6.1 Introduction

Chapter 5 described the direct and indirect energy flows through the Netherlands economy for the year 1985. This chapter focuses on the energy embodied in the capital stocks of the economic sectors as distinguished in the Netherlands ECCO model. The indirect energy input into production is known as ‘capital energy’ and is defined as the past energy expenditures required to produce durable goods such as machines, factories or buildings to enable human capital (i.e. labour) to produce economic goods and services. From the ECCO perspective there are several reasons to focus on the energy embodied in capital:

- ECCO calculates the output of economic sectors by evaluating the primary energy requirements to generate that output. As capital depreciates in production processes, the dissipation of energy related to the withdrawal of capital should be assigned to the production of goods and services. Capital is explicitly seen as a production factor. The past primary energy required for capital-build up has to be evaluated to estimate the annual contribution of depreciated capital as a fraction of the total energy requirements for production.

- Assessment of the embodied energy of the capital stock leads to insights in the physical investment/capital ratio. This is important since, physical investments strongly influence the scale and direction of economic development. Furthermore, knowledge about the energy embodied in the capital stock of a sector can be applied to determine the capital intensity as a degree of efficiency of that sector.

- Information on capital energy is scarce. There are no published data as yet on the primary energy embodied in the sectoral capital stocks of the Dutch economy. Therefore, the method developed to determine the embodied energy of a part of the capital stocks as well as the data set generated for this study are first-of-a-kind, and can be used as a basis for additional research in the field of energy analysis.
Chapter 6: Stocks of energy in the Netherlands economy in 1985

This chapter presents a method for assessing the past energy expenditures embodied in the various capital stocks in 1985. Before presenting this method in section 6.4, section 6.2 briefly discusses the role of capital in production. Since the method takes the financial costs of capital construction as a point of departure, section 6.3 reviews the present and past interrelationships of the financial construction costs and the primary energy equivalent of these costs.

The ‘money-energy conversion’ method was applied to determine the primary energy embodied in the capital stock of the industry, oil and natural gas production, transport and agriculture. To illustrate this method a detailed description of the calculation of the energy embodied in the industrial capital stock is presented in section 6.5. The results of the calculations of the energy embodied in the capital stock of oil and natural gas production, transport and agriculture are presented in the sections 6.6, 6.7 and 6.8 respectively. Where possible, the results are checked against data available from existing literature. Data availability restricts the application of the method. If essential data were not available, other (in that case more robust) methods were used to estimate the embodied energy of capital goods. The results of these methods concerning energy cumulation in the services capital stock, the residential sector and the electricity sector, are presented in the sections 6.9 to 6.11 respectively. Finally, in section 6.12 the main results are summarized and discussed.

6.2 The role of capital in production

From the ECCO perspective human-made capital can be used in production processes to generate output from which more physical capital can be produced. Within the same perspective, among others, Hall et al. (1992) have put forward that capital can be used to do produce goods and services thereby reducing the quantity of energy, labour or time required to produce a unit of output. So, a substitution potential exists that can fruitfully be studied from an energy perspective.

A complete energy analysis should include the energy embodied in the capital degraded during the production process. However, data on capital energy are scarce. Thusfar capital energy is neglected in most of the energy analyses carried out. This is related to the fact that the contribution of capital energy to overall
primary energy requirements is seldom greater than 5%, and is generally closer
to 1% (Boustead and Hancock, 1979). This arises because, although the initial
energy costs to construct the capital are very high, the lifetime for capital is
measured in decades rather than in years. As a result, the initial energy costs are
spread over the capital lifetime and distributed over the cumulative production of
the capital during this lifetime. Due to this, in most cases\(^1\), ignoring capital
energy in the analysis of the total primary energy requirements introduces only a
small error in the overall outcome.

In NLECCO it is assumed that capital depreciates at a constant rate. Depreciated
capital, as a proportion of the fixed capital stock, is determined by
dividing the total capital stock by its lifetime. The annual depreciation of capital
(i.e. the consumption of capital) is regarded as an indirect energy input into
production.

6.3 Determination of the primary energy requirements for investments

The construction of an ECCO model requires data on energy embodied in human
made capital. As these data are scarce, data on financial investments were used
as a starting point to determine the past energy expenditures of capital
investments. The conversion of financial data into energy data requires
information on the primary energy required to produce a guilders’ worth of man
made capital. In this connection two relevant questions need to be answered:
1 What is the average cumulative energy requirement of a guilders’ worth of
physical investments in 1985? (i.e. the energy intensity of the financial
investments in MJ/Dfl\textsubscript{1985}).
2 As it is unlikely that the energy intensity of investments is constant in time,
what is the past trend in primary energy requirements of investments? Since
a considerable part of the human made capital has a lifetime of several
decades, this trend should be traced back at least a one generation of lifetime.

\(^1\) If the capital lifetime becomes shorter the contribution of capital might increase to a significant part
of the total energy requirements. For instance, Chapman (1973) calculated that for a direct electrical
consumption of 8.04 MJ/ton ore extracted, the production of replacement bits for the drilling equipment
involves an additional indirect energy expenditure of 2.41 MJ/ton ore.
To start with the first question, data from IOEA as presented in the previous chapter can be applied to determine the cumulative energy requirements of a guilders’ worth invested in 1985. Using IOEA, the energy intensity of depreciated capital has been calculated upon 5.3 MJ/Dfl\textsubscript{1985}. It has been assumed here that depreciated capital from past investments has the same origin as the capital investments in 1985 (see also section 5.2.5). From this assumption it follows that the energy intensity of capital investments in 1985 is identical to the energy intensity of capital depreciation (i.e. 5.3 MJ/Dfl\textsubscript{1985}).

Since all capital goods are produced by the industry, at first sight, one would assume the energy intensity of capital investments to be equal to the energy intensity of the industrial output. However it turns out that the energy intensity of capital investments is only about half the average energy intensity of the industrial output (the latter has been calculated to be about 10 MJ/Dfl\textsubscript{1985}).

This difference follows from the trends in the additional energy inputs into a product and the increasing monetary value of that product in the successive stages of processing. This was discussed already in section 2.8. Basically, as products reach their final stage, the rate of additional energy inputs decreases, whereas the monetary value increases. For instance, when constructing a house, the production of basic building materials generally requires the highest energy inputs. In subsequent stages of construction the role of (highly qualified) labour such as engineers, architects or bank employees increases. From a thermodynamic point of view, the role of these labour inputs can be regarded as adding information (know-how) to the production process, herewith increasing the order of the product whereas hardly any energy and/or mass are added. As labour costs are high, the relative increase of the financial value exceeds the relative rise of the additional energy inputs.

To illustrate this, figure 6.1 shows the cumulative energy intensities and the fraction of the total production costs used for salaries of various sectors in 1985. Energy intensive sectors such as the basic chemical industry and the basic metal industry have low labour costs whereas services activities have high labour costs and low energy inputs. When assuming that the wages as a fraction of the total production costs represent the labour intensity of a sector, figure 6.1 shows that along the successive stages of producing goods and services, per unit of output, the relative increase of the labour intensity exceeds the increase of energy inputs.
when reaching final demand consumption (see also Molag et al., 1979).

Omitting the imports, in 1985 the primary costs\(^2\) comprise 45 percent of

![Figure 6.1 The energy intensities and the contribution of wages in the total production value of various sectors in the Netherlands economy in 1985.](image)

the total financial production costs of the industrial sectors contributing to capital investments (i.e. producing capital goods). As the primary costs carry low energy inputs one would expect the energy intensity of the investments to be about 50 percent of the energy intensity of the industry which has been estimated to be 10 MJ/Dfl\(_{1985}\). This assumption has been verified by the results of the input-output energy analysis for the year 1985.

The second question, raised at the beginning of this section, concerns the past pattern of the average energy intensity of a guilders’ worth invested in human made capital to estimate the past energy inputs accumulated in the 1985 capital stocks. Within the given constraints on available time and on availability of poor energy data, two well-accepted macro economic indicators have been used in order

\(^2\) In an input-output table the primary costs comprise of imports, depreciation costs, indirect taxes, wages, social charges, imputed banking services and net operating surpluses.
to trace back the energy requirements for investments from 1985 to 1945 rather than performing an IOEA over a forty-five years period. These indicators are: the GDP and the domestic energy consumption (see also Noorman, 1991). The direct energy required to generate one guilders’ equivalent of GDP has been used as an indicator to determine the annual changes in the energy intensities of investments, herewith assuming a linear relation between the direct energy intensity of the GDP and the cumulative energy intensity of capital investments.

![Trends in energy intensities of investments](image)

**Figure 6.2** Past trends in energy requirements for investments.

In a recent study, Wilting (1994) presented the results of an IOEA study, covering a twenty years period from 1969 to 1989. Figure 6.2 compares the (more detailed) results of the IOEA and the results of the earlier described method. The

\footnote{As a result of different methods used, the energy intensity of investments calculated by Wilting (5.9 MJ/£1985) differs slightly from the energy intensity of investments presented in this study (5.3 MJ/£1985). For a comparison of both patterns of energy intensities (in nominal prices), an index has been used (1985 = 100).}
results of the two methods match well \( (r = 0.99) \). In 1976 the two series deviate. The dotted line (ECCO study) shows an increase in the energy intensity of the investments as a result of a sudden rise of the direct energy consumption (from 2436 PJ in 1975 to 2766 PJ in 1976), whereas according to the results of IOEA the energy intensity of the investments has declined.

A possible explanation for this difference can be found in the examination of changes in the direct energy consumption of the various production sectors. For a significant part the rise in direct energy consumption has been caused by the chemical final products industry. As this sector produces little investment goods, the rise in the total domestic direct energy consumption does not directly affect the energy intensity of capital investments calculated by IOEA.

### 6.4 A method for the assessment of the energy embodied in man made capital

The method presented in this section to estimate past energy expenditures that accumulated in the capital stock in 1985, takes financial data as a starting point. The results of IOEA, representing the primary energy equivalents of a guilders’ worth invested in various types of capital goods have been used to convert the financial data into energy inputs. The method consists of three steps that will be elaborated below (see also figure 6.3 at the end of this section).

**Step 1** Financial data are collected on stocks of capital goods of the various NLECCO sectors. The CBS (1989) provides such data on the value of stocks of capital goods divided by type and vintage in current prices. The capital stocks are classified in 9 types of commodities, listed below.

1. land value
2. industrial/commercial buildings
3. other buildings and earthwork
4. external means of transport
5. internal means of transport
6. office machinery
Chapter 6: Stocks of energy in the Netherlands economy in 1985

7 instruments
8 other machines, apparatus and installations
9 other types of capital goods

As in ECCO ‘capital’ only includes physical human made capital, land value has not been included in the method. This introduces no significant bias in the results obtained. Investments associated with preparing the land for construction are normally incorporated in the investment costs and are therefore included in assessing the energy costs of construction.

Step 2 Data on the financial value of the capital stocks in 1985 prices (in some cases 1984 prices) are converted into the historical building costs of the various types of capital stocks. Deflators have been used to determine the historical costs from 1985 prices (CBS, 1991)\(^4\).

1 land value
2 industrial/commercial buildings
3 other buildings and earthwork
4 external means of transport
5 internal means of transport
6 computers
7 other machines, apparatus and installations
8 other types of capital goods

From this grouping it can be noted that the deflators are related to a new classification of types of commodities that differs from the classification of capital goods given at step 1 at a few points.

Per type of capital stock, the historical costs have been calculated for all eight successive five-year periods, between 1945 and 1985.

\(^4\) The deflators used are no official CBS-deflators. Although based on official deflators, the deflators used to estimate the historical costs of the various commodities in this ECCO study result from additional operations carried out by the main division ‘Statistics of stocks of capital goods and balances of the Dutch Bureau of Statistics (CBS). Within the scope of the statistics on capital stocks, these deflators are mainly used to reduce the historical costs of capital goods to current values.
Step 3 To estimate the energy costs of capital investments in various types of capital goods, the classification of types of capital goods as shown in step 2 was used: the energy inputs related to the historical costs of the various commodities were estimated by relating the historical costs of these commodities to the energy intensity of those industrial sectors from which it has been assumed that the type of capital goods classified in that category have derived (see table 6.1). In order to estimate the energy inputs of those categories that include a large compilation of various types of capital goods (type 7 and 8), the average energy intensity of the investments as presented in the previous section has been used.

Table 6.1 Types of capital goods distinguished in this study and the corresponding energy intensities of industrial sectors.

<table>
<thead>
<tr>
<th>type of capital good</th>
<th>corresponding sector</th>
<th>energy intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 industrial/commercial buildings</td>
<td>Construction and installation</td>
<td>(5.0 MJ/Dfl)</td>
</tr>
<tr>
<td>3 other buildings and earthwork</td>
<td>Construction and installation</td>
<td>(5.0 MJ/Dfl)</td>
</tr>
<tr>
<td>4 external means of transport</td>
<td>Automobile industry</td>
<td>(8.1 MJ/Dfl)</td>
</tr>
<tr>
<td>5 internal means of transport</td>
<td>Machinery industry</td>
<td>(5.4 MJ/Dfl)</td>
</tr>
<tr>
<td>6 computers Electrotechnical industry</td>
<td></td>
<td>(5.3 MJ/Dfl)</td>
</tr>
<tr>
<td>7 other machines etc.</td>
<td>energy intensity of investments</td>
<td>(5.3 MJ/Dfl)</td>
</tr>
<tr>
<td>8 other types of capital goods</td>
<td>energy intensity of investments</td>
<td>(5.3 MJ/Dfl)</td>
</tr>
</tbody>
</table>

For every five-year period the historical costs of each type of capital goods have been multiplied by the average energy intensity of the corresponding industry sector. In this way, for every vintage the primary energy expenditures related to the historical costs of the various types of capital goods have been determined. Finally, adding up the energy embodied in the various capital goods over the considered time period of 45 years results in an estimate of the past energy expenditures required to build up the capital stock present in 1985. Figure 6.3 summarizes the procedure of assessing the energy embodied in the human made capital stock in 1985. The level of aggregation is necessarily high and therefore less suitable for integrating in more detailed process analyses. However, the
Chapter 6: Stocks of energy in the Netherlands economy in 1985

6.5 Energy embodied in the industrial capital stocks

In 1985, the total value of the accumulated industrial capital stock in 1985 prices amounted to 250 billion Dfl. of which 18.5 billion Dfl. was related to the land value (CBS, 1989). Reducing the financial value of industrial capital (exclusive the land value) with the 1985 investments brings the total value of which we want to estimate the primary energy content down to 219 billion Dfl. Table 6.2 gives a break-down of the capital stock in 1985 prices (CBS, 1989).

Figure 6.3 Outline of the main steps of the method.

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accuracy of the data derived from the method does serve the purpose for which they are needed: an estimation of the primary energy embodied in the capital stocks of the various NLECCO sectors. To illustrate the described method, the calculation of the energy embodied in the industrial capital stock is presented in detail in the next section.

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Chapter 6: Stocks of energy in the Netherlands economy in 1985

Table 6.2 The financial value of the industrial capital stock in 1985 prices divided by type and vintage (millions Dfl.).

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</tbody>
</table>

The following step comprises of the determination of the historical costs from the 1985 prices. The results are shown in table 6.3 in nominal prices.

Table 6.3 The financial value of the industrial capital stock in nominal prices divided by type and vintage (millions Dfl.).

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</table>
Chapter 6: Stocks of energy in the Netherlands economy in 1985

The energy equivalent of the historical costs has been calculated by multiplying the historical costs of the various types of capital goods by the average energy intensity of the corresponding production sectors (see table 6.1) for every five-year period.

Analogous to the analysis of the trend of energy intensities of investments (see figure 6.2), the historical pattern of the energy intensities of the production sectors whose output is assumed to be typical for the distinguished categories of capital goods (see table 6.1), has been determined by assuming a linear relationship of the changes in direct energy requirements for producing one unit of GDP and the changes in the 1985 energy intensity of these industrial sectors. In order to validate these patterns constructed, these trends have been compared to the results of the input-output energy analysis carried out for the period 1969-1988 (Wilting, 1994). It turns out that the results of the two different approaches match well (for each sector it is shown that \( r > 0.98 \)). The results of the conversion of the financial costs into energy equivalents are summarized in table 6.4.

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<td>7.3</td>
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<td>141.4</td>
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<td>1.9</td>
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<td>19.0</td>
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<td>285.6</td>
<td>271.1</td>
<td>237.6</td>
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</table>

Some data on the financial value of capital stock are confidential. As this fraction is not divided by vintage, the above presented method can not be applied
to these confidential figures. In order to estimate the primary energy equivalent of these financial data they have been multiplied by the average energy intensity of investments in the period 1980 - 1984 (6.0 MJ/Dfl). Including the latter data, the primary energy embodied in the industrial capital stock as present in 1985 is estimated at 1330 PJ.

Figure 6.4 shows the development of the primary energy equivalents of the industrial capital stock between 1950 and 1985. In that period the energy embodied in industrial capital increased by more than twenty-five fold. However, since the beginning of the seventies the net increase in embodied energy has diminished.

With the help of figure 6.5 it can be examined whether this turn resulted from an increasing energy efficiency or a decreasing rise of the real volume of industrial capital. In figure 6.5, for every five years period, the relative changes of the real increase of industrial capital (measured in 1985 prices) and the embodied energy of the added capital are compared with regard to the period
Chapter 6: Stocks of energy in the Netherlands economy in 1985

1950 - 1955. The figure shows parallel growth patterns during the fifties, while in the sixties an increasing discrepancy between the rise in the embodied energy and the volume of the industrial capital stock arises. From the early seventies the energy costs per unit capital steadily decreased, most probably due to the substitutions induced by the oil crisis of 1973 (cf. Wilting, 1994).

6.5.1 Assessment of the energy embodied in the NLECCO industry sector

The industry sector as defined in the CBS statistics does not fully match the industry sector as defined in NLECCO. Firstly, in the Dutch statistics the industry sector includes the oil industry whereas in NLECCO the oil industry is part of the energy supply sector. Secondly, in NLECCO, sector 40 (construction and installation) was included in the industry. Therefore, in order to assess the energy embodied in the NLECCO industry sector, the outcome of the analysis presented in the previous sub-section has to be corrected for these differences.

The oil industry

Since no detailed financial data on the capital stock of the oil industry are available the energy embodied in the oil industry capital stock was estimated with two methods. The first method starts from the financial value of depreciated capital derived from the input-output table. Multiplying this figure (730 million Dfl) by the energy intensity of capital depreciation (see appendix 5.3) and an average assumed lifetime of 25 years, the energy embodied in the oil industry capital has been estimated as 96 PJ.

The second method uses the results of process analysis. It is assumed that the contribution of capital energy lies within a range of 1% - 5% of the overall system energy requirements (Boustead & Hancock, 1979). A minimum value of the overall system energy requirements can be found using the efficiency of the refineries. In 1985, from an input of 1825 PJ the refineries produced 1713 PJ of oil products with an efficiency of 94%. Herewith the total production energy is estimated to 6% of the total output (102 PJ).

Following Boustead and Hancock (1979), in this study the assumption has been made that 2.5% of the total production energy can be considered as capital energy (for the total industry sector the share of depreciated capital in the embodied energy of the industrial output was 2% [see table 5.4]). The energy equivalent of depreciated capital then becomes 2.55 PJ. As in 1985 the gross
production amounted to only 66% of the total capacity, the latter figure has to be corrected for the refinery over-capacity. When producing at full capacity the energy equivalent of depreciated capital becomes 3.9 PJ. Assuming a lifetime of 25 years the energy embodied in the capital stock of the oil industry is calculated to be 97 PJ.

Although the outcome of both estimates agree very well, it should be mentioned that both methods are based upon various assumptions which can affect the outcomes considerably. Therefore, the energy embodied in the capital stock of the oil industry is estimated here to be 100 PJ.

**Construction and installation**

As no desaggregated data on the financial value of this sector are available, the embodied energy of the capital stock has been estimated using the financial value of the depreciated capital in 1985. Multiplying this figure (1410 million Dfl) by the energy intensity of capital depreciation (5.3 MJ/Dfl) and an assumed average lifetime of 25 years, results in an estimate of about 186 PJ.

Combining all data, the energy required to build up the initial industrial capital stock as defined in NLECCO is estimated to be 1488 PJ.

**6.5.2 Industrial investments and depreciation**

Financial data on capital investments are derived from the National Accounts (CBS, 1987, 1992). The financial value of industrial investments as defined in NLECCO (exclusive V.A.T.) amounted to 15.4 billion Dfl in 1985. Multiplying this figure by the average energy intensity of a guiders’ worth invested leads to an estimate of the primary energy equivalent of the physical investments of 81.3 PJ.

The energy embodied in depreciated capital in 1985 has been presented in table 5.4 already (62.0 PJ). Dividing the energy embodied in the industrial capital stock by the energy equivalent of the depreciated capital results in an average lifetime of 24 years. Using the same method the capital investments of the oil industry are estimated as be 6.7 PJ.
6.5.3 Discussion
Although it is generally estimated that the capital contribution of various industrial activities range between 1 - 5% of the overall primary energy requirements of production, in reality they differ significantly (Boustead and Hancock, 1979). Applying the method presented in section 6.4, the energy embodied in the industrial capital is estimated while taking account of the different types of capital goods, and changes in the energy intensities of the economic sectors that produce these goods.

Comparison with the results of IOEA demonstrates that, in order to explore the past trends in energy intensities, the direct energy required to produce one guilder worth of GDP is an appropriate indicator at such a high level of aggregation. Since data on capital energy are scarce, validation of the results presented in this section is difficult. The capital contribution of the Netherlands industry sector to the overall primary energy requirements of industrial production turns out to be 2% (see table 5.4). This value lies within the range of 1 - 5% as has been put forward by Boustead and Hancock (1979).

In the next three sections the energy embodied in the capital stocks of the sectors 'oil and gas production', 'transport' and 'agriculture' are reviewed, applying the same method as used to determine the embodied energy of industrial capital (more details cf. Noorman, 1991).

6.6 Energy embodied in the capital stock of oil and gas production.

The value of the capital stock of the branch 'Mining and quarrying' (SBI 1) at the end of 1985 in prices at the end of 1985 amounts to 31.8 billion guilders (CBS, 1989). The largest fraction (89%) accounts for the 'Crude oil and natural gas production and exploration'. As no detailed data on the capital stock of the latter are available, all data of the branch 'Mining and quarrying' have been corrected for this fraction. The results are summarized in figure 6.6.

The energy equivalent of the capital stock of crude oil and natural gas production is assessed to be 171 PJ. Figure 6.6 indicates a sharp rise of the capital developments in this sector from the early sixties when the exploration of the domestic natural gas fields started.

NLECCO makes a distinction between crude oil production and natural gas
production. In order to
distribute the capital stock of the joined oil and
natural gas production sector over these two
NLECCO sectors, it was
assumed that the marginal
capital rates (output per
unit of capital stock) of oil
and natural gas production
are equal. From this, the
total production of each
sector can be used to
estimate the capital stock
of both sectors.

In 1985, the crude oil
production amounted to 159 PJ whereas the natural gas production amounted to
2555 PJ, representing 6% and 94% of the total domestic primary energy
production respectively. Herewith the capital stock of crude oil production is
estimated at 10 PJ, leaving 161 PJ of energy embodied in the capital stock for
natural gas production.

The financial investments in both NLECCO energy production sectors are
derived from the total investments of the branch ‘Mining and quarrying’, applying
the same distributional principle to distinguish between both NLECCO sectors.
The financial investments in oil and natural gas production have been assessed at
1970 million Dfl (CBS, 1992). The energy equivalent is calculated to be 10.4 PJ,
of which 9.8 PJ is assigned to the natural gas production sector and 0.6 PJ to the
oil production sector. In 1985, for oil and gas production, the costs of capital
depreciation were 1190 million Dfl, representing an energy equivalent of 6.3 PJ
of which 5.9 PJ is assigned to the natural gas production sector. Dividing the
capital stock of crude oil and natural gas production by the energy embodied in
depreciated capital results in an estimated lifetime of 27 years. This figure might
be too high as the energy intensity equivalent of past energy investments was
higher due to than prevailing lower efficiencies.
6.6.1 Discussion
Data on capital energy are scarce. Therefore it is difficult to compare the calculated value of the energy embodied in the energy production sector with existing data. For example, capital plant depreciation, in energy terms, for the U.S. coal mining industry has been estimated at 0.25% of the total fuel energy (i.e. fuel energy content plus production energy) (Boustead and Hancock, 1979). Assuming that this figure is representative for energy production activities, it can be used for comparative purposes.

Adding the direct energy input of the primary production sector (14 PJ) to the amount of natural gas (2555 PJ) and crude oil extracted (159 PJ) results in an estimate of the total fuel energy of 2728 PJ. The annual capital depreciation is assumed to be 0.25% of the total fuel energy or 682 TJ. Multiplying the figure by the estimated lifetime results in 184 PJ of energy embodied in energy production capital. Considering that the estimated lifetime (27 years) may be too high, this figure is consistent with the above presented results (171 PJ).

6.7 Energy embodied in the transport capital stock.

Two types of transport services are distinguished in NLECCO: freight transport services and passengers (or public) transport services. CBS provides financial data on the stocks of capital goods of 10 classes of the branch 'Transport, Storage and Communication' (i.e. SBI 7) (CBS, 1987). With the exception of the sector 'communication', these classes have been distributed over the two NLECCO transport sectors.

Table 6.5 lists the two NLECCO transport services and the corresponding classes of transport (related) activities as defined in CBS statistics. Air transport and railways include both freight transport and passengers transport. Assumptions were made about the size of the capital stock related to freight transport and the size related to passengers transport. In 1984, 17.5% of the economic value of the railways rolling-stock (with exception of the locomotives) represented freight transport (CBS, 1988). It was assumed that the same proportion of the railways capital stock can be assigned to freight transport. With respect to the air transport business the assumption was made that the distribution of the capital stock between freight transport and passengers
Chapter 6: Stocks of energy in the Netherlands economy in 1985

Table 6.5 The NLECCO transport sectors and the corresponding classes of transport activities.

<table>
<thead>
<tr>
<th>Freight transport</th>
<th>Public transport</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freight transport by road</td>
<td>Tram and bus services</td>
</tr>
<tr>
<td>Transport-related enterprises</td>
<td>Taxi enterprises</td>
</tr>
<tr>
<td>Air transport (related) business (25%)</td>
<td>Air transport (related) business (75%)</td>
</tr>
<tr>
<td>Railways (17.5%)</td>
<td>Railways (82.5%)</td>
</tr>
<tr>
<td>Ocean-going transport and shipping on coasting</td>
<td></td>
</tr>
<tr>
<td>Inland shipping</td>
<td></td>
</tr>
</tbody>
</table>

![Capital stock transport services in PJ.](image)

Figure 6.7 The energy embodied in the transport services capital stock in the Netherlands in 1985.
Chapter 6: Stocks of energy in the Netherlands economy in 1985

Transport is proportional to the division of the total transport revenue of KLM between passengers (75%) and freight (25%) in the fiscal year 1984/1985. The energy intensities as listed in table 6.1 were used to relate the historical costs of the nine transport classes to the primary energy inputs required to build up the capital stock.

As the external means of transport of the transport sectors range from aircrafts and tankers to taxis, the energy intensity of the automobile industry is replaced by the energy intensity of sector 35: 'Manufacture of transport equipment'. A break-down of the energy embodied in the total transport capital stock is shown in figure 6.7.

The primary energy embodied in transport capital is estimated at 712 PJ. The energy embodied in freight transport capital stock amounts to 429 PJ of which 237 PJ (55.2%) is embodied in external means of transport. Aside from the transport related enterprises, of which the share of external means of transport is relatively small, the fraction external means of transport of the capital stock freight transport rises to 77.4%.

The embodied energy of the public transport capital stock is estimated at 283 PJ of which 46.8% is related to external means of transport. Figures 6.8 and 6.9 show the development of primary capital energy inputs in both transport sectors.

In order to estimate the primary energy inputs in 1985 investments, the investments of the various transport classes, expressed in monetary terms, (CBS, 1985, 1986) were multiplied by the average energy intensity of 1985 investments.

The physical investments of the freight transport sector are calculated to be 24 PJ of which 16.3 PJ is invested in external means of transport. The physical investments in public transport are much less: 11 PJ of which 4.8 PJ is invested in external means of transport.

In 1985, the costs of capital depreciation of the transport sectors (I-O sectors

---

5 Investments in the transport sector are a-typical as a significant part is invested in means of transportation. Taking into account the different composition of the transport investments one could consider the use of a transport specific energy intensity of investments. To avoid complexity it was chosen to use the average energy intensity of investments. The error introduced in this way is small as the energy intensity of 'Manufacture of transport equipment' (5.7 MJ/Dfl1985) hardly deviates from the average energy intensity of investments.
Chapter 6: Stocks of energy in the Netherlands economy in 1985

44 and 45) amount to 4920 millions Dfl. Multiplying this latter figure by an energy intensity of 5.3 MJ/Dfl. results in an estimation of 26 PJ in depreciated capital. Dividing the total transport capital by the energy embodied in depreciated capital would result in a lifetime of about 27 years.

However, to emphasize the differences in capital lifetime, a distinction was made between external means of transport and other capital. Assuming a lifetime of 19 years for external means of transport (CBS, 1988), the energy embodied in disbanded means of transport is estimated at 19 PJ of which 12 PJ is assigned to freight transport and 7 PJ to public transport. The remaining energy embodied in depreciated capital has been divided proportionally over the other types of capital of the two transport sectors, assuming a capital lifetime of 50 years for the remaining capital. The results are summarized in table 6.6.
Table 6.6 Physical investments and capital depreciation divided by sector and type of capital in 1985 (PJ).

<table>
<thead>
<tr>
<th></th>
<th>Freight transport</th>
<th>Public transport</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>means of transport</td>
<td>other capital</td>
</tr>
<tr>
<td>investments</td>
<td>16.3</td>
<td>7.7</td>
</tr>
<tr>
<td>depreciation</td>
<td>12.0</td>
<td>4.0</td>
</tr>
</tbody>
</table>

6.8 Energy embodied in the agricultural capital stock

Although data on the financial value of the stock of capital goods of the branch 'Agriculture and Fishing' are available, the assessment of the energy equivalent of these costs is difficult for various reasons. Firstly, a significant part (35%) of the agricultural buildings has been constructed before 1950 (CBS, 1987). As the errors in the past trend of energy intensities increase in time, the conversion of monetary data in energy data becomes increasingly uncertain. Secondly, the financial value of the branch relates to both agriculture and fishing.

Therefore assumptions had to be made with respect to the share of the fishing capital stock in the agricultural capital stock. Of the financial value of the total capital stock 58% concerns agricultural land whereas 5% is related to livestock.

Taking into account the above mentioned restrictions and ignoring land value and the financial value of the livestock, the
energy equivalent of the agricultural capital stock has been assessed to be 292 PJ of which 179 PJ is related to agricultural buildings. In 1985, the investments amount to 4.13 billion Dfl. of which 11% concerns land (CBS, 1985). The energy equivalent of these investments is estimated at 21.8 PJ whereas capital depreciation is assessed to be 12.2 PJ. The developments of the agriculture capital stock since 1950 are shown in fig 6.10.

### 6.9 Energy embodied in the services capital stock

Both NLECCO services sectors (market services (MKS) and non-market services (NMS)) consist of a wide range of activities. As the financial value of by far the largest part of the services capital is not registered in the national statistics, the method presented in section 6.4 cannot be applied to determine the energy embodied in the services capital stock. In order to estimate the past energy inputs in the construction of services capital, the depreciation rate of services capital (measured in financial terms) has been used as point of departure.

In 1985, services capital depreciation amounts to 12 billion Dfl (CBS, 1987). A breakdown of the costs of capital depreciation among the various services sectors is given in table 6.7 (CBS, 1987). Assuming a 25 years lifetime, the total value of the services capital stock is estimated at 300 billion Dfl. To convert this value into energy terms, the average energy intensity of a guiders’ worth invested in the period 1960-1985 (5.8 MJ/Dfl.) has been used, assuming that the largest part of the services capital has been constructed in that period. Herewith the energy embodied in services capital is estimated to be 1725 PJ.

In 1985, capital investments (exclusive V.A.T.) amounts to 23.4 billion Dfl. (CBS, 1987), representing an energy input of 123.5 PJ.

Because in ECCO inputs into a sector are a function of capital stocks and no direct inputs are related to infrastructure, it is preferable to distinguish between energy embodied in infrastructure and that in other services capital. To estimate the energy embodied in infrastructure the energy equivalent of infrastructure
Chapter 6: Stocks of energy in the Netherlands economy in 1985

depreciation has been multiplied with the assumed lifetime of 25 years. Applying an energy intensity of 5.8 MJ/Dfl., the energy embodied in infrastructure is estimated at 144 PJ. In 1985, the investments in infrastructure amount to 9667 million Dfl. (exclusive V.A.T.), representing an energy equivalent of 51 PJ.

Table 6.7 Investments in market services (MKS) and non-market services (NMS) in 1985.

<table>
<thead>
<tr>
<th>sector</th>
<th>I-O sector</th>
<th>ECCO sector</th>
<th>depreciation (million Dfl.)</th>
<th>depreciation (TJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wholesale trade, retail trade</td>
<td>41</td>
<td>MKS</td>
<td>3660</td>
<td>21045</td>
</tr>
<tr>
<td>Hotels, restaurants, cafés etc.</td>
<td>42</td>
<td>MKS</td>
<td>420</td>
<td>2415</td>
</tr>
<tr>
<td>Repair of consumer goods</td>
<td>43</td>
<td>MKS</td>
<td>110</td>
<td>633</td>
</tr>
<tr>
<td>Communication</td>
<td>46</td>
<td>MKS</td>
<td>1570</td>
<td>9028</td>
</tr>
<tr>
<td>Banking</td>
<td>47</td>
<td>MKS</td>
<td>180</td>
<td>1035</td>
</tr>
<tr>
<td>Insurance</td>
<td>48</td>
<td>MKS</td>
<td>180</td>
<td>1035</td>
</tr>
<tr>
<td>Business services etc.</td>
<td>50</td>
<td>MKS</td>
<td>570</td>
<td>3278</td>
</tr>
<tr>
<td>Other services</td>
<td>57</td>
<td>MKS</td>
<td>150</td>
<td>863</td>
</tr>
<tr>
<td>Government: civilian</td>
<td>51</td>
<td>NMS</td>
<td>1713</td>
<td>9850</td>
</tr>
<tr>
<td>Government: education</td>
<td>53</td>
<td>NMS</td>
<td>1034</td>
<td>5946</td>
</tr>
<tr>
<td>Social services</td>
<td>54</td>
<td>NMS</td>
<td>220</td>
<td>1265</td>
</tr>
<tr>
<td>Health and veterinary services</td>
<td>55</td>
<td>NMS</td>
<td>2010</td>
<td>11558</td>
</tr>
<tr>
<td>Culture, sports and recreation</td>
<td>56</td>
<td>NMS</td>
<td>160</td>
<td>920</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>11977</td>
<td>68871</td>
</tr>
</tbody>
</table>

In 1985, 60% of the government investments are used for infrastructure. Since no detailed data on the depreciation rate of infrastructure were available it is assumed that an equal fraction of the total costs of depreciated capital of the government (I-O sector 51) could be assigned to depreciated infrastructure capital. Herewith the depreciation rate of infrastructure is estimated at about 1 billion Dfl.
Chapter 6: Stocks of energy in the Netherlands economy in 1985

The embodied energy of the services capital stock has to be divided between the two NLECCO services sectors, i.e. market services and non-market services. Following the breakdown of depreciated capital among the various services sectors (see table 6.7) it has been assumed that respectively 57% and 43% of the total services capital stock could be assigned to the market services and the non-market services. Table 6.8 summarizes the results of the outcomes of the analysis of the energy equivalent of the services capital stock.

Table 6.8 Energy embodied in fixed capital, capital investments and depreciated capital of the services sector, in 1985 (PJ).

<table>
<thead>
<tr>
<th></th>
<th>Fixed capital stock</th>
<th>Capital investments</th>
<th>Capital Depreciation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market services</td>
<td>900</td>
<td>41</td>
<td>28</td>
</tr>
<tr>
<td>Non-market services</td>
<td>681</td>
<td>31</td>
<td>27</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>144</td>
<td>51</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>1725</td>
<td>123</td>
<td>69</td>
</tr>
</tbody>
</table>

6.9.1 Discussion
As 'the services sector' refers to a wide range of activities, difficulties arise when assessing the capital stock of this sector. In other studies the total floor area is sometimes presented as a measure of services activity (Schipper et al., 1992). However, the estimates of total floor area are somewhat uncertain as the surveys in different countries are not always comprehensive and comparable. In some countries the data refer to total floor area, while in others they refer to conditioned or heated area (Schipper et al., 1992). Typical for OECD countries the total enclosed floor area (including train stations, markets etc.) ranges between 15-17 m² per capita (Schipper et al., 1986).

For the Netherlands, the total floor area of commercial buildings, including offices, schools, stores, hospitals and other buildings, have been estimated to be 117.3 million m² in 1990 (WM consults, 1990). Assuming an annual increase of 2% between 1985 and 1990, the total floor area of commercial buildings has been estimated at about 106 million m² in 1985.

To estimate the energy inputs into the construction of commercial buildings,
information on the energy requirements per m\(^2\) is essential. Stein (1977) estimates the energy costs for construction of new buildings at about 1.3 MBtu/ft\(^2\) or 14.7 GJ/m\(^2\) (based on 1973 data). Correcting this figure for the trend in the average energy intensity of investments in the period 1960 - 1985, the average energy costs for new buildings construction in this period has been estimated to be 12.7 GJ/m\(^2\). Assuming a total floor area of 106 million m\(^2\), this results in an estimate of the energy construction costs of commercial buildings of 1346 PJ (since the floor area taken into account only includes commercial buildings the figure used (about 7 m\(^2\) per capita) is much lower than suggested by Schipper et al.).

As mentioned earlier, the total capital stock consists of various types of capital goods. CBS (1987) only provides data on the total value divided by type of capital goods for the educational sector. In this sector buildings include 84\% of the total capital stock (exclusive infrastructure). Accepting this percentage as representative for the complete services sector, the total energy equivalent of the services sector can be estimated to 1603 PJ. Adding the energy embodied in the infrastructure results in an estimate of 1747 PJ, about 1\% more than shown in table 6.8.

Although the outcomes match very well, it should be emphasized that the methods presented in this section include a wide error range. However, the degree of detail obtained is sufficient for application in NLECCO.

### 6.10 Energy embodied in the residential sector

Various difficulties arise when assessing the accumulated primary energy costs of the total housing stock in 1985. Firstly, there are many difficulties inherent in obtaining consistent energy inputs in housing construction. This is partly due to the diversity of construction methods and materials used. Furthermore, a large variety in types of houses makes it difficult to evaluate the primary energy inputs into an 'average' dwelling. Studies aimed at evaluating the energy costs of housing construction all showed significant variations in the results (Gartner et al., 1976; de Vos et al., 1979).

Secondly, in the Netherlands 28\% of the fixed stock of dwellings in 1985 was built before the second world war (CBS, 1988). Evaluating the energy inputs of this part of the dwelling stock becomes more uncertain as material requirements,
construction methods and the average size of dwellings have changed over time.

For these reasons the level of aggregation in the evaluation of the energy embodied in the fixed capital stock of the residential sector is necessarily high. As a first step the financial construction costs (in nominal prices) of the number of houses built in the period 1945 - 1985 were estimated. This was done by making a distinction in two categories of houses: Social Rental Housing and Other Housing. The historical construction costs of these two categories of houses were derived from 1980 construction costs, using price indices for the output of housing construction (CBS, 1988, 1985a).

For every year the number of completed houses in each of both categories was multiplied with the average construction costs of that category of houses. This resulted in an estimate of the total financial investment costs in housing construction (in nominal prices).

In order to assess the primary energy equivalent of the financial investments, these construction costs were multiplied by the average energy intensity of a guilders’ worth invested.

Figure 6.11 shows the post-war pattern of the average financial construction costs and the corresponding energy costs per dwelling (in the figure no distinction is made between Social Rental Housing and Other Housing). Following the trend of the energy intensities of investments, the annual changes of the primary energy costs show an erratic pattern. Most likely, in reality changes in the energy costs will follow a more steady pattern. The figure shows an increasing disconnection of the financial building costs and the primary energy requirements after the oil price hikes in 1973 and 1979. Over the total period, the average
The energy costs per dwelling are calculated at 485 GJ.

Figure 6.12 depicts the number of new dwellings added each year and the accumulated energy in the dwelling stock constructed between 1945 and 1985. The latter amounts to 1946 PJ. As already mentioned, the dwelling stock built up after the second world war comprises 72% of the total dwelling stock up to 1985. Assuming that the energy costs of the remaining 28% of the dwelling stock are equal to the post-war dwelling stock, the total primary energy costs are estimated at 2700 PJ.

The investments in the dwelling stock include investments in new dwellings as well as maintenance costs. The total investments amount to 21.6 billion Dfl. (about 20 billion exclusive of V.A.T.), representing an energy equivalent of 102 PJ (CBS, 1987). In 1985, 98127 new houses have been added to the existing dwelling stock (CBS, 1994). Multiplying the average financial building costs per dwelling by the energy intensity of the 1985 investments results in an average energy investment of 512 GJ per dwelling. Herewith the energy costs corresponding to new houses built in 1985 are estimated at 50 PJ, leaving an energy equivalent of 52 PJ for maintenance.

Capital depreciation amounts to 6560 million Dfl., representing an energy equivalent of 34.6 PJ. In 1985, the average lifetime of houses at the time of withdrawal is 75 year (CBS, 1986). Multiplying the average lifetime by the energy intensity of capital depreciation results in an estimate of the embodied energy in the domestic capital stock of 2600 PJ. This estimate differs only slightly from the 2703 PJ, derived from historical building costs and the post-war energy intensities of a guilders’ worth invested.
6.10.1 Discussion
In this section the average energy investments in house construction were estimated at a high level of aggregation. The deviations from this average value are significant due to a large variety in different types of houses, construction methods and material inputs. As a consequence of the applied method, using historical building costs (excluding land costs and V.A.T.) and historical series of the average energy inputs into investments, the energy costs of house construction may vary considerably over time. The question arises whether the highly aggregated results presented in this section are comparable with available literature references.

De Vos et al. (1979) estimated the energy inputs in two types of government subsidized terraced houses, representative for the type of houses built in the early eighties, at 505 GJ and 586 GJ. These outcomes correspond well with the outcome of the method presented in this study; 530 GJ for an 'social renting house' built in 1980.

More recently, Fraanje (1990), only taking into account the main building materials, transport and direct energy use during the construction process, estimated the energy costs of a terraced house at 400 GJ. Combining process analysis and input-output analysis and using energy intensities of 1989, Vringer (1993) estimated the energy costs of an identical house at 462 GJ. Furthermore, Vringer estimated the primary energy costs related to constructing a detached house and an apartment building at 581 GJ and 352 GJ respectively. Using the same method with 1987 data, van Rossum (1991) estimated the energy requirements of a house of which the financial building costs amounted to 91800 Dfl (exclusive land costs and V.A.T.) at 501 GJ. Multiplying these building costs by the energy intensity of 1987 investments (5.3 MJ/Dfl.) results in an estimate of 489 GJ, only about 2% lower than the estimate of van Rossum. It must therefore be concluded that the NLECCO input data for the energy embodied in the residential sector are consistent with the results of recent detailed studies.
6.11 Energy embodied in electricity generating plants

The estimate of the past energy requirements for building up the electricity generation capacity (15255 MW in 1985) is subject to many uncertainties. From the NLECCO perspective, the present and future investments in this sector are more relevant than the past energy costs required to build up the electricity supply sector as different types of power stations demand for different material and energy inputs. In this section the assessment of past energy investments into the electricity supply sector is discussed first, making a distinction between fossil fuelled plants and nuclear plants. Furthermore the energy requirements related to the current investments in electricity generation are discussed.

Fossil-fuelled capacity

In 1985 the installed fossil-fuelled capacity amounted to 14747 MW (see figure 4.5). To estimate the past energy expenditures to build up this capacity the average financial investments in the period 1970 -1985 have been multiplied with the average energy intensity of a guilders’ worth invested in the corresponding years.

To estimate the average financial costs of investment over the period 1970 -1985, the costs of investment of various types of conventional power plants for 1985 are used as point of departure. In 1985 the costs of investment of coal-fired plants, gas-fired plants and STAG installations are 2030, 1150 and 1450 Dfl/kW respectively (ECN, 1988). As a considerable part of the generation capacity is suitable for dual firing, it is assumed that for 1985 the average costs of investment of fossil fuelled power plants amount to 1550 Dfl/kW.

In the period 1970 - 1985 the real cost increase for coal-fired power plants is calculated to be 4% per year (Motor Columbus, 1985). Assuming this annual increase as being representative for past developments in costs of fossil-fuelled power plants, the average costs of investment in the period 1970 -1985 can be estimated at 1174 Dfl/kW (in constant 1985 prices), having an energy equivalent of 6907 GJ/MW. Multiplication of this figure with an installed capacity of 14747 MW results in an estimate of 102 PJ embodied in fossil-fuelled power plants in 1985.
Chapter 6: Stocks of energy in the Netherlands economy in 1985

Nuclear power plants

Only two small nuclear plants, in production since 1968 and 1973, with a total capacity of 508 MW, are operating in the Netherlands. A multitude of literature on the net energy output from nuclear power, has been published since the early seventies. An overview is given in Noorman (1991) and Dwarshuis (1992). Recently, applying the results of input-output energy analyses carried out for the years 1985 and 1987, the energy costs of investment in a new 1300 MW nuclear power plant (LWR) are calculated to be 33 PJ (this corresponds to about 25000 GJ/MW) (ECN, 1993). In order to estimate the energy costs of building a nuclear power plant in the early seventies, information of the past costs developments and the material and energy inputs involved are required. In the period 1974-1984, the costs of a nuclear power plant rose about 120% in real (inflation adjusted) terms (about 8% per year) (Motor Columbus, 1985). Furthermore a strong correlation was found between the financial costs of investment and the increase in the quantity of materials: in the same period the increase in materials used was about 100%. Shaw (1979) concluded that both the investment cost of an AGR built in the UK and the input of materials increased with 7% a year between 1965 and 1970. Assuming an annual increase of 7% in the quantity of materials used in the period 1970 - 1985, the energy costs of investment into a 1000 MW nuclear power plant built in the early seventies can be estimated to be 10 PJ (about 10,000 GJ/MW). Herewith the primary energy cost of the nuclear capacity of 508 MW in the Netherlands is estimated to be 5 PJ.

6.11.1. Investments in the electricity supply sector

Based on the costs of investment of the various types of fossil-fuelled power plants (see the previous sub-section), the primary energy inputs for coal-fired plants, gas-fired plants and STAG installations are estimated at 10700 GJ/MW, 6100 GJ/MW and 7700 GJ/MW respectively. In 1985, the conventional capacity has been extended with 223 MW of coal/gas fired MW, representing an energy input of about 2.4 PJ. The total investments in the electricity supply sector amount to 1990 million Dfl. (Electriciteit in Nederland, 1987), representing an energy equivalent of 10.5 PJ. Assuming a lifetime of 25 years, capital depreciation is estimated at 4.3 PJ.
Chapter 6: Stocks of energy in the Netherlands economy in 1985

6.12 Overview of the main results

This chapter presents the outcome of a study aimed at assessing the past primary energy inputs required to build up the capital stock in the Netherlands as present at the beginning of 1985. As a result, a substantial set of data, derived from various sources, are presented. Table 6.8 summarizes the main results of this chapter.

Table 6.8 Primary energy embodied in the fixed capital stock, investments and depreciated capital of the various sectors as distinguished in the NLECCO in 1985 (in PJ).

<table>
<thead>
<tr>
<th>Sector</th>
<th>Capital Stock</th>
<th>Investments</th>
<th>Depreciation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industry</td>
<td>1488 (20.4%)</td>
<td>81.3 (20.8%)</td>
<td>62.0 (29.6%)</td>
</tr>
<tr>
<td>Oil industry</td>
<td>100 (1.4%)</td>
<td>6.7 (1.7%)</td>
<td>3.9 (1.9%)</td>
</tr>
<tr>
<td>Oil production</td>
<td>10 (0.1%)</td>
<td>0.6 (0.2%)</td>
<td>0.4 (0.2%)</td>
</tr>
<tr>
<td>Gas production</td>
<td>161 (2.2%)</td>
<td>9.8 (2.5%)</td>
<td>5.9 (2.8%)</td>
</tr>
<tr>
<td>Freight transport</td>
<td>429 (5.9%)</td>
<td>24.0 (6.1%)</td>
<td>16.0 (7.6%)</td>
</tr>
<tr>
<td>Public transport</td>
<td>282 (3.9%)</td>
<td>11.0 (2.8%)</td>
<td>10.0 (4.8%)</td>
</tr>
<tr>
<td>Agriculture</td>
<td>292 (4.0%)</td>
<td>21.8 (5.6%)</td>
<td>12.2 (5.8%)</td>
</tr>
<tr>
<td>Market services</td>
<td>900 (12.3%)</td>
<td>41.0 (10.5%)</td>
<td>28.0 (13.4%)</td>
</tr>
<tr>
<td>Non-market services</td>
<td>681 (9.3%)</td>
<td>31.0 (7.9%)</td>
<td>27.0 (12.9%)</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>144 (2.0%)</td>
<td>51.0 (13.1%)</td>
<td>5.0 (2.4%)</td>
</tr>
<tr>
<td>Dwellings</td>
<td>2700 (37.0%)</td>
<td>102.0 (26.0%)</td>
<td>34.6 (16.5%)</td>
</tr>
<tr>
<td>Electricity supply</td>
<td>107 (1.5%)</td>
<td>10.5 (2.7%)</td>
<td>4.3 (2.1%)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7295 (100%)</strong></td>
<td><strong>390.7 (100%)</strong></td>
<td><strong>209.3 (100%)</strong></td>
</tr>
</tbody>
</table>

Although the assessment of primary energy embodied in capital concerned a high level of aggregation, comparison with the results of other methods available in the literature showed a satisfactory level of similarity. The total quantity of
primary energy embodied in capital stock at the beginning of 1985 amounts to about 7300 PJ, i.e. almost three times the direct domestic energy consumption in that year. Almost 40% of the energy is embodied in dwellings whereas about 20% is embodied in industrial capital. The embodied energy in services capital corresponds to 23% of the total energy inputs into capital.

Herewith, more than 80% of the primary energy inputs into capital is embodied in dwellings, industrial capital and services capital. About 10% concerns the energy embodied in the transport sector. The remaining 10% is distributed over a number of different categories.

6.13 Discussion of the overall results

Due to various uncertainties, the results obtained from several methods presented in this chapter should be interpreted at a high level of aggregation. Where possible, the results presented in this chapter were compared with the results of other studies. From this comparison the conclusion can be drawn that most of the results obtained are consistent with the results presented in the available literature.

Uncertainties particularly concern the financial data input and the historical pattern of energy intensities. In general terms, the error range in the capital investment estimates can be significant. Motor Columbus (1985) for instance, considers the accuracy of the presented investment costs of electricity generation plants to be in the order of - 10% to + 20%. With respect to the applied energy intensities Wilting (1994) concluded that for one year the error of the sectoral energy intensities lies within a range of - 5% to + 5%. This error range increases when composing a time series, applying the direct energy intensity of the GDP as an indicator of annual changes in energy intensities.

Taking these error ranges as a starting point, for the sectors of which the monetary value of the capital stock is relatively well documented in the CBS statistics (i.e. the industry, oil and natural gas winning, transport, agriculture and the electricity supply sector) the error range is assumed to be in the order of -15% to + 15%. For the other sectors (services and dwellings) the error range is assumed to be in the order of - 25% to + 25%.