, and will be discussed further below.

In Figure 3.1 the trends in these indicators are presented. The improvement of the final energy intensity since 1980 was 37%. Compared to other countries, the level of this indicator is high, mainly because of the energy intensive industry in the Netherlands.

In the period 1980-1996, the overall energy productivity of the economy, as measured by the primary energy intensity, has improved by 22%. The difference between the primary energy intensity and the final intensity is relatively large in the Netherlands, because of the large chemical industry and refinery sector [7].

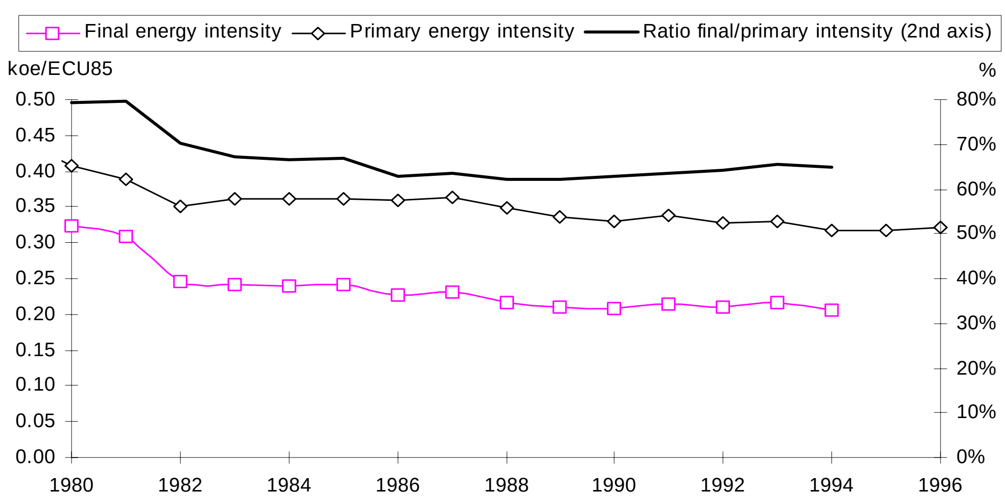


Figure 3.A *Primary and final energy intensity in the Netherlands*

Naturally the trends in primary and final intensities are a result of many factors in the different economic sectors, which are analysed in more detail in Chapters 4-7. The main factors influencing the intensities at macro level are the fuel prices, the sectoral structure (influenced by economic growth), and the effort and funds devoted to energy conservation policy. Three periods can be distinguished, based on developments with regard to these factors in the Netherlands [8].

- 1980-1986: high fuel prices, economic recession, and active conservation policy,
- 1986-1991: low fuel prices, economic recovery, and less attention paid to energy conservation,
- 1991-1996: low fuel prices, economic growth, and increasing effort in conservation policy.

In table 3.a, the average annual decrease in intensities is given for these periods. The general picture is consistent with the trends in fuel prices and conservation policy. The second oil shock caused the largest intensity decrease at the level of final consumers. The economic recession in the beginning of the eighties may have contributed to this decrease. After 1986, the economic growth, in particular growth of the energy intensive industry, may have slowed down the improvement of the final energy intensity compared to the primary energy intensity. In addition, a series of mild winters after 1986 also caused a further decrease in the final energy intensity (see also figure 3.c).

Table 3.A *Average annual change in primary and final energy intensity in the Netherlands (%/year)*

	1980-1986	1986-1991	1991-1996
Primary intensity	-2.0%	-1.2%	-1.0%
Final intensity	-5.5%	-1.0%	-1.3%[2]
Final intensity; climate correction	-5.7%	-0.8%	-0.7%[2]

The ratio of final and primary energy intensity is used as an indicator of the efficiency of the energy supply in the Netherlands. This indicator is also presented in figure 3.a. There is a slight decrease, implying that on average for all final energy carriers, more and more primary energy per unit of final energy consumption is required.

The difference between final and primary energy intensity gives an indication of the consumption and losses in the transformation sector, the role of non energy uses and bunkers for international transport that have been excluded from the final consumption. In the Netherlands, the ratio of final and primary energy intensity has an average value of 65% in the considered period, implying that 35% of the primary energy consumption goes to the transformation sector, non-energy uses and bunkers, with 14% for non-energy uses and bunkers. This share of non-energy use is large, because of the energy intensive industry.

The average overall supply losses and consumption in the transformation sector in this period amount to approximately 21%. This share of overall supply losses is not extremely large, compared to other countries, because the share of electricity in final demand is relatively low, and natural gas is used directly for space heating, causing no additional losses at the supply side.
There is a downward trend in the ratio of final and primary energy intensity. Between 1982 and 1990, this ratio decreased from 70% to 63%, with a slight increase after 1990. The change is mainly due to a growth of the share of non-energy use of energy carriers between 1982 and 1990. The increasing share of electricity in the final consumption also contributes to the downward trend. With regard to the transformation sector, there are a few counterbalancing trends. The efficiency of electricity generation has increased in the eighties. However, the number of coal plants has also increased, and more electricity is imported, causing the average efficiency to remain more or less stable. The consumption of oil in refineries and the consumption of natural gas in gas production have increased [8]. These increases also contribute to the downward trend of the ratio.

[2] For the period 1991-1994.

3.2 Interpretation of final energy intensity

Although the final energy intensity does give an indication of the energy efficiency in the Netherlands, it is influenced by many other factors as well. One of the most obvious factors is the weather. The severeness of winters has a significant impact on the consumption of natural gas, which is the main fuel used for space heating in the Netherlands. As natural gas accounts for almost 50% of the final energy consumption in the Netherlands, the overall final intensity is also affected considerably.

figure 3.b gives an illustration of this relationship. It is clear that the cold winters of 1985-1987, 1991 and 1993 caused a peak in the consumption of natural gas in these years. The final consumption of other energy carriers is not significantly influenced by climatic variations (see Figure 2.2).

Therefore, the final energy intensity with climatic corrections is a better indicator of final energy efficiency, as it is cleaned from these annual variations. This indicator is presented in figure 3.c. It must be mentioned that the role of climatic variations is less important when looking at long periods, but it is useful for understanding the differences between individual years.

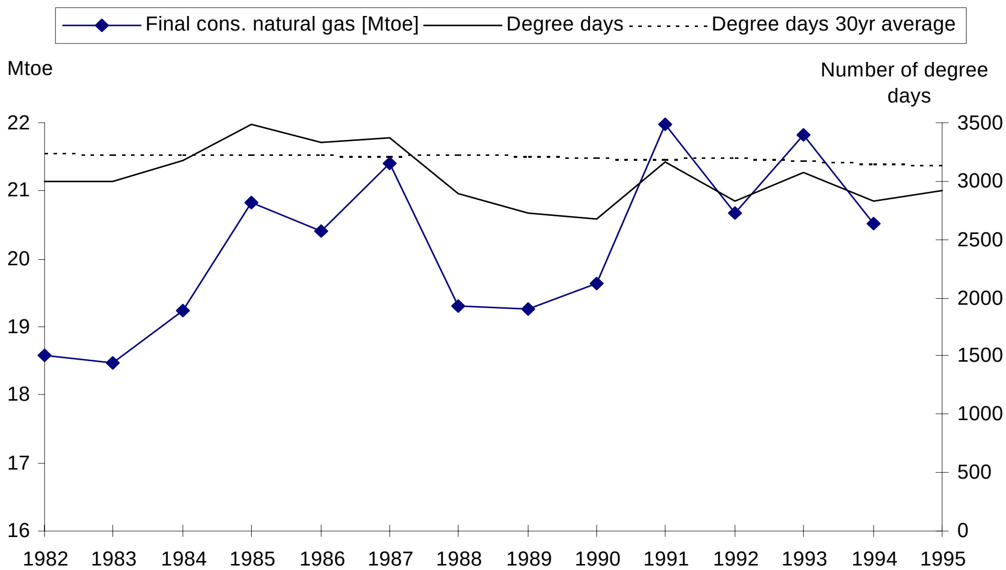


Figure 3.B *Comparison between number of degree days and final consumption of natural gas in the Netherlands*

In figure 3.c, the intensity with climate correction is higher than the ‘regular’ final intensity after 1990, which is consistent with the relatively mild winters in that period. The average annual intensity improvement between 1991 and 1994 is lower after climate correction: 0.7% instead of 1.3% without the correction. This is an important observation. It means that part of the intensity decrease has been due to mild winters, and thus no energy efficiency improvement.

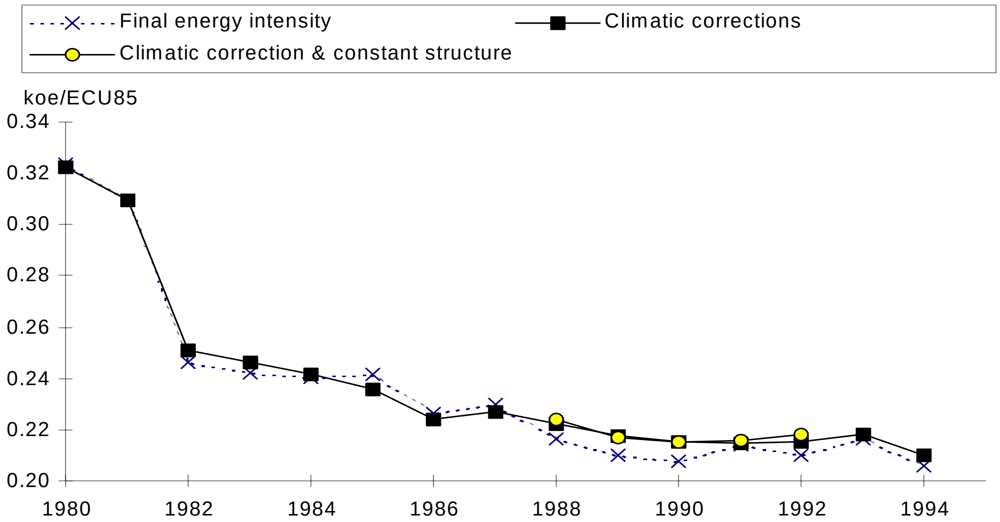


Figure 3.C *Final energy intensity: role of climate and structural changes*

Another factor influencing variation in final energy intensities is the change in economic structures. A change in the GDP structure between subsectors, for instance a decreasing contribution of energy intensive branches, will also result in a decrease of the final energy intensity, but should not be regarded as an energy efficiency improvement. Therefore another indicator is also presented in figure 3.c, the final energy intensity at constant structure (after climate correction). This indicator leaves out the influence of macro-economic structural changes, because all intensities are calculated at the economic structure of 1990.

Although the intensity at constant structure and climatic corrections is only available for a few years, it has the highest values for these years. This indicates that in the years after 1990, structural changes have also contributed to the intensity decrease.

3.3 Energy efficiency

The energy intensity at constant structure does not take into account other structural changes within the sectors, and therefore is still quite a soft indicator for assessing energy efficiency trends for final consumers. A better assessment can be made through a ‘bottom-up’ approach by aggregating energy savings resulting from energy efficiency improvements at a detailed level in all end-use sectors.

In the methodology used in ODYSSEE, energy savings are calculated from ‘technico-economic effects’. For each (sub)sector, the energy consumption variation, compared to 1990, is explained by two main effects [2]:

- the *quantity* effect (or volume effect), capturing the influence of growth in an activity indicator (number of cars, appliances, tons produced) affecting the energy consumption,
- the *unit consumption* effect, measuring the influence of change in the unit consumption or specific consumption in a (sub)sector on the energy consumption (for instance kWh per appliance, litre/100 km, toe/ton).

For some sectors the unit consumption effect itself can be further explained by changes in technology, behaviour, or substitutions between energy carriers. The amount of detail depends on the sector and the availability of information.

The energy efficiency effect is used as a measure of energy savings by sector (in Mtoe, compared to 1990). The exact definition of this effect differs by sector, but generally it is a result of aggregating the unit consumption effects in subsectors or energy services. This way, an assessment of the Mtoe saved in each end-use sector is obtained (see also the next chapters). The sum of these savings by sector gives an estimate of energy savings at national level.

In Figure 3.4 these energy savings are presented. The calculation could only be done for a limited number of years, because the unit consumption effect in all end-use sectors is used. Due to lack of data, there is no clear trend in this line. The tertiary sector has been omitted, because inconsistencies in the data (see Chapter 7) cause large fluctuations that disturb the overall picture.

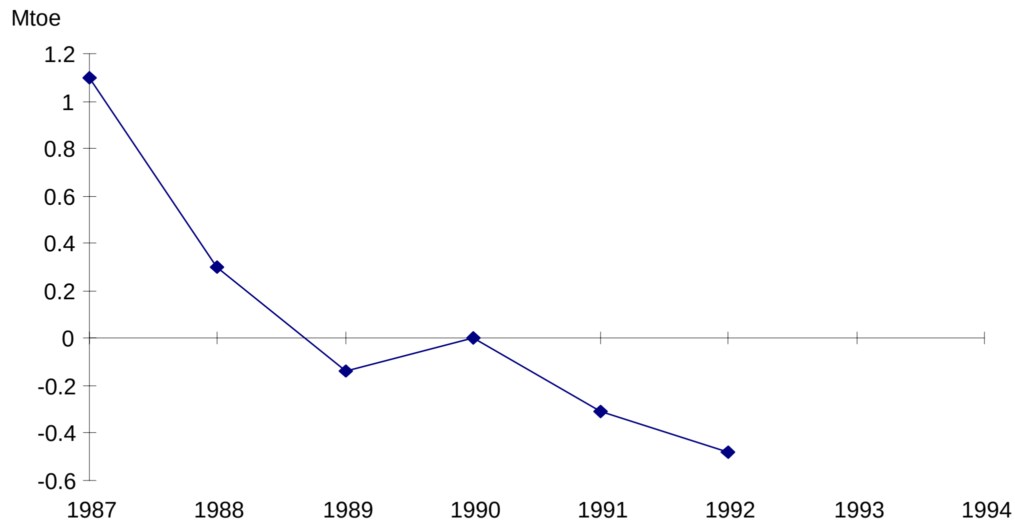


Figure 3.4 *Energy savings in the Netherlands (excl. tertiary sector); energy savings >0 before 1990 and <0 after 1990*

4. INDUSTRY

Data from this section are based on the sectoral energy balance sheets of the Netherlands Energy Statistics (CBS, NEH). Economic data are derived from National Accounts (CBS). It is in particular in the industry sector that the differences between the Dutch statistics and the international conventions become apparent (see sections 2.1 and 2.3.1).

4.1 Energy consumption by industrial branch

Industrial branches include manufacturing industry, construction and mining. Mining here concerns only gas- and oil extraction. The manufacturing industry is subdivided in several main branches. The oil industry is not included in the manufacturing sector, but in the transformations sector. In figure 4.a, the development of final energy consumption is depicted for manufacturing and total industry, the difference being solely the construction sector. In figure 4.b, shares of the different main industry branches are presented for 1982 and 1994, the first and last years within the available time series.

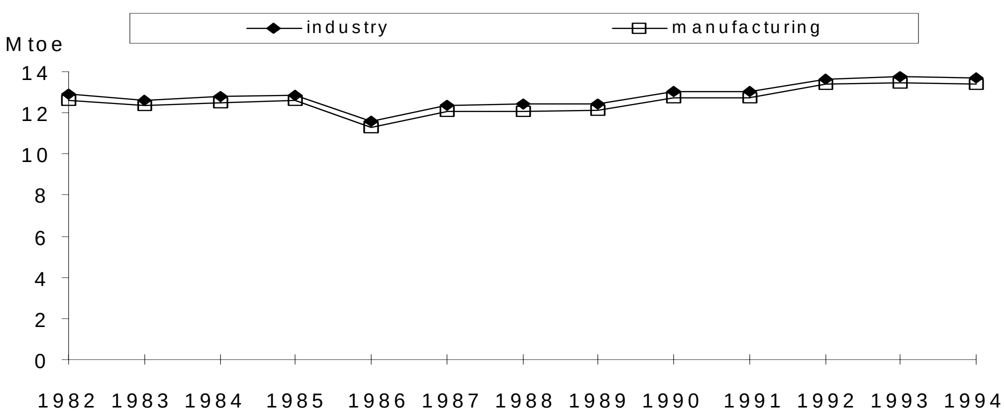


Figure 4.A *Development of final energy consumption in industry and manufacturing*

The Dutch chemical sector is dominant with respect to energy consumption, and the growth of total industrial energy consumption reflects the activities in this sector. Basic metals is the second largest sector, with respect to energy. Equipments refers to all other metal sectors, and includes foundries; metal products, machinery; transport equipment and electrotechnical equipment. The structure of energy consumption by sectors is relatively stable, but fluctuates with the cyclical movements of the chemical and basic metals sector.

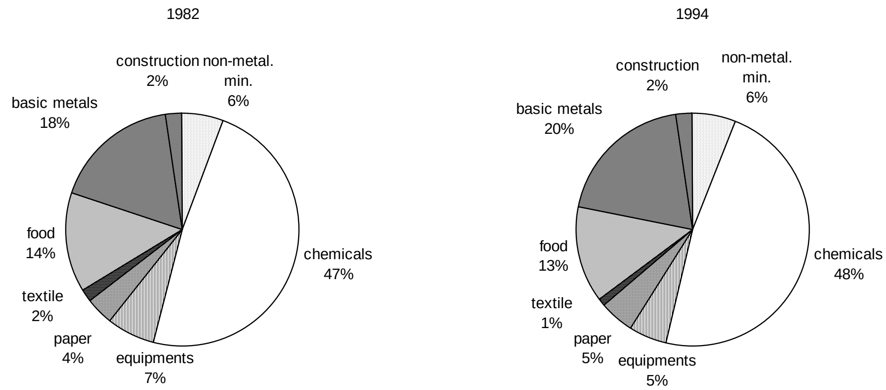


Figure 4.B *Final energy consumption shares of main industry branches*

4.2 Energy intensities by industrial branch

For the main branches of industry, final energy intensities are calculated, based on the added value from each branch. figure 4.c indicates energy intensity of industry and manufacturing respectively, the difference indicating the low energy consumption and considerable contribution to GDP of the construction sector. figure 4.d presents intensity developments within separate manufacturing branches.

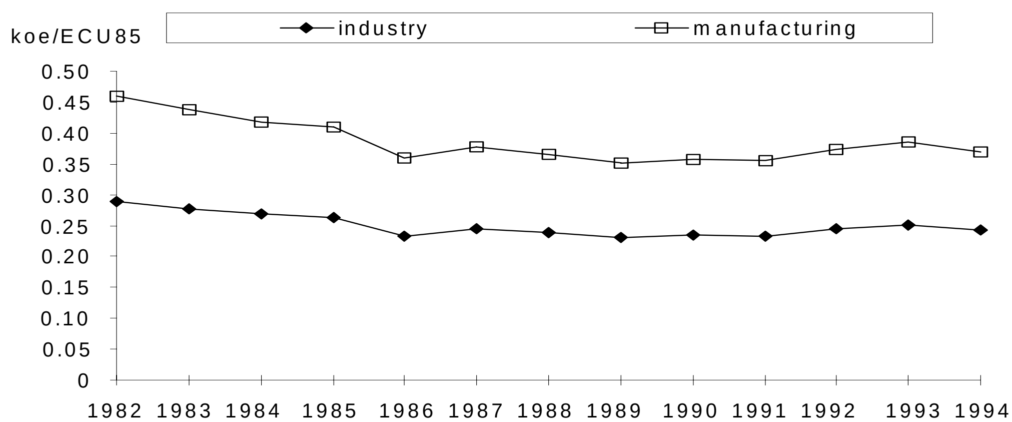


Figure 4.C *Final energy intensity of industry and manufacturing*

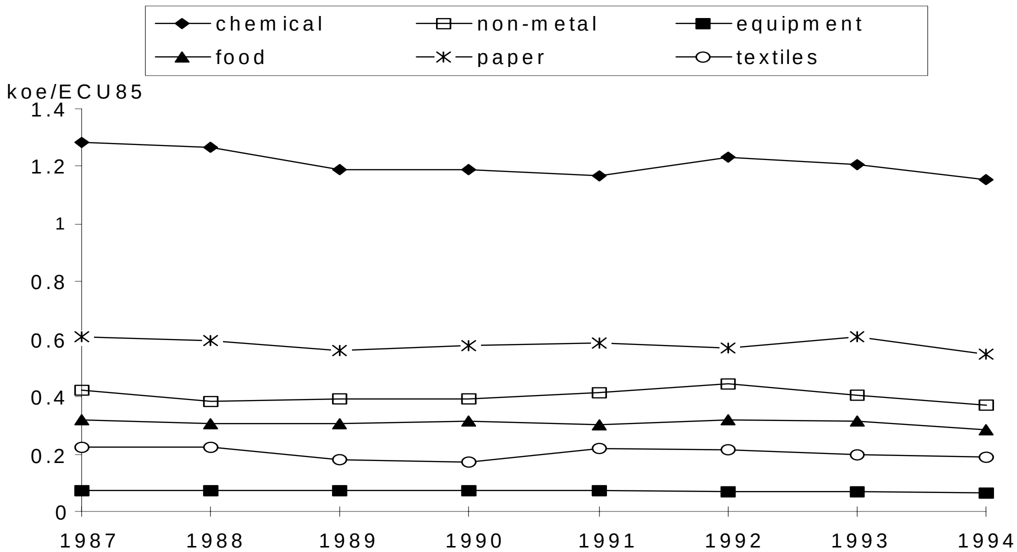


Figure 4.D *Energy intensity of manufacturing branches*

The chemical industry is clearly energy intensive, as it includes a large basic chemicals production section. However, basic metals is twice as energy intensive as chemicals but it is not depicted here because of data problems. Here in basic metals all coal and coke inputs for iron production are included. Food industry is energy intensive as far as dairy, sugar and starch production is concerned. The energy intensity of all branches has decreased over the observed period with 1 to 2% annually. This seems to contrast with the results of figure 4.c, where energy intensity of total manufacturing has hardly decreased between 1987 and 1994. In the next section, part of this contrast will be explained. The underlying phenomena that explain sectoral energy intensity include technical energy efficiency improvements and all kinds of intrasectoral effects.

4.3 The influence of the sectoral structure

In this section, the influence of structural effects on energy intensity is discerned. The effect of sectoral growth in manufacturing branches is separated from total energy intensity. In figure 4.e, energy intensity development is depicted in two different ways. The first way is total manufacturing energy consumption divided by total manufacturing value added (at constant prices). The second way is the energy intensity development that would have occurred if value added growth was equal in all sectors.

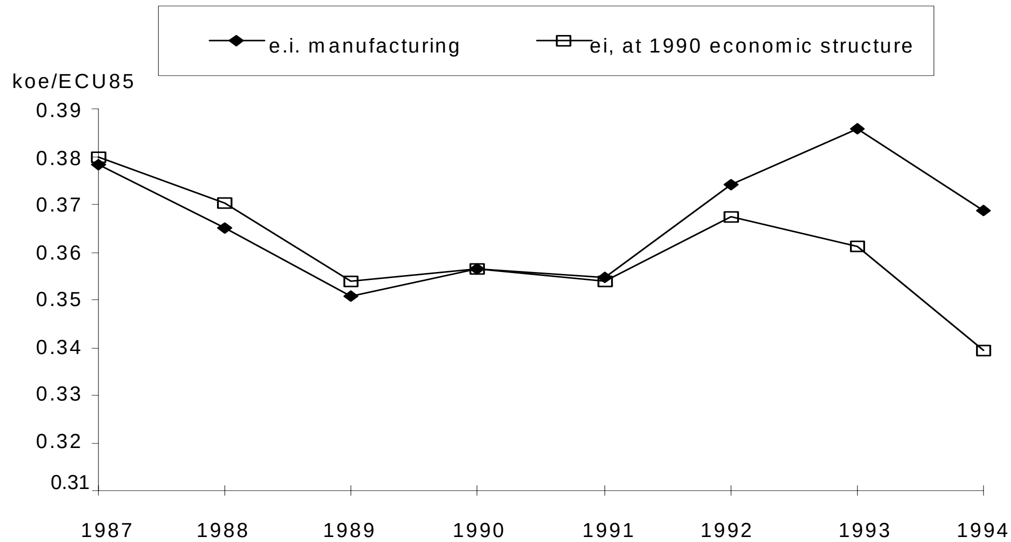


Figure 4.E *Effect of economic structure on energy intensity in manufacturing*

After 1990, the relatively large growth of value added of the chemical industry compared to total manufacturing, has made the structure of the economy more energy intensive. Relatively high growth rates in food, basic metals and paper industries also contributed to this effect. The recent high growth of the energy intensive industry has offset its energy efficiency improvements, so the apparent steady share of its energy consumption hides the underlying changes (figure 4.b).

4.4 Energy efficiency

When energy consumption in some process or branch can be related to a meaningful physical indicator, energy efficiency can be calculated from a technological viewpoint, e.g. as specific consumption or unit consumption. In a follow-up of this project, in some branches, physical indicators will be defined that are expected to be closely related to energy consumption. In these branches, development of the added value per physical unit can then be separated from unit consumption.

5. HOUSEHOLDS

In this chapter, the results will be presented for the residential sector. First, the total final energy consumption is given. Next, the development of the use of energy carriers by households or dwelling is presented. Some attention is paid to explanatory factors, such as energy use in new dwellings and specific consumption of appliances, that have influenced the energy use. Finally, some conclusions are drawn with respect to the effect of the explanatory factors on the energy efficiency in the household sector.

5.1 Energy consumption by end-use

In the Netherlands, natural gas and electricity are by far the most important energy carriers in the residential sector. The use of oil and coal in the period 1980 - 1996 can be neglected (about 2 to 3% of the total energy use). Approximately 10% of all dwellings is connected to a collective heating system (district heating or central heating of a whole block of flats). In figure 5.a total energy consumption of households in the Netherlands is given.

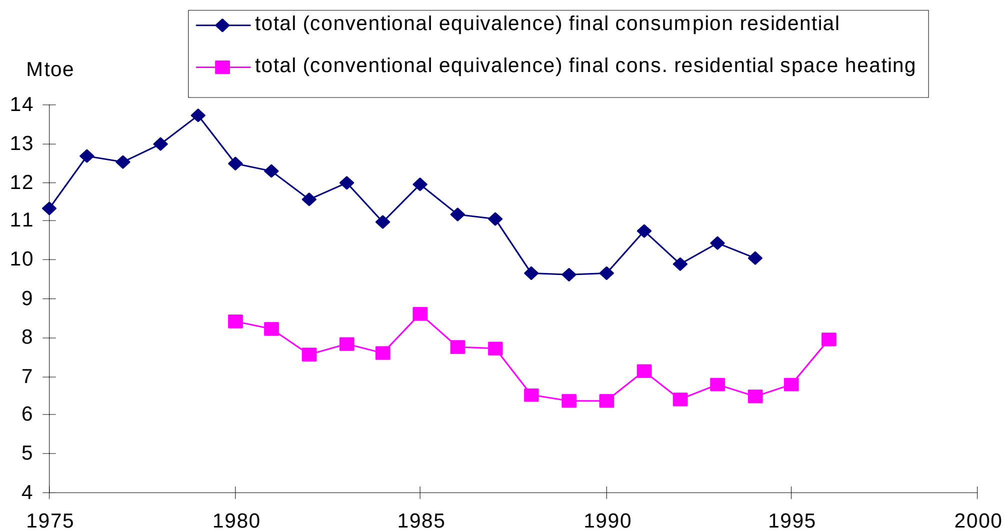


Figure 5.A *Total final energy consumption and total final energy consumption for space heating of households in the Netherlands.*

In the period 1975 - 1979 the total final energy consumption of households increased from about 11.3 Mtoe to 13.7 Mtoe (a rise of 5.3 % annually). Due to regulation with respect to insulation of houses, public information of households and high energy prices in the period 1979 - 1985, total final energy consumption decreased to 9.6 Mtoe in 1989 (3.6 % annually). In the period 1990 - 1995 the decrease in energy used for space heating was not sufficient to counterbalance the effect of the increase in energy used for domestic appliances.

The total primary energy use in the residential sector has decreased in the period 1982 - 1988 with 13%. In the period 1989 - 1994 the total primary energy use remained almost stable. In 1995 and 1996 however, total primary energy use has increased with respectively 3.7% and 1.2% annually. Especially the total use of electricity has increased rapidly since 1989 as a result of the increase in both the number of households and the electricity consumption per household [11]. The consumption of natural gas per dwelling also shows a decrease in the period 1980 - 1992, a stabilisation in the period 1993 - 1995 and a slight increase in 1996. The use of electricity per household shows a minimum value in 1988. In 1996, the consumption of electricity is back at the same level as in 1980.

5.2 Unit consumption trends of households

In Figure 5.2 the average energy consumption and electricity consumption per dwelling is given.

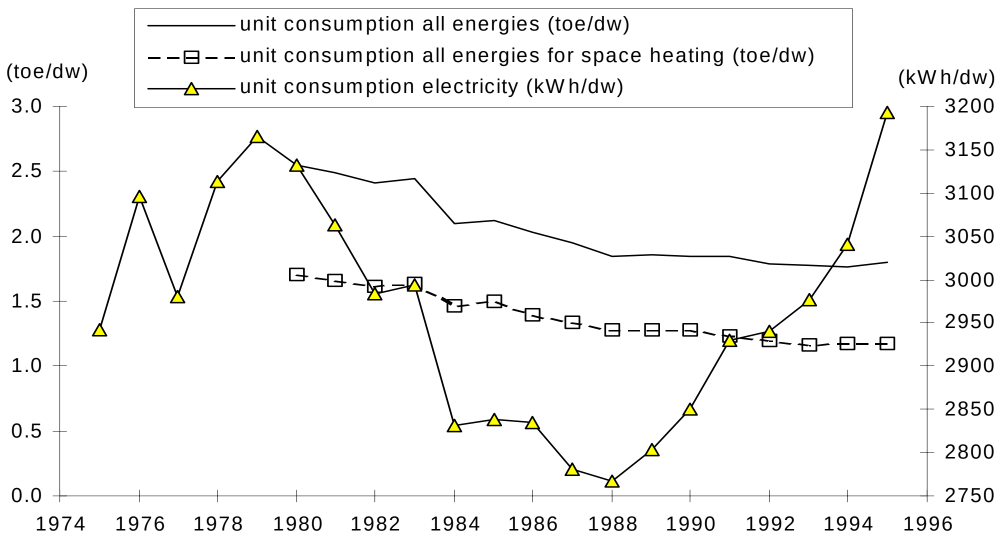


Figure 5.2 *Total average energy consumption per dwelling, average energy consumption for space heating per dwelling (both incl. climatic corrections) and total average electricity consumption per dwelling*

The average consumption of electricity per household decreased from 3250 kWh in 1980 to about 2750 kWh in 1988 due to good housekeeping and improved efficiency of domestic appliances. In 1996 however, the average electricity consumption per household increased again to 3250 kWh, the same level as in 1980. This growth can be explained by the rise in penetration of several domestic appliances such as dish washers and cloth dryers. Moreover, the average consumption of certain domestic appliances seems to grow due to an increase in the time the appliances are used and a rise in capacity [11].

The energy consumption per (occupied) dwelling has decreased from 2.6 toe in 1980 to 1.8 toe in 1995, due to the improved insulation of dwellings. The share of space heating in the use of natural gas per dwelling decreased from 85% to 79%, see Figure 5.3. However, when the fuel prices declined, the attention for energy savings decreased ('bad housekeeping'). This resulted in a higher average indoor temperature in dwellings. It is estimated that the average indoor temperature rose with approximately 1° C in the period 1986 - 1992.

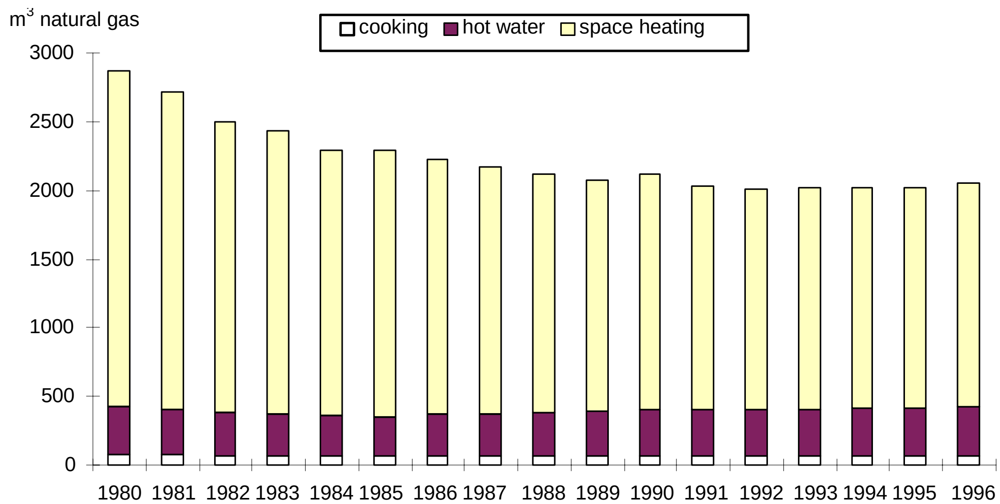


Figure 5.3 *Natural gas consumption per household of space heating, hot water production and cooking (incl. climatic corrections)*

The share of energy required for the production of hot water increased from 12% in 1980 (350 m^3 natural gas) to 18% (360 m^3 natural gas) in 1996. The decrease in average size of a household from 2.7 persons per household in 1980 to 2.3 persons per household in 1996, is exceeded by the increase of hot water consumption per household member. This can be explained by a change in lifestyle and the increase in capacity of the hot water boilers. The share of cooking in the natural gas consumption per household is nearly constant at 3%. In absolute terms however, the natural gas consumption decreases from 75 m^3 in 1980 to 65 m^3 in 1996. However, the penetration of households that use electricity for cooking has increased from about 12% in 1989 to about 16% in 1996 [11].

5.3 Space heating

The average consumption of natural gas for dwellings is decreasing, as a result of the substitution of old and poorly insulated dwellings by new properly insulated dwellings, renovation of dwellings and efficiency improvement of boilers. In Figure 5.4 the specific consumption of natural gas for space heating in new dwellings is given.

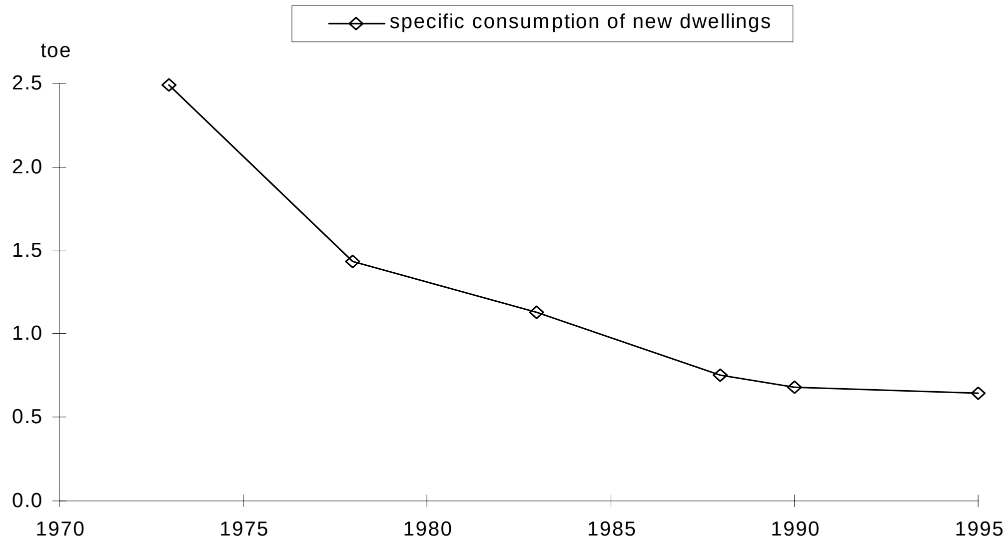


Figure 5.4 *Specific consumption of new dwellings (incl. climatic corrections) [5,9,10]*

Due to the decrease in the average size of households, the economic recession in the early 80's and the tendency of older people to keep living in self reliant dwellings, the demand for smaller houses has increased. In the period 1977 - 1983 the average size of a new dwelling decreased with 25%. However, in the period 1983 - 1996, the average size of a new dwelling increased with 25% due to a rise in share of private property [11]. Nevertheless, the natural gas consumption of new dwellings still decreased in the period 1983 - 1996 because of higher efficiency of boilers and improved insulation. Although there is a fluctuation in the average size of new dwellings, the average size of a dwelling remains nearly constant in the period 1980 - 1996 (difference < 1%). The penetration of several insulation options is given in Figure 5.5.

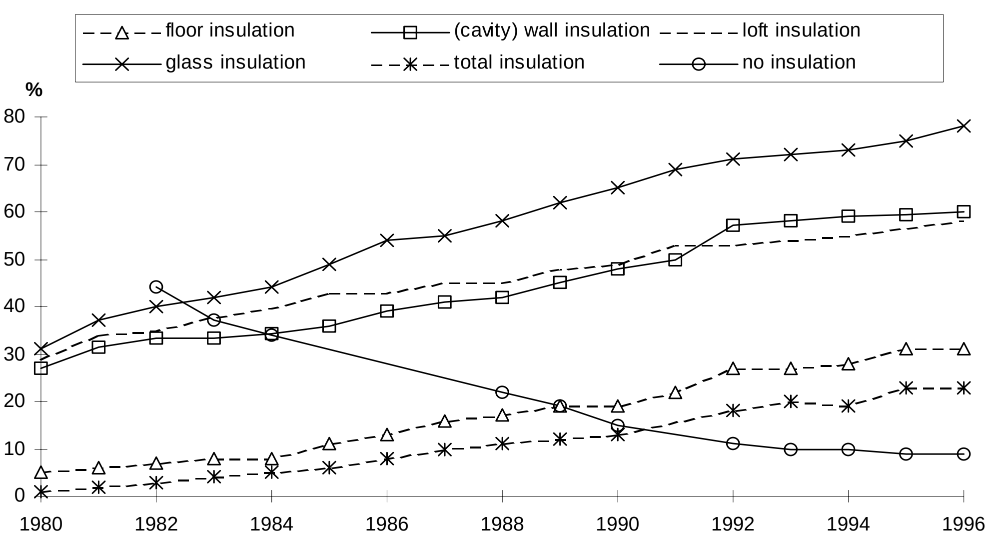


Figure 5.5 *Penetration of insulation measures in dwellings [12]*

The penetration of roof insulation, loft insulation and floor insulation has increased with approximately 30% in the period 1980 - 1996. This increase can be explained by the substitution of old and poorly insulated dwellings by newly built totally insulated houses [11]. The penetration of glass insulation has increased with about 50% in the same period. Since 1979, it is obliged to install glass insulation in new dwellings. The fraction of dwellings without any insulation decreases from 44% in 1982 to 9% in 1996. The fraction of dwellings which are equipped with floor insulation, wall insulation, loft insulation and glass insulation increased from 1% in 1980 to 23% in 1996. The average efficiency of heating systems has improved with approximately 7% in the period 1980 - 1996 [11].

The change in total energy use for space heating can be broken down into three explanatory factors:
- a quantity effect (more dwellings)
- a climatic effect (variation of climate)
- a unit consumption effect (energy savings).

The quantity effect due to an increase in the amount of dwellings is almost constant in the period 1980 - 1995, see Figure 5.6.

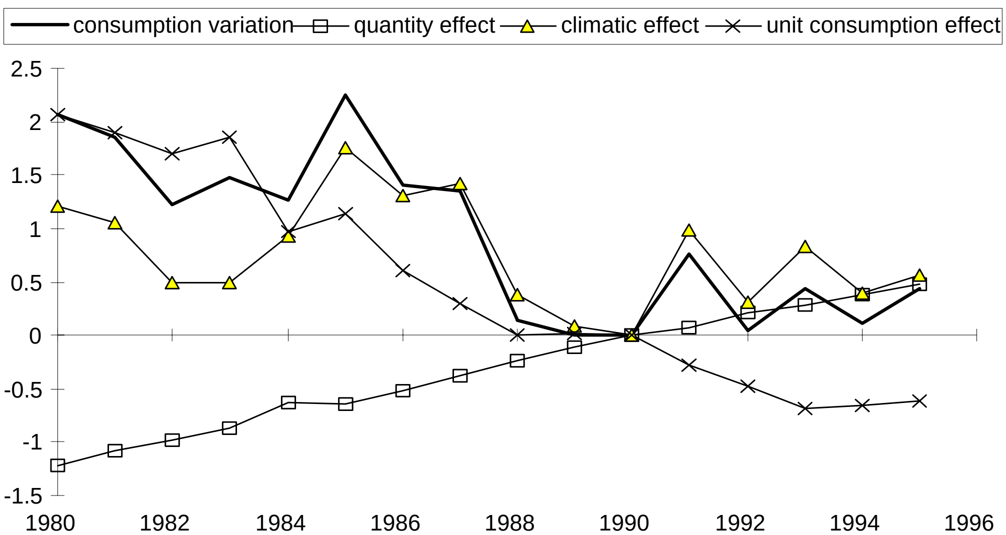


Figure 5.6 *Change in space heating consumption due to changes in quantity, climate and unit consumption*

The unit consumption effect leads to a decrease in the rise of the total energy use in the period 1980 - 1993. Since 1993 however, total energy use for space heating increases due to the changes in the unit consumption. This is due to changes in lifestyle which result, amongst others, in higher indoor temperatures.

5.4 Electrical appliances

In Figure 5.7 the specific electricity consumption of some domestic appliances is given.

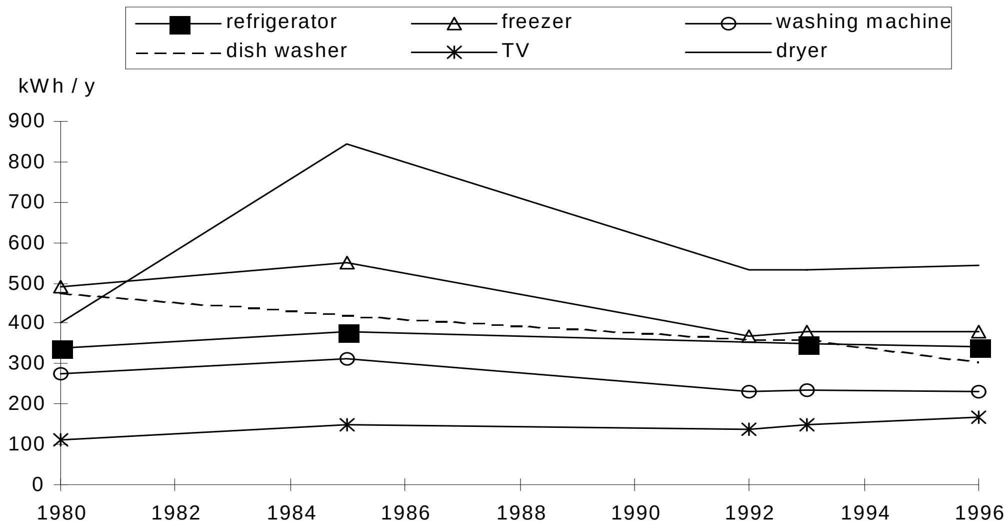


Figure 5.7 *Specific electricity consumption of some domestic appliances*

The values presented in Figure 5.7 are average values of the amount of electricity used by domestic appliances in a household [13,14,15]. A change in lifestyle could alter the use of an appliance. The frequency of the use of washing machines, for example, has increased over the period 1980 - 1996 [15]. Although the specific energy use of the washing machine has not changed, the average electricity consumption per household of a washing machine has increased due to an increase in the number of times the washing machine is used. However, part of this effect is compensated by the decrease in the average number of persons per household, since the frequency of using the washing machine increases with the size of the household (not linearly!).

For all appliances except the dish washer, there is a (small) increase in the specific energy consumption in the period 1980 - 1985. The specific energy consumption of the dryer is the highest of the domestic appliances given in Figure 5.7. The specific energy consumption of the dryer increases by 2.2% annually in the period 1980 - 1996. However, in the period 1985 - 1996 the specific energy consumption decreases with 3.3 % annually. It seems likely that the specific energy use of the dryer in 1980 is underestimated.

The specific energy use (actually: average use of electricity per household) of the TV is increasing from about 110 kWh annually to 170 kWh annually per household. Due to an increase in the number of TV's per household (households having more than one TV-set), the average energy consumption per household increases. Moreover, it is likely that due to a change in lifestyle the number of hours that people are watching TV has also increased in the period 1980 - 1996.

With respect to the specific energy use of the refrigerator, one has keep in mind that there is, again due to a change in lifestyle, a tendency to buy larger refrigerators. The penetration rate of (small) one-door refrigerators with only a small or no freezing compartment is decreasing. The penetration rate of (large) two-door refrigerators with large cool and freezing compartments is increasing [15]. This tendency leads to a decrease in the energy efficiency of refrigerators. However, one could argue that the technical energy efficiency is not decreasing since the decrease in efficiency is due to a change in type/size of refrigerator.

5.5 Energy efficiency in the residential sector

Due to the decrease in electricity and natural gas consumption per household/dwelling, the energy efficiency increases in the period from 1980 to about 1990. After 1990, the rise in electricity use per household and the stabilisation of the use of natural gas per dwelling have lead to a decrease in energy efficiency in the household sector.

6. TRANSPORT

6.1 Transport consumption by mode

Since 1980 the energy consumption in the transport sector has increased with 35%. figure 6.a shows the energy consumption in the transport sector for the different modes. Air transport seems not important in this diagram. This is because the energy consumption only applies to flights within the national frontiers.

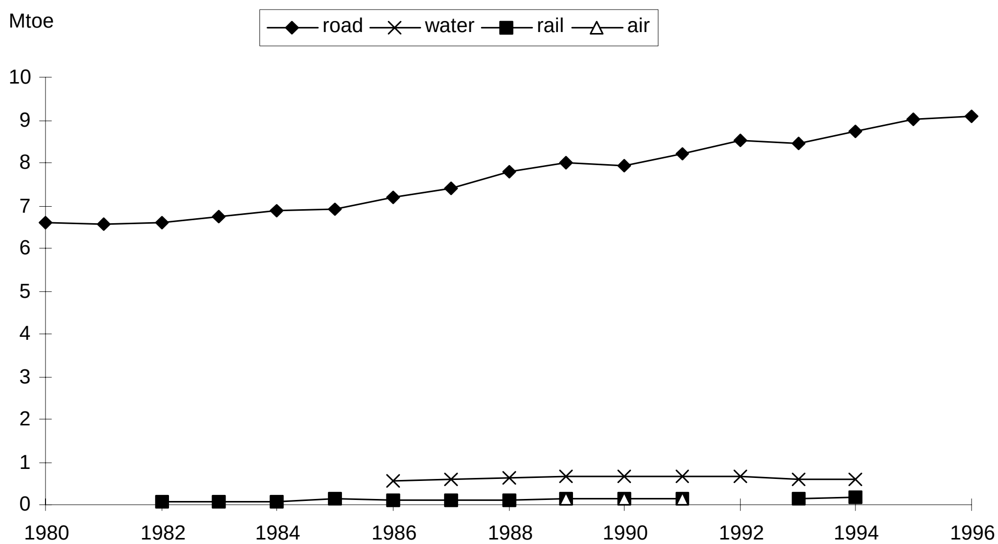


Figure 6.A *Transport energy consumption by mode*

Only the energy consumption for road transport increased significantly. The energy consumption for all other modes remains more or less constant.

Despite an increase in vehicle efficiency, the energy consumption shows an upward trend for road transport. Until 1985 the energy consumption has a low increasing rate. The high increasing rate between 1985 and 1989 is caused by the lower fuel prices. In 1985 the prices of motor fuels dropped drastically.

The general upward trend is caused by the economic growth, which had a boost around 1990. The higher economic growth from 1990 onwards results in a higher increasing rate between 1991 and 1996. The economic growth has its effect on passenger transport and freight transport. The number of vehicles has increased, just as the yearly performance of the vehicles (distance travelled per year).

figure 6.b presents the total energy consumption by service; passenger transport and freight transport. Again the general upward trend is caused by the economic growth and the resulting income development.

For freight transport the total energy consumption increases, while the energy consumption per vehicle decreases because of an improved efficiency. The growth in the total energy consumption is the result of an increase in the number of vehicles and the vehicle performance.

The energy consumption for passenger transport increases mainly because of the developments with private cars (see Figure 6.3). Furthermore, just as for freight transport, the same holds for passenger transport: an increase in the number of vehicles and the vehicle performance and a decrease in the energy consumption per vehicle (improved efficiency) results in an overall increase in the energy consumption.

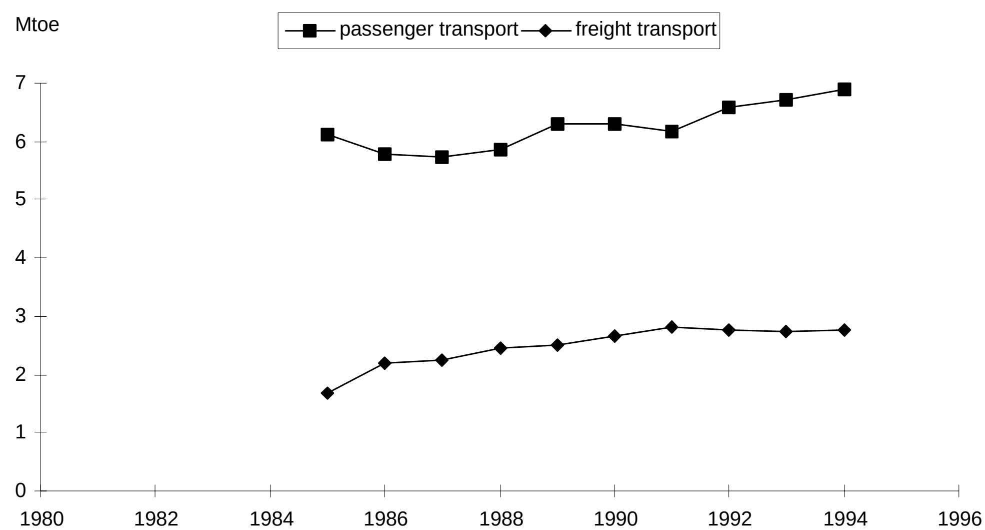


Figure 6.B *Transport energy consumption by service: passenger and freight*

The road transport energy consumption by type of vehicle is given in Figure 6.3. Private cars dominate this energy consumption, followed by trucks and light vans. Busses and motorcycles both only have a small share in the energy consumption by type of vehicle. The energy consumption of busses and motorcycles remains more or less constant, despite an increase in the overall energy consumption for passenger transport. Thus the increasing energy consumption for passenger transport (see figure 6.b) must be a result of the increase in energy consumption for the private cars. The energy consumption of trucks and vans has also increased.

The total energy consumption of private cars has increased in particular between 1982 and 1994 (22%). The development of the person kilometres shows a higher increasing rate [16]. The increase of energy consumption of private cars is caused by a combined effect of an increasing number of private cars and a higher yearly performance of the cars. On the other hand the efficiency of the cars improved. This is further discussed in section 6.2.

The upwards trend in the energy consumption of trucks is also the result of decreasing energy consumption per vehicle kilometre together with a growing performance of the trucks and a growing number of trucks. This is discussed in more detail in section 6.3.

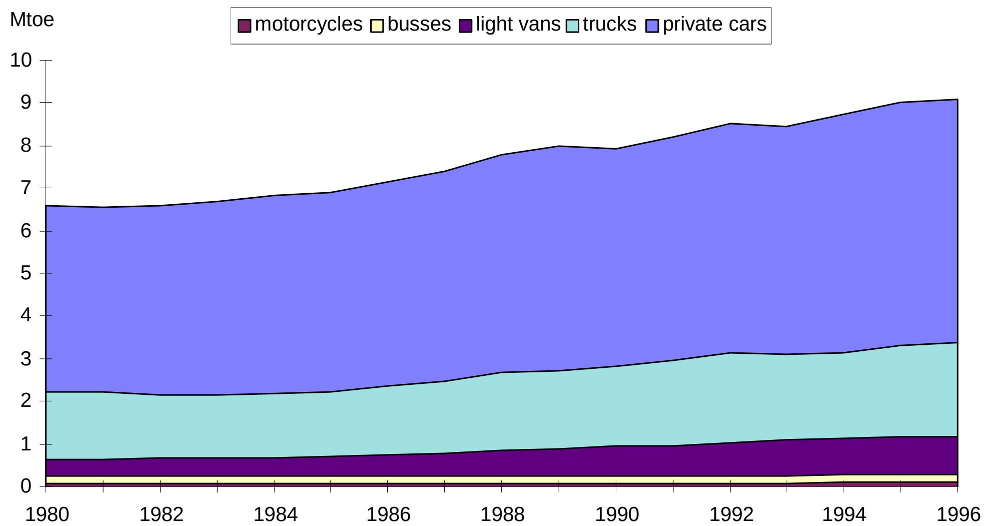


Figure 6.C *Road transport energy consumption by type of vehicle*

6.2 Cars

6.2.1 Specific consumption

For road vehicles the overall efficiency can be monitored with the average specific consumption, expressed in litres/100 km. For cars, the average specific consumption is calculated from the total energy consumption of cars, the stock of cars and the average yearly performance. figure 6.d shows the specific energy consumption of cars.

Until 1990 the specific consumption of cars decreases. This trend is partly due to a general efficiency improvement and to a shift in the fuel mix. In the year 1978 an agreement was made within the European Union with the car manufacturers about a higher efficiency of private cars. In 1985 the cars should be 10% more efficient compared to the cars in 1978. This goal has been more than achieved, actually in 1985 the cars were 14% more efficient.

During the years the share of diesel cars has grown. Diesel cars are more efficient than gasoline cars and as a result, the total specific energy consumption has decreased. Also the introduction of the APK (obligatory general periodic inspection) had a positive effect on the energy consumption of cars. The APK was introduced in 1988.

Another important development is the increase in energy consumption because of environmental legislation. For instance, the introduction of the controlled three-way catalyst for passenger cars and light vans, resulted in a 3% increase in energy consumption.

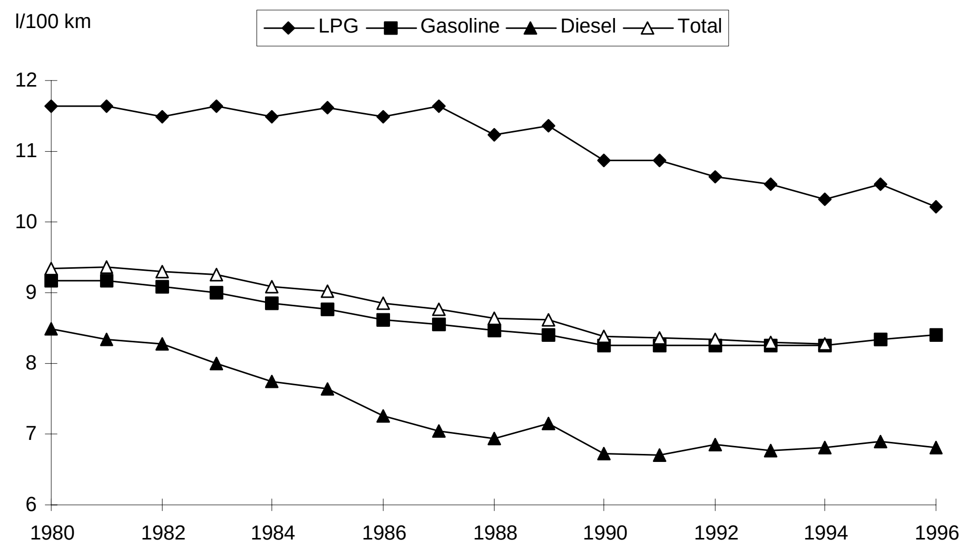


Figure 6.D *Specific consumption of cars*

From 1990 on, the specific consumption of cars more or less stabilises, at least for gasoline and diesel cars. This stabilisation is caused by the vehicle weight. The motor-industry succeeded in increasing the engine efficiency with 10%, but the engine power increased during the past years due to an increase in vehicle weight. More extra parts and equipment were built in the vehicles for a higher level of comfort and safety.

6.2.2 Unit consumption

The unit consumption of cars (toe/vehicle) depends on the average specific consumption of cars (l/100 km) and the average distance travelled per year, see table 6.a. The unit consumption is more or less stable over the years 1984-1994, but the specific consumption decreases significantly (-1% per year). The difference between these two effects is caused by an increase in the yearly performance of cars of 0,9% per year.

Table 6.A *Variation in unit and specific consumption of cars in % per year*

year	Unit consumption [toe/veh]	Specific consumption [l/100 km]	Influence yearly performance
1984-1994	- 0.1	- 1.0	0.9

6.2.3 Savings

The variation of the unit consumption between years, the unit consumption effect, can be divided into three effects:

- the kilometre effect, the variation in yearly performance of cars,
- the technology effect, the variation in efficiency of cars,
- the behavioural effect, the variation in the driving behaviour, this is a residual effect.

figure 6.e shows the trends in the three different effects. The year 1990 is the reference year, which means that savings before 1990 are > 0 and savings after 1990 are < 0.

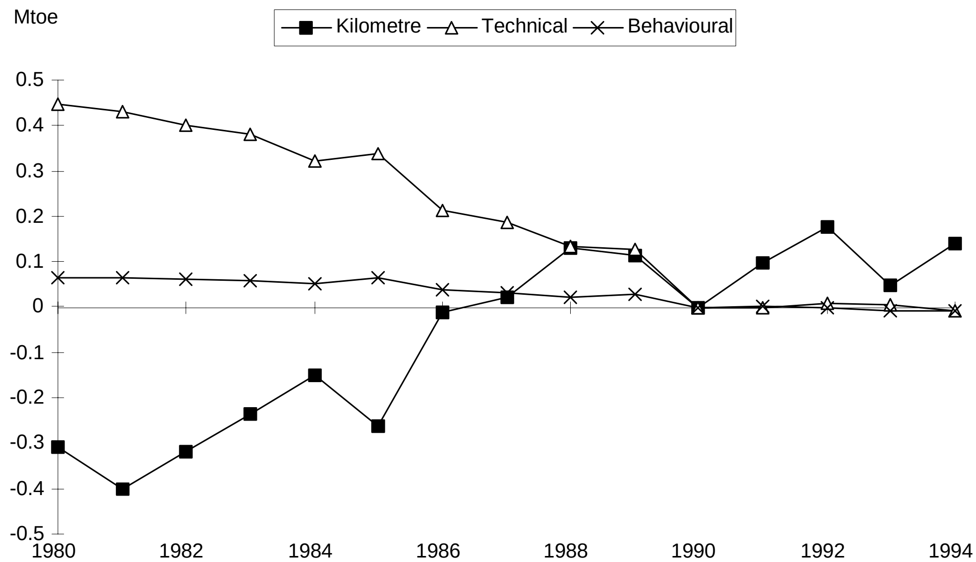


Figure 6.E *Energy savings for cars*

Before 1990 there was a trend towards more efficient cars. This is caused by a general efficiency improvement of cars. From 1990 onwards the efficiency of the drive-line still improved but the vehicles became heavier. This caused a stabilisation of the technical energy savings for cars. The curve of the kilometre effect shows the increasing yearly performance of the cars. Especially after 1990, this is the most important factor which influences the unit consumption.

6.3 Trucks

6.3.1 Specific consumption

The specific consumption of trucks in litres/100 km, can be considered as an indicator of the vehicle efficiency.

Over the years, vehicles became more efficient but on the other hand some factors resulted in stabilisation of the specific consumption of trucks between 1980 and 1994 (table 6.b). First of all, trucks became heavier. From 1981 to 1989 the average vehicle weight increased with 12% [17]. Secondly, the weight of the load increased over the years. The specific consumption of trucks also increased because of the environmental legislation. The introduction of the EURO 3 emission norm for trucks resulted in an increase in the energy consumption of 0.5 - 4% [18].

The improved efficiency of the trucks together with an increase in the weight of the vehicle/load and the introduction of emission norms results in a stabilisation of the specific consumption.

6.3.2 Unit consumption

The unit consumption of trucks (toe/vehicle) depends on the average specific consumption of trucks (l/100 km) and the average distance travelled per year. table 6.b gives the variation in unit and specific consumption between the years 1980 and 1994.

The specific consumption is more or less stable, while the unit consumption increases with 0,7% per year. The performance increased significantly over these years. This development results in an increase in the unit consumption of trucks. The difference between the specific consumption and the unit consumption is the influence of the yearly performance of trucks, which increased 0,8% per year between 1980 and 1994.

Table 6.B Variation in unit and specific consumption of trucks in % per year

year	Unit consumption [toe/veh]	Specific consumption [l/100 km]	Influence yearly performance
1980-1994	0.7	-0.1	0.8

6.3.3 Efficiency

The efficiency of freight transport by trucks can be monitored with the unit consumption per ton-kilometre. Changes in the unit consumption per ton-km depend on:

- energy efficiency of vehicles: variation in the specific consumption of trucks (per vehicle kilometre), which is an indicator of vehicle efficiency,
- energy efficiency of transport services provided by the vehicles: fleet management, this is expressed in a variation of the ratio ton-km performed per vehicle-km.

Figure 6.6 gives the energy consumption of trucks per ton-km and per vehicle-km.

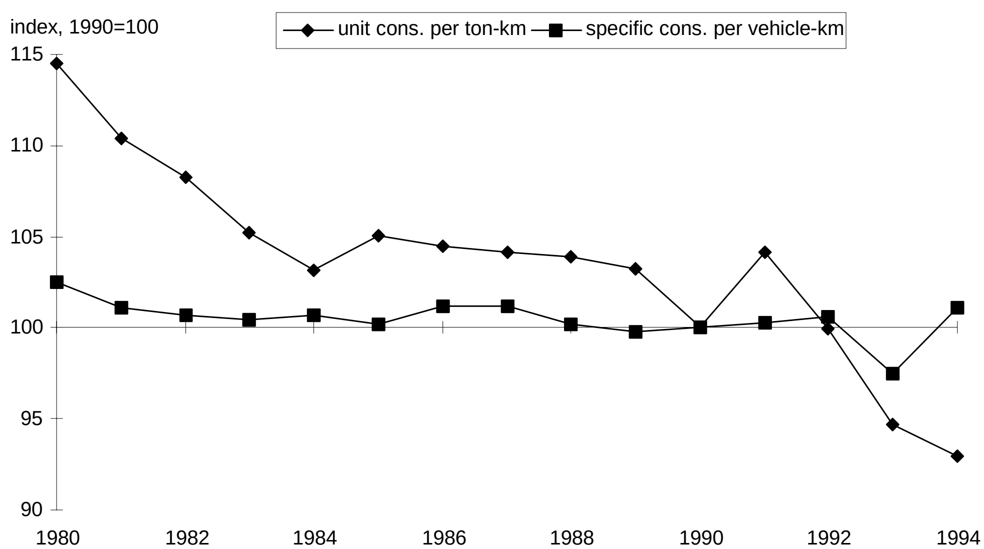


Figure 6.F *Energy consumption of trucks*

There are two reasons for the different slopes in the curves for specific consumption of trucks and unit consumption per ton-km. First there is a shift towards bigger trucks, more tons are transported with each truck. Secondly, the load factor is increasing. Both effects are the consequence of better fleet management and result in a decreasing unit consumption per ton-km. On the other hand the two effects increase the specific consumption but, because of the efficiency improvements of the trucks, the overall specific consumption decreases.

6.4 Energy savings for road transport

The energy savings for road transport can be calculated from the technical and the behavioural/management savings for cars and trucks (Figure 6.7).

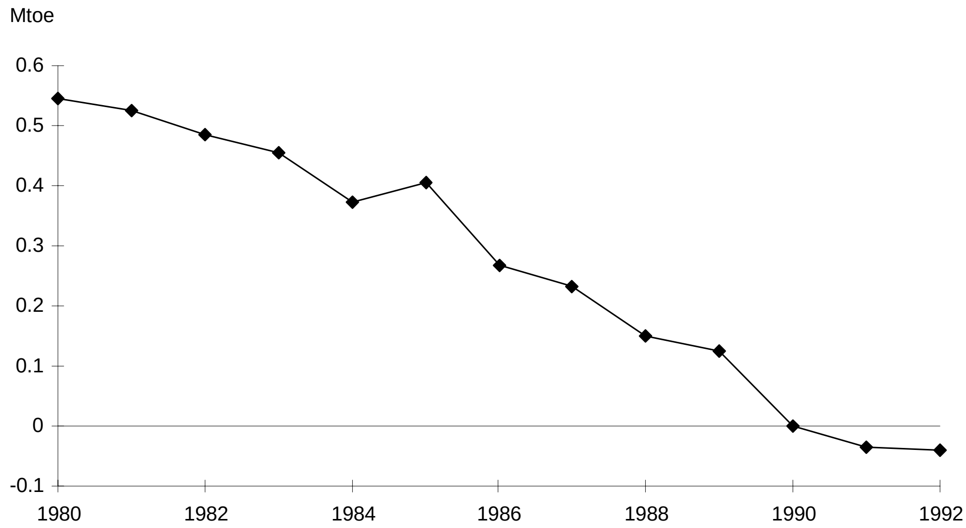


Figure 6.G *Energy savings for cars and trucks*

Energy savings for cars:
- technical savings; these are based on the variation in the theoretical (test) value of the specific consumption of new cars,
- behavioural savings; the difference between the theoretical and the actual specific consumption.

Energy savings for trucks:
- technical savings; these are related to the actual specific consumption,
- management savings; the variation of the load factor.

The reference year for the energy savings is 1990, which means that savings before 1990 are > 0 and savings after 1990 are < 0. Because of the stabilisation of the savings for cars (figure 6.e), it can be concluded that the savings after 1990 are mostly due to savings for trucks.

6.5 Water and rail transport

There is not enough data available to draw conclusions on the energy efficiency of water and rail transport. For rail for instance, only combined data for passenger and freight transport are available.

By approximation, the share of the ton-km hauled for water and rail transport can be an indicator for the energy efficiency of the freight transport, because water and rail transport are more energy efficient than road transport. figure 6.h shows the shares of ton-km hauled per mode for 1984 and 1994. The shares of water and rail transport both decrease, for water transport - 8% and for rail - 2%.

Between 1984 and 1994 there is a trend towards more energy consuming freight transport, i.e. road transport. It can be concluded that the overall energy efficiency of freight transport has decreased over the years.

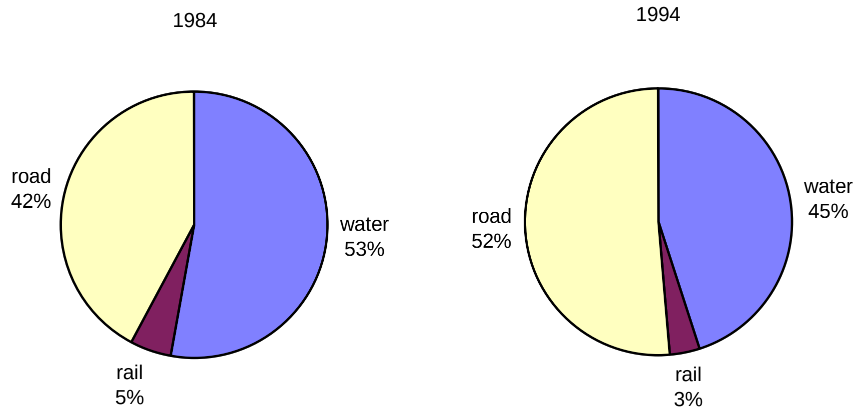


Figure 6.H *Impact of modal shift on freight transport: Ton-km per mode*

7. SERVICE SECTOR

The total energy intensity in the service sector has decreased about 20% in the period 1980 - 1994, see figure 7.a. The electricity intensity however, has increased with 35% in the same period. The rise in energy intensity of electricity is compensated by improvements in labour productivity and building insulation.

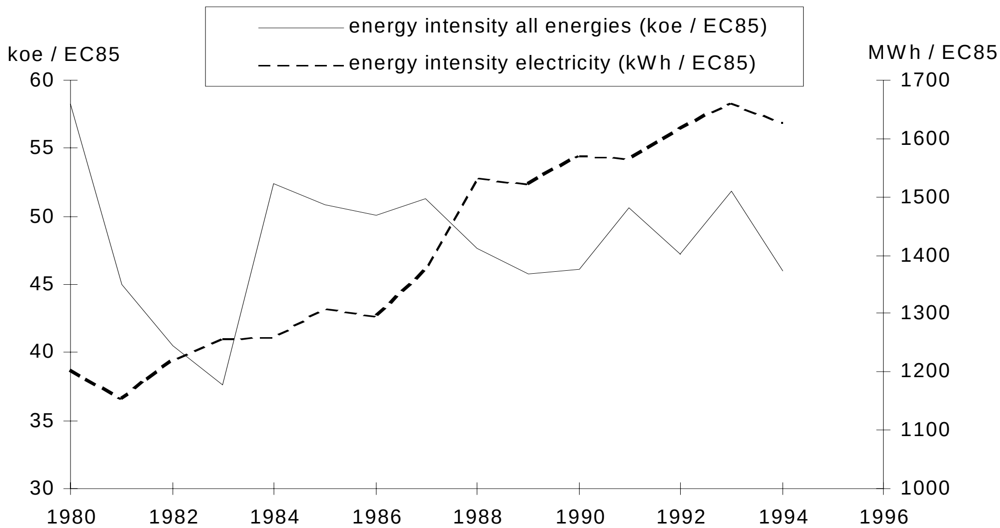


Figure 7.A *Energy intensity and electricity intensity in the service sector*

Although the total energy intensity of all energies has slightly decreased, the total energy use in the service sector is increasing. The total use of electricity in the service sector more than doubles from about 1 Mtoe in 1982 (40 Pee) to 2 Mtoe (83 PJe) in 1996. The final demand for heat increased from approximately 3.1 Mtoe (90 PJ) in 1982 to 5.3 Mtoe (160 PJ) in 1996 [19].

In figure 7.b the unit consumption of electricity per employee is given.

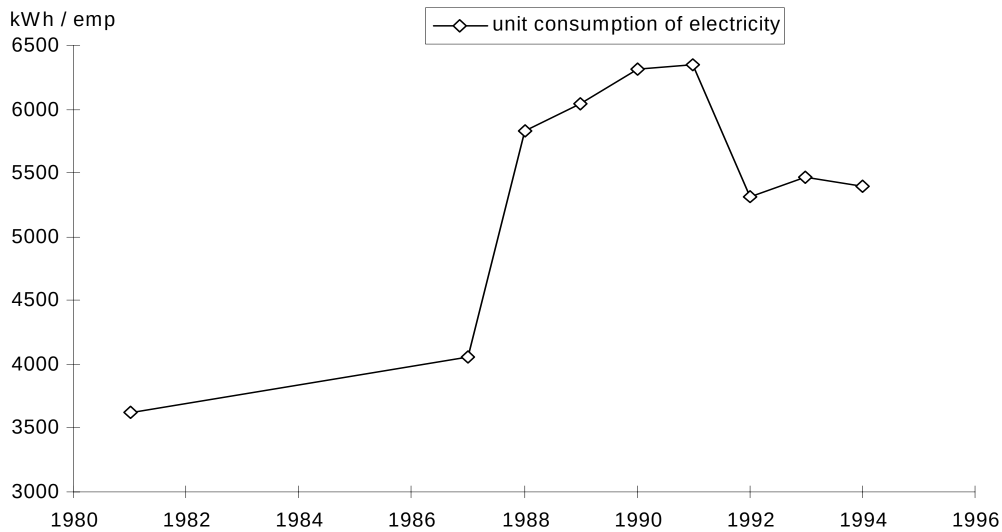


Figure 7.B *Unit consumption of electricity in the service sector*

In 1991, the electricity consumption per employee is about 75% higher than in 1981. In 1994 the electricity use per employee has dropped with 15% compared to 1991. These cannot be explained by changes in explanatory factors. It is likely that these changes in unit consumption of electricity are due to poor statistics, since (part of the energy use in) the service sector is the residual category of total energy use in the Netherlands. Computerisation, lighting and climate control are among the most important factors with respect to the increasing electricity use per employee.

8. TRANSFORMATIONS

This chapter will focus on the electricity production sector in the Netherlands. In 1996, 65% of the final consumption of electricity was produced in power plants, 25% was the result of cogeneration, and the remaining 10% was imported. Since 1980, central production in power plants has hardly increased. The growth in the consumption has been addressed by cogeneration and imports [8].

The fuel mix for electricity production is shown for one year in figure 8.a. In the eighties, the share of oil has been reduced, due to the international energy policy of the IEA, and stricter emission regulations. In 1982-1984, oil was mainly substituted with natural gas, but since the end of the eighties, a further diversification towards (clean) coal was carried out.

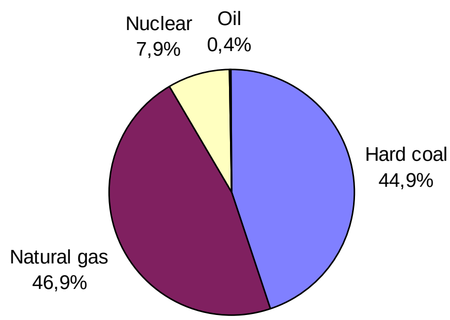


Figure 8.A *Fuel input for electricity generation in the Netherlands in 1994 [1]*

figure 8.b shows the average efficiency of electricity generation, calculated on the basis of EUROSTAT data. This efficiency is almost identical to the efficiency of thermal plants only, because the share of nuclear and renewables is very small in the Netherlands.

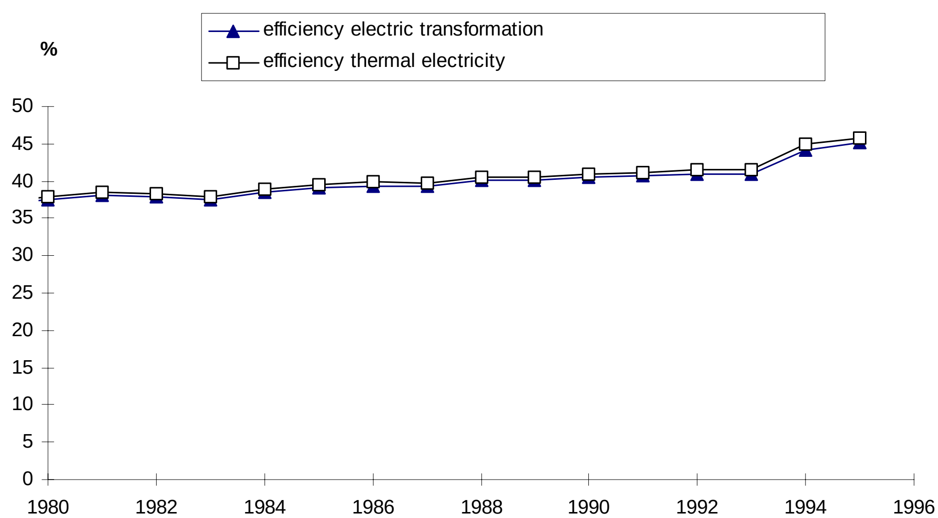


Figure 8.B *Development of efficiencies electricity production in the Netherlands*

The efficiency of electricity generation has increased in the eighties, for instance by placing gas-turbines in existing plants. However, the number of coal plants has also increased, which has a reverse effect on the average efficiency. Recently two natural gas plants with a high efficiency (55%) have been put into operation, increasing the average efficiency after 1994 [5,8].

9. CONCLUSIONS

Overall energy efficiency has improved most rapidly in the years 1980-1986 (with an average annual decrease of the final energy intensity of over 5%), when fuel prices were high due to the second oil shock, the economy was in a recession, and an active energy conservation policy was carried out. When the prices dropped and the economy recovered, energy efficiency improvement slowed down to an average rate of 0.8% annually.

The development of overall energy efficiency in the Netherlands is a result of developments within the different end-use sectors. For all sectors, energy efficiency improvements have been slowing down after 1990, some sectors even showing increases in energy intensity.

In industry, the relatively large growth of value added of the chemical industry compared to total manufacturing has made the structure of the economy more energy intensive after 1990. Relatively high growth rates in food, basic metals and paper industries also contributed to this effect. The recent high growth of the energy intensive industry has offset its energy efficiency improvements.

In the residential sector, the rise in electricity use per household and the stabilisation of the use of natural gas per dwelling have lead to a decrease in energy efficiency after 1990.

Despite an increase in vehicle efficiency, the energy consumption for road transport keeps growing. Both for freight transport and passenger transport, increases in the number of vehicles and in the distance travelled per year counterbalance the technical efficiency improvements.

The total energy intensity in the service sector has decreased with about 20% in the period 1980 - 1994, slightly slowing down after 1990. The electricity intensity however, has increased with 35% in the same period. The rise in energy intensity of electricity is compensated by improvements in labour productivity and building insulation.

With regard to the transformation sector, there are a few counterbalancing trends. The efficiency of electricity generation has increased in the eighties. However, the number of coal plants has also increased, and more electricity is imported, causing the average efficiency to remain more or less stable.

In a follow-up project, additional effort will be required with respect to data collection. In particular for the industry sector, the gap between the Dutch statistics and international conventions will have to be bridged without severe disruptions in time series. This should also allow for the calculation of more meaningful (physical) indicators, that assess energy efficiency in industry from a technological viewpoint, e.g. as specific consumption or unit consumption.

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ABBREVIATIONS

CHP	Combined Heat and Power, or co-generation
dw	dwelling
ECU85	ECUs of the year 1985
emp	employee

EPS	Energy Performance Standard
EU	the European Union
GDP	Gross Domestic Product
koe	kilogramme oil equivalent
kWh	kilowatt hour
(M)toe	(10^6) ton of oil equivalent
PJ	Petajoule
VAT	Value Added Tax
veh	vehicle