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Realised energy savings 1995 -2002

According to the Protocol Monitoring Energy Savings

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Abstract

In this report the realized energy savings in the Netherlands for the period 1995-2002 are presented for the sectors households, industry, agriculture, services, transportation, refineries and electricity and for the national level. First a short description is given of the 'Protocol Monitoring Energy Savings', a common methodology and database for calculating the amount of energy savings that was set up earlier by four Dutch institutes CPB, ECN, Novem and RIVM. Results are presented for savings on final energy use, conversion in end-use sectors (co-generation) and for conversion in the energy sector. National savings of 1.0% per year are found, with a decreasing tendency in recent years.

Much attention is given to the uncertainty margins that result from the uncertainty in the input data and the 'quality' of the variable that is used to calculate the reference energy use (without savings). It turns out that it is impossible to supply a reliable savings figure for final energy use in the services sector. On the other hand, the savings from better conversion can be calculated quite well. Overall, a margin of +/-0.3% is found for the national yearly savings figure.

Next to savings, an analysis has also been made of volume and structural effects with respect to energy consumption, energy intensity developments and other relevant factors in different sectors. Finally, savings have been put in perspective: a comparison is made with the savings of the EU-countries, the contribution of savings to the reduction of the CO_2 emissions is examined and a comparison with other evaluation studies is made.

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SUMMARY

At the request of the Dutch ministry of Economic Affairs, the institutions CPB, ECN, Novem[1] and RIVM/MNP, with assistance of CBS, developed a common method for the calculation of the realised energy savings, the so-called ‘Protocol Energy Savings’. Energy savings for 1990 to 2000 and 2001 respectively were reported in previous publications. This report covers the results for the period 1995-2002.

Realised savings

When calculating savings according to the Protocol, a distinction is made between:

- final energy consumption in end use sectors and refineries,
- conversion in end use sectors, among which cogeneration production,
- conversion in the electricity supply (see Table S.1).

Table S.1 *Energy savings 1995-2002 according to protocol method*

[%/year]	National	Industry[a]	Services	Households	Agriculture and horticulture	Transport[b]	Refineries
Final energy	0.7	0.8	0.0	1.2	1.1	0.4	0.8
Conversion	0.2	0.2	0.5	0.0	0.6	0.0	0.2
Total end users	0.9	1.0	0.5	1.2	1.7	0.4	1.0
Supply	0.1						
National	1.0						

[a] Including construction.
[b] Including energy consumption mobile equipment.

The savings on final energy consumption in different sectors result in national savings of 0.7% annually. If savings from cogeneration are included, savings amount to 0.9%. The savings in electricity supply add 0.1%-point to the total national savings of 1.0% annually. It must be noted that it was impossible to establish a final savings figure for Services due to unreliable energy consumption data and unavailability of variables to determine the reference consumption. In this case the final savings were set at nil. The uncertainty in the national savings figure amounts to 0.3 %-point. With a certainty of 95% it can be said that national savings lie between 0.7% and 1.3%. The figures on final energy consumption for the separate sectors have a larger uncertainty range. The figures for conversion, however, are relatively firm.

Table S.2 illustrates the recent trends in national savings. From these data it can be concluded that the level of savings is decreasing gradually, both in final energy consumption and in cogeneration and power plants. This trend is visible in various sectors and is also supported by additional analyses (see Chapter 4).

Table S.2 *Trend in national savings as of 1995*

[%/year]	1995-2000	1995-2001	1995-2002
Final energy consumption	0.8	0.8	0.7
Cogeneration and power plants	0.4	0.3	0.3
Total	1.2	1.1	1.0

[1] The name has changed to SenterNovem in the mean time.

Energy consumption developments
The analysis covers the period starting from 1990, in coherence with previously defined policy. The energy consumption trend is not only influenced by savings but also by volume developments, such as economic growth, and structural developments such as sectoral shifts, more appliances per household, heavier cars and more air-conditioning in offices. The growth of the gross domestic product (GDP) would, everything else unaltered, have led to an annual increase of in energy consumption of 2.6%. This increase is lowered by structural developments with 0.4%-point. Taking into account the 1.0% savings, the total energy consumption increases with 1.2% per year (see Table S.3, last column).

The energy intensity, defined as the relation between economic growth and energy consumption, appears to decrease more rapidly in case of a larger economic growth (see Table S.3). As a result, energy consumption does not increase much faster in a period with a larger than average economic growth compared to periods with a smaller economic growth.

Table S.3 *Development of GDP, energy consumption and energy intensity*

[%]	1990-1994	1994-1998	1998-2002	1990-2002
GDP growth	1.9	3.6	2.2	2.6
TPES growth	1.0	1.3	1.3	1.2
Energy-intensity	-0.9	-2.2	-0.9	-1.3 to -1.4

Remarkably, the historically decreasing trend for the national energy intensity ended in recent years (see Figure S.1). This recent development also deviates from trends in other European countries.

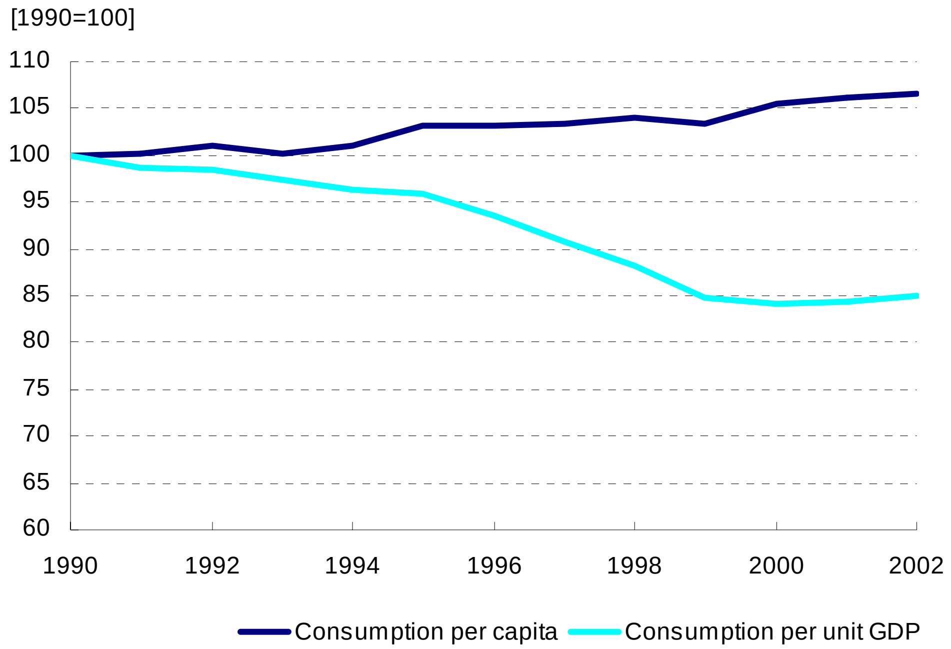

Figure S.1 *Energy consumption per capita and per € GDP for 1990-2002*

Savings in power plants and cogeneration production
The average conversion efficiency of power stations increased by 1995 due to the start of the newer and very efficient Eems Power Plant. After 1998, efficiency is decreasing again as a result of energetically less optimal deployment of production capacity. This probably relates to the abandonment of the national optimisation scheme for the deployment of power plants of Sep and the substantial growth in imports of electricity.

Total savings due to (non-central) cogeneration production increased rapidly as of 1990. After reaching a maximum value in 1998 the savings decreased again. Savings from cogeneration have been determined using the average power production efficiency in the base year. If the current average efficiency would be chosen, lower savings are found as of 1995 but relatively higher savings as of 1998 (due to the decreased average efficiency of power plants).

CO_2 emission reduction of savings
The avoided CO_2 emission, resulting from realised energy savings since 1990, amounted to 14-16 Mton or approximately 8% of the total Dutch emissions. About 3-4 Mton of this amount is the result of more efficient conversion (cogeneration and power plants); the rest stems from savings on final energy consumption. This emission reduction is partly due to energy policy and partly the result of autonomous technological advancement. Compared to the avoided emissions of renewable energy production, approximately 3 Mton, savings have contributed five times more to the emission reduction than renewable energy.

International comparison of realised savings
The saving figures have been compared with the realised efficiency improvements in the EU as determined in the Odyssee project. For households the Netherlands show higher savings than the EU in total. For industry and transportation it is difficult to draw firm conclusions because of the differences in method. Overall it may be concluded that the Netherlands do not score worse than EU countries as a whole.

Necessary improvement of the monitoring
For industry a new method has been used to calculate energy savings that is based on detailed physical production data. This appears to be a valuable alternative for the prior information derived from the LTA-monitoring that was ended recently. However, this does not constitute a solution for refineries where necessary data for a proper division of energy consumption development into saving- and structure effects are missing (changes in crude oil input, use of semi manufactured products and changes in output mix). As for the sector Services, reliable energy consumption data from distribution companies databases have to be awaited. Also a substantial effort is needed, for example by means of a survey, to determine the reference consumption and savings.

1. INTRODUCTION

Monitoring energy savings

Dutch figures on energy consumption and savings have not been calculated and presented in a uniform manner in the past, by policy makers (Ministries of Economic Affairs and Spatial Planning, Housing and the Environment) as well as by the institutes involved (CPB, ECN, Novem[2] and RIVM/MNP). In addition, little attention has been paid to the uncertainties in the data. By request of the Ministry of Economic Affairs the institutes have elaborated on a joint method laid down in the report 'Protocol Monitoring Energy savings (PME)' (Boonekamp, 2001). The protocol defines the quantities and system boundaries to be used. The report also describes the applied decomposition method and the calculation scheme, including the variables and data needed.

Performed evaluations

Since the establishment of the protocol, results on savings have been presented twice:

- for the period 1990-2000, as part of the report 'Energy savings trends 1990-2000' (Boonekamp, 2002),
- for the period 1990-2001, at a workshop organised by the platform (Vreuls, 2003).

In addition, a publication was devoted to uncertainty margins (Gijsen, 2003).

Changes in the protocol method

This report presents the realised savings for 1995-2002. As data from the Long Term Agreements (LTA) were no longer available for calculating industrial savings as of 2000, a new approach had to be used (Neelis, 2004). An outcome of this new method was a shift in base year from 1990 to 1995. Moreover, the sector definitions were adjusted to the new division, agreed upon as part of the formulation of sectoral indicative targets for CO_2 emissions. Furthermore, the opportunity was seized to improve the protocol method in a number of other sectors and to provide for a better linking of the calculation scheme to the energy data from the MONIT system (Boonekamp, 2004). Finally, the presentation of results on savings has been extended with information on general energy consumption developments over a longer period of time and in a broader framework.

Reading instructions

Given the substantial changes an extended report is published. Chapter 2 summarises the previously established protocol method. Chapter 3 presents the savings for the period 1995-2002, including a trend and uncertainty analysis. Chapter 4 elaborates on energy consumption developments per sector and elucidates the protocol method into more detail. Moreover, developments are explained as good as possible. Finally Chapter 5 sheds a light on the savings from different perspectives, including a comparison with abroad and the emission reduction of savings.

[2] Name has changed to SenterNovem recently.

2. PROTOCOL METHOD IN BRIEF

2.1 Definition of energy savings

General definition
Energy is saved when the same activities are performed or the same functions are provided with less energy consumption. The energy savings are expressed in absolute units (PJ) or relative (%) to the energy consumption before the savings were achieved.

Determination of savings using the reference consumption
Energy savings cannot be measured or observed directly because it entails energy that has not been used. Energy savings must therefore be determined in a different way. The protocol makes use of the so-called reference consumption that is equal to the theoretical energy consumption in case no energy savings would take place. By definition energy savings are the difference between realised energy consumption and reference consumption in the end year (see Figure 2.1). In this way the problem of calculating energy savings is replaced by the problem of determining the correct reference consumption.

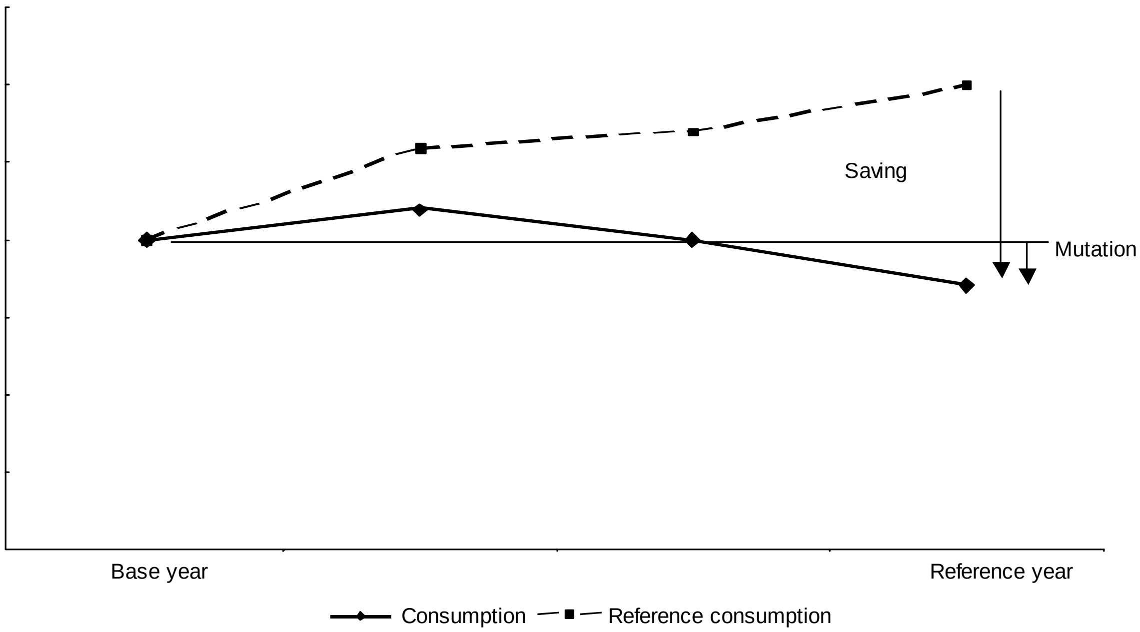

Figure 2.1 *Energy consumption, reference consumption and savings*

Energy relevant quantities for the determination of the reference consumption
The reference consumption is determined by linking it to a so-called energy relevant variable (ERG in Dutch). The changes over time for such a variable determine the decrease or increase of the reference consumption. The ERG is connected to the activities, the performances or the social needs that require energy. It is expressed in physical, social or economic units, e.g. tons of steel production in the industrial sector or the number of households in the households sector. The definition and determination of savings thus entails choosing the relevant physical and socio-economic quantities. At a high aggregation level it is often not possible to use just one variable for calculating the reference consumption. Industry, for example, does not produce one single product where the production level would qualify as a good energy-relevant variable. In order to find suitable quantities lower des-aggregation levels of energy consumption have to be

sought, e.g. space heating in households or fertilizer production in the chemical industry. Some examples of ERGs for various reference consumptions are:

- aluminium production for the electricity consumption of the non-ferro sub-sector of base metal industry,
- the floor area of offices for the gas consumption of space heating in the services sector,
- hot water consumption of households for the gas consumption of tap water systems in households.

Base year and end year
Evaluation of energy savings entails a time span: the realised savings are always determined for a certain period of time. Therefore the protocol uses a base year and an end year (see Figure 2.1). In the base year, reference consumption and actual energy consumption are the same by definition. The difference between the two in the end year constitutes the savings after the base year.

Change in energy consumption and savings
The change in energy consumption is equal to the difference between observed energy consumption in the base year and that in the end year (see Figure 2.1). Energy savings lead to a change in energy consumption, but a change in energy consumption does certainly not equate savings. The energy consumption change refers to differences between base year and end year. Savings regard differences in the end year (i.e. reference consumption and realised energy consumption).

Efficiency improvement and savings
Next to 'savings' the term 'efficiency improvement' is often used. In the energy field the term efficiency refers to the conversion efficiency of power plants or central-heating boilers. Meanwhile efficiency is also used for the relation between a certain performance and the energy consumption of that performance. If the insulation of a dwelling decreases its energy consumption per m^2, this decrease is considered an efficiency improvement. The broader defined efficiency increase means the same as savings in the protocol, albeit that efficiency is often expressed in relative units.

2.2 Volume, structure and saving effects

Volume, structure and saving effects
The change that was observed in the energy consumption between base year and end year (see Figure 2.1) is attributed to three effects, namely:

- volume effect,
- structure effect,
- saving effect.

Figure 2.2 illustrates these volume, structure and saving effects.

Volume effect
Society shows a continuous increase of activities in various areas that often require extra energy. The extent of socio-economic activities is usually described by:

- gross domestic product (GDP) on a national level,
- value added or production volume in production sectors,
- total inland expenditure in households,
- transport performance in transportation.

These quantities are called 'volume quantities' here. If the volume of socio-economic activities grows, but all other factors remain unchanged, then the energy consumption will increase in accordance with the growth of the volume variable. On a national level, for example, this means that the total energy consumption increases with the same speed as GDP. The energy consumption development according to the socio-economic volume quantities is called 'volume energy consumption' in the protocol (see Figure 2.2).

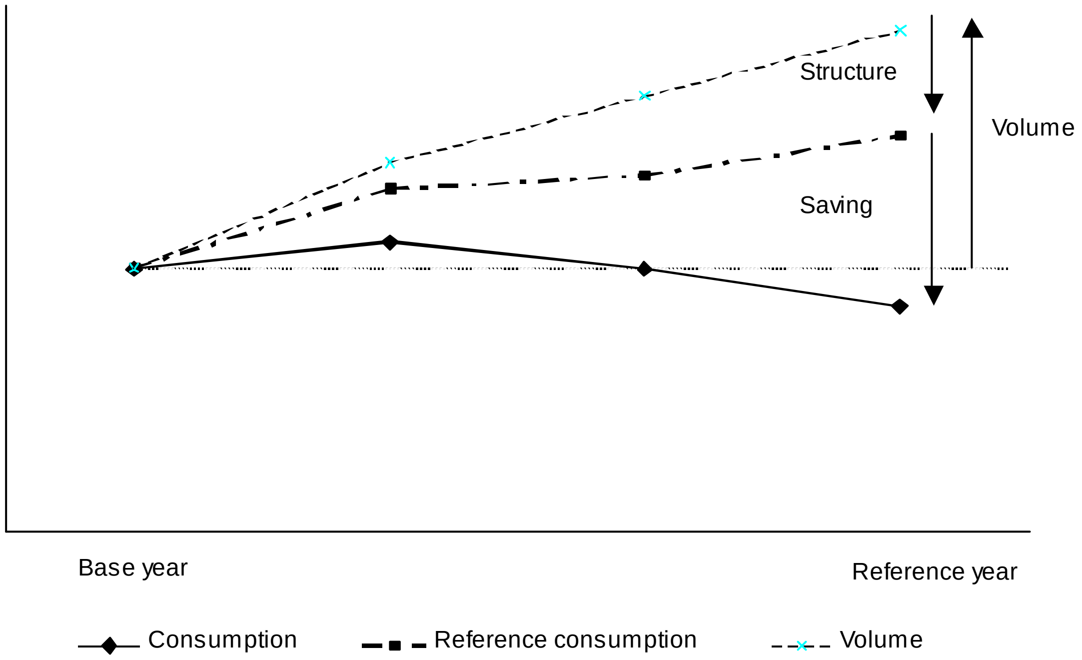

Figure 2.2 *Energy consumption developments and volume, structure and saving effect*

The volume effect is equal to the increase of the volume energy consumption compared to the energy consumption level in the base year. It is assumed here that the energy consumption increases proportional to the increase of the volume of the activity.

Structure effect

As described earlier, the development of the reference consumption is linked directly to the trend for an energy-relevant variable. This trend is not only influenced by volume developments, but also by various changes in the nature of the production and energy consumption that influence energy consumption (see Chapter 4 for examples per sector). The reference consumption usually develops along a different path than the volume energy consumption. This difference can be ascribed to changes in the structure of productive and consumptive activities and is called the 'structure effect'. The structure effect presented equals the difference between the reference consumption and the volume energy consumption in the end year. In Figure 2.2 the structure effect slows down energy consumption trends as the reference consumption increases less than the volume energy consumption. The structure effect can also have an energy consumption promoting character.

Saving effect

As described earlier, the saving effect equals the difference between reference consumption and observed energy consumption in the end year. Taken together, the volume, structure and saving effect account for the total change in realised energy consumption between base year and end year. Further explanation of the volume, structure and saving effect can be found in Chapter 4 and in the Protocol report (Boonekamp, 2001).

Energy intensity and specific energy consumption

In energy consumption analyses, the terms 'energy intensity' and 'specific energy consumption' are often used. The protocol method refers to the relation between energy consumption and (volume of) economic activity as the energy intensity (expressed in MJ/€). The term specific energy consumption is used here in cases where energy consumption is related to physical variables (e.g. MJ/ton steel or MJ/vehicle-km).

By definition, the volume effect no longer plays a role in the development of the energy intensity; the change in energy intensity is due to saving- and structure effects. For that reason, a decrease in energy intensity cannot be called savings or improved energy efficiency.

2.3 Energy consumption quantities

The protocol method adheres as much as possible to the statistical information of Statistics Netherlands (CBS). The energy statistics are published annually in the Dutch NEH (Nederlandse Energie Huishouding). However, for the protocol choices have to be made on which data to use, and the data will have to be processed. These adaptations are done in the MONIT system and will be discussed below (Boonekamp, 1998).

Energy consumption sectors

In statistics the division of energy consumers is based on SBI codes (Standard Industrial Classification of economic activities). In the Energy Balance format CBS distinguishes end user sectors (households, industry, transportation and other consumers) and energy sectors (refineries, electricity generation and other energy companies). Transportation comprises both transport companies, own freight transport of other companies and passenger cars in households. The category other energy consumers consists of agriculture and horticulture, construction and services (trade, commercial services and public services). Other energy companies consist of gas supply, coke plants and distribution companies. In this recent analysis the sector definition has been slightly altered due to the new division that was agreed upon in the framework of the formulation of sectoral indicative targets for CO_2 emissions (See Annex A).

In 1994 a new sector, decentralized (co-)generation of electricity, was introduced in the energy statistics of CBS. This sector involves mainly cogeneration plants that are administered by more than one party, e.g. an industrial company and an energy distribution company (so-called joint ventures). In the protocol calculations the joint venture capacity is transferred to the industrial sectors where the plant is physically present.

Energy carriers

Energy consumption means consumption of energy carriers such as coal, coke, crude oil or oil products, residual gases, electricity and steam or hot water. The consumption of various energy carriers can be added up as the energy content for every energy carrier has been defined (e.g. 31,65 MJ per m^3 natural gas). Energy carriers are often divided in primary energy carriers, such as crude oil, coal, uranium and natural gas, or secondary energy carriers such as motor fuels, electricity and heat. The energy companies transform primary energy carriers into secondary energy carriers that can be used by energy consumers.

Energy use

CBS provides an energy use figure for all sectors that equals:
- energy deliveries (+),
- own energy supply, among which renewable energy (+),
- energy deliveries to other sectors (-).

This energy use is corrected - if necessary- for changes in the stock of energy carriers at the site of the energy consumers.

Total Primary Energy consumption (TPEC)
Energy use at the national level is the Total Primary Energy consumption (TPEC). This quantity is the sum of all energy extraction and import, minus export and changes in the stocks of energy carriers. Export also includes bunkering, i.e. fuels bunkered by international shipping and aviation. The TPEC also equals the sum of energy use of all end users and energy suppliers.

Non-energetic energy consumption
According to the NEH approximately 14% of total energy consumption in the Netherlands was used for ‘non-energetic purposes’ in 1995. This is mainly the case in the chemical industry, where this energy consumption is usually referred to as ‘feedstocks’. In international analyses (e.g. IEA) the so-called ‘non-energy use’ is often not included. In the protocol, however, this energy consumption is included, but as a separate part of total energy consumption. In this way statements can also be made about the energetic applications of energy carriers only.

Temperature-corrected energy use
The average outdoor temperature during the heating season influences the energy consumption for space heating. In the past this effect amounted to approximately 10% in some years (see Figure 4.14). This stochastic effect hampers the analysis of energy consumption trends in relation to socio-economic trends and policy measures. Therefore the statistical energy consumption data are corrected for temperature. The part of the statistical energy consumption that is used for space heating is increased or decreased depending on the deviation of outdoor temperature from the 30-year average. The deviation is expressed in the number of degree days compared to the standard number of degree-days (3200 in the period 1960-1990). The largest corrections (in PJ) occur for gas consumption of dwellings and buildings, but heat deliveries from district heating systems show also substantial corrections.

Final energy consumption
The relation between final energy consumption and energy use is illustrated in Figure 2.3. Purchased energy carriers are converted at the consumer into the so-called final energy carriers heat and electricity. In particular production with cogeneration plants causes a (small) conversion loss. As a result total final energy consumption of a sector is smaller than total energy use. More important however is the fact that final energy consumption has a different composition than energy use. For instance electricity use of the paper industry regards only half of final electricity consumption; the remainder is produced in own cogeneration plants. Thus energy use does not offer a correct view of the real energy consumption of electricity within the sector. Therefore the protocol uses final energy consumption to adequately specify the relation between energy consumption and the activities for which the energy was used.

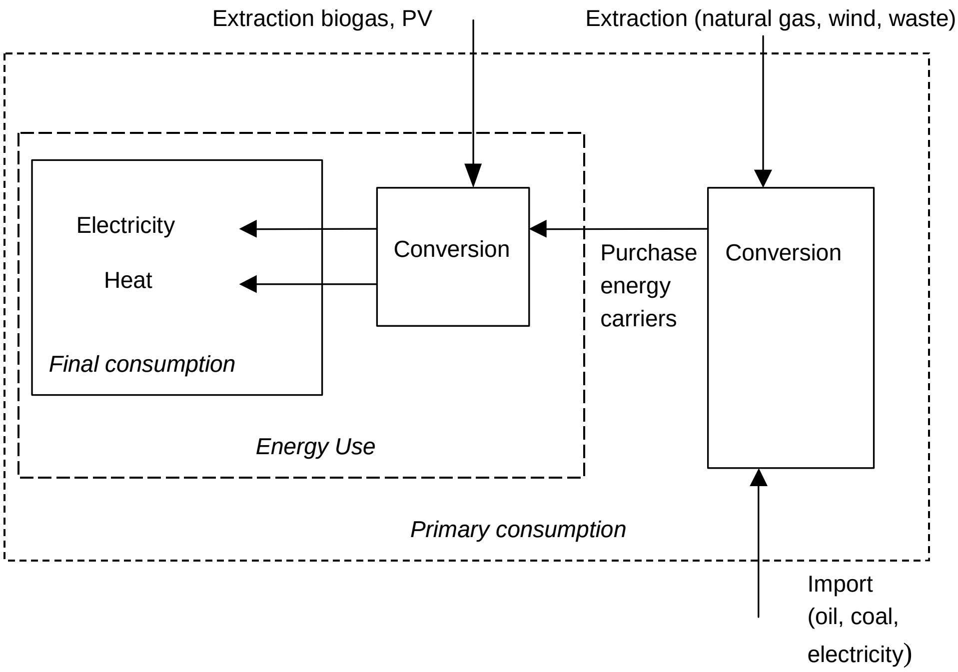

Figure 2.3 *Relation energy use with final energy consumption and primary energy consumption*

In addition, it appears in practice that the consumption and savings for final electricity consumption show a completely different pattern than final consumption of fuel/heat. This coheres with the very different applications of both energy carrier types. The same reasoning holds for non-energetic energy consumption. Thus, three nearly separated end use applications can be distinguished in the protocol method:
- final electricity consumption,
- final fuel/heat consumption,
- final non-energetic energy consumption.

The final electricity consumption is the sum of purchased electricity and own electricity production. In the transportation sector, the final fuel/heat consumption consists entirely of motor fuels. In other sectors, it is the sum of steam and hot water deliveries, own production of heat in cogeneration plants and heat from conversion of final fuel consumption (fuel, not used for cogeneration or used as feedstocks).

Energy consumption in primary units

One adaptation of the statistical data that is necessary for the protocol involves the translation of energy use into energy consumption in primary units. Total energy use of a sector is the aggregate of all energy carriers on the basis of their energy content. The highest-quality energy carrier electricity can be used everywhere with a very high conversion efficiency. Therefore large-scale application of electricity appears to have a positive effect on energy use trends. However, in order to deliver the electricity, power plants are facing substantial conversion losses. To provide a true insight into the developments, the losses that occur elsewhere should be taken into account.

The protocol therefore uses the quantity ‘energy consumption in primary units’ in end user sectors (see Figure 2.3). The energy consumption in primary units of an end user sector equals energy use times a correction factor per energy carrier, representing the losses that occur elsewhere due to the delivery of this energy carrier to the sector (see also the end of this section).

An important practical reason to use energy consumption in primary units is to unhide the saving effect of combined cogeneration production. This is illustrated in Figure 2.4 where the same amounts of heat and electricity are produced via either cogeneration or power station/boiler production. For cogeneration energy use is higher (100 to 90) but the energy consumption in primary units is lower (100 to 135). Thus, energy consumption in primary units is needed to visualise the saving effect of cogeneration.

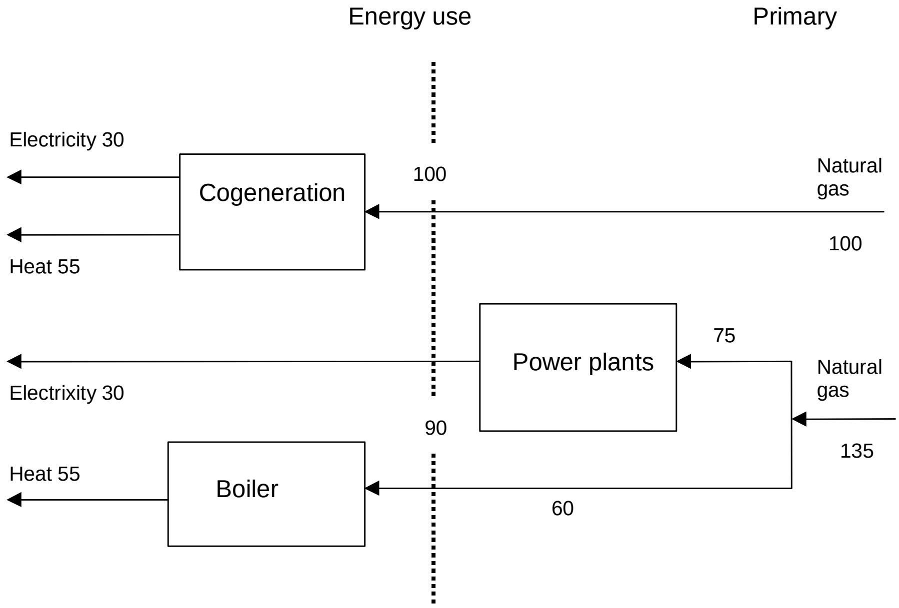

Figure 2.4 *Energy use and energy consumption in primary units for cogeneration and separate generation of heat and electricity*

Static and dynamic energy consumption in primary units
The energy consumption in primary units in a certain year can be determined using multiplication factors that apply to the year in question. The development of this 'dynamic energy consumption' in primary units is the result of energy consumption developments on the one hand and changes in the energy sectors on the other hand. For example, the dynamic energy consumption in primary units for households will decrease when electricity generation becomes more efficient, even if household will continue to consume the same amount of electricity.

The energy consumption in primary units can also be determined with fixed multiplication factors that apply to the base year: the so-called 'static energy consumption in primary units'. The development of this energy consumption variable is only influenced by developments at the end user. The static energy consumption in primary units provides a more transparent view of energy consumption trends for end users. In the protocol all energy consumption figures of the end use sectors are defined in primary units with fixed multiplication factors.

Multiplication factors
The multiplication factors that were used in the protocol indicate the conversion losses in the energy sectors. These factors are specified per type of energy carrier for a fixed base year (see Table 4.1). For the Dutch electricity supply the overall conversion efficiency (including grid losses) lies beneath 40%. This means that approximately 2.7 PJ fuel is needed to generate 1 PJ of electricity, or a multiplication factor of approximately 2.7. For oil products, the multiplication factor amounts to 1.05-1.10 and for natural gas to approximately 1.01. Grid supplied heat has a factor lower than 1, because less than 1 PJ extra fuel is needed to generate 1 PJ of heat from a power plant (see Table 4.1). In the calculation of the multiplication factor no distinction is made between energy consumer types; the value is based on the total deliveries of energy companies and is the same for all end users. The multiplication factors also apply to energy carriers that are used for non-energetic applications.

2.4 Calculation of savings per sector and national

In line with the preceding starting points a calculation scheme has been set up to actually calculate the energy savings. A condensed description of the scheme is given.

Sectors distinguished

The protocol distinguishes the following sectors[3]:

- Households
- Industry (including Construction)
- Agriculture and horticulture
- Services
- Transportation
- Refineries
- Electricity supply
- Other energy companies.

Where necessary for the analysis the sectors will be split up further but the results are only presented at sector and national level.

The protocol method determines figures on savings for:

- final energy consumption in 5 end user sectors and refineries,
- conversion in the same sectors (cogeneration production and heat delivery),
- conversion in electricity supply (more efficient plants and cogeneration).

Savings on final energy consumption

Final energy consumption per sector is divided into a number of applications with their own ERG (energy relevant variable). For each application the trend in the ERG is used to compose time series for the reference consumption. These figures per application are aggregated to sector level and compared to the figures for realised final energy consumption. The difference constitutes the savings on final energy consumption. As described earlier all energy consumption data are in static primary energy units. The savings on final energy consumption are also expressed in $PJ_{primary}$.

Savings from cogeneration

Savings by means of more efficient conversion at end users mainly involve cogeneration production. The savings are calculated by comparing the cogeneration input with the total input for separate heat and electricity production. The reference system for heat is a gas fuelled boiler with a sector-specific conversion efficiency. The reference system for electricity is central electricity production with its average conversion efficiency. The savings are calculated in PJ, both for the base year and the year of analysis. The increase in savings between both years is taken as the savings achieved with cogeneration.

Grid supplied heat to end use sectors also contributes to the savings of more efficient conversion, because this heat generally originates from cogeneration by electricity companies. The amount of savings is calculated by converting delivered heat into primary units and comparing this figure with the fuel consumption in case of own heat production. For grid supplied heat multiplication factor of only 0.5 is used (see also Section 2.3). As own heat production demands more than 1 unit of fuel per unit of heat grid supplied heat will lead to savings for the end use sector.

[3] See Annex A for sector definitions.

Savings in electricity production

The savings of energy companies regard refineries and electricity production. The savings of refineries are calculated in a similar manner as in industry. The conversion losses of power plants are calculated per type of plant (coal, waste combustion, nuclear and gas). This is done both for the actual efficiencies and for the base year efficiencies. The differences per type of plant are aggregated, resulting in total savings (in PJ) for power plants. This approach forestalls shifts in fuel mix influencing the savings. The savings of extra cogeneration by electricity companies are calculated in the same manner as with cogeneration of end users.

Sectoral and national savings

The savings (in PJ) of final energy consumption and cogeneration are added to determine total sectoral savings. Aggregate sector savings and that of power plants constitute national savings. Linking this result to the TPEC finally results in the national savings percentage.

Uncertainty analysis

All input data are subject to an uncertainty margin. In addition, a margin is ascribed to the relationship between ERG and the reference consumption. This margin indicates how well the ERG trend 'predicts' energy consumption in case of no savings. Using a Monte-Carlo algorithm, the margins in the inputs are translated into a margin in the calculated saving results. Because of the so-called 'law of the large numbers' the margin in the national saving figure is smaller than the margin for the sectors. The margins are also smaller as the length of the period increases (see Gijsen, 2003). Due to the relatively large uncertainty, especially in the data of the most recent year, the protocol method uses average values that include the previous two years. This also decreases the uncertainty margin.

3. ENERGY SAVINGS 1995 - 2002

3.1 Calculation method and input data

The method applied here to calculate savings in conformity with the protocol energy savings has been described in the previous chapter. In this report 1995 is used as the base year; in previous analyses 1990 was used as the base year (Boonekamp, 2002; Vreuls, 2003). One reason to change the base year was the need for a new approach in industry, which demanded data that were not available for previous years (see Chapter 4). The change in base year was seized as an opportunity to apply minor changes in the determination of savings in other sectors as well.

All energy consumption data used are retrieved from the MONIT system of ECN (Boonekamp, 1998) that relies heavy on CBS energy statistics. In MONIT the CBS data are corrected for yearly variations in outdoor temperature; moreover industrial cogeneration production is transferred from decentralized production to industry. Also determined are final end use and the multiplication factors (see Chapter 2) that are needed in the analysis of savings. The socio-economic and physical data needed have been taken from various sources (see Chapter 4).

3.2 Savings per sector and national

The savings as of 2002[4] are determined as an average for the period 1995-2002, distinguishing between:

- end use sectors: households, industry[5], agriculture/horticulture, services and transportation[6],
- energy sectors: refineries and electricity supply,
- the national level (see Table 3.1).

For end use sectors and refineries both the savings on final energy consumption and the effect of more efficient conversion (cogeneration production and heat deliveries) have been determined. The savings in the electricity sector are displayed under ‘national’. Total national savings turn out to amount to 1% per year; per sector the annual savings vary between 0.4 and 1.7%. The contribution of more efficient conversion amounts to approximately 0.2 to 0.6% for the relevant sectors.

Table 3.1 *Saving results for the period 1995-2002*

[mean % per year]	National	Industry	Services	Households	Agriculture	Transport	Refineries
Final consumption	-0.7	-0.8	0.0	-1.2	-1.1	-0.4	-0.8
Cogeneration end users	-0.2	-0.2	-0.5	0.0	-0.6	0.0	-0.2
Power station	-0.1						
Cogeneration energy sector	0.0						
Total	-1.0	-1.0	-0.5	-1.2	-1.7	-0.4	-1.0

The determination of savings in each sector is explained in Chapter 4. The following remarks on the results can already be made:

- For Services it was impossible to determine a figure for savings in final energy consumption. A suitable variable to calculate the reference consumption was not available and the energy consumption data were unreliable (see also Chapter 3.3). There is no reason to as-

[4] The energy consumption data for 2002 have been averaged with that of the previous two years before the results were determined

[5] Including construction, coke plants and decentralized cogeneration production.

[6] Including mobile equipment in Agriculture and Horticulture, Construction and Services.

sume that dissavings have occurred given the realisation of low energy new buildings. However, savings cannot be proved either. The final savings have been set at nil for practical reasons, as the national savings figure is not influenced by an (unreliable) negative figure for Services. The cogeneration savings for Services have been determined, though.
- In industry, the figure on savings is related to total energy consumption including feedstocks. This figure is not directly comparable to that from the LTA evaluations (based on consumption for energetic purposes only).
- Cogeneration savings for Services and Agriculture include also savings due to grid-supplied heat (from cogeneration elsewhere). Cogeneration in industry includes both own production and joint-venture (decentralized) production.

3.3 Volume, structure and saving effects

In Figure 3.1 the actual change in national energy consumption is divided into so-called volume, structure and saving effects. At the national level the volume effect is the (hypothetical) increase in total energy consumption in conformity with the growth of GDP. At the sectoral level an energy consumption trend can be determined on the basis of the volume development per sector: growth of value added in industry, growth of number of households in the domestic sector, growth of haulage in the transportation sector, etcetera. Together this results in a smaller growth of total energy consumption. This difference is represented by the main structure effect. Within the sectors all kind of changes (not savings) are taking place that affect energy consumption. This structure effect is sometimes positive, i.e. more electrical appliances per household, and sometimes negative, i.e. a more energy-extensive production structure in industry. Over all sectors the structure effect leads to relatively larger energy consumption (see Figure 3.1). Finally a number of saving effects are shown. The sum of saving, structure and volume effects delivers by definition the mutation in energy consumption.

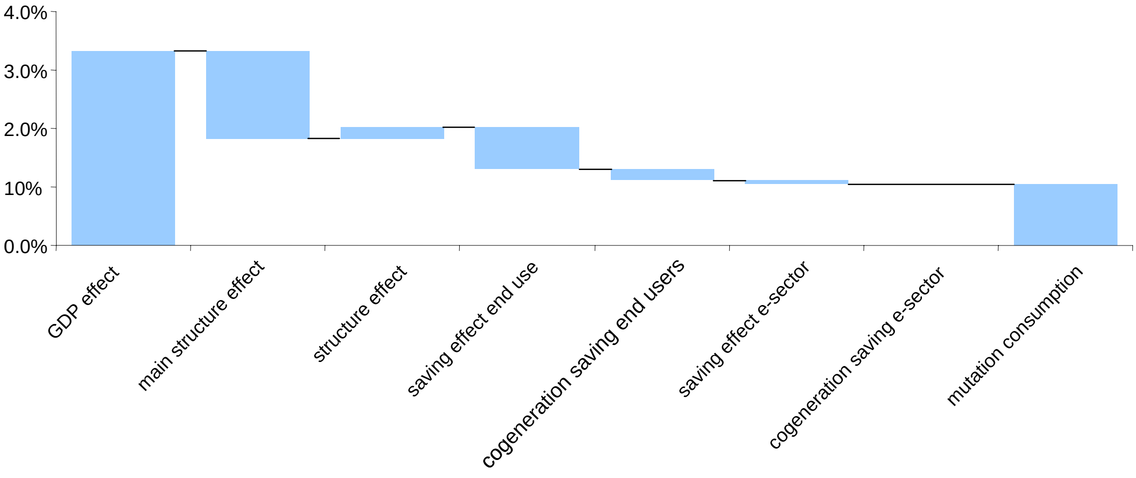

Figure 3.1 *Decomposition of change in national energy consumption 1995-2002*

3.4 Uncertainty margins in the results

In (Gijsen, 2004) the uncertainty margins for the savings figures have been analysed. The amount of uncertainty is determined by three factors:
- the error margin in the energy data for the base year and all analysed years,
- the error margin in the value of the ERG (energy relevant variable)
- the quality of the ERG as 'predictor' of energy consumption without savings.

The margins in all inputs have been translated into a margin for total savings per sector and national savings, using a stochastic Monte Carlo simulation method The margin in the national savings figure for 2002 amounts to 0.3%-point; the margins for the different sectors are higher (see Annex C, table C.1). For Services the uncertainty was so high that is was impossible to present any figure on savings on final energy consumption. This uncertainty was due to a lack of suitable ERG-quantities to determine the correct reference consumption and the bad quality of the energy consumption data.

3.5 Trend in development of savings

Table 3.2 provides the national savings data for various periods as of 1995. From these data it can be concluded that the rate of savings is gradually decreasing, both for final energy consumption and for cogeneration and power plants.

When drawing conclusions one should take into account on the one hand the rather large uncertainty margins in the results, especially for final energy consumption. On the other hand, it should be noted that this trend appears in various sectors and is also supported by supplementary analyses (see Chapter 4).

Table 3.2 *Trend in national savings as of 1995*

[mean % per year]	1995-2000	1995-2001	1995-2002
Final energy consumption	0.8	0.8	0.7
Cogeneration and power plants	0.4	0.3	0.3
Total	1.2	1.1	1.0

4. SECTORAL ENERGY CONSUMPTION AND SAVINGS TRENDS

4.1 Introduction

In this chapter the determination of the amount of savings per sector is explained into more detail. Also the underlying energy consumption developments per sector are analysed. This includes, among others, the development of energy intensities over time and sector specific trends: stabilisation of electricity consumption in households, shifts in the sector structure in industry, the influence of assimilation lighting in horticulture, etcetera. The analysis period is extended to 1990-2002, as to put the energy developments in the general policy perspective since Kyoto.

Finally it must be noted that all energy consumption figures are corrected for yearly variations in mean outdoor temperature in the heating season, unless stated otherwise.

Used multiplication factors

As described earlier in Chapter 2, the protocol method uses energy consumption data in primary units. In this respect, the consumption of each energy carrier is multiplied by a specific multiplication factor. The multiplication factor is based on the conversion losses that occurred in base year 1995, in order to deliver the energy carrier to the end use sectors. Table 4.1 presents the multiplication factors for 1995 that were used in the protocol calculations. For the purpose of comparison the values of 2002 have been provided too.

Table 4.1 *Used multiplication factors per energy carrier*

	Multiplication factors	
	1995	2002
Coal/coke	1,087	1,051
Oil products	1,070	1,080
Natural gas	1,012	1,018
Heat (delivered)	0.5	0.5
Electricity	2,746	2,689

Explanation of multiplication factors

The conversion losses of coke production determine the multiplication factor for coal and coke. The multiplication factor decreased after 1995, due to closing down one of the two production locations (see Section 4.9). The utilities energy consumption of refineries determines the multiplication factor for oil products. That factor increased due to extra processing of crude oil because of higher product quality demands (see Section 4.7). In gas supply natural gas - and recently also electricity - is used for compressors. The multiplication factor increases because more and more compression is needed as a result of decreasing pressure in the main gas fields. The multiplication factor for grid supplied heat is a value determined on the basis of an assessment of the extra PJ of fuel that are needed in electricity production to supply a PJ of heat. As this heat would otherwise have been dumped into the cooling water, this heat is partly ‘free of charge’, resulting in a multiplication factor of less than 1. The fuel input of power plants, insofar fuel is not ascribed to heat production, determines the multiplication factor for electricity. This multiplication factor also covers production in waste combustion plants and grid losses of distribution companies (see Section 4.8).

4.2 Households

Development of savings according to protocol method

In the protocol method sectoral energy consumption is divided into different segments or applications, each with its own ERG-quantity (see Chapter 2). For households the following applications and ERG-variables apply:

- fuel and heat for space heating (number of households),
- fuel and heat for hot tap water (number of inhabitants),
- electricity consumption for appliances and lighting (overall penetration degree).[7]

Without savings each energy consumption segment is assumed to increase in conformity with the growth of the ERG-quantity specified. The aggregate of all applications, transferred to primary energy units, constitutes the reference consumption. This energy consumption appears to increase faster than the total statistical energy consumption (corrected for temperature), meaning that savings are realised indeed. Table 4.2 shows the calculated savings expressed in a mean percentage per year. Because of uncertainties in the data for the last observed year an average value, including the previous two years, has been constructed. The savings on final energy consumption amount to 1.2% for the period 1995-2002. Since the end of the nineties, the savings appear to decrease slightly, from 1.4% to 1.2%.

Table 4.2 *Development of savings for Households, according to the protocol method*

[%/year]	1995-1999	1995-2000	1995-2001	1995-2002
Final energy consumption	1.4	1.2 - 1.3	1.1 - 1.2	1.2
Cogeneration and district heating	*0.0*	*0.0*	*0.0*	*0.0*
Total	1.4	1.2 - 1.3	1.1 - 1.2	1.2

Next to final energy consumption, other savings can be realised in the households sector through the application of district heating. The number of connections has increased with 50% as of 1990. The total heat delivery has barely increased though (according to statistics and corrected for temperature) because the heat consumption per household has decreased significantly. To the extent that this is the result of savings on heat demand, it is taken along in the saving figure for final energy consumption. As no extra heat has been produced compared to 1995, nor any change in the production, no extra savings have been realised for district heating. As a consequence no savings can be ascribed to the households sector (see Table 4.2).

Volume, structure and saving effects

The limited increase of energy consumption in the households sector is the result of relatively large, yet opposing, effects (see Figure 4.1).

[7] The overall penetration rate is an average of the increase of the penetration rates of all large households appliances, weighed for the electricity consumption per appliance.

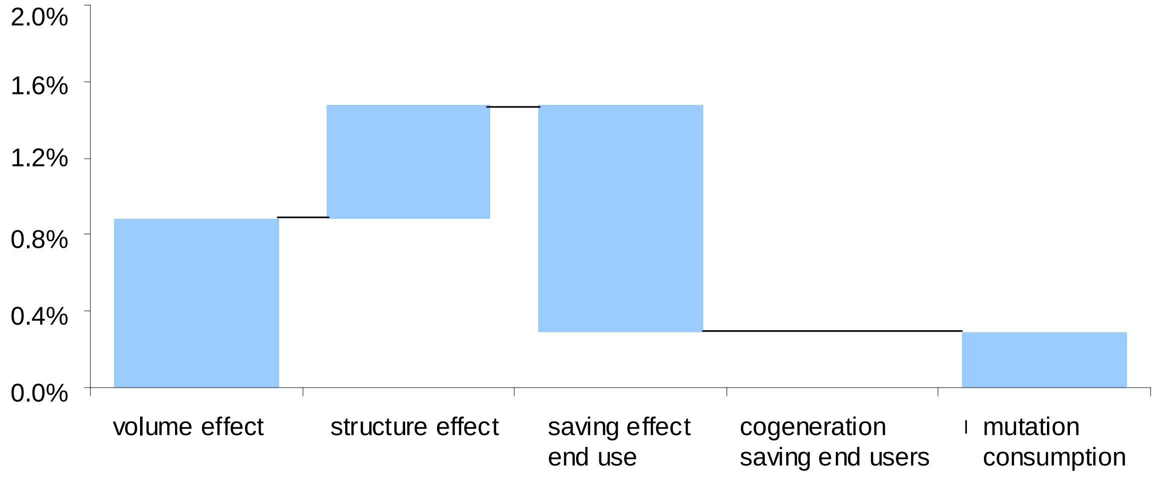

Figure 4.1 *Volume, structure and saving effects for Households 1995-2002*

The volume effect involves the energy consumption increase in conformity with the growth of the number of households. The structure effect entails:

- a faster increase in the number of dwellings compared to the number of households (application space heating),
- a decrease in the average size of households (application hot water consumption),
- an increase in the number of large household appliances per household (application electricity for appliances).

Together, these three structural trends lead to a larger energy consumption increase than could be expected on basis of the number of households; the structure effect comes on top of the volume effect (see Figure 4.1). If the saving effects are taken into account too, the energy consumption increase amounts to only 0.3% per year.

Next to the above-mentioned factors other factors have also influenced energy consumption, among which:

- decreasing occupation of the dwelling (due to increased labour participation),
- more intensive use of appliances,
- higher settings for space heating thermostat.

These factors are not part of the structure effect, though. Any possible effect on energy consumption of these factors will be part of the saving effect.

Background energy consumption developments in Households

In the period 1990-2002 the number of inhabitants has increased with 0.6 to 0.7% per year and the number of households has increased with 1.2%. Household expenditures have increased on average with 2.8%. The increase in energy consumption (corrected for temperature) is very limited, i.e. 460 to 467 PJ. There have been very few changes in the fuel mix over the last decades. Important fuels are gas, electricity and grid supplied heat. The electricity consumption increased with 38% in the period 1990-2002; gas consumption decreased with 2-3%; heat consumption increased strongly from 5.6 to 7.7 PJ, but the share remained limited. Because the share of electricity consumption increases from 13% to 18%, primary energy consumption increases more strongly than energy consumption itself, i.e. with 5%.

In Figure 4.2, the growth of final consumption of heat and electricity is compared to that of population and number of households. Contrary to the growth trend for electricity per household the trend for heat shows almost stabilisation. It should be noted that the intensity of fuel consumption develops even more favourably, because the average boiler efficiency has increased.

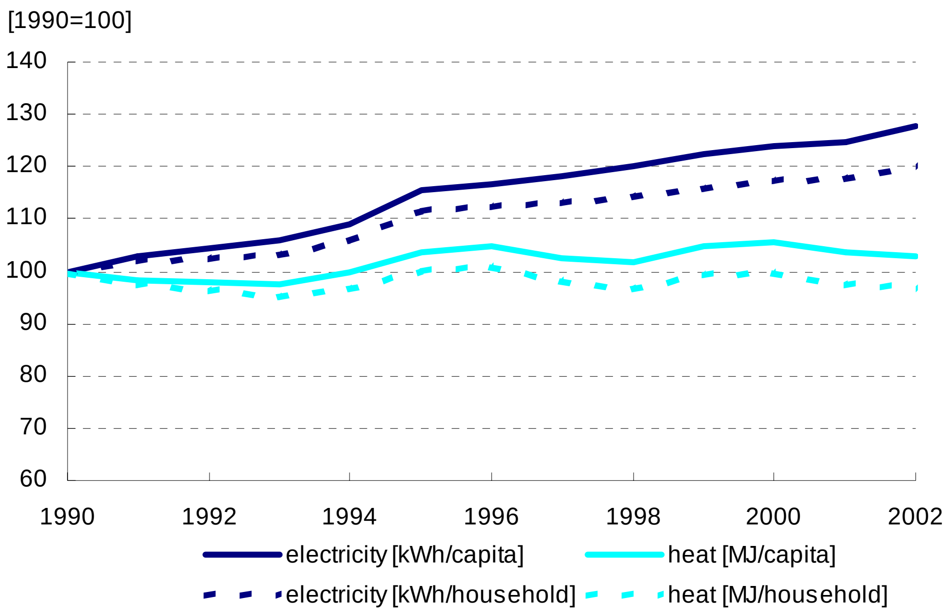

Figure 4.2 *Heat and electricity intensity for Households 1990-2002*

Domestic energy consumption can be divided according to energy functions: space heating, hot tap water, cleaning, cooking, refrigerating, lighting and other appliances. The energy consumption trends per application for the period 1990-2000 are provided in Figure 4.3.

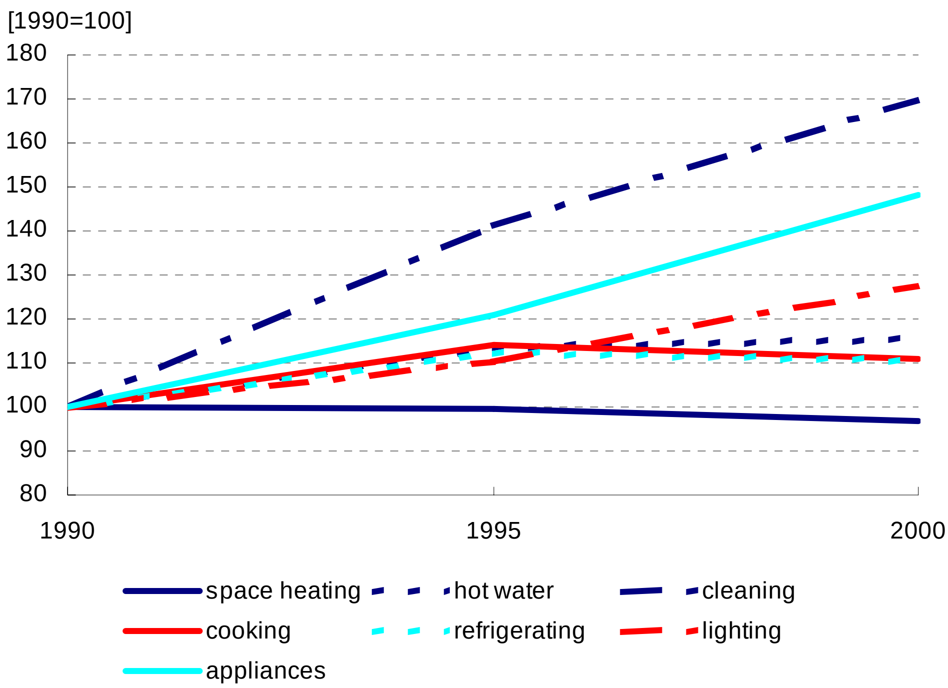

Figure 4.3 *Primary energy consumption per energy function for Households (1990=100)*

For the sake of comparability electricity consumption has been converted into primary energy consumption. The trends per energy function are based on a separate analysis with the simulation model of historic household energy consumption (Boonekamp, 1997). The energy consumption for space heating decreases a bit due to insulation, high efficiency boilers and more energy-efficient new dwellings. The energy consumption for cleaning increases the most, due to the penetration of the clothes dryer. The energy consumption of other appliances increases too as a result of a large increase in ownership of various appliances. However, since the energy consumption of these appliances is small, the total primary energy consumption increases only slightly.

The growth of expenditures, expressed in billion €, is often seen as an important cause for increasing energy consumption. Figure 4.3 demonstrates that this is mainly the case for energy functions where electricity consumption plays a role. Table 4.3 illustrates the relation with expenditures for different periods.

Table 4.3 *Growth of expenditures and electricity consumption for Households*

[%/year]	1990-1994	1994-1998	1998-2002	1990-2002
Expenditures	2.3	3.4	2.6	2.8
Expenditures per household	0.8	2.4	1.6	1.6
Final electricity	2.9	3.0	2.3	2.7
Final electricity per household	1.4	2.0	1.3	1.5
Electricity compared to expenditures	+0.6	-0.4	-0.3	-0.1

Until 1994, electricity consumption appears to increase more rapidly than expenditures (intensity +0.6%, but with a larger income increase in the period 1994-1998 the electricity consumption increase lags behind (intensity -0.4%). This unlinking remains intact with a decreasing growth of expenditures after 1998. This could point to a structural saturation trend in which several electric appliances such as the dryer and dishwasher have reached their maximum penetration and no new ‘heavy’ energy consumption devices developing.

4.3 Industry (including construction)

Development of savings according to the protocol method

The energy consumption in construction and coke plants (4% and 1% of industrial energy consumption respectively) has also been ascribed to industry. That coheres with the definition of sectors used in the formulation of indicative targets for sectoral CO_2 emissions.

To determine savings total industrial energy consumption is divided into the three applications electricity, fuel/heat and feedstock, as well as the following subsectors:

- food and beverages,
- chemical industry,
- iron and steel production,
- non-ferro (aluminium, zinc),
- paper and printing,
- building materials,
- other metal,
- other industry.

Neelis (2004) has determined the development of the reference consumption for the first six subsectors (i.e. excluding other metal and other industry). For these subsectors electricity and heat consumption in the base year is ascribed to a number of physical products. Energy consumption is scaled in conformity with the development of physical production[8]. The reference consumption for ‘other metal’ and ‘other industry’ is determined using the trend in sales in con-

[8] In earlier protocol analysis the reference energy consumption was retrieved from the evaluation of the LTAs.

stant prices. The total reference consumption thus determined, minus the statistical energy consumption, results in savings on final energy consumption.

Table 4.4 provides the calculated savings as an average from 1995 until the year in question. The savings on final energy consumption appear to decrease since 2000, namely from 1.0% to 0.8% per year. It should be noted that physical data for the year 2002 were not available in the food and chemical industry and non-ferro. Therefore the last year was partly based on estimates. However, this has only a limited effect on the margin for 2002 as the figures for 2002 have been averaged with that of the two previous years.

Table 4.4 *Development of savings in Industry according to the protocol method*

[%/year]	1995-2000	1995-2001	1995-2002
Final energy consumption	1.0	1.0	0.8
Cogeneration and heat delivery	*0.1 - 0.2*	*0.1 - 0.2*	*0.2*
Total	1.1 - 1.2	1.1 - 1.2	1.0

Note: Industry including Building industry and coke plants.

Next to final energy consumption, the application of cogeneration also leads to savings. Savings from cogeneration in industry originate from:

- own cogeneration production,
- decentralized (cogeneration) production in industrial companies,
- grid supplied heat from cogeneration production elsewhere (small contribution).

As can be seen in Table 4.4 cogeneration has delivered a substantial contribution to the total industrial savings (see also the extended analysis of cogeneration savings in Chapter 5).

Volume, structure and saving effects

The increased energy consumption of industry is the result of relatively large, yet opposing, effects (see Figure 4.4). The volume effect involves the energy consumption increase following the growth of total value added in industry. The structure effect involves:

- the shift between the shares of energy-intensive and energy-extensive subsectors in total value added,
- changes in the relation between the total value added and the physical production in the six subsectors analysed,
- changes in the relation between the total value added and the sales in constant prices (other metal and other industry).

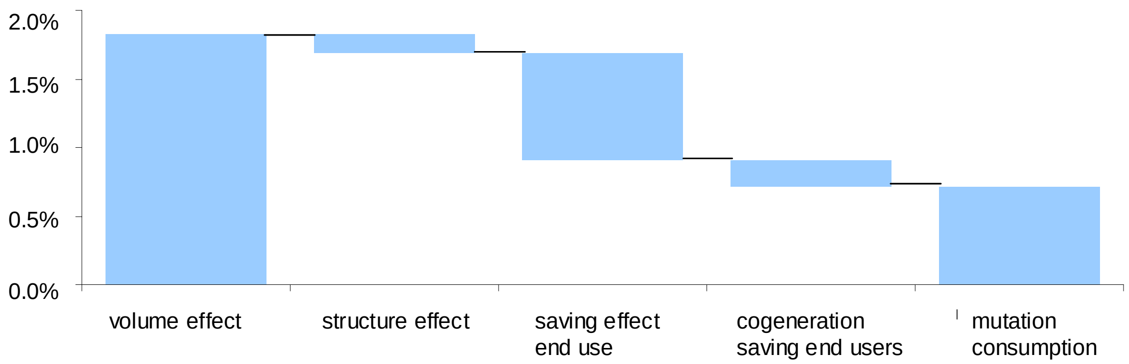

Figure 4.4 *Volume, structure and saving effects in Industry (including construction) 1995-2002*

Together, these developments lead to a slightly smaller energy consumption increase than would have been the case according to the value added trend for industry; the structure effect compensates the volume effect for a small part (see Figure 4.4). When the different saving effects are included, the energy consumption increase amounts to 0.7% per year.

Other factors than mentioned previously (excluding savings) influence energy consumption too. These are not part of the structure effect though. Some examples are:
- extra operations for physical bulk products (e.g. coating of steel),
- extra measures due to safety regulations or environmental regulations,
- physical production trends in other metal and other industry that deviated from sales trends,
- changes in the rate of capacity utilisation of energy intensive production processes.

The possible energy consumption effect of these factors is included in the saving effect.

Background energy consumption developments in industry
The analysis limits itself to the industry only, without the (relatively small) energy consumption of construction and coke plants. This facilitates the comparability of the results with that of other studies and data sources.

The total energy consumption in the period 1990-2002 varies between 960 and 1132 PJ (corrected for temperature). On balance the increase amounts to 17% (1.3%/year). Figure 4.5 shows that oil consumption is increasing the most, especially for use as feedstock (+4.6% per year). Electricity consumption decreases because more and more electricity comes from own generation. As a result of the decreasing share of electricity, total energy consumption in primary units increases with 12% only.

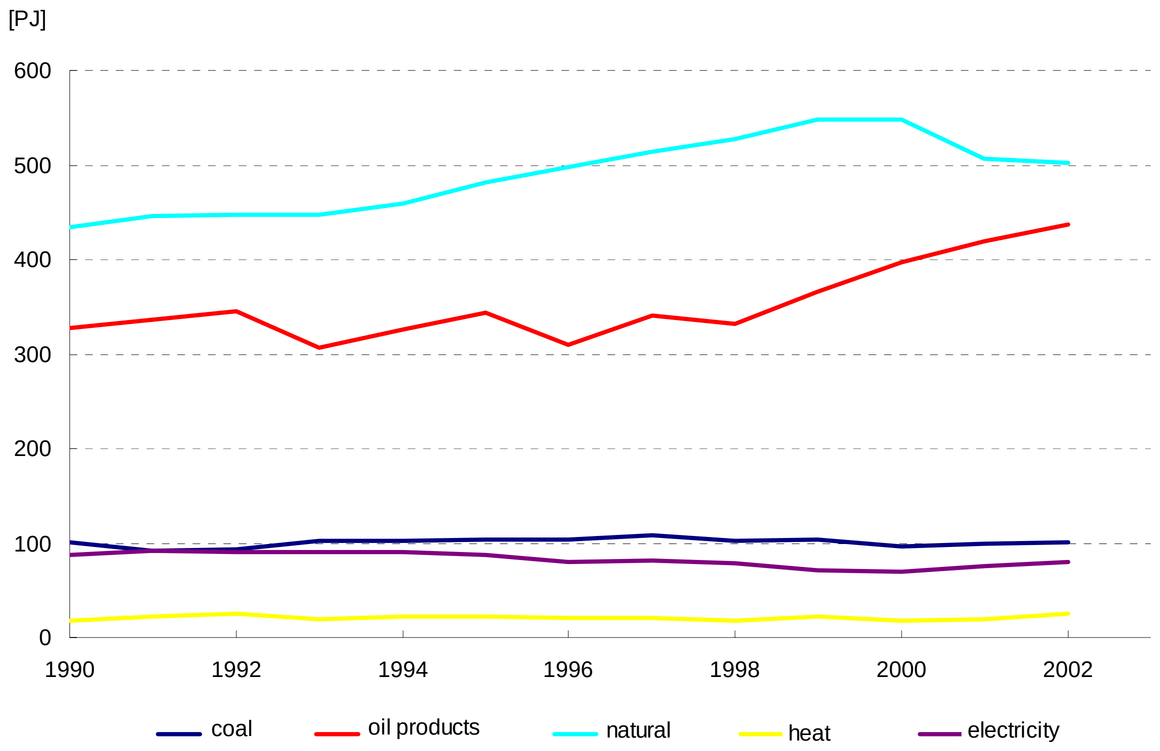

Figure 4.5 *Consumption per energy carrier in Industry 1990-2002 (excluding construction)*

The industry is divided in subsectors food and beverages, base metal, chemicals, paper, other metal, building materials and other industry. The primary energy consumption of the chemical industry is by far the largest. Its fraction in industrial energy consumption is still increasing, especially in later years (57 to 60%). Base metal follows with a share of 15% in 1990 that has slightly decreased in 2002. The share of food and beverages increases from 9% to 10%; the share of building materials decreases relatively strongly (4.4% to 3.1%), as does the share of other industry (5.0% to 3.6%). The subsectors paper and other metal maintain their share (approximately 4% and 6% respectively).

In final energy demand three distinctive applications are distinguished:
- heat production in boilers, furnaces, etcetera,
- electricity consumption,
- use of energy carriers as feedstocks.

Figure 4.6 shows the ratio of final energy demand to production, expressed in € value added. Final electricity demand, covered by cogeneration or the grid, increases nearly as fast as value added in the period 1990-2002 (1.7 and 1.8% per year respectively). From 1990 tot 2002 the feedstock energy consumption increases similarly to the value added. But this is the result of a remarkable trend break in the mid nineties. Final heat demand barely increases; the heat intensity decreases with 1.6% per year on average. But in this case too, a remarkable change in the trend is visible recently. It must be remarked that a recent investigation of CBS indicates that the observed shift in later years, from fuel use to feedstock use, has to be revised.

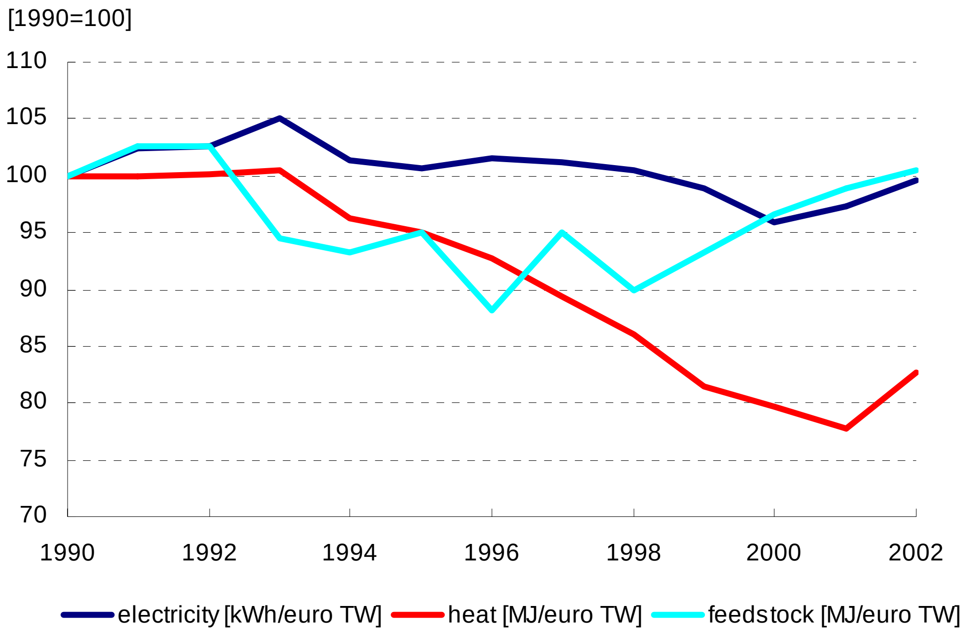

Figure 4.6 *Electricity, heat and feedstock intensity for Industry 1990-2002*

Table 4.5 describes the economic development of the most energy-intensive sectors and of total industry. It shows that the most energy-intensive part of industry, the chemical industry, grew faster than total industry in the period 1990-2002. In eight out of the twelve years in this period, the growth of chemicals exceeds that of total industry. Other energy-intensive subsectors, such as base metal and paper, grew slower than total industry. But all in all, the subsector developments between 1990 and 2002 have led to a more energy-intensive production structure, especially in the last four years.

Table 4.5 *Annual growth rate value added of industry and energy-intensive subsectors*

	90-91	91-92	92-93	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	90-02
Industry	0.6	1.0	-1.7	6.8	3.2	0.4	3.5	3.0	3.0	3.9	-0.9	-1.2	1.8
Chemicals	-3.7	-3.3	0.2	10.9	6.4	-3.7	5.3	-0.4	6.7	7.9	3.5	2.9	2.6
Base metal	-3.3	-7.0	-2.5	9.6	1.1	-2.4	8.3	2.0	0.3	1.7	-1.3	-1.9	0.3
Paper	2.6	0.6	-0.1	4.3	0.8	1.8	4.4	5.8	1.4	1.9	-1.6	-3.1	1.5

Apart from shifts between subsectors other developments within the subsectors are also important for the relation between total production and total energy consumption. Figure 4.7 and 4.8 provide the trends for the most important sectors with regard to the electricity and heat intensity. For electricity, the intensities are always close to the level of 1990, except for the chemical industry since of 1998. For heat, a downward trend can be seen for all sectors, with the exception of base metal that first shows an increase from 1990 on. Here, the differences between the subsectors are larger than for electricity.

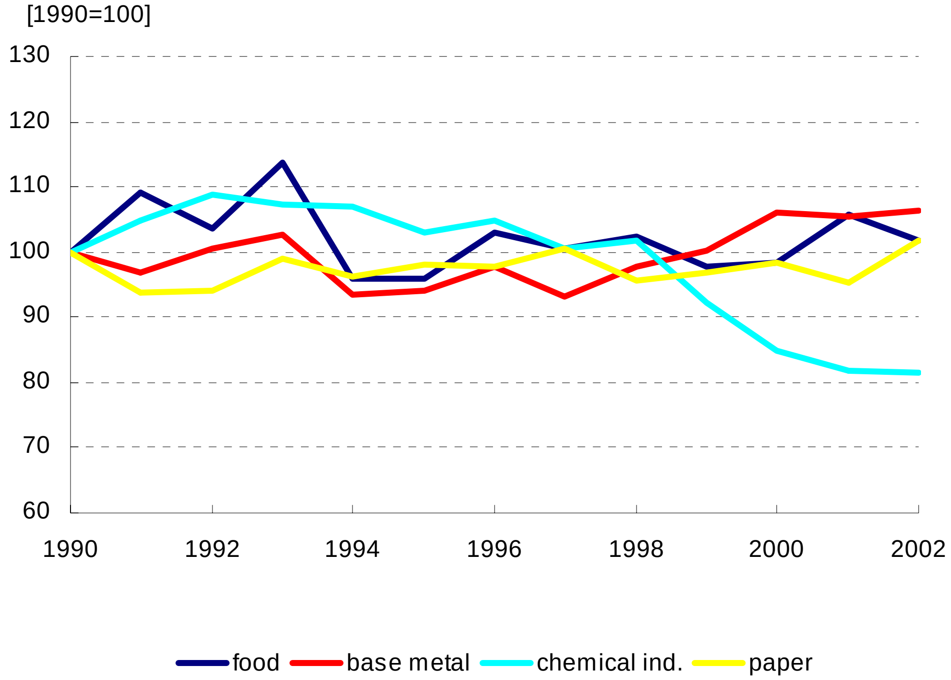

Figure 4.7 *Final intensity of electricity consumption in industrial sectors [MJ/€]*

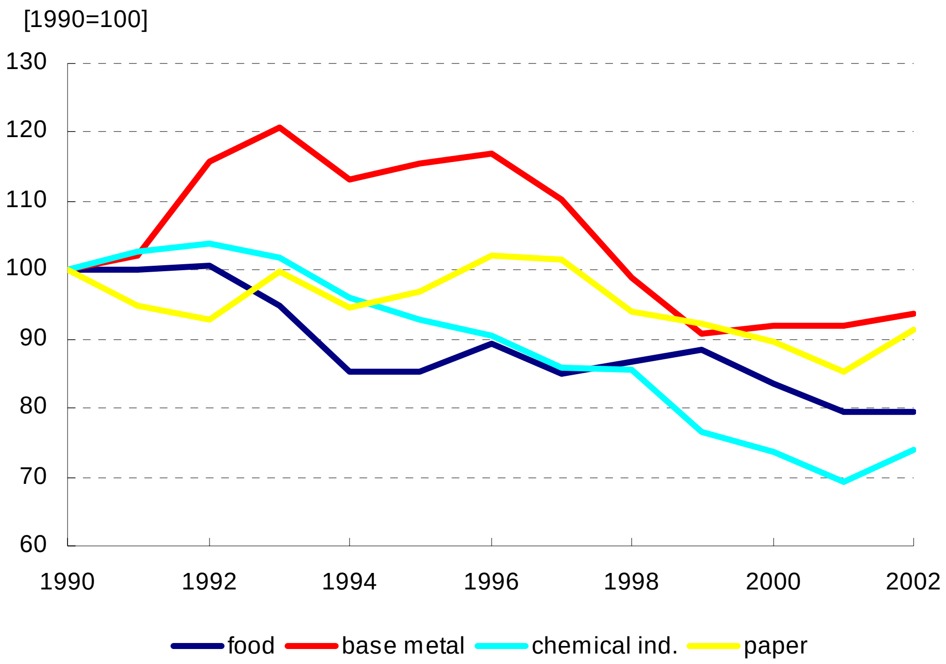

Figure 4.8 *Final intensity of heat consumption in industrial sectors [MJ/€]*

The favourable final intensity trends in the subsectors, especially for heat, compensate for the upward energy consumption effect of the less favourable sector structure. For feedstock energy consumption a decoupling appears to occur with value added after 1990, but this is totally counterbalanced by the very substantial growth between 1998 and 2002 (see Figure 4.6). All in all this results in total primary energy consumption that shows a smaller growth (1%) than industrial production (1.8%).

In industry it is often assumed that a larger than average growth coincides with dematerialisation, due to a lagging physical growth, and decreasing energy intensities. However, no relationship has been found here between a high growth rate of value added and a decoupling between economy and energy. Other factors seem to play a role in the development of the intensities, such as the strongly fluctuating profit margins in the world market and the attractiveness of the Netherlands as production location within Europe.

4.4 Agriculture and horticulture

Development of savings according to the protocol method

The consumption of motor fuels for mobile equipment (tractors) in agriculture has been ascribed to the transportation sector. The energy consumption of agriculture and horticulture is divided into two segments, each with their own ERG-variable:

- greenhouse horticulture (horticulture production),
- other agriculture and horticulture (sales volume).

For greenhouse horticulture it is assumed that, without savings, electricity and heat consumption will increase in conformity to the amount of products, as determined by the Agricultural Economics Research Institute LEI (Knijff, 2003). For other agriculture and horticulture the reference consumption increases in conformity with the sales in €1995. The difference between total reference consumption and statistical energy consumption (corrected for temperature) leads to the savings shown in Table 4.6.

Table 4.6 *Development of savings in Agriculture and horticulture, according to the protocol method*

	1995-1999	1995-2000	1995-2001	1995-2002
Final energy consumption	0.6	0.5	1.1	1.1
Cogeneration and heat delivery	*0.8*	*0.7*	*0.6*	*0.6*
Total	1.4	1.2	1.7	1.7

Note: excluding energy consumption of mobile equipment.

Savings on final energy consumption appear to have fluctuated strongly in recent years; in 2001 and 2002 it is twice as high as in preceding years. This coheres with the significant year-to-year fluctuations in the efficiency index that is published annually by LEI (Knijff, 2003).

In greenhouse horticulture savings are also realised through cogeneration, such as:
- own cogeneration units (gas engines),
- gas engines of distribution companies at greenhouses,
- waste heat from large conventional power plants,
- large-scale STAGs in joint venture ownership.

The last three options show in statistics as heat delivered to the sector agriculture and horticulture. In the protocol method the savings ascribed to delivered heat are comparable to that of own cogeneration. As can be seen in Table 4.6, cogeneration and delivered heat have made a large contribution to total savings in the period 1990-2002 (see also extended analysis of cogeneration savings in Chapter 5).

Volume, structure and saving effects
The increased energy consumption in agriculture and horticulture is the result of opposite effects (see Figure 4.9). The volume effect is the energy consumption increase in conformity to growth of total value added. The structure effect entails:
- shifts between the value added shares of the two subsectors,
- changes in the relation between value added and physical production in greenhouse horticulture,
- changes in the relation between value added and sales in other agriculture and horticulture.

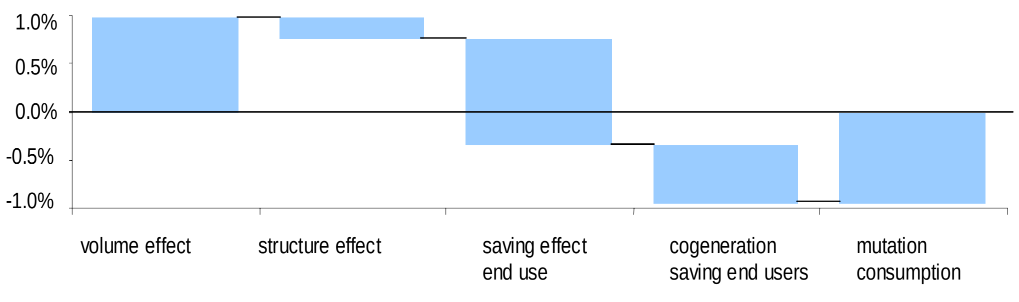

Figure 4.9 *Volume, structure and saving effects in Agriculture and horticulture 1995-2002*

Together, these structural developments lead to a slightly smaller energy consumption increase than would have been the case according to the volume development (see Figure 4.9). Therefore the structure effect compensates for part of the volume effect. When the various saving effects are taken into account a 1% energy consumption decrease per year results.

Next to the above-mentioned factors there are also other factors that influence energy consumption. These are not part of the structure effect though. Examples are the differences in growth rates for total sales and physical production in other agriculture and horticulture (e.g. the number of livestock and area per crop). The possible energy consumption effect of these factors will be part of the calculated saving effect.

Background energy consumption developments in Agriculture and horticulture
Because of comparability with existing studies and data sources, the background analysis involves energy consumption including that of mobile equipment. Total energy consumption (corrected for temperature) varies between 180 PJ and 202 PJ. However, over the period 1990-2002 the increase amounted to 3% only. A decreasing trend can be observed: a yearly energy consumption growth of 2.8% between 1990 and 1994 changes into a decreasing trend of -1.3% in the period 1998-2002. Fuel consumption is dominated by the gas consumption of greenhouse horticulture. Electricity consumption increases strongly in the period 1990-2002 (+54%), which is mainly caused by a very strong growth in artificial (assimilation) lighting in greenhouses. Gas consumption decreases, but the consumption of supplied heat increases enormously from 2 PJ to 17 PJ.

Energy consumption trends in total agriculture and horticulture can be compared to the developments of production, expressed in € value added. Final electricity consumption increases with 7% annually, which is mainly covered by the strongly increasing own cogeneration production. Compared to the 1.4% growth of value added this involves a major increase in the electricity intensity (with +5% per year, see Figure 4.10). Final heat consumption that is covered by conversion of gas in boilers or by cogeneration units, decreases slightly as a result of which the heat intensity decreases with 1.8% per year.

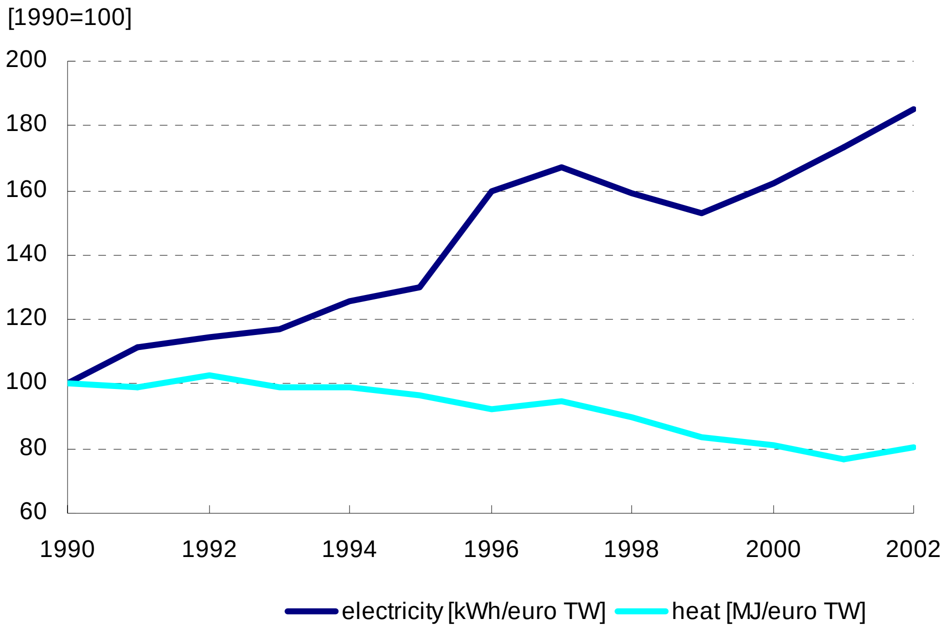

Figure 4.10 *Electricity and heat intensity in Agriculture and horticulture 1990-2002*

Energy consumption and production trends excluding assimilation lighting
The major increase of final electricity consumption is mainly caused by a large increase of assimilation lighting in horticulture. Without assimilation lighting electricity consumption would have increased with 4% only (Bakker, 2004). It is difficult to analyse the relationship between the growth rate of energy consumption and that of the value added. The value added in agriculture and horticulture often fluctuates strongly from year to year and a great part of value added is created in farming and cattle breeding where little energy is consumed.

4.5 Services sector

Development of savings according to the protocol method

The consumption of motor fuel for mobile equipment in the services sector is ascribed to the transportation sector here. The total final energy consumption is divided into the subsectors:

- trade/catering/repair companies,
- other commercial services,
- education,
- care and social services,
- government.

When determining the reference consumption it is assumed that in a situation without savings the final energy consumption of most subsectors increases in line with the development of sales in €1995. Yet, the heat consumption of the non-profit sector subsectors has been scaled up in accordance wit the number of employees or students in the subsectors of interest. The resulting reference consumption of the Services sector turns out to grow *less* than realised energy consumption. This would imply that an annual *dissaving* of approximately 1% would have occurred (see value between brackets in Table 4.7).

The protocol assumes that savings will be larger than 0, exceptional cases left aside. When more efficient techniques have been applied, they will not be replaced by the less efficient older techniques. A fall back in good housekeeping could result in a temporary dissaving though. On the other hand, the continuous extension of the building stock with new buildings that are significantly more efficient assures a constant contribution to savings. The uncertainty analysis shows that final savings figures for Services have a very large margin. Therefore it is assumed here that savings in final energy consumption are equal to 0. As a consequence total national savings will not be influenced by the (wrong) saving figure for Services.

Table 4.7 *Development of savings in the Services sector, according to the protocol method*

[%/year]	1995-2000	1995-2001	1995-2002
Final energy consumption	0 (-1.0)[a]	0 (-1.0)	0 (-1.1)
Cogeneration and heat deliveries	0.6	0.5 a 0.6	0.5
Total	0.6	0.5 a 0.6	0.5

[a] The originally found dissaving for final energy consumption that has not been used here.

The savings of cogeneration production in the Services sector involve:

- own gas engines for hospitals and sewage plants,
- gas engines of distribution companies in offices,
- heat deliveries to offices with district heating.

The last two options are registered in statistics as heat deliveries to Services. In the protocol the savings ascribed to this heat deliveries are comparable to that of own cogeneration. As can be seen in Table 4.7, cogeneration and heat deliveries made a large contribution to savings in the period 1990-2002 (see extended analysis of cogeneration savings in Chapter 5).

Volume, structure and saving effects

The increase in energy consumption of Services is mainly the result of the volume effect (see Figure 4.11). The volume effect involves the energy consumption increase in conformity with the growth of total value added.

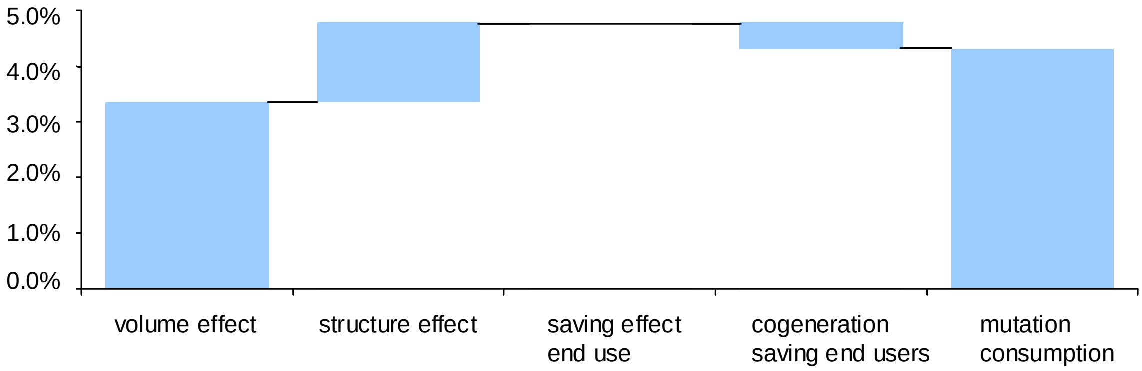

Figure 4.11 *Volume, structure and saving effects in the Services sector 1995-2002*

The structure effect involves:
- the shift between value added shares of the five previously mentioned subsectors,
- the change in the relation between value added and sales in subsectors,
- changes in the relation between value added and physical quantities in non-profit subsectors (employees, student).

Together, these developments lead to a larger energy consumption increase than would have been the case according to the volume development. As previously described, the final saving effect has been set at 0. Despite the substantial saving effect of cogeneration this leads to a strong increase of energy consumption.

Other factors that influence energy consumption that have not been included as part of the structure effect are, among others:
- an increasing floor area per employee in offices,
- an increasing floor are per € sales in retail trade,
- a strong increase for ICT applications in all subsectors.

In most cases, these factors lead to larger energy consumption. These effects are part of the final saving effect; they constitute a probable cause for the observed negative value for the originally found saving effect.

It must be concluded that the quantities used (sales and employees) and the energy consumption data are not suitable for determining the correct reference consumption. Large structural changes in energy consumption, such as the ICT trend and air conditioning, are not covered in the analysis of savings. At the moment the necessary data that are needed to assimilate these structural energy consumption trends in the reference consumption are lacking.

Background energy consumption developments for Services

In order to compare with other studies and data sources this background analysis involves energy consumption including (small-scale) use of mobile equipment. First of all, it should be noted that the energy consumption data, especially for oil and delivered heat, are less reliable than for other sectors. Total energy consumption (corrected for temperature) in the period 1990-2002 increases from 251 PJ to 351 PJ, an increase of 40%. The annual growth varies significantly: from 0.5% for 1990-1994 it increases rapidly to 5.5% per year and finally decreases again in the period 1998-2002 to 2.6%. The electricity consumption increases significantly (+48%); gas consumption also increases remarkably (+37%). The (unreliable) trend of heat consumption points at a very large growth, possibly by a factor 3, to approximately 20 PJ in 2002.

The development of the energy consumption in the services sector can be compared to the value added in €, or to employment, expressed in number of full-time employees (fte). Figure 4.12 shows the energy intensities for final electricity consumption and heat consumption, both related value added and employment. Because value added increases faster than employment, the trend for energy consumption per €1995 deviates increasingly from the trend for energy consumption per fte. The 'dip' in heat intensity in 1999 is caused by statistical data on fuel consumption that deviates strongly from the trend.

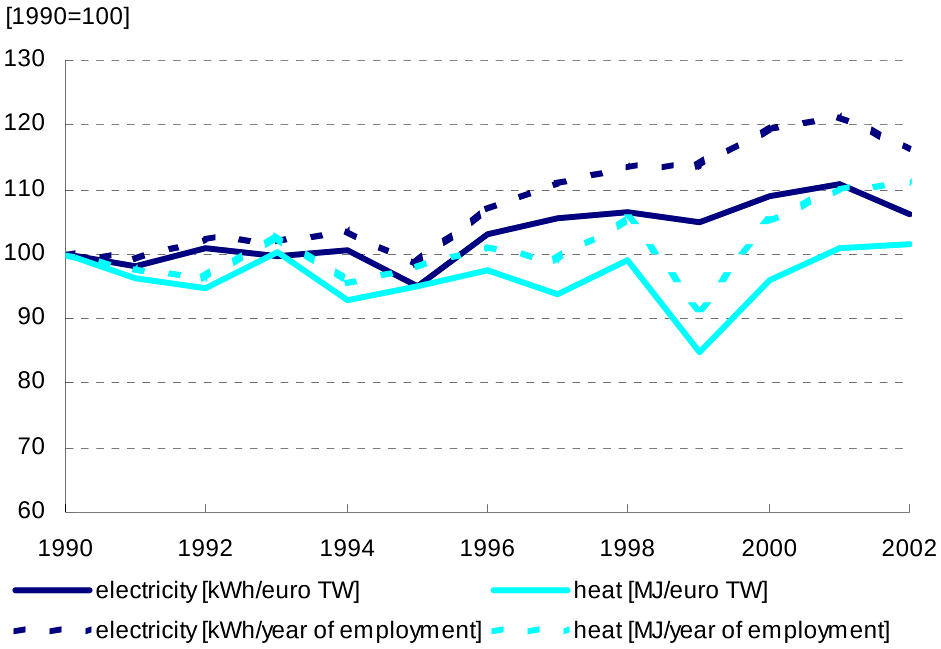

Figure 4.12 *Electricity and heat intensities for Services 1990-2002*

Development of value added over time

The economic growth in the Services sector fluctuated significantly in the period 1990-2002 (see Table 4.8). The effect of these fluctuations on energy consumption is examined into more detail. In a 'normal' growth situation electricity consumption in this sector appears to develop similar to the value added (see period 1990-1994 and 1998-2002). But consumption per employee does increase. In the extreme growth period 1994-1998 electricity consumption grew even faster than value added. The intensities (both for value added and employment) are higher than before or after this period. Heat consumption shows similar trends. So, it is supposed that more than average growth levels in Services have been achieved through new activities that demanded a relatively large amount of energy.

Table 4.8 *Relation between growth of value added and final energy consumption in Services*

[%/year]	1990-1994	1994-1998	1998-2002	1990-2002
Growth				
Value added	2.0	4.4	2.7	3.1
Employment volume	1.3	3.5	2.0	2.3
Final electricity	2.2	5.9	2.7	3.6
MJ_e/€	+0.2	+1.4	-0.1	+0.5
MJ_e/employment year	+0.9	+2.3	+0.6	+1.3
Final thermal	0.2	6.1	3.4	3.2
MJ_{th}/€	-1.9	+1.6	+0.6	+0.1
MJ_{th}/employment year	-1.2	+2.5	+1.4	+0.9

4.6 Transportation

Development of savings according to the protocol method

In order to adhere to the sector definition that was used for the indicative targets on CO_2 emissions (Boonekamp et al., 2004), fuel consumption of all mobile equipment has been allocated to transportation. Total energy consumption is divided into a number of transportation categories, each with its own ERG-variable (see Table 4.9).

Table 4.9 *Energy consumption categories and ERG in Transportation*

Category	*ERG (Energy Relevant Variable)*
Persons-road	Person-km travelled
Delivery vans	Vehicle km covered
Lorries	Cargo ton-km inland transport
Tractors	Cargo ton-km inland transport
Local transportation	Person-km travelled by bus/tram/metro
Inland shipping	Cargo ton transported
Aviation (inland)	PJ consumed
Railway-Passengers	Person-km travelled by rail
Railway-Freight	Cargo ton-km by rail
Other (Mobile Equipment)	PJ consumed by Mobile equipment

For each category it is assumed that the reference consumption increases in accordance with the trend for the energy relevant variable (ERG) in question. Aggregated over the categories total reference consumption is found; the difference with statistical energy consumption leads to the savings shown in Table 4.10. Recently there appears to show a decreasing trend for savings. However, given the influence of factors that are not included (see volume and structure effect), it is difficult to draw any solid conclusion. As production from cogeneration is not present, total savings equal the savings in final energy consumption.

Table 4.10 *Development of savings in Transportation, according to the protocol method*

[%/year]	1995-1999	1995-2000	1995-2001	1995-2002
Final energy consumption	0.6	0.7	0.6	0.4
Cogeneration	0	0	0	0
Total	0.6	0.7	0.6	0.4

Volume, structure and saving effects

The volume effect in the transportation sector is not linked to the growth of value added of transportation companies because a large share of energy consumption, i.e. the share of private car use, is not related to this value added. The volume effect is defined here as the increase in energy consumption in accordance with the development of total transportation performance[9] (see Figure 4.13). The trends for the ERG per category of transportation deviate from this total performance. Often it regards shifts in the so-called modal split for passenger and freight transport. These shifts often lead to an extra energy consumption increase, presented here in the structure effect. The saving effect more or less compensates the structure effect. All in all, a substantial increase of energy consumption results.

[9] Performance expressed as a combination of person-km and ton-km, weighted by energy consumption in the base year.

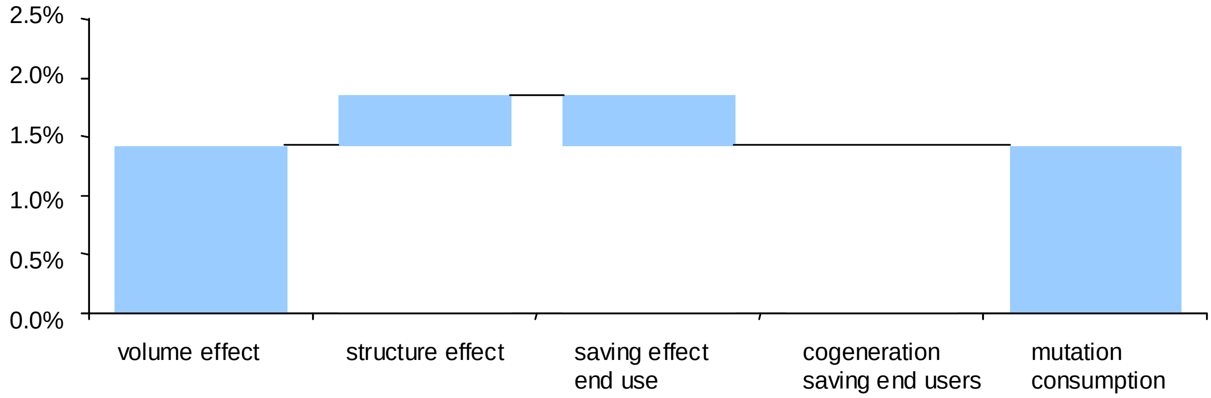

Figure 4.13 *Volume, structure and saving effects in Transportation 1995-2002*
Note: Including energy consumption for mobile equipment in Agriculture and Horticulture, Construction and Services.

Other factors that influence energy consumption are:
- heavier passenger cars,
- the recent penetration of air-conditioning,
- lower maximum and average driving speed,
- higher loading rates for lorries.

The first two factors result in extra energy consumption for passenger transport. The last two factors mitigate the increase in energy consumption. As these factors are not part of the structure effect, the possible effect will be part of the final saving effect.

Background energy consumption developments in Transportation
The transportation sector entails both passenger and freight transport, mainly by car but also by rail, bus, inland shipping and aviation (inland). Moreover, mobile equipment has also been included in the sector. The total energy consumption in the period 1995-2002 increases from 453 PJ to 508 PJ, which is a 12% increase. The fuel mix can hardly change as oil is the fuel that is almost exclusively used. The share of transportation in total inland oil consumption amounts to nearly 50% (approximately 30% passenger and 20 % freight transport). Electricity consumption of rail transport increased from 5.3 PJ to 5.6 PJ.

The *energy intensity* of transportation is presented here from 1995 on, but with an index starting in 1990 (see Figure 4.14). Contrary to other sectors, heat consumption is not analysed here because it cannot be observed in the process of converting fuel to mechanical energy for moving vehicles. The consumption of fuel or electricity, for person- and freight transport apart, is related to transportation performance expressed in either persons or ton-kilometres (pkm or tkm).

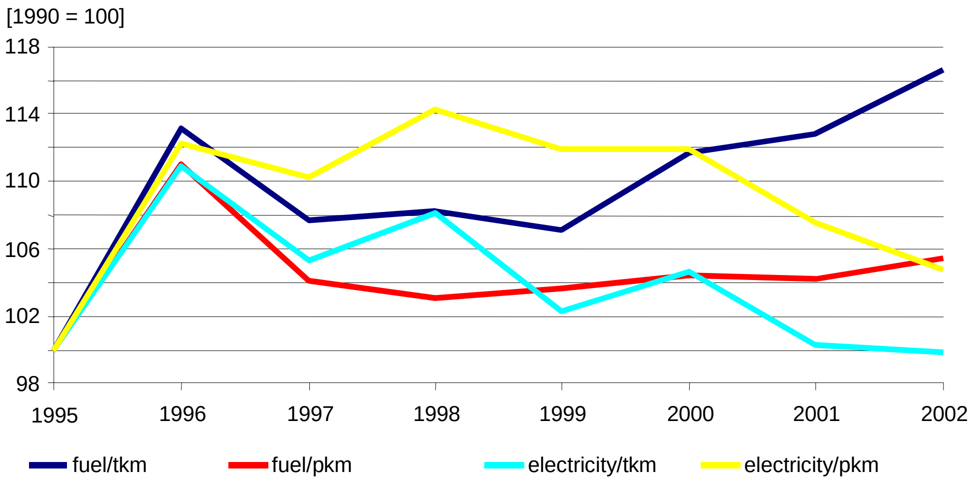

Figure 4.14 *Fuel and electricity intensities of passenger and freight transport 1990-2002 (index, 1990=100)*

From 1998 on an unfavourable intensity trend for fuel shows up, especially for freight. In passenger transport this could be the result of a run out of the effect of improved efficiency standard for new cars by 1983. When by the mid nineties the total stock of cars is fully replaced by less consuming cars the mean fuel use does not decrease any more (Brink, 1999). However, in view of the method used here, this effect could also be the result of structure effects such as heavier cars. The same explanation holds for freight transport. The annual increase of total fuel consumption (including mobile equipment) is larger than the increase in transportation performance. As a result, total fuel intensity increases with 0.3% per year in the entire period. Total electricity consumption also increases faster than total transportation performance, causing the electricity intensity to increase (+0.4% per year).

Passenger car use, in kilometres driven, has increased 10% in 2002 compared to 1995. Approximately one-third of the increase in car mileage can be explained by the autonomous growth of the population (source (AVV, 1997), update of the data from (Statline, 2003) by RIVM). Two-thirds of the growth is due to an increase in the average mileage per person as a result of higher incomes en socio-cultural (behavioural) changes, such as fewer persons per household, higher job rates for women and the combination of work and household activities (Harms, 2003). A larger diversity in outdoor leisure activities is another trend that influenced car use. Moreover, *the infrastructural policy* has also stimulated car use. The improved road system has stimulated car use resulting in travel distance increases (Annema and Wolf, 1997). Due to this infrastructural policy, car use has increased approximately 10 to 20% (RIVM, 2003).

Between 1990 and 2002 the government's mobility policy tried to reduce the amount of car mileage through measures aimed at behavioural change, the encouragement of carpooling and the stimulation of public transportation, mainly through investments in public transport infrastructure. This has resulted in an increase for public transportation use of 20%, but this did not replace car use. In the people's perception the car remains the superior option, offering more comfort and (much) shorter travelling time (RIVM, 2003).

The *savings for passenger transport* have been calculated separately; these amount to approximately 0.4% per year in recent years. As mentioned earlier, this figure includes the effect of some factors that are not taken account of in the structure effect, and thus become part of saving effect.

The freight transport performance (in ton-km) in the Netherlands has increased with 11% in the period 1990-2002. More freight was transported as a result of economic growth. But other economic factors have led to an increasing distance over which freight is transported. The average length of trips in inland transportation increased with approximately 35% between 1985 and 1991 (AVV, 2002; OECD, 2002).

The share of road in total freight transport increased because road transport was much more innovative than the 'competitors' inland shipping and rail. As a result inland road transport became 2% cheaper and almost 1% quicker every year in the period 1972-1997. This explains one-third to on-half of the growth in freight transport by road (Dings, 1999).

The *savings in freight transport* that were have been calculated too; they decreased significantly in recent years, from 2% to approximately 1% per year.

4.7 Refineries

Development of savings according to the protocol method

Due to a lack of data, the total own energy consumption of all refineries cannot be divided into different parts, each with their own ERG, to calculate reference consumption. Time series for the following variables are available for the determination of the total reference consumption:

- sales in €, base prices 1995,
- value added in €, base prices 1995,
- value added in €, market prices 1995,
- total deliveries of oil products in PJ (source MONIT),
- own production of oil products in PJ (source CBS statistics),
- throughput of crude oil and natural gas condensate (CBS statistics),
- supply of crude oil and condensate (source Statline).

All time series, except that for total deliveries of products, show a decreasing trend. If these series are used as ERG, the reference consumption will decrease too between 1995 and 2002. However, the realised final heat consumption increased with 10% in this period and final electricity consumption increased even with 20%. So, using these ERG's, would result in large dissavings for refineries. However, using the (increasing) deliveries of products does not provide for a good measure stick for growth in energy consumption. These delivered products increasingly involve purchased semi-manufactured and final products that require little processing. The reason that it is so difficult to extract savings from the trends for energy consumption and production lies in the fact that the refinery process is complex with many inputs and outputs. Own energy consumption is influenced by changes in the composition of the crude oil input, changes in the output mix and sharpening of the demands regarding product quality.

In order to determine the reference consumption a different approach is chosen here. For the period until 1999 the so-called LTA efficiency indicators are available (Nuijen and Booij, 2000). With these indicators the reference consumption can be determined. Moreover, the Benchmark Covenant assumes savings of 4% over the period 2001-2010, including autonomous savings (Kroon, 2004). Supposing 0.4% savings for the years 2001 and 2002 and an estimate for 2000, the reference consumption has been determined for the years after 1999. A comparison with the realised energy consumption leads to the savings for final energy consumption as shown in Table 4.11. For cogeneration the savings have been calculated as described earlier. It appears that in recent years savings decrease, both for final energy consumption and cogeneration.

Table 4.11 *Development of savings in Refineries, according to the protocol method*

[%/year]	1995-2000	1995-2001	1995-2002
Final energy consumption	1.0	0.9 a 1.0	0.8
Cogeneration and heat delivery	0.3 a 0.4	0.2 a 0.3	0.2
Total	1.3	1.2	1.0

Some remarks must be made on the results. The LTA indicators of Novem for 1990-1999 result in savings in PJ that gradually increases until 1997, but double in 1998 and 1999. The realised savings percentage according to the LTA evaluation (including cogeneration savings) is significantly higher than the intended savings percentage in the Benchmark period. Even taking into account a stagnating contribution of cogeneration savings it is difficult to explain the differences in level of savings.

Volume, structure and saving effects

The volume effect for refineries is linked to the growth of the total deliveries of oil products (see Figure 4.15). The structure effect entails the difference between this delivery trend and the trend for the reference consumption on the basis of LTA and Benchmarking data. The structure effect mitigates the substantial increase in energy consumption due to the volume effect. This is probably because more and more and more semi-products that are barely processed are used for deliveries. After taking account of the different types of savings there results a limited energy consumption increase of 0.6% per year.

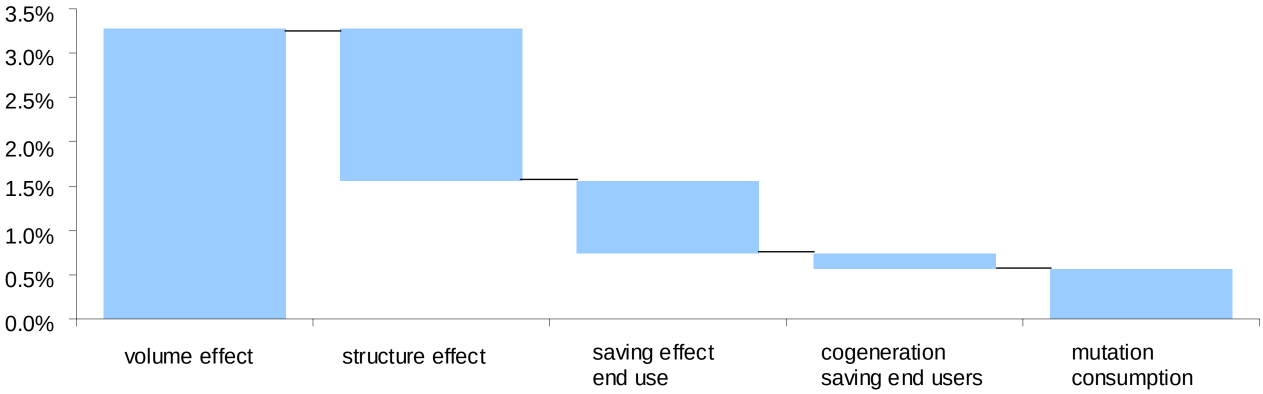

Figure 4.15 *Volume, structure and saving effects in Refineries 1995-2002*

Other factors that influence the reference consumption:

- more strict environmental standards for refinery products,
- higher fraction of high-grade products (extra secondary capacity needed),
- refining capacity utilisation,
- heavier or lighter crude oil.

In principle these factors all have been incorporated in the reference consumption that is determined on the basis of the LTA and Benchmarking data.

Background energy consumption developments for Refineries

In energy statistics refineries are not included in the end user sectors but are part of energy supply (the energy sector). Actually, the refining activity follows energy consumption developments in the end user sectors. Therefore the analysis does not use value added as driving factor (volume variable) but the physical output. On the other hand the utility part of refineries looks much the same as that in the chemical industry. Therefore refineries are treated similarly as industrial sectors.

The total energy consumption varies between 157 PJ to 191 PJ; from 1990 to 2002 energy consumption increases with 7%. However, until 1998 there was a much larger growth (1.9% per year). The fuel mix in refining has always been based on oil. But the share of natural gas has doubled from 11% to 22% because of production of hydrogen that is processed in products. Electricity consumption fluctuates around 0 because the final electricity consumption is almost fully covered by own generation. The energy consumption balance of heat is negative because heat is delivered to industry.

When final energy consumption development is compared to that of product output, the intensities for electricity and heat consumption are found (see Figure 4.16). Final electricity consumption increases with 2.8% per year. The output of oil products has increased with 2.6% per year, resulting in a slight intensity increase (+0.2%/year). Heat consumption does hardly increase, resulting in a heat intensity decrease of 2.4%/year. The relatively strong decrease of heat consumption in more recent years coheres with a larger growth of the output. Beside the effect of the capacity utilisation, a shift between purchased intermediary products and own production could also play a role.

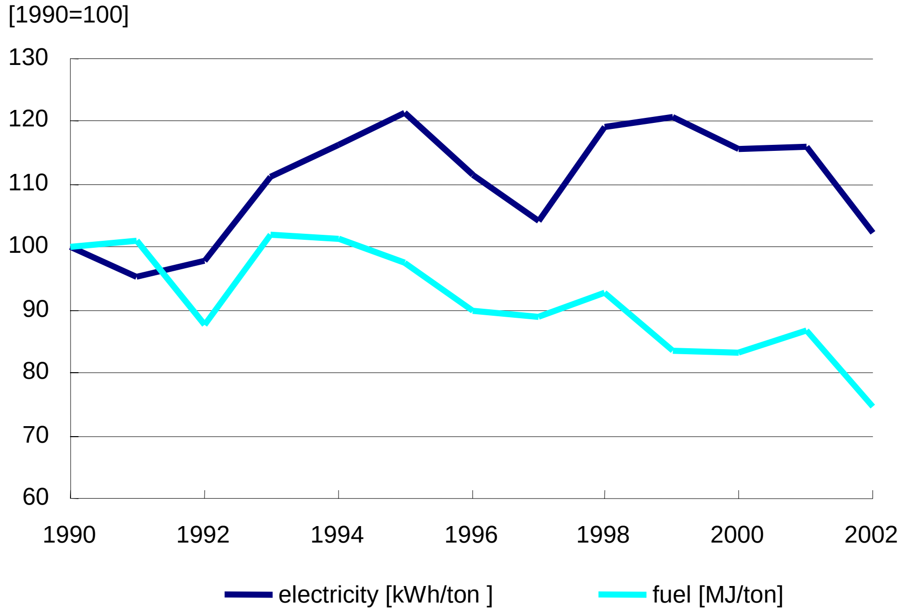

Figure 4.16 *Electricity and fuel intensities for Refineries 1990-2002*

4.8 Electricity supply

Composition of electricity supply
The total electricity demand is covered by:

- central production (conventional power plants),
- waste incineration plants,
- cogeneration of distribution companies,
- import.

Another category in statistics, namely decentralized production, consists mainly of joint-venture cogeneration plants. These have been assigned to the industrial sectors that buy the steam production. Conventional power plants are the supply category that still covers the largest share of demand, although the share of the other sources has increased strongly (see Figure 4.17). The share of imported electricity has increased significantly since 1998.

Developments in power plants
The energy consumption of power plants entails the conversion losses, i.e. the input of fuels minus the output of electricity and heat. This energy consumption is not linked to economic developments but to the electricity demand trends in end user sectors. Until 1992 an increase in total energy consumption occurred (4%) but in the period until 2002 it decreased again to 292 PJ.

The cause of this development lies in the large increase in decentralized production and extra electricity import. In recent years electricity production increased again; heat production has even doubled from 13 PJ to 26 PJ. The fuel mix, mainly consisting of coal and natural gas, experiences little change in the period 1990-2002 (see also Table 4.12).

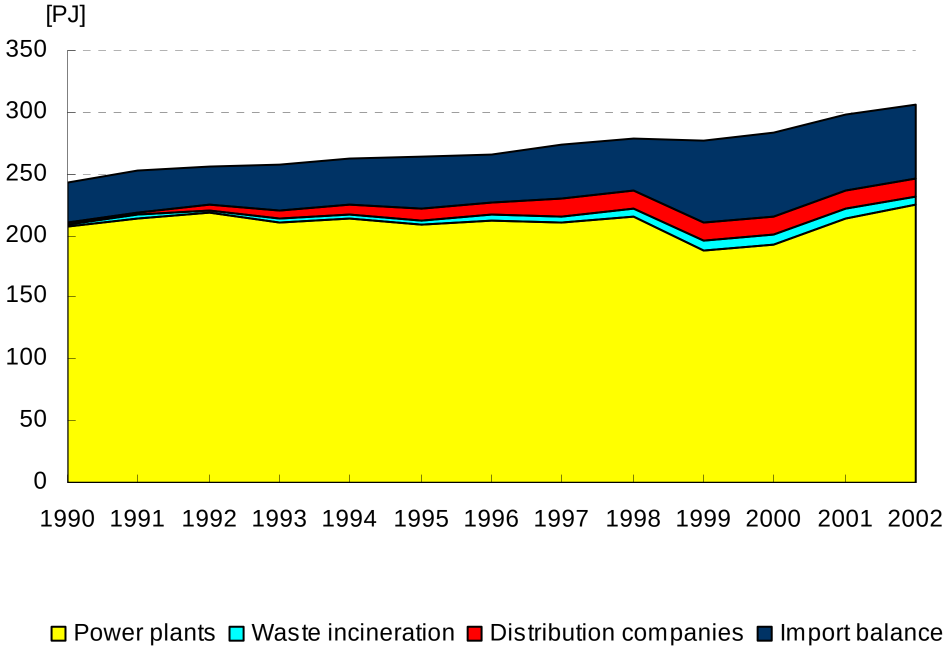

Figure 4.17 *Composition of electricity supply 1990-2002*

Table 4.12 shows the trend in the input and output (statistical values) and the total conversion efficiency (including/excluding heat deliveries). Beside coal and natural gas, nuclear energy (approximately 40 PJ) and residual gases (20-25 PJ) are also used as input. Between 1990 and 1995 there is little change in production and efficiency levels, but coal input does reach its peak in 1995. In 1996 and 1997 the efficiency increases significantly, especially in gas-fired power plants (see Figure 4.18), because the Eems power plant was put into operation. In 1999 the input was at its minimum because of a strong increase in import. This does not affect the efficiency however. After 1999 the production level recovers as a result of a larger electricity demand and less import; this is accompanied by a slight decrease in efficiency. This is probably due to the closing of the national optimisation scheme, aimed at minimizing fuel inputs, because this scheme did not fit in a liberalised electricity supply. As a result, the most efficient power plants were not used with highest priority any more.

Table 4.12 *Input, output and overall efficiency of power plants 1990-2002*[a]

[PJ]	1990	1995	1999	2002
Input	524.6	535.9	453.4	546.0
- Coal	231.0	240.0	186.6	226.8
- Natural gas	234.7	229.1	200.9	252.3
Output				
- Electricity	207.2	210.1	190.8	226.2
- Heat	11.9	15.6	20.2	22.9
Efficiency				
- Total	41.8%	42.1%	46.5%	45.6%
- Electricity[b]	40.0%	39.8%	43.0%	42.3%

[a] On the basis of statistical energy consumption data, not corrected for temperature.
[b] Input corrected for fuel that can be ascribed to heat production (indirect co-combustion factor 0.5).

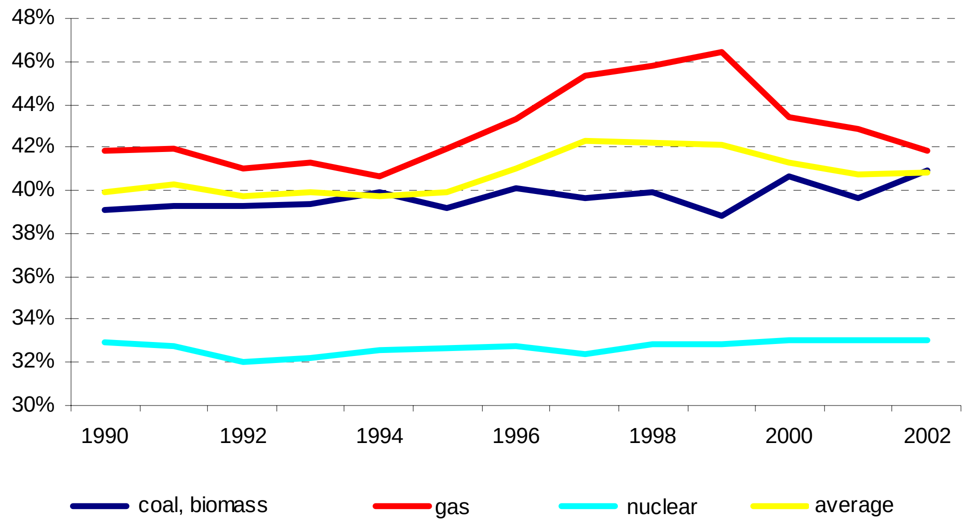

Figure 4.18 *Conversion efficiency developments per type of power plant 1990-2002*

Developments in waste incineration

Table 4.13 shows the developments of input and output and the efficiency of waste incineration plants. The consumption of heat from incineration increased significantly in the period 1999-2002. Especially around 1996 there was a large increase in electricity production. The electric efficiency hardly changed over the years. The total efficiency did increase from 20% to 32% as a result of increased heat deliveries

Table 4.13 *Relation between input and output for waste incineration*

	1990	1994	1998	2002
Input [PJ]	16.1	19.8	42.6	45.8
Output [PJ]				
- Electricity	2.6	3.3	6.5	7.1
- Heat	0.6	0	5.9	7.8
Efficiency	16.5%	16.8%	16.3%	16.9%

Developments distribution companies

The final energy consumption of distribution regards the grid losses (12 PJ of electricity). Natural gas is used for cogeneration production. Table 4.14 shows a very strong increase in production and energy consumption.

Table 4.14 *Input and output and efficiency of cogeneration production*

	1990	1994	1998	2002
Input [PJ]	1.9	17.2	32.9	38.4
Output [PJ]				
- Electricity	0.6	6.0	11.2	11.8
- Heat	0.7	7.2	14.9	16.4
Efficiency	68.4%	76.4%	79.3%	73.4%

Trend in energy intensities
The energy consumption of the electricity supply system could be compared to the value added or to the turnover. However, the main driver for the activities, and accompanying energy consumption, is the electricity demand of other sectors. Therefore energy consumption should be related to physical output, i.e. the electricity production. This comes down to an analysis of the total conversion efficiency of electricity supply.

Total conversion efficiency
The trend in total efficiency for electricity supply is provided in Figure 4.19 (see 'average'). Corrections of the fuel input for heat deliveries result in a slightly higher efficiency. The inclusion of waste incineration, which has an efficiency of approximately 20%, results in a lower average figure. If the average of production and import (without conversion losses) is taken, this leads to a significantly higher 'efficiency'.

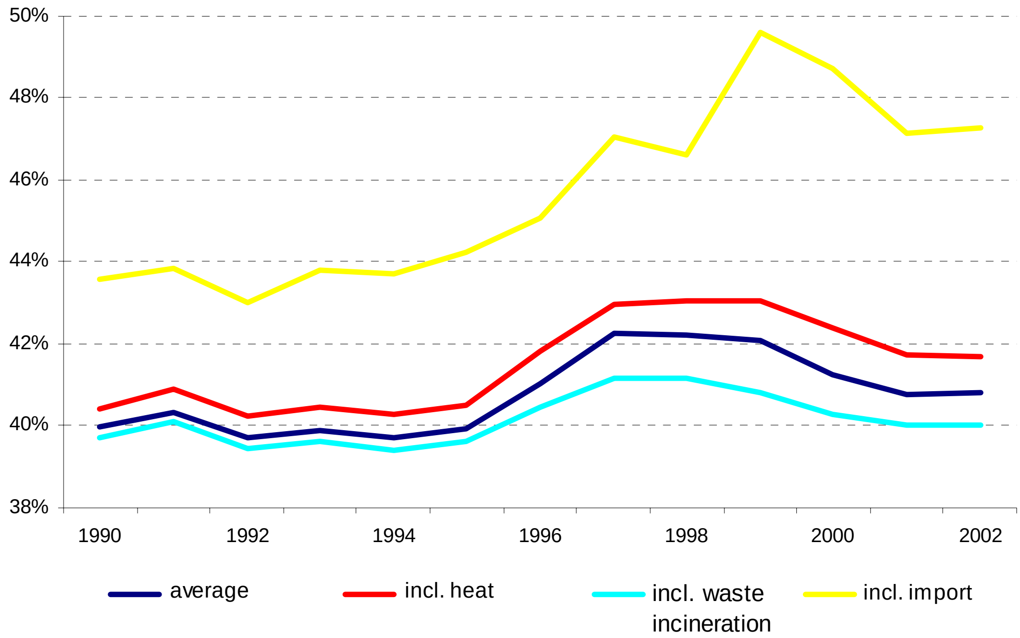

Figure 4.19 *Total efficiency of electricity supply, including or excluding heat delivery, waste incineration or import*

Savings according to the protocol method
The savings in power plants after 1995 are defined as the difference between the fuel input for actual efficiencies and the (hypothetical) fuel input for efficiencies in the base year. The comparison regards different types of power plant; therefore shifts between fuels do not influence total savings. As of 1998 large savings, amounting to 8% of the total input, have been realised. As described earlier, the efficiency decreases again after 1998. From 1995 until 2002 savings have been realised of approximately 15 PJ that is equal to 0.5% of total national energy consumption.

The savings attained by waste incineration and cogeneration production of distribution companies are calculated in the same manner as for end use sectors. In total extra savings of 3 PJ are realised compared to 1995. Initially large savings were achieved by substantial expansion of capacity, but these savings were partly lost due to a decreasing efficiency for cogeneration. For the entire electricity supply, the above-mentioned developments result in an annual contribution to national savings of 0.1%-point (see also Table 3.1).

4.9 Other energy companies

Energy consumption development

Next to electricity production and oil refining, the energy sector also comprises the production of coke and extraction/transportation of natural gas and crude oil. The energy consumption of coke plants has been ascribed to industry when calculating industrial savings. However, the developments for coke plants will be presented here into more detail.

The energy consumption for oil/gas extraction and gas transportation regards the running of compressors. Consumption increased from 26 PJ to 40 PJ in the period 1990-2002. Until 2000 it consisted almost exclusively of natural gas. After 2000 there is a substantial increase in electricity consumption (from 0.6 PJ to 6 PJ). The increase in consumption is partly caused by higher gas exports, but the main cause is the decreasing pressure in the gas fields. More and more compressor capacity is needed to pressurize the gas enough for transportation. The higher energy consumption can be seen as a structure effect on the national level that stimulates energy consumption. Due to a lack of data the savings of this subsector could not be determined. Given the limited energy consumption, the possible saving effect will be marginal at the national level.

In coke plants there appear few changes in total input until 1998 (see Table 4.15). A gradual decrease in the efficiency leads to more conversion losses. The closure of one of the two coke plants lowers in- and outputs after 1998. However, it appears that the remaining plant has a lower than average efficiency.

Table 4.15 *Input, output and efficiency of coke production*

[PJ]	1990	1994	1998	2002
Input	111.6	119.7	114.6	85.9
Output				
- coke	78.0	82.3	80.6	60.3
- coke gas/other	20.7	21.1	18.1	12.3
Conversion losses	12.9	16.4	15.9	13.3
Efficiency	88.4%	86.3%	86.1%	84.5%

4.10 Total energy consumption

National energy consumption

Total energy consumption (corrected for temperature) in the period 1999-2002 increases from 2816 PJ to 3243 PJ, which is a 1.2% increase per year. As of 1995, the increase is slightly less at 1.1% per year. The statistical energy consumption increases slightly more, i.e. 16% (see Figure 4.20).

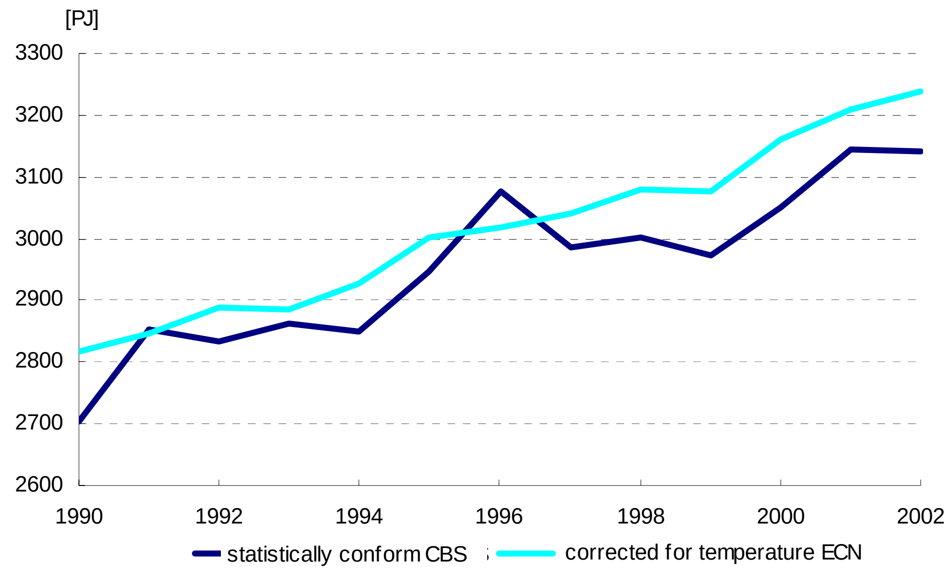

Figure 4.20 *Statistical and temperature corrected energy consumption in the Netherlands for 1990-2002*

National Fuel Mix

The national fuel mix of coal, oil, gas and other energy carriers changed only slightly in the last few decades. The same can be said for the period 1990-2002. Oil consumption increased fastest in this period (1.4% per year), while coal consumption decreased a bit (-0.3% per year). As a result, the share of oil increased to more than one-third, the share of gas remains around 50% and the share of coal decreased to 11%. The substantial growth for oil is related to the relatively high growth rates in the two most important sectors with respect to oil consumption, namely transportation and chemical industry. The high growth in chemical industry occurred in the last part of the period 1990-2002 and regarded oil as feedstock. As for gas, the increase is more modest in recent years as a result, among others, from decreased gas consumption in Agriculture and horticulture.

National energy intensity and per capita consumption

The national energy intensity is defined as the ratio between total energy consumption and GDP; the per capita consumption uses total population. Total energy consumption increased faster than population in the period 1990-2002 (0.7% per year). Thus a slight increase of the per capita intensity results (see Figure 4.21). The GDP increased much faster than energy consumption, i.e. with 2.5% per year. This caused a decrease in the national energy intensity of 1.3 to 1.4% per year. Remarkably, the national energy intensity remains nearly unchanged from 1999 on, after the large decrease in previous years. This recent development also deviates from the trend in other European countries (Odyssee, 2003). The causes for the stagnation in the decrease of the national intensity can be found in (EVN, 2004).

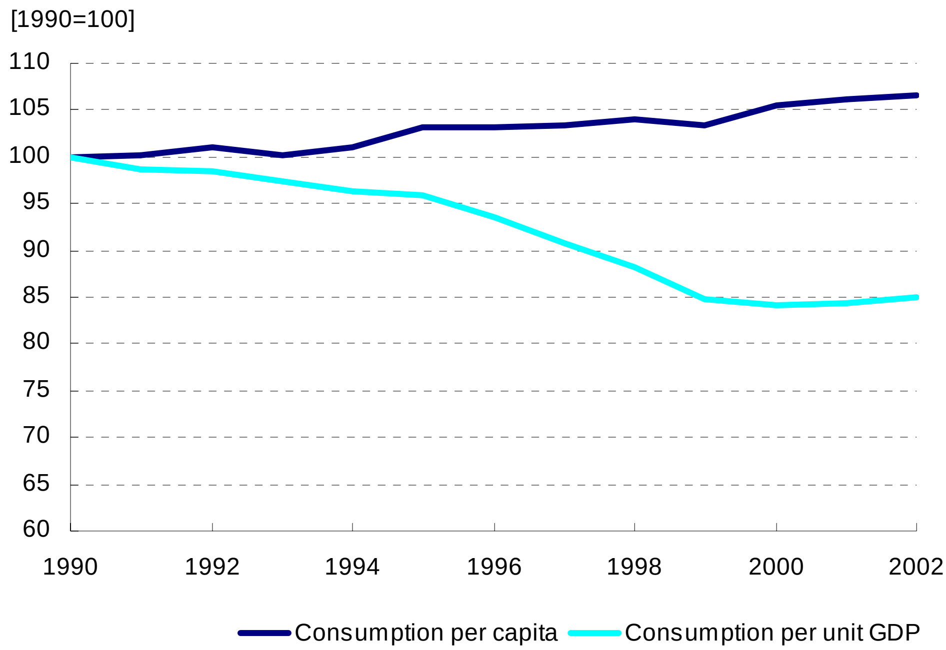

Figure 4.21 *Energy consumption per capita and per unit of GDP*

Table 4.16 illustrates a clear correlation between intensity decrease and the level of GDP growth. In periods with a more than average economic growth, the energy intensity decreases with such a speed that the energy consumption growth is not much larger than in periods with a smaller economic growth.

Table 4.16 *Trends in growth of GDP, energy consumption and energy intensity*

[%]	1990-1994	1994-1998	1998-2002	1990-2002
GDP growth	1.9	3.6	2.2	2.6
TPES growth	1.0	1.3	1.3	1.2
Energy intensity	-0.9	-2.2	-0.9	-1.35

Energy consumption for end use forms

Energy carriers are converted into the following so-called end use forms of energy:

- electricity
- heat
- feedstocks.

These end use forms provide for the different energy demands of society with respect to heating spaces, moving vehicles, generating process heat in industry, etcetera. Consumption of electricity is smallest (378 PJ in 2002, excluding grid losses), yet growing fastest, namely with 2.8% per year. The consumption of heat is by far the largest (1732 PJ in 2002, end users and refining), yet growing slowest (1% per year). Use of energy carriers as feedstock lies between that for heat and feedstocks (482 PJ in 2002). Feedstock trends show a large reversal, from -0.3% yearly growth (1990-1994) to +3.7% (1998-2002).

Sectoral developments

Compared to the growth of total energy consumption (1.2% per year), the growth of energy consumption of the Services sector (2.8% per year) and Transportation (1.7% per year) is above average (see Figure 4.22). The growth of energy consumption of Refining (0.6% per year), Agriculture and horticulture (0.3% per year) and Households (0.1% per year) lies far below average. The energy consumption of power plants even decreases with 0.4% per year. Industry nearly equals the average growth (1.3% per year). The share of industry in total energy consumption is largest and remains almost constant (nearly 35%).

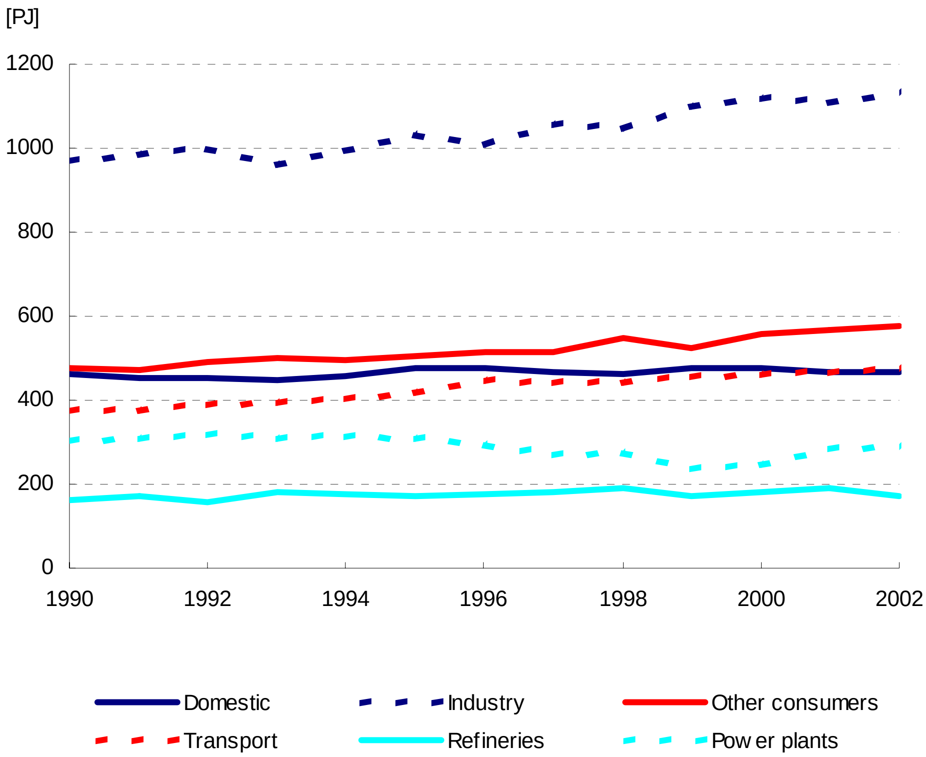

Figure 4.22 *Development of energy consumption per sector 1990-2002*

Energy consumption and CO_2 emission

Figure 4.23 shows that energy-related CO_2 emission trend resembles that of energy consumption (TPES), taking into account the 'jump down' as of 1998.

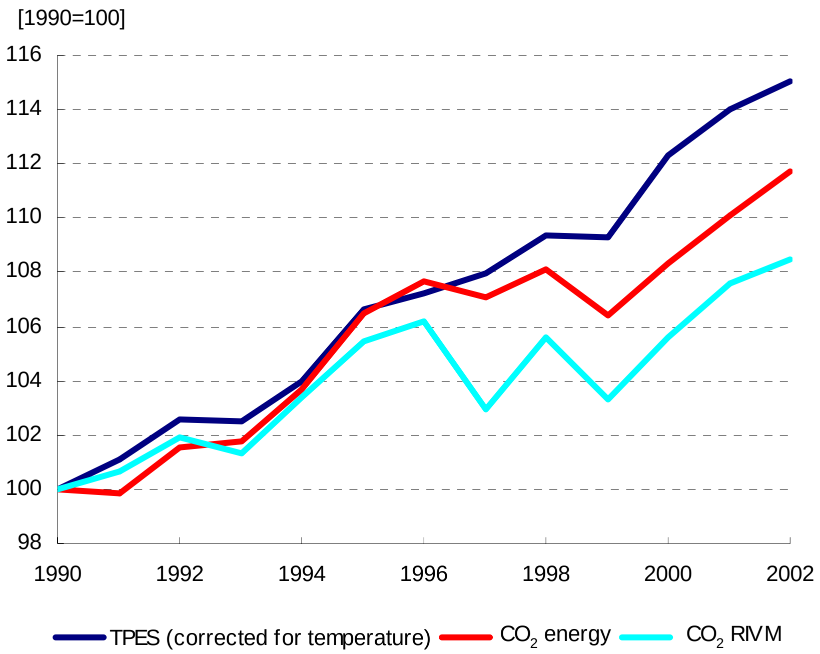

Figure 4.23 *Development of TPES and CO_2 emissions 1990-2002*

This ‘jump’ is the result of a major increase in electricity import that is considered CO_2 free in national evaluations. The emission trend according to the format of the emission registration (CO_2-RIVM in figure 4.23) shows more deviations but after 1998 it develops in line with that of energy consumption. The differences with the emission registration are partly caused by the emission coefficients employed, but a different method of data collection accounts for the largest part.

Structure effect in total energy consumption

In the protocol method total energy consumption development is explained via:

- the GDP effect,
- structure effects,
- total saving effect.

The GDP effect is similar to the (hypothetical) energy consumption increase if the TPES grows at the same pace as the GDP. The total saving effect is the sum of saving effects in different sectors and different applications (see preceding sections). GDP effect and total saving effect do not add up to the change in realised energy consumption. The difference must be attributed to the structure effects. Table 4.17 provides for a list of factors that determine the structure effect at the national level. These structure effects are quantified in the MONIT system (Boonekamp, 2004). To give an impression of the size of each contribution Table 4.17 specifies mean values for the period 1990-2002.

Table 4.17 *Build-up of the national structure effect in the protocol method*

Protocol	MONIT structure factors	Contribution [PJ]
Structure effect	Growth differences between main sectors and GDP	-330
	Shifts between subsectors industry	-40
	Structural changes end use per sector	-300 a -400
	Fuel substitution end users	-20
	Export energy carriers	+80
	Structural changes in energy sectors	+10
	Import energy carriers	-55
	Fuel substitution in energy sectors	+20

The most important contributions come from the differences in growth rates and the structural changes in the sectors. These are of the same size as the change in total energy consumption in the period 1990-2002. Increased export of oil products and gas constitutes a 12% share in the increase of total energy consumption. More import results in an opposite contribution in the period 1990-2002. Shifts in the fuel mix of end users and energy companies even out and therefore do not affect total energy consumption development. Some structure effects turn out to curb the energy consumption increase, as is also the case for savings. However, these energy consumption-curbing trends are not considered as savings in the protocol method.

5. ENERGY SAVINGS IN PERSPECTIVE

5.1 International comparison

Due to the increasing importance of the European energy and climate policy for the Netherlands, the Dutch energy consumption and savings trends are compared with that of the entire EU-15. The EU-data were acquired in the framework of the Odyssee/MURE project on energy indicators (Odyssee, 2004). Odyssee also presents figures for the Netherlands; these are also compared with PME-results (Protocol Monitoring Energy savings) in order to detect differences in the approach.

Table 5.1 shows the trends for economic growth and energy consumption (temperature corrected) from 1990 on. These data are also given for the period 1995-2002 that is of interest for the saving results. The Netherlands have realised a larger economic growth than the EU as a whole. In the entire period Dutch energy consumption has increased faster too, but the energy intensity has decreased relatively more than in the EU. In recent years Dutch energy consumption growth lags behind; this results in a still more favourable intensity compared to the EU. It must be remarked that after 1995 PME and Odyssee disagree on the growth rate of energy consumption in the Netherlands.

Table 5.1 *Comparison of energy consumption trends for the Netherlands and the EU*

[%/year]	Netherlands according to PME	Europe according to Odyssee	Netherlands according to Odyssee
1990-2002			
GDP growth	+2,6	+1,9	+2,5
Total energy consumption	+1,2	+0,9	+1,1
Intensity	-1,3 a -1,4	-1,0	-1,3 a -1,4
1995-2002			
GDP growth	+2,9	+2,3	+2,9
Total energy consumption	+1,1	+1,3	+0,9
Intensity	-1,7	-1,0	-2,0

In Table 5.2 the total efficiency increases for 1995-2002 are compared. In industry the efficiency increase according to PME equals that of the EU. However, according to Odyssee (see third column in Table 5.2) the Dutch savings are much higher. This is remarkable because the substantial savings from industrial cogeneration are not taken into account in the Odyssee figures (cogeneration is part of energy supply in European statistics). The high Odyssee figure is probably caused by the method that makes less use of physical quantities than PME to calculate energy savings.

Table 5.2 *Total increase in energy efficiency for 1995-2002 in the Netherlands and the EU*

[%]	Netherlands according to PME	Europe according to Odyssee	Netherlands according to Odyssee
Energy efficiency			
- National	7	4	7
- Industry	7	8	13
- Households	8	-1	7
- Transportation	3	5	-4

For Households the figures of PME and Odyssee agree very well. The Netherlands realise a 1% efficiency increase per year while the EU does not realise any efficiency increase. The EU figure seems unrealistic given all saving activities in different countries. Probably the Odyssee figures underestimate the real household savings. All in all it can be concluded that more energy is saved in Dutch households than elsewhere.

In transportation the PME figure coheres with that of the EU. However, Odyssee shows negative savings for the Netherlands, so a much more unfavourable trend than for the EU. Taking into account the differences in method and the data problems in this sector (e.g. border crossing traffic) it is not possible to draw conclusions on the relative position of the Netherlands in the EU.

The national saving figures from PME and Odyssee agree very well. The Dutch efficiency appears to increase more strongly than the EU-efficiency in the period 1995-2002. Given the remarks made earlier, further analysis of the comparability of the figures is needed before strong conclusions van be drawn.

5.2 Energy savings and CO_2 emission reduction

Total realized energy savings consist of savings on final energy consumption of heat/fuel and electricity, savings through cogeneration or heat deliveries and savings through more efficient conversion in the energy sector (see Chapter 3). Calculated in absolute figures, total savings amount to 225 PJ.

In order to determine the avoided CO_2 emissions, the savings on fuels are translated to kton CO_2 using fixed emission factors. The savings on final electricity consumption (in PJ_e) are translated into kton CO_2 with a calculated emission factor per kWh. In the electricity sector the relation between total deliveries and total emission is significantly influenced by import (or export) of electricity. However, here it is assumed that savings on electricity lead to a decrease in Dutch electricity production only. Moreover, for every kWh saved the average emission factor for the base year is used. If the emission factor of power plants changes, e.g. through higher conversion efficiencies, this effect is considered to be an emission reduction of the energy sector itself. This approach avoids double counting and is analogous to the method of determining savings. As for cogeneration production, the emission of the extra fuel needed is compared to the avoided emissions from less consumption of electricity from the grid. In the case of heat deliveries, the reduction is equal to the avoided emission of less fuel consumed, minus the emission that can be ascribed to heat delivery (emission of the extra fuel input in power plants).

The avoided emissions resulting from realised energy savings since 1995 amount to 14-16 Mton in recent years. Only 3 to 4 Mton can be ascribed to more efficient conversion (cogeneration and power plants); the remainder comes from savings on final energy consumption. The savings are partly the result of implemented energy policy and partly due to autonomous technological progress. The avoided CO_2 emission is approximately equal to 8% of total emissions in 2000.

Next to savings, renewable energy production also contributes to less fossil fuel use and CO_2 emission reduction. Since 1995 about 44 PJ of primary energy consumption has been avoided this way. Using the same emission coefficients the avoided emission from renewable energy production amounts to 3 Mton CO_2 in recent years. Thus, the contribution of savings to emission reduction is five times larger than the contribution of renewable energy.

5.3 Savings through cogeneration

Savings by means of cogeneration have made an important contribution to the realised savings in the period 1995-2002, but a trend break occurred after 1998. The savings contribution of cogeneration has been presented for several sectors apart (see chapter 4). In order to provide for an overview, all cogeneration production is taken together here. Total cogeneration entails:

1. own cogeneration plants in Industry (excluding Refineries),
2. decentralized production (mainly joint venture cogeneration in Industry),
3. own cogeneration of gardeners (Agriculture and horticulture) and in offices (Services),
4. small-scale cogeneration of distribution companies (gardeners, Services and Households),
5. cogeneration in Refining.

Not analysed here are:

- central district heating for dwellings or buildings,
- large-scale cogeneration in central production,
- waste heat from conventional gas and coal plants,
- waste incineration plants with heat delivery.

Cogeneration savings are equal to the saved fuel input of boilers and power plants minus the input of the cogeneration plants. Boilers have an 85-90% efficiency depending on the sector. For electricity, the average efficiency of electricity supply in the base year is used. The calculated savings are presented in Table 5.3. An explanation per sector follows.

Industry and decentralized production

As of 1993, energy statistics distinguish two types of cogeneration production in industry, i.e. ‘own’ cogeneration production and joint venture cogeneration (see Table 5.3). The saving effect of own cogeneration appears to diminish with 19 PJ in the period 1990-2002. Only 1991 and 1992 show a slight increase. A major reason is the decrease of own production capacity, as a result of closing down plants en converting to joint venture cogeneration (decentralized). More recently the decrease is due to less running hours and a lower efficiency, especially since 1998. In the case of joint venture cogeneration savings increased strongly since 1993, which was partly due to the transfer of own cogeneration capacity. However, joint venture savings in 2002 were not higher than in the top year 1998. This stabilization, which occurred despite an increased production, is due to decreasing conversion efficiency as of 1999, mainly by a lower heat output.

Agriculture and horticulture and Services

In Agriculture and horticulture the efficiency remains at the same level and cogeneration savings increase all the time. In the Services sector the efficiency increases significantly after 1995. But as a result of decreasing production since 1997 energy savings have stabilised.

Table 5.3 *Savings from cogeneration production 1990-2002*

[PJ]	1990	1995	1998	2002
Industry				
- Own plants	32.3	21.9	17.4	13.3
- Joint venture	×	23.5	41.7	44.6
Small-scale				
-Agriculture and horticulture	1.5	4.7	6.4	9.4
- Services	1.6	3.7	7.5	7.7
Energy sector				
- Refineries	9.8	7.7	11.8	9.6
- Distribution companies	0.6	10.2	15.7	13.0
Total	45.8	71.6	100.5	97.6
(Integral efficiency)	(45.8)	(75.6)	(92.1)	(94.8)

Distribution companies
Distribution companies have encountered a very strong increase in cogeneration production between 1990 and 1996. Between 1995 and 2002 a slight worsening of the efficiency occurs. The maximum saving was achieved in 1998. The decrease that occurred after 1998 is caused by the lower efficiency and not by less production (that increased slightly since 1998).

Refineries
Despite an increase in cogeneration production the savings of cogeneration hardly increase. Heat production lags behind compared to the increase of electricity production, resulting in a total efficiency decrease from 91% in 1990 to 80% in 2002. As was the case for other sectors, the maximum savings were achieved in 1998.

Total savings cogeneration
Total savings with (non-centralized) cogeneration increased strongly since 1990 and reaches a maximum in 1998 after which savings decreased again (see Table 5.3). On balance, total savings increase with approximately 50 PJ between 1990 and 2002. The end user sectors experience a 40 PJ increase in savings (35 PJ to 75 PJ). The increase as of 1995 amounts to merely 25 PJ, which is lower than indicated in the Protocol, because a number of cogeneration production types have not been included here (see the beginning of this section), among which extra heat delivery from power plants (7 PJ) and waste incineration (8 PJ).

The total savings have been calculated with the electricity supply efficiency of the base year. The table also provides for savings when using the current efficiency of electricity supply (see 'integral efficiency'). Especially after 1995 the integral saving was lower than total savings because the efficiency of electricity supply increased. After 1998 the power plants became less efficient and integral cogeneration savings increased slightly (in contrast with the decrease in total savings).

5.4 Other evaluations

LEI monitoring of efficiency in greenhouse horticulture
In the framework of the GLAMI Covenant, the LEI-institute has been monitoring the efficiency developments in greenhouse horticulture every year. In Table 5.4 the LEI-results for recent years are compared with the results according to the protocol (PME). First of all it should be noted that the LEI only analyses greenhouse horticulture that constitutes 80% of total energy consumption in Agriculture and horticulture. Moreover, the method of calculation differs with respect to temperature corrections and translation into primary energy units. Nevertheless, it can be concluded that the overall trends in recent years cohere. However, LEI shows a major efficiency increase from 2000 to 2001 and no increase from 2001 to 2002.

Table 5.4 *Energy efficiency trends in Agriculture and Horticulture, according to PME and LEI*

	1995	2000	2001	2002
PME, total agriculture and horticulture				
- As of 1995 [%/year]	×	1.1	1.5	1.6
LEI, greenhouse horticulture:				
- Efficiency index (1980 = 100)	60	56	52	52[a]
- As of 1995 [%/year.]		1.4	2.3	2.0

[a] Index was 50 according to (Knijff, 2003) but was revised to 52 in June 2004.

LITERATURE

Annema, J.A. and T. D. Wolf (1997): *Generation and substitution of traffic by expansion of the main infrastructure; the consequences for the national environmental pressure (Generatie en substitutie van verkeer door uitbreiding van de hoofdinfrastructuur; de gevolgen van de landelijke milieudruk)*, Bilthoven, RIVM, 1997 (in Dutch).

AVV (1997): *Trends - mobility in a changing Netherlands (Trends - Mobiliteit in veranderend Nederlands)*, Rotterdam, Adviesdienst Verkeer en Vervoer, 1997 (in Dutch).

AVV (2002): *Freight transport in the Netherlands*, edition 2002 *(Goederenvervoer in Nederland, uitgave 2002)*. Rotterdam, Adviesdienst Verkeer en Vervoer, 2002 (in Dutch).

Bakker, S.J.A. and P.G.M. Boonekamp (2004): *The ProgNET model: robust prognoses of Dutch electricity demand (Het ProgNET-model; Robuuste Prognoses van Nederlandse Elektriciteitsvraag Trends)*, ECN-C--04-036, ECN, Petten, May 2004 (in Dutch).

Boonekamp, P.G.M. (1997): *Monitoring the Energy Use of Households using a Simulation Model*, in: Energy Policy, 1997.

Boonekamp, P.G.M. et al. (1998): *Monitoring energy consumption 1982-1996. Method, results and perspectives (Monitoring energieverbruik 1982-1996. Methode, resultaten en perspectieven)*, ECN-C--98-046, Petten, December 1998 (in Dutch).

Boonekamp, P.G.M., H. Mannaerts, H.H.J. Vreuls en B. Wesselink (2001): *Protocol Monitoring Energiebesparing* (*Protocol Monitoring Energy Savings*), ECN-C--01-129, Petten, December 2001, (in Dutch).

Boonekamp, P.G.M., R. Harmsen, A. Kets and M. Menkveld (2002): *Saving trends 1990-2000 - savings, instruments and effectivity (Besparingstrends 1990-2000 - Besparing, instrumenten en effectiviteit)*, ECN-C--02-015, Petten, March 2002 (in Dutch).

Boonekamp, P.G.M. (2004): *Energy and emission monitoring for policy use - Trend analysis with reconstructed energy balances*, in: Energy Policy 32 (969-988), July 2004.

Boonekamp, P.G.M. et al. (2004): *Sectoral CO_2 emissions in the Netherlands up to 2010: Update of the Reference Projection for Policy-making on Indicative Targets*, ECN-C--04-029, Petten, March 2004.

Brink, R.M.M. van den and J.A. Annema (1999): *Traffic and transport in the Environmental Balance 1998* (*Verkeer en vervoer in de Milieubalans 1998)*, report 251701 036, RIVM, February 1999 (in Dutch).

CBS-NEH: *Dutch Energy Management (De Nederlandse Energiehuishouding)*. Annual publication, CBS, Voorburg (in Dutch).

CBS-NR: *National Accounts (Nationale Rekeningen)*. Annual publication CBS, Voorburg (in Dutch).

Dings, J. et al. (1999): *Better supply, more freight transport? (Beter aanbod, meer goederenvervoer?)*, Delft, CE, 1999 (in Dutch).

EVN (2004): *Dutch Energy Report (Energie Verslag Nederland)*. Annual publication ECN Policy Studies, Petten.

Gijsen, A. en P.G.M. Boonekamp (2003): *Certainty about energy savings (Zekerheid over energiebesparing)*, in: Energietechniek 11, November 2003 (in Dutch).

Gijsen, A. (2004): *Uncertainty analysis savings data (to be published) (Onzekerheidsanalyse besparingscijfers (in voorbereiding))*, Autumn 2004 (in Dutch).

Harms, L. (2003): *Mobility in time (Mobiel in de tijd)*, The Social and Cultural Planning Office of the Netherlands, The Hague, 2003 (in Dutch).

Knijff, A. van der and J. Benninga (2003): *Energy in greenhouse horticulture in the Netherlands - Developments in the sector and in companies until 2002 (Energie in de glastuinbouw van Nederland - Ontwikkelingen in de sector en op de bedrijven t/m 2002)*, Report 3.03.06, LEI, Den Haag, 2003 (in Dutch).

Kroon, P. (2004): *Personal communication*, ECN, 2004.

Neelis, M., A. Ramirez and M. Patel (2004): *Physical indicators as a basis for estimating energy savings in the Dutch industry*, NW&S, Utrecht University (to be published).

Nuijen, W. and M. Booij (2000): *Experiences with long term agreements on energy efficiency*, Novem, Utrecht, 2000.

OECD (2002): *Project on decoupling transports impacts and economic growth. Review of the Links between Transport and economic growth*. Paris, Organisation for economic cooperation and development, OECD, 2002.

Odyssee (2003): *Energy efficiency in the EU 1990-2001; SAVE-Odyssee project on energy efficiency indicators*, ENERDATA and FhG/ISI, June 2003.

Odyssee (2004): *Odyssee database 1990-2002*, ADEME, July 2004.

RIVM/NMP: *Environmental Balance* (Milieubalans). Annual Publication RIVM/NMP, Bilthoven (in Dutch).

RIVM (2003): *Environmental Balance 2004 - Accounting for the Dutch environment (Milieubalans 2003 - Het Nederlandse milieu verklaard)*, Bilthoven, RIVM, 2003 (English summary available).

Statline: Internet: http://www.cbs.statline.nl, Statistics Netherlands.

Vreuls, H.H.J. (ed.) (2003): Workshop 26 March 2003 - Proceedings of discussion and conclusions, Presentations and Participant list, Platform Monitoring Energy Savings, Novem, April 2003 (in Dutch).

ANNEX A SECTORAL DIVISION PROTOCOL ENERGY SAVINGS

Table A.1 *Division of energy consumers according to CBS and current / original protocol*

Protocol analysis 1995-2002	CBS/MONIT sectors	Original protocol
Households	Domestic	
Industry	Chemical Industry	
	Food and Beverages	
	Paper	
	Base metal	
	Coke plants	Part of energy sector
	Building materials	
	Other metal	
	Other industry (excl. recycling)	
	Construction (incl. sand/gravel, excl. mobile equipment)	Part of Services
	Decentralized cogeneration	
Agriculture and horticulture	Agriculture and horticulture (excl. mobile equipment)	Incl. mobile equipment
Services	Services (excl. mobile equipment)	Incl. mobile equipment
Transportation	Transport (incl. mobile equipment in Construction, Agriculture and Services)	Excl. mobile equipment
Refineries	Refineries	
Electricity supply	Central generation	
	Waste incineration	
	Distribution companies	
Other energy companies	Oil/gas supply	Also coke plants

ANNEX B COMPARISON WITH PREVIOUS EVALUATIONS

General comparison with previous results

In Table B.1 the savings figures of the two previous Protocol evaluations are compared with the current one. To facilitate comparison figures are given in two decimal digits; however, the second digit has no meaning for conclusions. First of all, it should be noted that different periods are involved. Moreover, the method in this report has been altered significantly, namely in the following respects:

- Changes in the sector definition as a result of the new division that is being used in the policy for sectoral indicative targets. The energy consumption of mobile equipment has been transferred from Agriculture and horticulture, Services and Construction to the Transportation sector. Moreover, the Construction sector has been transferred from Services to Industry. Finally, the coke plants have been transferred to Industry.
- In industry the reference consumption is no longer calculated on the basis of LTA information (that is no longer available), but on basis of physical production (Neelis, 2004).
- Limited adaptations to previously used data of CBS.
- Various minor alterations in other sectors with regard to the division of total energy consumption and the choice of the ERG.

Table B.1 provides the savings data for all annual Protocol evaluations.

Table B.1 *Comparison of savings data of the three Protocol evaluations*

3-year averages	1990-2000	1990-2001	1995-2002
National savings	1.24	1.19	0.98
among which:			
- Power plants	0.16	0.12	0.08
- Cogeneration savings	018	0.13	0.19
- Final energy consumption	0.93	0.94	0.71
Savings per sector (incl. cogeneration):			
- Industry	1.27	1.32	0.97
- Households	1.49	1.15	1.18
- Agriculture and Horticulture	1.79	1.99	1.70
- Services	0.57	0.59	0.47
- Transportation	0.41	0.39	0.44
- Refining	1.21	1.02	0.99

Realised energy savings 1990-2000 according to the Protocol Energy Savings

The results of the first protocol analysis have been summarised in Table B.2. Next to savings also volume and structure effects are provided. The increase in volume usually involves the growth of the value added; in the Households sector spendings are involved and in Transportation the transport performance in person-km or ton-km. The structure effect concerns all other socio-economic changes that affect energy consumption (i.e. excluding saving- and volume effect).

Annual savings provided in the table are the sum of a decrease in final energy consumption and more efficient conversion with cogeneration. Especially in the Services sector and Agriculture, the contribution of cogeneration has been relatively large. The savings figure for the industry involves the total energy consumption including feedstocks. Without feedstocks, the percentage is 1.5 times as high. The national figure also comprises the savings in power stations.

Table B.2 *Volume, structure and saving effect period 1990-2000*[a]

[%/year]	National	Industry	Energy sector	Transport	Household sector	Services	Agriculture
Volume	+3,4	+2,0	+2,3	+4,3	+2,8	+3,7	+2,0
Structure	-0,9	+0,1	-1,3	-1,7	+0,1	-1,0	+1,1
Savings	-1,2	-1,3	-0,9	-0,4	-1,5	-0,6	-1,8
Energy consumption	+1,4	+0,9	+0,1	+2,1	+1,4	+2,1	+1,3

[a] Also averaged over the years 1998, 1999 and 2000.

The savings percentage for cogeneration can be determined quite precisely. Its contribution to total savings amounts to 0.2 percent point.

Realised energy savings data 1990-2001 according to the Protocol Energy Savings

The results of the second protocol calculations are presented in Table B.3. For end users savings on final consumption and savings from cogeneration are distinguished. The savings for power stations are shown under ‘savings conversion’ in the column ‘Netherlands’. The uncertainty margins that were calculated are presented at the bottom of the table.

Table B.3 *Energy savings for 1990 - 1999/2000/2001*

3-year average [%]	Netherlands	Industry	Refining	Transport	Households	Services	Agriculture
2001[a]							
Volume effect	*2.8*	2.2	2.0	4.1	3.0	3.1	2.0
Structure-effect	-0.3	0.0	-.	-1.6	-0.4	-0.2	1.1
Saving.-effect end use	-0.9	-1.2	-1.0	-0.4	-1.1	-0.3	-1.2
Saving.-effect cogeneration	-0.1	-0.1	0.0	-.	0.0	-0.3	-0.7
Savings consumers	-1.1	-1.3	-1.0	-0.4	-1.2	-0.6	-2.0
Energy consumption	*1.4*	*0.9*	*1.0*	*2.1*	*1.5*	*2.3*	*1.1*
Savings conversion	-0.1						
Total savings	-1.2						
Uncertainty (+/-)	0.3	0.3	0.4	0.5	0.7	1.4	1.3

[*] Averages of the calculated annual savings for the periods 1990-1999, 1990-2000 and 1990-2001.

ANNEX C UNCERTAINTY ANALYSIS SAVINGS DATA

The uncertainties are determined by three factors (Gijsen, 2004):

- the error margin in the energy data for the base year and all years of analysis,
- the measuring errors in the value of the ERG (energy relevant variable, used for determining the reference consumption),
- the quality of the ERG as 'predictor' of the energy consumption-excluding savings.

The first factor was assessed by the CBS and relies for the industrial sectors on checks on the surveys; for other sectors it has been based on 'expert judgement'. It is often difficult to draw the line between the second and third factor. A large margin in the value of the ERG often automatically implies a low quality of ERG. In most cases the uncertainty of the third factor dominates, which is the reason why the second and third factor are combined. The limited quality of a variable as 'predictor' is usually clear enough. In Transportation, for example, other quantities beside 'person-km travelled' are of influence on the energy consumption of passenger transport, such as the seat occupancy, air-conditioning and weight. The amount of person-km is therefore not an ideal 'predictor' of the trend in this type of energy consumption. Nevertheless, it is difficult to express the quality of the ERG in a margin in terms of percentage, as a 'predictor' involves a large degree of subjectivity ('expert judgement').

The margins of all uses inputs are translated into a margin for the savings per sector and national level by means of a stochastic method (see Table C.1). The margin at the national level is relatively smaller than that on a sectoral level due to the 'law of large numbers'. It is assumed that the deviations on sectoral level more or less compensate for each other. The uncertainty with respect to the national savings figure should be interpreted as follows: on the basis of current insights it can be said with a 95% certainty that the national savings figure for 1995-2002 lies between 0.7% and 1.3%. Moreover, it can be said with a 67% certainty that savings will lie within the range of 1.15% and 0.85%. The savings data in Table C.1 have been provided with one decimal for practical reasons. The uncertainty margins of Table C.1 show that this is not always a sound approach.

Table C.1 *Uncertainty margin in the saving data (including cogeneration)*

	1996	1997	1998	1999	2000	2001	2002
Industry	2,6	1,3	1,0	0,8	0,6	0,5	0,5
Households	5,9	2,8	2,4	1,8	1,4	1,2	1,0
Services	×	×	×	×	×	×	×
Transportation	3,4	1,7	1,4	1,0	0,8	0,7	0,6
Agriculture and horticulture	6,5	3,7	3,4	2,5	2,0	1,7	1,5
Refineries	5,0	2,7	2,5	1,8	1,5	1,2	1,1
National	1,8	0,9	0,8	0,6	0,5	0,4	0,3

Explanation of uncertainty margins:

- As the trend increases, the uncertainties decrease. In later years the calculated total margin will be spread over more years and thus become smaller per year.
- In Industry, the reference consumption per sector is based on the physical developments. Because the physical data of CBS for 2002 could not be released, some estimates had to be made for 2002. The uncertainty margin in the saving figure for 2002 is therefore larger than in previous years.

- In Refineries the reference consumption is based on information from the LTA evaluation and the Benchmark exercise. It is uncertain to what extent the structural effects, such as shifts in the product mix and sharpening of product demands, have been included. Here the margin is larger than in industry.
- In Services the uncertainty margin is thus large that it is factually impossible to present a figure. This is due to the lack of suitable quantities to determine the correct reference consumption and the poor quality of the energy consumption data.

On a national level, the following factors contribute the most to the uncertainty:
- the uncertainty of the predictability of the ERG of the Households sector,
- the uncertainty of the predictability of the ERG of the Chemical sector,
- the uncertainty of the realised final energy consumption of the Services sector.

If these uncertainties were set at zero, then the national uncertainty margin would decrease from 0.3% to 0.2%. An extended analysis of uncertainties can be found in (Gijsen, 2004).

ABBREVIATIONS/GLOSSARY

CBS	Statistics Netherlands
CPB	Netherlands Bureau for Economic Policy Analysis
ERG	Energy relevant variable
GDP	Gross Domestic Product
LEI	The Agricultural Economics Research Institute
LTA	Long Term Agreement
Novem	The Netherlands Agency for Energy and the Environment
PME	Protocol Monitoring Energy savings
RIVM/MNP	The National Institute for Public Health and the Environment/ The Netherlands Environmental Assessment Agency
SBI codes	Standard Industrial Classification of economic activities
TPEC	Total Primary Energy Consumption
TPES	Total Primary Energy Supply
LEO System	National Electricity Optimisation System