HANDBOOK ENERGY EFFICIENCY MONITORING OF DIRECT ENERGY CONSUMPTION IN LONG-TERM AGREEMENTS

Novem
Utrecht, February 1999

CONTENTS

1. INTRODUCTION

Background

The NOVEM Institute was commissioned by the Ministry of Economic Affairs to carry out certain long-term agreements (MJA's). A major aspect of this commission involves the monitoring of energy use and energy efficiency. The measure for energy efficiency assessment in this process is to be the Energy Efficiency Index (EEI). This relates commercial energy use to production performance.

In the course of the MJA process the monitoring methodology is added to and refined constantly. Thus choices have been made regarding the processing of energy products in Cogeneration installations, the introduction of combustible waste products, the effects of environmental and work-place demands on energy consumption and the consequence of changes in product and raw material specifications etc. Differences have emerged in the way certain data in the monitoring process are complemented per sector.

Aim of the Handbook

This handbook sets out unequivocally assumptions and methodology for the quantification of the Energy Efficiency Index for direct energy use. Thus the handbook should form the basis for the monitoring of the MJA agreements from the year 2000 onwards. It also forms a frame of reference for the remaining monitoring years of current MJA projects. As long as this is inkeeping with the agreements reached and there is continuity in the series of values, reports will be drawn up as far as possible according to the methodology of this handbook right up to the year 2000. Alterations will need to be clearly indicated.

For whom?

This handbook is aimed primarily at those parties directly involved in MJA projects. These are not only the parties setting up the MJA project (company sectors, Ministry of Economic Affairs), but also the parties supporting the process, or that take on the responsibility for certain aspects (such as aggregating and testing monitoring reports).

Particularly for those responsible for the actual monitoring, this handbook gives calculation examples and tables which clarify what action to take in certain cases and what elements to incorporate.

For other interested parties this handbook makes the monitoring process transparent, so that they may form an opinion on the reliability of the reported results. Thus it also discharges responsibility concerning the manner of implementation of the MJA projects.

Reading Guide

The first chapters give definitions and assumptions. Chapter 2 briefly describes the assumptions made in respect of monitoring, the distinction between direct and indirect energy use and the Direct Energy Efficiency Index (DEEI).

In this the aggregate of monitoring data is given at company, corporation and sector level.

The remaining chapters give EEI determining factors and the interpretation of results. Chapter 4 describes the energy aspect and investigates the processes involved in energy transmission and conversion (e.g. Cogeneration). Chapter 5 rates performance and establishes the relation between this rating and energy use, while the last chapter gives the correction factors to be applied and analyses EEI developments.

The Appendixes give a number of calculation examples relating to the various themes dealt with.

2. LONG-TERM AGREEMENTS AND MONITORING

2.1 LONG-TERM AGREEMENT FOR EFFICIENCY IMPROVEMENTS

The goal of an MJA agreement is the achievement of energy efficiency improvements within a certain period. This aim is implemented through energy saving plans in which each participating concern indicates what concrete measures are to be taken, phased in time. By this means a change in energy efficiency is to be achieved and this could relate to a number of aspects of company management, among which:

- *Process efficiency*
  This involves the energy efficiency of the actual production processes; changes in energy efficiency resulting from a different way of carrying out the relative process. No changes occur in the product itself. This includes:
  - process synthesis
  - new process technology
  - breakdown reduction
  - internal logistics
  - reduction in non-energetical use of E-carriers.

- *Product Efficiency*
  This involves changes in energy efficiency resulting from changes in the energy content of the produced item itself, though without altering the function performed by the product. Changes could, for example, be due to the use of different raw materials, fewer materials etc. This includes:
  - dematerialising
  - renewable raw materials
  - energy-focussed product development
  - new product technology.

- *Industrial Collaboration*
  This involves changes in energy efficiency resulting from projects which supersede individual company limits. This includes:
  - transport (external logistics)
  - recycling of materials
  - long-term company premises
  - chain collaboration

- *Non-expendable energy*
  The application (in industry) of generation forms of non-expendable energy (sun, wind, biomass).

This manual restricts itself to those themes related to direct energy use, i.e. the use of energy within the company itself.
Thus it principally concerns the themes falling under the notion “process efficiency”.
Insofar as dematerialisation leads to reduction of the direct energy input, this also falls hereunder.

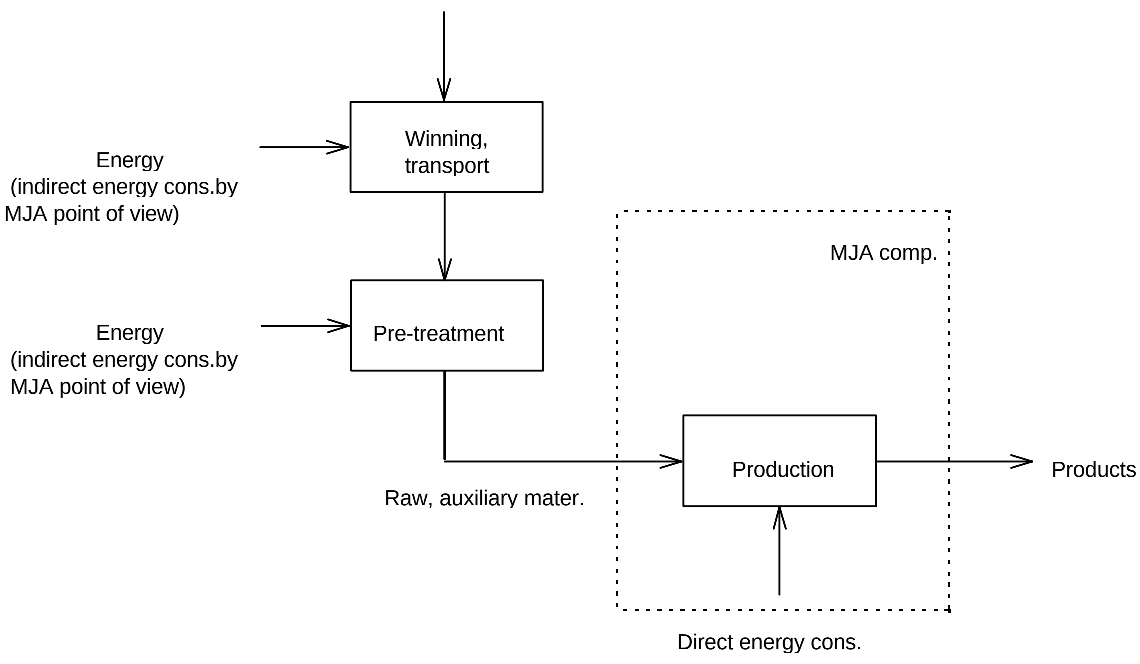
2.2 MONITORING OF CHANGES

2.2.1 Direct and indirect energy use

To determine the (intermediate) results of the MJA project, the actual use of energy by companies is determined in relation to their production. This process is called monitoring.

The creation of products leads to direct energy use and indirect energy use.
The *direct* energy use of a production process is the use of energy in the process itself. *Indirect* energy use concerns the use of energy which can be attributed either to purchased (raw) material being used in the relevant process or to the further processing and use of the product up to and including the refuse phase. In the monitoring process these forms of energy use are pursued separately. This handbook describes the monitoring of direct energy use and how corresponding change in the energy efficiency index is determined.

Figure 1: Direct en indirect energy use



2.2.2 The Direct Energy Efficiency Index (DEEI)

The energy efficiency of direct energy use will further be expressed in this handbook as the direct energy efficiency index (DEEI). This index shows the quantitative improvement in direct energy efficiency that has been reached in any year regarding direct energy use, in relation to the year of reference.

The direct energy efficiency index (DEEI) is determined by comparing actual direct use E_x in the year x with a referential use $E_{reference}$. This referential use is determined on the basis of ‘performance’ (production) in the year x and specific use in the reference year.

Figure 2: Relations between direct energy efficiency index, energy use, performance and savings.

$$\text{DEEI (direct Energy efficiency index) in year x} = \frac{\dfrac{\text{Direct energy use in year x}}{\text{Perform in year x}}}{\dfrac{\text{Direct energy use in ref. year}}{\text{Perform. in ref. year}}}$$

⇓

$$\text{DEEI (direct Energy efficiency index) in year x} = \frac{\text{Direct energy use in year x}}{\text{Specific use in ref. year} * \text{Perform. in year x}}$$

$$\text{Savings and influences} = (\text{Specific use in ref. year} * \text{Perform in year x}) - \text{Direct energy use in year x}$$

The direct energy efficiency index for a sector as a whole is influenced, next to the executed savings projects, by several factors such as companies joining the scheme and companies leaving it, new products, altered product specifications and product quality, altered raw material specifications, government demands (environment, workplace conditions etc.), integration or specialisation, climatic variations and differences in manning levels. The effect of these factors is shown and at times can lead to adjustments, if the OGE agrees; these adjustments are then shown further by determining, next to the unadjusted DEEI, an adjusted DEEI, where the effect of the mentioned factors is included as an adjustment. Other factors cannot lead to adjustments, but can further explain developments; these are also shown in the monitoring process. Chapter 5 will expand on the subject.

2.3 CALCULATION OF THE DIRECT ENERGY EFFICIENCY INDEX

General definitions of the direct energy efficiency index

The direct energy efficiency index in year x is the quotient of actual direct energy consumption in year x (E_x) and a referential use ($E_{reference}$) which indicates what amount of direct energy consumption would have been necessary if the volume of production for year x

had been manufactured with the same consumption per unit product as in the reference year.This quotient is multiplied by 100 so as to express it as a percentage in relation to the reference year.

The DEEI of one product

The simplest case is the calculation of the direct energy efficiency index (DEEI) over one single activity (product). The direct energy efficiency index gives the proportion of the consumption per unit of that product for the present year and the reference year; thus the DEEI is the non-dimensional quotient of consumption in the present year (E_x) and the reference consumption ($E_{reference}$).

The DEEI for a combination of products in one company

The DEEI for a combination of activities within one company is calculated by way of actual use and the sum of reference uses for the various products.

The DEEI for a combination of products and companies/departments

The direct energy efficiency index over several companies with several products is calculated by way of the sum of actual use by the companies and the sum of the reference use for the companies in relation to all products. The DEEI calculation is illustrated in the figure below.

Formula: direct energy efficiency index for one product in one department

$$DEEI_x = \frac{E_x}{V_x * (E_0 / V_0)} * 100 = \frac{E_x}{V_x * e_{spec,0}} * 100 = \frac{E_x}{E_{reference}} * 100$$

Wherein:
- $DEEI_x$ = direct energy efficiency index in the year x
- E_0 = direct energy use in the reference year
- E_x = direct energy use in the year x
- V_0 = performance in the reference year
- V_x = performance (production volume) in the year x
- $e_{spec,0}$ = specific use (E_0/V_0) in the reference year
- $E_{reference}$ = reference use for the present year

Formula: direct energy efficiency index for several products in one department

$$DEEI_x = \frac{\sum_{p=1}^{n} E_{x,p}}{\sum_{p=1}^{n} \left[\frac{E_{0,p}}{V_{0,p}} * V_{x,p} \right]} * 100 = \frac{E_x}{\sum_{p=1}^{n} e_{spec,p} * V_{x,p}} * 100 = \frac{E_x}{E_{reference}} * 100$$

Wherein:
- $DEEI_x$ = direct energy efficiency index in the year x
- $E_{0,p}$ = direct energy use attributed to product p in the reference year, with $\sum_{p=1}^{n} E_{0,p} = E_0$ = direct energy use in the reference year
- E_x = total direct energy use of the company in the year x
- $V_{0,p}$ = performance in the reference year for product p
- $V_{x,p}$ = performance in the year x for product p
- $e_{spec,p}$ = specific use for product p in the reference year
- n = total number of products included in the monitoring
- $E_{reference}$ = reference use for the present year

Formula: direct energy efficiency index for several products in several departments

$$DEEI_x = \frac{\sum_{b=1}^{m} E_{x,b}}{\sum_{b=1}^{m} E_{reference,b}} * 100 = \frac{\sum_{b=1}^{m} E_{x,b}}{\sum_{b=1}^{m} \left[\sum_{p=1}^{n} e_{spec,b,p} * V_{x,b,p} \right]} * 100 = \frac{\sum_{b=1}^{m} E_{x,b}}{\sum_{b=1}^{m} \left[\sum_{p=1}^{n} \left[\frac{E_{0,b,p}}{V_{0,b,p}} * V_{x,b,p} \right] \right]} * 100 = \frac{E_x}{E_{reference}} * 100$$

Wherein:
- $DEEI_x$ = direct energy efficiency index in the year x
- E_x = total direct energy use over the group of MJA companies in the year x
- $E_{reference}$ = reference use over the group of MJA companies and products in the year x
- $E_{reference,b}$ = reference use for company b over the products in the year x
- $E_{x,b}$ = direct energy use in the year x for company b
- $e_{spec,b,p}$ = specific use for product p in company b in the reference year
- $V_{x,b,p}$ = performance in year x for product p in company b
- $V_{0,b,p}$ = performance in the reference year for product p in company b
- $E_{0,b,p}$ = direct energy use in the reference year for product p in company b
- n = total number of products
- m = total number of participating companies within the sector

Figure 3: Calculation of the DEEI

3. ENERGY CARRIERS AND CONVERSIONS

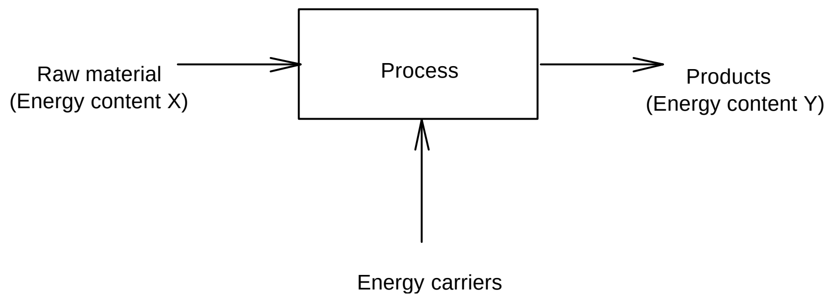
3.1 ENERGETICAL USE AND NON-ENERGETICAL USE

General definitions

The direct energy use for a company, as used in the MJA scheme, regards the direct, energetically used part of the primary energy surplus. A distinction is made in the use of energy between energetical use and non-energetical use. In certain sectors the non-energetical use is called feedstock. These notions are elaborated further in this section.

By non-energetical use of energy carriers, the energy referred to is that taken up in the product and that can in principle again be released. This can take place through energy carriers being used as raw material, or through the necessity of supplying energy in the conversion of chemical raw components into end products for the creation or destruction of chemical compounds. Energetical use is all the direct use of energy carriers for production processes that are not regarded as non-energetical.

Figure 4: Energetical and non-energetical cons.



Energy content Y - Energy content X = non-energetical use
Energy carriers - non-energetical = energetical

The energetical use is thus equal to the total energy supply to the company minus the non-energetical use. That is why it is important to employ usable definitions for non-energetical use.

Operational definitions

In using operational definitions for non-energetical consumption it is of practical importance to keep as close as possible to the method by which the CBS (Central Statistics Bureau) includes this consumption in its statistics. That is why distinction is made between:

- *the lower heating value of the formed products in the use of energy carriers as raw material.*
  Energy carriers are used as raw material in the petrochemical industry and in the production of fertilizer substances. The non-energetical use is set as equal to the lower heating value of the products.
- *the change in enthalpy in the conversion from raw material to product.*
  In chemical conversions in chemistry and base metals, the molecular structure of the elements involved in the reaction is altered. Thus a use of energy occurs corresponding to the change in chemical formation energy or molecular enthalpy. The non-energetical use is then equal to the change in molecular enthalpy. This energy can in principle be recuperated by way of a reversible process.

The notion of enthalpy

For the determination of the non-energetical use in chemical conversions use is made of the notion of 'enthalpy'. Enthalpy is a measure for the content of energy of chemical compounds. Molecular enthalpy is specific for a certain substance and is determined by measurements and computations at a temperature of 25 ^{o}C and 10 kPa (1 bar).

The enthalpy of a substance consists of the molecular enthalpy and the thermal enthalpy. The thermal enthalpy consists of 'sensible' heat (with respect to 25 ^{o}C) and non-sensible heat (at a change of state).

The enthalpy of pure elements at 25 ^{o}C and 110 kPa is set at zero. For important chemical substances the enthalpy is known and mostly included in manuals.

The non-energetical use is determined by establishing the total enthalpy of the produced substances and subtracting the enthalpy of the raw material. The non-energetical use is equal to the increase in enthalpy. This increase is also known as 'energy of formation'.

In certain circumstances it needs to be indicated in the MJA scheme by which definition the non-energetical use is determined.

3.2 ACQUISITION OF ENERGY CARRIERS

3.2.1 Energy surplus and energy carriers

Energy use surplus
For the use of energy the net purchased is assumed. Any energy supplied onwards is subtracted from the purchase on the basis of the energetical value. The result corresponds to the notion of 'energy surplus', as used by the CBS.

Energy carriers
At purchase the following are distinguished as energy carriers:
- natural gas, oil, coals and other fossile fuels
- electricity
- heat, cold and steam
- secondary fuels

Some company substances, like compressed air, can be energy carriers.

Electricity and cold are converted to the primary energy input necessary for their generation.

In converting to primary energy, fixed conversion factors need to be used. As a rule these are established every five years by EZ (Economic Affairs) in consultation with Novem on the basis of current, conventional efficiencies and conversions. The following section gives the factors valid at the time of composition of this handbook.

3.3.2 Conversion factors for the most common energy carriers

Natural gas
For conversion in MJA projects the lower heating value (without condensation of the flue gas) of natural gas under atmospheric conditions is used. As a rule, natural gas is of 'Slochteren'-quality, as supplied by Gasunie (Gas Utility) under standard pressure and temperature. It is measured in normal m^3 (Nm^3):

- natural gas: 31,65 MJ/Nm3.

Oil
The enthalpy of oil derivatives is set as equal to the lower heating value under atmospheric conditions. This value varies with the composition of the derivatives. For monitoring in MJA projects the average heating values as supplied by the CBS[1] are used:

- Heavy crude 41 MJ/kg
- Crude (<20 centiStokes) 42,7 MJ/kg

---
[1] Source: CBS, Energy Economy in the Netherlands, Voorburg/Heerlen, 1995

Other fossil fuels
Heating values for other fossil fuels such as coal, coke and other derivatives varies according to source and treatment process. For MJA monitoring, average heating values are used as submitted by the CBS.

- Coal-coke 28.5 MJ/kg
- Coke oven gas, blast furnace gas or other gas types (expressed in natural gas equivalents): 31.65 MJ/Nm3

Electricity
Primary use is calculated as equal to 2,5 times electricity use. This tallies with the average productivity of large-scale turnover in conventional power stations (40%). This value is taken for all electricity supplied by or re-supplied to the national grid:

- Electricity 9,0 MJ/kWh

Heat and steam
Heat is generally assessed in availability terms against an average ambient temperature of 10ºC. In some cases, where heat is traded between two MJA concerns, a different value may be chosen. The proviso for this is that both concerns keep to the same energy content in the monitoring process. The energy content of steam is coherent with pressure and temperature. To establish the energy content of steam, steam and hot water tables are used.

- Heat: dependent on medium (mostly water), temperature, pressure and phase, determined according to availability

Secondary fuels[2]
This refers to energy from combustion of secondary materials such as residual and waste products. In assessing secondary fuel, account should be taken of the alternative processing routes. The proviso for this is that in any residual material transfer from one company to another the same energy content be maintained for monitoring purposes. The relevant company, or companies, will submit a proposal in this regard to the OGE. Appendix 1 shows a calculation example by way of illustration.

3.3.3 CO_2-emission

The government's energy saving policy aims at the eventual restriction of CO_2-emissions. That is why in the monitoring reports the consequences of the reported energy saving for CO_2-emissions must also be consistently indicated.
CO_2-emissions vary per energy carrier. The table below surveys the emmission factors for different energy carriers.

[2] The notion of secondary fuel as used here is not to be confused with the notion of secondary energy carrier as used by the CBS: energy carriers resulting from conversion of primary energy carriers.

Table: CO2-emission upon employment of energy carriers

Product	CO_2-emission factor (kG/GL)
natural gas	56,10
crude oil	73,3
(extra) heavy oil	77
light oils (HBO, diesel, petrol)	73
blast furnace gases	71,6
hydrogen	0
black coal	94
electricity	74,6
heat	dependent on medium, temperature, pressure and phase

3.4 ENERGY CONVERSIONS

3.4.1 General

Significant savings can be achieved with combined energy conversions.
Exampels of these are:

- Combined heat and power (Cogeneration)
- Combined cold and power
- ORC (Organic Rankine Cycle)
- Combined heat and compressed air
- Heat and cold storage.

Calculation of the effects of energy conversions is achieved in two steps:

- *Calculating project savings:* project savings are calculated as compared with the reference situation. In a Cogeneration project for example, this means the situation where electricity and heat are generated separately in a power plant and boiler.
- *Attribution of savings:* the savings are then attributed to the companies buying the energy. The assumption here is that the savings are attributed in proportion to consumption and not, for example, according to the company's share in the financial risk of the installation.

3.4.2 Sample calculation for Cogeneration

Calculating savings

In calculating savings, a comparison is made with the use of energy in the reference situation. In the following example a Cogeneration project is compared to separate generation. The figure below gives an indication as to the method to follow (the numerical values serve only as an example):

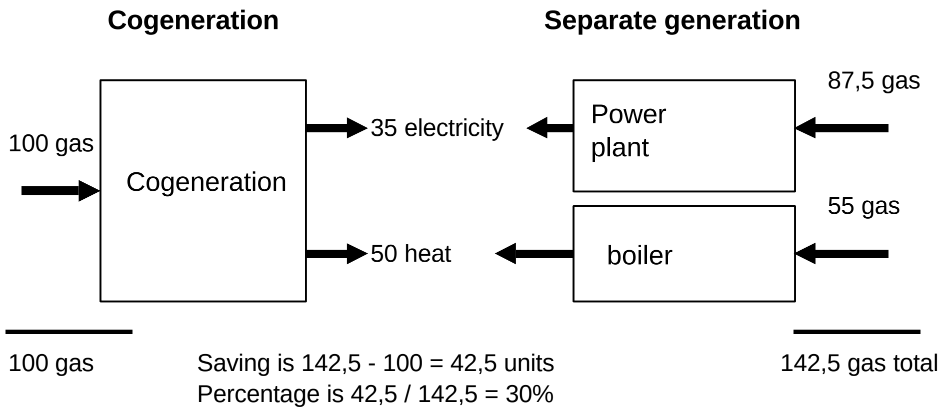


Figure 5: Sample comparison Cogeneration and separate generation (numerical values simply indicative)

The following rules are applied:

1. Assumed is the actual production of electricity and heat by the Cogeneration plant in the year to be monitored, based on measurements.
2. The necessary primary energy (usually natural gas) is determined on the basis of measurements.
3. The reference situation and the necessary primary energy therein are established: in this case that is the situation whereby electricity and heat are generated separately in a power plant with an electrical efficiency of 40% and a boiler with an efficiency of 90% (values serving as an indication).
4. The saving is the difference between the situations described in points 3 and 2.

Attributing savings

A cogeneration plant can be run in two ways, in <u>non-condensing operation</u> (whereby both heat and electricity are produced and used) and <u>condensing operation</u> (whereby only electricity is produced and the produced heat is discharged to the surroundings and the produced steam is condensed). The same plant can be operated in both ways at different times. The electricity production supplied to the national grid and the relevant gas consumption when only electricity is produced (condensing operation), are exempted from the energy efficiency assessment of the company.

The energy conversion can occur both inside and outside the company. In attributing savings in energy conversion the following conditions are distinguished (see also by way of illustration Appendix 2):

<u>The Cogeneration plant in a company using up all its heat</u>

Full savings are ascribed to the company having installed the Cogeneration plant. Determining the energy efficiency index requires the savings not to be determined separately. Savings are directly displayed in the direct energy efficiency index by way of a lower acquisition level for electricity (and a higher acquisition level for gas).

<u>The cogeneration plant in a company selling on its heat to another MJA agreement company</u>.

The energy content ascribed to the sold-on heat is maintained both at point of sale on the part of Company A with the Cogeneration Plant and at point of acquisition by Company B. The attributed energy content of the sold-on heat is subtracted from Company A’s primary energy use and added on to Company B's direct energy use.

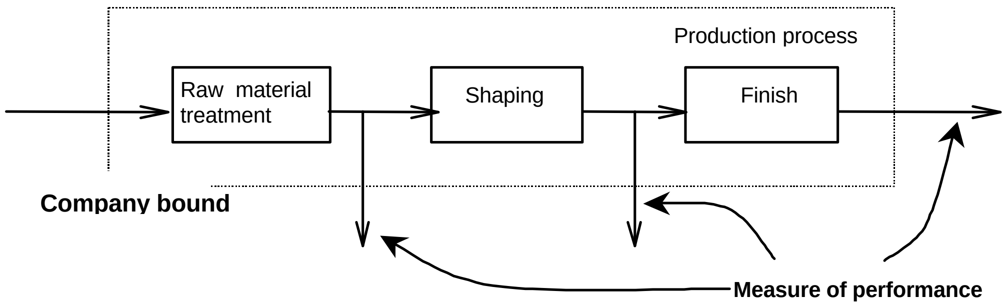
<u>The Cogeneration Plant installed by a third party or controlled by several companies</u>
The direct energy use of the companies is determined by way of their acquired energy flows. Electricity and acquired heat are evaluated as being generated separately (power plant and boiler). The established savings relating to the Cogeneration Plant are then - proportionately to the extracted heat - attributed to the companies and subtracted from the calculated primary direct energy use value.

4. MEASURE OF PERFORMANCE

4.1 GENERAL ASSUMPTIONS

The measure of performance is a vital part of the monitoring methodology and together with direct energy use forms the basis for determining the direct energy efficiency index DEEI.

Figure 6: Relation between production process and energy conversion



In establishing the measure of performance, the following assumptions are valid:

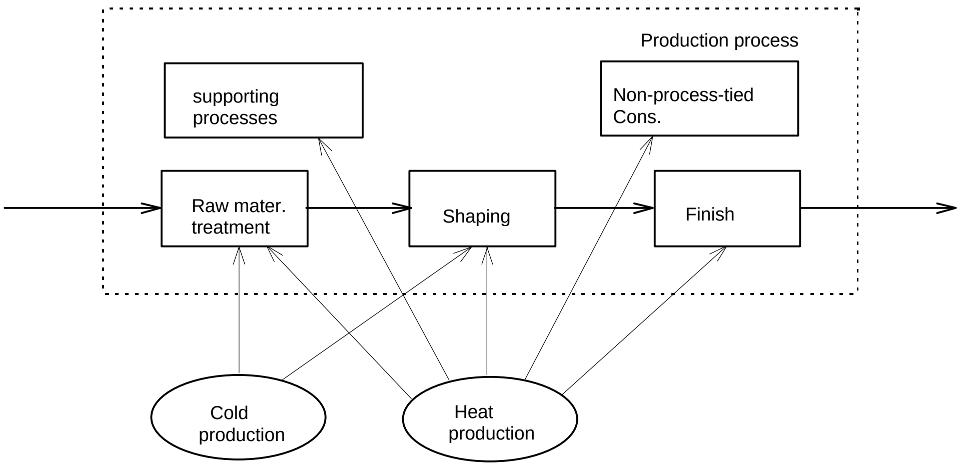
- A measure of performance is etsablished only for flows delivered as a product across company boundaries. Products passed on internally as semi-manufactured products are not included in the monitoring process as performance.
- For the establishing of performance physical measures are used reflecting as well as possible the function of the use of the product. In this way the actual delivered performance of the production process is represented best.
- In general, several measures of performance are used within a company, connected to the different products or subprocesses that can be distinguished.

4.2 DETERMINING THE MEASURES OF PERFORMANCE

The measures of performance to be applied for monitoring are to be established before joining the MJA scheme. They are laid down in the EBP, inter alia.

In order to establish the performance of a company, the company is divided into subprocesses, to which energy flows can be attributed. In their turn these can serve as a basis for the attribution of energy use to products or product groups (measures of performance). A distinction is made between production processes and energy conversion. Energy conversions (Cogeneration, cold generation, compressed air production) are in this case supporting processes, of which the energy use is to be attributed – in relation to the amount of energy used – to the production processes.

Figure 7: Sample processes



The number of process steps or subprocesses can be restricted by applying the precept that each step is to represent, for example, at least 5% of the energy use of a company. The method followed in establishing specific uses is:

1. Set up a survey of direct energy use and subdivide it into direct processes, supporting processes and non-process-tied use

The flows connected with the different subprocesses are to be determined for all direct energy carrier. This means basically a listing of energy use according to apparatus or processes.

2. Attribute the direct energy use to performance carriers (product/process steps)

Subsequently the use is attributed to products or process steps. The main point here is to assign the energy flows as quickly and as directly as possible to a measure of performance. The attribution is carried out in the following way:

- use in a production process is attributed in total to the corresponding product. In the case of simultaneous creation of several products (e.g. in many chemical processes) a subdivision can be made according to the formed products;
- use in supporting processes connectable to a product, is added to the use in the production process for that product;
- use in supporting processes not directly connectable to a product and non-process-tied use are attributed on the basis of physical magnitudes. Weight of the products, number of people, department surface area, company hours or combinations hereof could be used, for example.

3. Calculate the specific use per performance carrier

When all direct energy use has been attributed, the specific use per performance carrier is to be determined. By adding up all specific uses of each process, the total specific use per product or process step is obtained. In Appendix 3 an example is set out for a slaughter house.

5. RELATION OF DIRECT ENERGY EFFICIENCY INDEX (DEEI) TO SAVINGS

5.1 EFFECTS ON THE DIRECT ENERGY EFFICIENCY INDEX (DEEI)

The direct energy efficiency index (DEEI) reflects changes in the direct energy efficiency - in the year to be monitored – in relation to the year of reference. In order to provide an insight into the causes of the development of direct energy efficiency a paragraph with explanatory factors is incorporated in the monitoring report. Distinction is made between:

1. *Changes to the membership situation of companies taking part in the monitoring scheme:*
   - by way of companies joining (whether extant or not in the year of reference).
   - by way of companies leaving the scheme.

2. Direct energy savings from measures taken:
- regarding savings projects
- regarding shifts in installations with differing efficiency

3. Changes in the nature of products, raw materials or environment:
- as a result of new products
- as a result of changes in product specification or quality
- as a result of changes in raw material specification or a different raw material
- as a result of process changes due to government demands relating to environment or workplace conditions etc.
- as a result of changes within the company due to integration or specialisation.
- as a result of climatic variation
- as a result of manning level differences

These effect categories are more closely dealt with in the following sections.

5.2 CHANGES IN COMPOSITION OF COMPANY MEMBERSHIP

Changes in membership composition of the monitoring scheme as a result of joiners and leavers will lead to changes in the DEEI. A DEEI which has been established formally, however, will not be modified. The consequences of this fact will be indicated by showing the time scale of indices with and without modifications in the report relating to the modification year.

Companies may leave by choice or obligation. Company close-downs also come under this regulation. Changes resulting from companies leaving will be processed by way of excluding their direct energy consumption and production volume from further observation. Changes resulting from newly formed companies joining the MJA agreement will be processed by including their data starting from the year of entry to the scheme. For this company a specific energy use rating will be deduced as described in section 5.4 relating to new products or processes. Appendix 4 gives a calculation example to illustrate same.

5.3 SAVINGS MEASURES

5.3.1 Changes by way of measures taken

As a result of savings measures a direct saving (or possibly the reverse) is realised in relation to actual energy use on the part of a company in the current year. The following situations are identified:

- *Savings projects*
  These projects can relate either to production processes or to the supporting energy conversions (cooling, heat generation, air compression, vacuum and combined heat and power). Re-utilisation of raw materials or de-materialisation can also deliver significant savings.

- *Production decisions*

The direct energy efficiency index is also affected by shifts in production volume within a company between installations with differing energy efficiency. This occurs, for instance, when new, more efficient production lines are introduced which take over from existing ones. A temporary reversal of savings comes about when out-dated, less efficient production lines are put into service for the purpose of meeting an increase in demand.

5.3.2 Project monitoring

In addition to monitoring performance levels, a company is also required to monitor according to a project method. This involves adding up the savings of each separate project carried out. This project-monitoring involving individually carried out projects is for the purpose of controlling established indices based on physical mensuration. The aim of project monitoring is to be able to underpin with savings measures the actual DEEI savings component to an extent of 80%.

5.4 CHANGES IN THE NATURE OF ACTIVITIES, RAW MATERIALS AND GOVERNMENT DEMANDS

5.4.1 Changes in the nature of activities

Changes in type of activity can bring about changes in a company's direct energy use. In the monitoring process adjustments stemming from changes in activity type should be treated with reserve. If agreed with the OGE, a corrected DEEI value can be registered to process the effects. This adjusted DEEI value will be indicated in the sector monitoring report next to the unadjusted value.

The nature of activities, and consequently company performance, can change as a result of:

- adding new products to the total company package.
- changes to product specification resulting, for instance, from changes in market demand or with quality enhancing in mind.
- changes in raw material specifications or utilisation of other raw materials.
- government demands relating to environment and workplace conditions etc.
- changes in company policy by way of integration or specialisation (such as raw material acquisition instead of semifinished product acquisition)
- changes in circumstances by way of climate change, changes in manning levels etc.
- structural effects within a sector (e.g. job cuts) can modify the DEEI figures for a sector.

5.4.2 Some outside factors can be taken into account

Only by way of exception, and then only if agreed by the OGE, certain factors may bring about adjustments. These will be wholly outside the sphere of influence of the companies in question.

Adjustments may be considered when:

- a significant effect on energy use is involved. The guidelines in this are that the size of the anticipated effect on energy within the sector is greater than 1% or more than 1 PJ. Certain effects will allow adjustments in some companies and not in others. Climate variation, for instance, can constitute an adjustment factor in utility construction and in small companies but this will not be the case with heavy industry.
- either the sector or the company is not able to influence the change. Climate variation and government demands are not controllable. This also applies to some product adaptations resulting from swings in market demand.
- data and calculations used in adjustments are checkable.

Improvements in manning levels can constitute a definite saving measure (coming under the effects listed in 6.2). Incidental swings in manning levels may affect DEEI development and should also be shown separately. This allows a proper distinction to be made in savings effects through differences in manning levels and through savings measures.

5.4.3 Determining adjustment factors

In order to process the effects of approved adjustments in the monitoring data an adapted reference use (the specific use of the reference year) must be set out for the adapted situation and products. To this end the following methods are available (see also Appendix 5 for calculation examples):

<u>a. Comparison with comparable products or processes:</u>
The feasibility of this method is tried first, with priorities:-

- comparison with the same products or processes in the same plant
- comparison with the same products or processes in the same concern
- comparison with the same products or processes in comparable Dutch companies outside the concern being monitored
- comparison with the same products or processes with comparable companies outside the concern and outside the Netherlands.

Comparison with other products or processes may only be applied where the relevant conditions are met as judged by the OGE. In some cases the comparison process may itself be split up into parts which are compared individually, after which total specific consumption for the year of reference is established by adding the parts together.

b.Calculating an energy use project from engineering data
In cases where none of the above methods appear to be sufficiently reliable, energy use can be calculated on the basis of project data relating to the new product or process and to manning levels; this in respect of the situation that would have been in place during the reference year. Thereafter the relevant specific use is determined.

c. Based on values metered in the company in practice
If the above option also fails to make available reliable data, specific consumption for a new product or process is determined by mensuration in actual practice. To remain representative, this should only be done, as a rule, when the product or process has first completed a full year of production. From the use metered and from the production, specific consumption is determined for the current year. This consumption is incorporated unaltered also for specific consumption for the year of reference.

Companies wishing to make use of adjustment options will have to show the need for and significance of the adjustments reliably and submit same to the scrutiny of the OGE. The OGE may draw advice in the matter. If the OGE approves the adjustment case itself, but no agreed adjustment method has been set down, option “c” will apply.

5.5 TOTAL OVERVIEW OF AFFECTING FACTORS

Effects on direct energy efficiency are listed in the monitoring reports. Basic assumptions are summarised thus:

- the direct energy efficiency index is determined by current energy use, production figures for actual performance in the current year and specific energy use for the reference year.
- savings through savings measures are determined by each actual measure (project) implemented.
- effects of changes in the nature of activities and environmental effects are determined by each actual change involved.
- in very exceptional cases the OGE may decide to set down effects of changes in activity type and environment in an adjusted index. Both the adjusted and the unadjusted DEE Indexes are presented. Approved adjustments must be made by adding additional consumption from changed activity type or environment to the reference consumption for the year to which the monitoring refers.
- If the OGE so wishes, the changes and their relevant effects will be divided up into subjects:-
  - process efficiency
  - product efficiency
  - industrial co-operation
- Actual savings must be underpinned, for checking purposes, to an extent of 80% by implemented savings projects within the company or by production decisions.

The order of calculation is as follows:

- Determine actual use (energy surplus) based on application of primary energy carriers.
- Determine reference use (based on physical production and specific energy use in the years of reference).
- Determine explanatory factors and check for 80% minimum cover from directed initiatives (project cover).
- Where the OGE approves certain adjustments: set these out and calculate the adjusted reference use.
- Finally, determine both the unadjusted and the adjusted DEEI values. Both figures will be stated in the report, from the reference year up to and including the monitored year.

APPENDIXES

APPENDIX 1: QUANTIFYING THE ENERGY IN SECONDARY FUEL

Example: Incineration of rubber tyres

In the following example the energetical value of used rubber tyres is calculated, taking into account the alternative processing. Rubber tyres are used as secondary energy source in the production of cement.

	ktons/a	energy yield/ton (primary, GJ/ton)	energy yield (TJ)
Dump	10000	0	0
Incineration in waste incineration plant with electricity production	10000	24	240000
Incineration in cement oven	5000	38[3]	190000
Recycling and sensible applications	5000	78 [4]	390000
TOTAL	30000	average: 27,3	820000

In the valuation of processing via alternative ways the national avarage is the reference point.
If it can be shown that the used substances follow processing paths different to this average way, the calculation is adapted accordingly.

Table: Heating values for some secondary fuels[5]

by-product	Lower heating value [MJ/kg]
refinery gases, chemical residual gases, other oils	dependant on composition
fresh wood	10,7
wood, air-dried	15
beach wood	20
sawdust	9,5-14,5
paper	13,5
woodwool cement	0,8-2
cotton	17
cork slabs	20
polyethane	43
polystryrene	40
polyurethane	28
rubber	38
straw	15

[3] Heating value as in table 3.2.4.5.
[4] GER value for rubber according to Van Heijningen: 'Energy units in relation to prevention and recycling of refuse flows'
[5] Source: Polytechnical Pocket Guide

APPENDIX 2: DIFFERENT COGENERATION CONFIGURATIONS

Figure. Cogeneration in a company without heat output

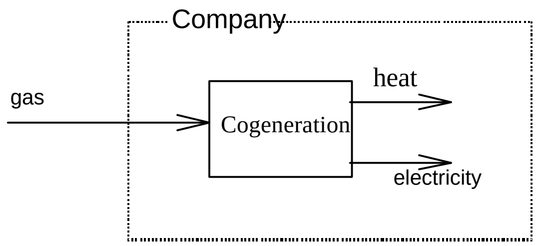


Figure. Cogeneration in a company with heat output

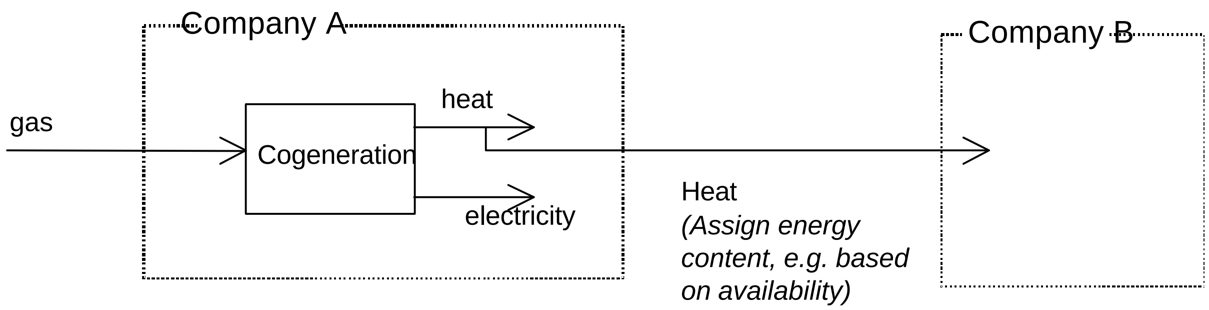
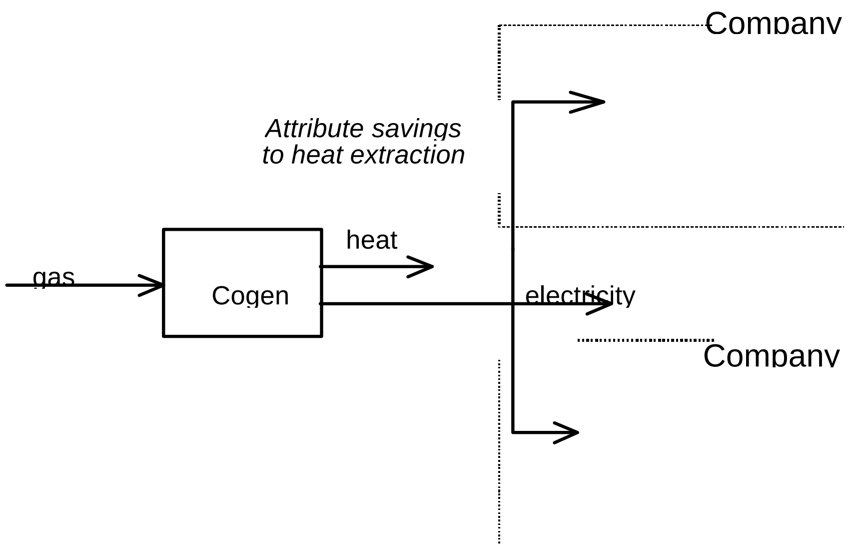


Figure: Cogeneration by third party in joint control



APPENDIX 3: SAMPLE ATTRIBUTION OF ENERGY FLOWS

Figure Product flows meat processing

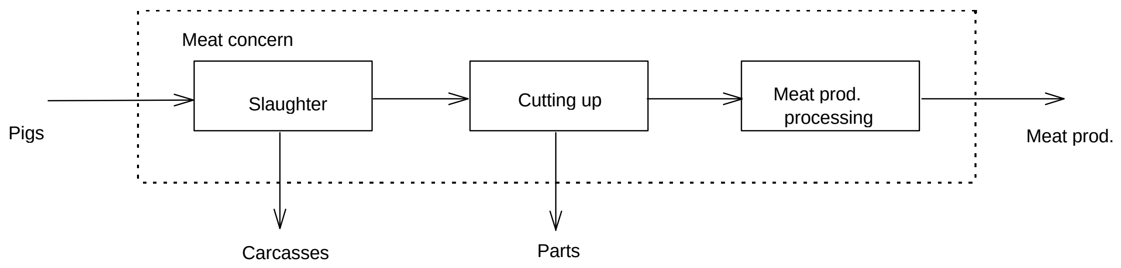


Figure. Solely cutting-up meat concern

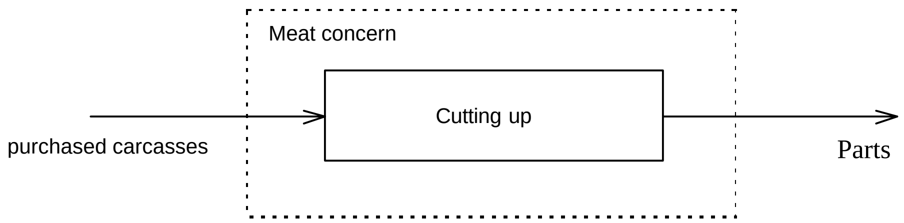


Figure: Sausage manufacturer

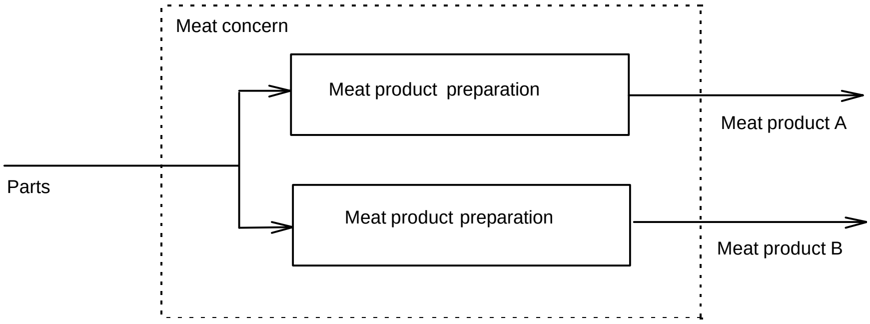
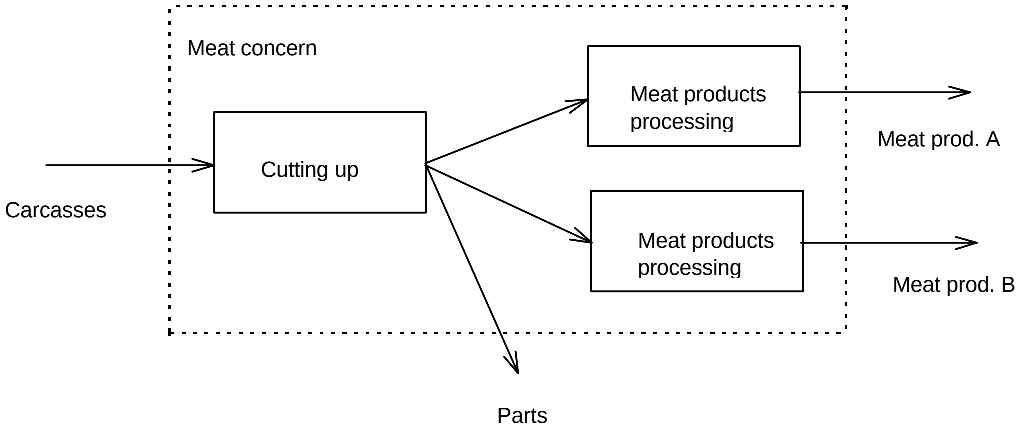


Figure Meat producer with cut-up section



Example of an electricity use survey (electricity balance) for a slaughter house

apparatus	**installed power kW**	**take-up factor cos phi**	**used power kW**	**service hours hours**	**consumption per year kWh**
Supporting processes					
1. Cooling equipment					
refrigeration	111,1	0,9	100,0	4000	400000
air conditioning	73,3	0,9	66,0	4000	264000
2. Steam/hot water generation					
boiler	0,4	0,9	0,4	4000	1600
hot water distribution	0,4	0,9	0,4	4000	1600
high-pressure cleaning sets	44,4	0,9	40,0	50	2000
process water pumps	3,3	0,9	3,0	4000	12000
3. Air compressors	18,1	0,9	16,3	3000	48750
4. Waste water cleaning	17,8	0,9	16,0	4000	64000
Production processes					
5. Production lines					
line 1: slaughter line	3,3	0,9	3,0	4000	12000
line 2: cut-up line	2,2	0,9	2,0	4000	8000
Non-production-tied consumption					
6. Lights	20,0	1	20,0	4000	80000
7. Office	20,0	1	20,0	2000	40000
8. Ventilation	4,2	0,9	3,75	4000	15000
TOTAL					***948950***

Example of direct electricity use attribution to products/process steps

products	***directly attributable electricity consumption(kWh)***			
	cooling	**production lines**	**water cleaning**	**compressed air**
pig slaughter	400000	12000	64000	
pig cut-up		8000		48750
TOTAL	**400000**	**20000**	**64000**	**48750**

Example of indirect consumption attribution to products/process steps

products	***attribution magnitudes***			***Electricity consumption of supprting processes (kWh)***				
	tons	**m2**	**number of people**	**office**	**lights**	**ventilation**	**air con-ditioning**	**cleaning**
pig slaughter	80000	600	…	26667	30000	5625	99000	11467
pig cut-up	40000	1.000	…	13333	50000	9375	165000	5733
TOTAL	**1E+05**	**1.600**		**40000**	**80000**	**15000**	**264000**	**17200**
attribution basis				tons	m2	m2	m2	tons

Example of specific electricity uses

products		***specific electricity consumption (kWh/ton)***									
	tons	**office**	**lights**	**venti-lation**	**air con-ditioning**	**clea-ning**	**cooling**	**productio n lines**	**water cleaning**	**compres-sed air**	**total**
pig slaughter	80000	0,3	0,4	0,1	1,2	0,1	5,0	0,2	0,8	0,0	8,1
pig cut-up	40000	0,3	1,3	0,2	4,1	0,1	0,0	0,2	0,0	1,2	7,5

APPENDIX 4: SAMPLE CALCULATION OF THE EFFECT OF A NEWLY JOINING COMPANY

Tabel Monitoring results for a new composition of company membership.

Types of modification

	1995 (reference)	2000	2001	2002	2003	2004
BASIC CALCULATION EEI						
Eactual	648758	653948	665188	735998	764913	786598
Volume	80000	84000	88200	92610	97241	102103
Especific reference year	8,1					
Ereference	648758	681196	715256	751019	788570	827998
EEI	100%	96%	93%	98%	97%	95%
ALTERED USES						
Especific for extra refrigeration of remnants, reference year				1,76	1,76	1,76
Especific for extra water cleaning in reference year					0,8	0,8
Extra Ereference by refrigeration of remnants				162994	171143	179700
Extra Ereference by water cleaning					77792	81682

By adding the company in this way, the DEEI of this new composition of company membership alters from 2004 onwards. By comparing the set of figures for the old composition (without the joining company) with those for the new composition (with the joining company) it is evident that the direct energy efficiency has worsened.

APPENDIX 5: SAMPLE CALCULATIONS OF ADJUSTMENTS

In the following example a meat concern is obliged, as from 2002, to additionally refrigerate slaughter remnants until these can be carried off, whereas before only products needed to be kept refrigerated. To take this into account, the change in specific use in relation to the reference year has to be calculated first. Thereto the following question needs to be answered:

"What would the extra use have been in the reference year if this measure had been applied in that year as well."

Table Calculation of specific use in refrigerating slaughter remnants by comparison with refrigeration of product (carcass) within the same department.

Specific use by refrigeration in reference year:	1.80 kWh/ton product
Slaughter remnants per ton of product (carcass)	0.3 tons of remnants/ton product
Extra specific use for refrigeration of remnants in reference year	1.50 kWh/ton product
Use by refrigerated storage in reference year	2.64 / ton product
Surface area for refrigerated storage of product	1500 m2
Extra space for remnants storage	150 m2
Surface area relation	0.1 m2 product / m2 remnants
Extra use by refrigerated remnants storage	0.26 / ton product
Total extra use by refrigeration and refrigerated storage of remnants	1.76 / ton product

Furthermore, a biological water cleaner will be installed in 2003 by demand of the purification department.

Table Specific use for water cleaning by comparison with water cleaning in colleague companies

Average specific use for cleaning in colleague companies	0.80 kWh/ton product

The alterations in use by the changing nature of activities can be determined with the established specific uses for alterations in the reference year.

Example Modifications in energy uses with changing nature of activities

Types of modification

	1995 (reference)	2000	2001	2002	2003	2004
BASIC CALCULATION EEI						
Eactual	648758	653948	665188	735998	764913	786598
Volume	80000	84000	88200	92610	97241	102103
Especific reference year	8,1					
Ereference	648758	681196	715256	751019	788570	827998
EEI	100%	96%	93%	98%	97%	95%
ALTERED USES						
Especific for extra refrigeration of remnants, reference year				1,76	1,76	1,76
Especific for extra water cleaning in reference year					0,8	0,8
Extra Ereference by refrigeration of remnants				162994	171143	179700
Extra Ereference by water cleaning					77792	81682

Examples of engineering calculation

In connection with public health, the obligatory storage temperature for coarse milk at the farm is

reduced from 5 to 4 ^{0}C. The performance of refrigeration comprises two aspects: cooling the milk down and storing the milk at low temperature. The average temperature of the surroundings of the milk tank is 10 ^{0}C. The milk starts the cooling down process at 37 ^{0}C.
The effect on direct energy use by reducing the temperature is phisically calculated as follows:
E1: cooling the milk down from 37 ^{0}C to the lower temperature.
This part of the energy use is augmented by a factor: 1- [(37-4) / (37-5)] = 0,03
E2: storing the milk.
This part of the energy use is augmented by a factor: 1- [(10-4) / (10-5)] = 0,20
The total use is thus augmented by 0,03*E1 + 0,20*E2

Example based on experimental values

A producer of bricks uses drinking water silt with high organic fraction as filler. The organic fraction combusts during baking and ensures a light brick with an advantegous heat transfer coefficient. The specific energy use cannot be indicated clearly beforehand and thus is measured.
In the case of a specific use of the new brick of e.g. 2 MJ/ton Waal size, this value for the specific use of the brick is taken up in the monitoring process.

APPENDIX 6: EXAMPLES OF PRODUCTION DECISIONS AND SAVINGS PROJECTS

An example of a production decision is putting a new production line into use in a meat concern. This is set out quantitatively below, by way of example.

Table Example of a shift in production between lines

Production decision

		(reference)					
EXISTING PRODUCTION LINE							
	especific current	104	104	104	104	104	104
	Volume	100	110	80	40	40	0
	Eactual	10400	11440	8320	4160	4160	0
NEW PRODUCTION LINE							
	especific current			80	80	80	80
	Volume			30	80	80	120
	Eactual			2400	6400	6400	9600
TOTAL							
	Volume	100	110	110	120	120	120
	Eactual	10400	11440	10720	10560	10560	9600
EEI							
	especific reference	104					
	Ereference	10400	11440	11440	12480	12480	12480
	EEI	100%	100%	94%	85%	85%	77%

In this example, there is an existing production line next to the new and more energy-efficient production line installed in 2000. As from 2000, production increases and part of the production is shifted towards the new production line. Because the specific energy use of the new production line is lower than that of the existing production line, in the shifting of production the total actual use in relation to the reference use decreases. The reference use is by the specific use of the existing production line in 1995. By shifting production between production lines with different specific uses, savings – or the reverse – can be made.

Example of savings projects

Regarding the savings projects, each year the savings made by each project are etablished. Different methods can be applied, depending on the choice of savings. In the following survey, the obtained savings are established for two savings projects (cogeneration and frequency control of cooling compressors) , on the basis of current data. In the Cogeneration plant the savings are assumed to be directly dependant on the heat-intake from the plant. If this amount is known for each year, then for each year the savings can be determined. In the second example, the savings obtained with frequency control of the cooling compressors for the refrigeration of the product is made dependant on production volume. By establishing the specific savings (savings per unit production volume), the total savings can be deteremined with the production figures. A third example is the production of vacuum-packed meat instead of frozen meat. By avoiding the need of refrigeration energy for freezing, the direct energy use turns out to be smaller.

Table Examples of savings projects and calculated savings

savings projects

		1995 (reference)	2000	2001	2002	2003	2004
Cogeneration							
	heat intake (TJ)			1200	1300	1650	1400
	savings per TJ of heat (TJ/TJ)			0,25	0,25	0,25	0,25
	savings TJ			300	325	412,5	350
Frequency control of cooling compressors							
	specific use for refrigeration (GJ/ton)	0,4	0,4	0,4	0,4	0,4	0,4
	savings percentage			25%	25%	25%	25%
	specific savings of frequency control (GJ/ton)			0,1	0,1	0,1	0,1
	volume (tons)	850	900	910	945	920	930
	Savings (TJ)	0	0	91	95	92	93
Etc.	..	..	..	..	..	..	..

APPENDIX 7: EXAMPLE ON INFLUENCES ON EEI

Table: Survey of the effects on the direct energy efficiency index

	1995 (reference)	**2004**
Eactual	10000	11430
Volume	850	930
especific reference year	11,8	
Ereference	10000	10941
ALTERED NATURE OF ACTIVITIES		
Extra Ereference for the refrigerating of remnants		946
Extra Ereference for water cleaning		880
Ereference with modification for altered nature of activities		12767
SAVINGS PROJECTS		
Cogeneration in joint venture		-350
Frequency control of cooling compressors		-93
Production of vacuum-packaging instead of freezing		-760
CALCULATION OF EFFECTS ON EEI		
EEI	100,0%	104,5%
Virtual EEI after modification for altered nature of activities		89,5%
Difference in EEI by altered nature of activities:		14,9%
- refrigeration of remnants		7,7%
- water cleaning		7,2%
Difference in EEI by savings projects:		-9,4%
- cogeneration in joint venture		-2,7%
- frequency control		-0,7%
- production of vacuum-packaging instead of freezing		-6,0%

By increase in production volume and by an altered nature of activities (the refrigeration of remnants and extra water cleaning) and through savings projects (cogeneration, frequency control and vacuum-packaging of products) the direct energy efficiency index changes.
A DEEI is calculated from the actual and referential uses. Furthermore, a virtual DEEI is determined, wherein the modifications through altered activity nature are taken into account. The difference between the DEEI and the virtual DEEI (14.9% in 2004) is distributed over the changes in the nature of the activities. The refrigeration of slaughter remnants caused a rise in the DEEI of 7.7%. The installing of a water cleaner caused a rise of 3.7%.

The virtual DEEI in 2004 is 89.5%. The 10.5% fall is to be explained by savings projects. The total savings achieved by cogeneration, frequency control and vacuum-packaging make up 9.4% of the virtual reference use. The decrease in the DEEI (10.5%) is thus explained for more than 80% of its worth.

Table: Survey of the effects on the direct energy efficiency index

Subdivision of efficiencies

	Effect on direct energy use	
	(TJ)	***%***
PROCESS EFFICIENCY	*1733*	*10,7%*
- refrigeration of remnants	946	7,7%
- water cleaning	880	7,2%
- frequency control	-93	-0,7%
PRODUCT EFFICIENCY	*-760*	*-6,0%*
- production of vacuum-packaging instead of freezing	-760	-6,0%
INDUSTRIAL CO-OPERATION	*-350*	*-2,7%*
- cogeneration in joint venture	-350	-2,7%
TOTAL	623	2,0%