**Doc. CEN/TC 228 N544**

**CEN/TC 228**

Date: 2006-08

**CEN/TC 228 WI 027**

CEN/TC 228

Secretariat: DS

# Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 4-5 Space heating generation systems, the performance and quality of district heating and large volume systems

*Einführendes Element — Haupt-Element — Ergänzendes Element*

*Élément introductif — Élément central — Élément complémentaire*

ICS:

Descriptors:

Document type: European Standard
Document subtype:
Document stage: Formal Vote
Document language: E

C:\Mine dokumenter\TC 228\WG 4\WI 00228027\TC version\N544_prEN 15316-4-5_WI00228027_2006-08.doc STD Version 2.1c

# Contents

Page

## Foreword

This document (prEN 15316-4-5:2005) has been prepared by Technical Committee CEN/TC 228 “Heating systems in buildings”, the secretariat of which is held by DS.

The subjects covered by CEN/TC 228 are the following:

- design of heating systems (water based, electrical etc.);
- installation of heating systems;
- commissioning of heating systems;
- instructions for operation, maintenance and use of heating systems;
- methods for calculation of the design heat loss and heat loads;
- methods for calculation of the energy performance of heating systems.

Heating systems also include the effect of attached systems such as hot water production systems.

All these standards are systems standards, i.e. they are based on requirements addressed to the system as a whole and not dealing with requirements to the products within the system.

Where possible, reference is made to other European or International Standards, a.o. product standards. However, use of products complying with relevant product standards is no guarantee of compliance with the system requirements.

The requirements are mainly expressed as functional requirements, i.e. requirements dealing with the function of the system and not specifying shape, material, dimensions or the like.

The guidelines describe ways to meet the requirements, but other ways to fulfil the functional requirements might be used if fulfilment can be proved.

Heating systems differ among the member countries due to climate, traditions and national regulations. In some cases requirements are given as classes so national or individual needs may be accommodated.

In cases where the standards contradict with national regulations, the latter should be followed.

# Introduction

This standard presents a method for calculation of the energy performance of district heating systems and dwelling substations. The results of the calculation are the primary energy factor of the specific district heating system and the heat losses of the building substations. The method is applicable for all kinds of heat sources, including heat and power cogeneration. The method is independent of the use of the heat supplied, including subsequent generation of cooling energy in the building. The method may be applied in the same way for district cooling based on cogeneration or use of lake or sea water.

The calculation is based on the performance data of the district heating system and the building substations, respectively, which can be calculated or measured according to this standard and other European standards cited herein.

This method can be used for the following applications:

— judging compliance with regulations expressed in terms of energy targets;

— optimisation of the energy performance of a planned district heating system and building substations by varying the input parameters;

— assessing the effect of possible energy conservation measures on an existing system by changing the method of operation or replacing parts of the system.

The user shall refer to other European standards, European directives and national documents for input data and detailed calculation procedures not provided by this standard.

Only the calculation method and the accompanying input parameters are normative. All values required to parameter the calculation method should be given in a national annex.

# 1 Scope

This standard is part of a set of standards on the method for calculation of system energy requirements and system efficiencies.

The scope of this specific part is to standardise the method of assessing the energy performance of district heating and cooling systems and to define:

- system borders;
- required inputs;
- calculation method;
- resulting outputs.

The method applies to district heating and cooling systems and any other kind of combined production for space heating and/or cooling and/or domestic hot water purposes.

Primary energy savings and $CO_2$ savings, which can be achieved by district heating systems compared to other systems, are calculated according to prEN 15315.

# 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

prEN 15315, *Heating systems in buildings – Energy performance of buildings - Overall energy use, primary energy and $CO_2$ emissions*

prEN 15316-4-1, *Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies – Part 4-1: Space heating generation systems, combustion systems*

EN ISO 12241, *Thermal insulation for building equipment and industrial installations - Calculation rules (ISO 12241:2006)*

# 3 Terms and definitions

## 3.1 Definitions

For the purposes of this document, the following terms and definitions apply:

**3.1.1**
**cogeneration**
simultaneous generation in one process of thermal energy and electrical and/or mechanical energy

**3.1.2**
**delivered energy**
energy supplied through the system boundary to satisfy the energy requirement

**3.1.3**
**net energy**
energy supplied by the energy systems to provide the required services. Recovered losses or gains are taken into account

**3.1.4**
**primary energy**
energy that has not been subject to any conversion or transformation process (e.g. oil in the oil fields). Primary energy may be either resource energy or renewable energy or a combination of both

**3.1.5**
**primary energy factor**
primary energy divided by delivered energy, where primary energy is the energy required to supply one unit of delivered energy of the same type, taking into account the primary energy required for extraction, processing, storage, transport, generation, transformation, transmission, distribution, and any other operations necessary for delivery of energy to the building in which the delivered energy will be used. Delivery operations may call for energy of various types (e.g. electricity, oil), and each of those should be given as primary energy using the appropriate primary energy factor

**3.1.6**
**primary resource energy factor**
resource energy divided by delivered energy, where resource energy is the energy required to supply one unit of delivered energy, taking into account the resource energy required for extraction, processing, storage, transport, generation, transformation, transmission, distribution, and any other operations necessary for delivery of energy to the building in which the delivered energy will be used. Any renewable energy component of the delivered energy is ignored. Delivery operations may call for energy of various types (e.g. electricity, oil), and each of those should be given as resource energy using the appropriate primary resource energy factor.

**3.1.7**
**recoverable losses**
part of the losses from the heating, cooling, ventilation, domestic hot water and lighting systems, which may be recovered to lower the energy requirements

**3.1.8**
**recovered loss**
part of the recoverable losses which are recovered to lower the energy requirements

**3.1.9**
**renewable energy**
energy taken from a source which is not depleted by extraction (e.g. solar, wind)

**3.1.10**
**resource energy**
energy taken from a source which is depleted by extraction (e.g. fossil fuels)

**3.1.11**
**district heating system**
a heating system, which supplies hot water or vapour to the building heating system from a heat generation system outside the building

**3.1.12**
**building substation**
a technical system to transform the parameter (temperature, pressure etc.) of a district heating system to the parameter of the building heating system and to control the building heating system

## 3.2 Symbols and units

For the purposes of this document, the following symbols and units (Table 1) and indices (Table 2) apply:

**Table 1 — Symbols and units**

| *Symbol* | Name of quantity | Unit |
|---|---|---|
| B | coefficient depending on the type of dwelling substation and its insulation level | - |
| D | coefficient depending on the type of dwelling substation and its control | - |
| f | primary energy factor | - |
| H | heat exchange coefficient | kWh/K |
| Q | quantity of energy | kWh |
| W | cogenerated electricity | kWh |
| $\eta$ | efficiency | - |
| $\sigma$ | relation of power production to heat production of a cogeneration appliance | - |
| $\beta$ | relation of heat produced by a cogeneration appliance to the total heat production | - |
| $\Theta$ | Temperature | °C |
| $\Phi$ | heat power | kW |

**Table 2 — Indices**

| | | | | | |
|---|---|---|---|---|---|
| amb | ambient | F | fuel | i, j | indices |
| CHP | combined heat and power | | | | |
| DH | district heating system | Gen | generation | p | primary |
| BS | building substation | | | | |
| elt | electrical | HP | heating plant | S | secondary |
| ext | external | HN | heating network | | |

# 4 Principle of the method

## 4.1 General

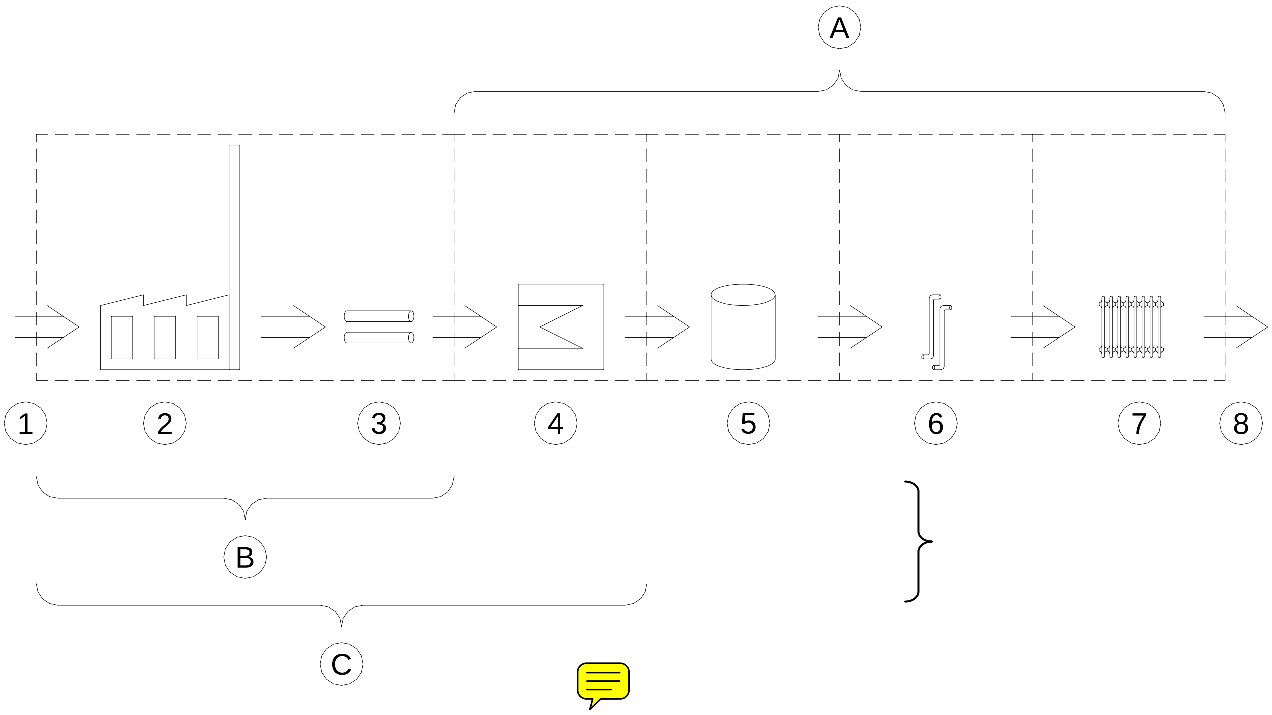
The performance of a district heating system is evaluated by dividing the district heating system into two parts according to Figure 1:

— outside part, i.e. parts of the system situated outside the building

— inside part, i.e. parts of the system situated inside the building.

The outside part is the district heating system and consists of the heat generation appliances and the district heating network up to the primary side of the building substations. All systems needed to operate the system are included. It is rated by the balance of primary energy consumption of the heat generation and the heat distribution of the district heating system.

The inside part is the building substation including all system from its primary side to the building heating system. The building substation is rated by its additional energy requirements. Thus, the building substation can be considered to replace the heat generator within the building.




| | | | |
|---|---|---|---|
| 1 | fuel input | 7 | Emission |
| 2 | heat (and power) generation | 8 | heating demand of the building |
| 3 | heating network | | |
| 4 | building substation | A | building heating system |
| 5 | storage | B | district heating system |
| 6 | distribution | C | covered by this standard |

**Figure 1 — Systematic of rating the performance of district heating systems**

## 4.2 District heating system situated outside the building - primary energy (resource) factor

The performance of a district heating system can be rated by evaluating the primary energy (resource) factor $f_{P,DH}$ of the specific district heating system. The primary energy (resource) factor of a district heating system is defined as the primary energy (resource) input $Q_P$ to the system divided by the heat $Q_C$ delivered at the border of the supplied buildings, i.e. at the primary side of the building substations. Thus, the heat losses of the heat distribution piping system are taken into account as well as all other energy used for extraction, preparation, refining, processing and transportation of the fuels to produce the heat. The primary energy factor is calculated by:

$$f_{P,DH} = \frac{Q_P}{Q_C} \qquad (1)$$

where:

$Q_P$ primary energy input to the system

$Q_C$ heat delivered at the border of the supplied buildings

The primary energy factor is greater than or equal to one, the primary energy resource factor is defined to be greater than or equal to zero*).

The primary energy (resource) factor has to be determined within the thermodynamic system borders of the specific district heating system. This is usually the area supplied by one heat distribution piping system bordered by the primary side of building substations.

Within this area, all energy inputs and all energy outputs are considered. Energy as input to the system is weighted by its specific primary energy (resource) factor.

For this energy balance, electrical power is included as well using a primary energy (resource) factor according to that part of the fuel mix, which is replaced by heat and power cogeneration (power bonus method).

Waste heat and regenerative heat sources are included by appropriate primary energy (resource) factors. Primary energy (resource) factors for fuels and electricity (informative values) are given in prEN 15315. According to the regional situation of energy supply, deviating values may be defined in a national annex.

Thermal losses and auxiliary energy in the building substation are taken into account not as part of the district heating system but as part of the building heating system (cf. figure 1 and clause 4.3).

In principle, the energy balance is given by:

$$f_{P,DH} \cdot \sum_j Q_{C,j} + f_{P,elt} \cdot W_{CHP} = \sum_i f_{P,F,i} \cdot Q_{F,i} \qquad (2)$$

where

$f_{P,DH}$ primary energy (resource) factor of the district heating system

$f_{P,F,i}$ primary energy (resource) factor of the i-th fuel or final energy input

$f_{P,elt}$ primary energy (resource) factor of replaced electrical power

$\Sigma Q_{C,j}$ sum of the heat energy consumption measured at the primary side of the building substations of the supplied buildings within the considered time period (usually one year)

---

*) In the case of heat and power cogeneration based on regenerative energy such as biogas, negative primary resource factors may occur. These are set equal to zero.

$W_{CHP}$ cogenerated electricity as defined in Annex II of Directive 2004/08/EC within the same time period

$Q_{F,i}$ final energy consumption of the i-th fuel for the production heat and power within the same time period

### 4.3 Energy requirements of the building substations

The energy performance of the building substations is rated by evaluation of their heat losses.

The electrical energy consumption of auxiliary equipment can be neglected.

The heat losses depend on:

— the thickness and the material of the insulation,

— the piping material,

— the surface of the whole piping system,

— the load of the substation,

— the difference between the heating media temperatures and the ambient temperature.

## 5 District heating system calculation

### 5.1 Primary energy (resource) factor

#### 5.1.1 Calculation based on measurements

For existing district heating systems, all required inputs are usually known by measurements. The method of calculation is indicated in Figure 2.

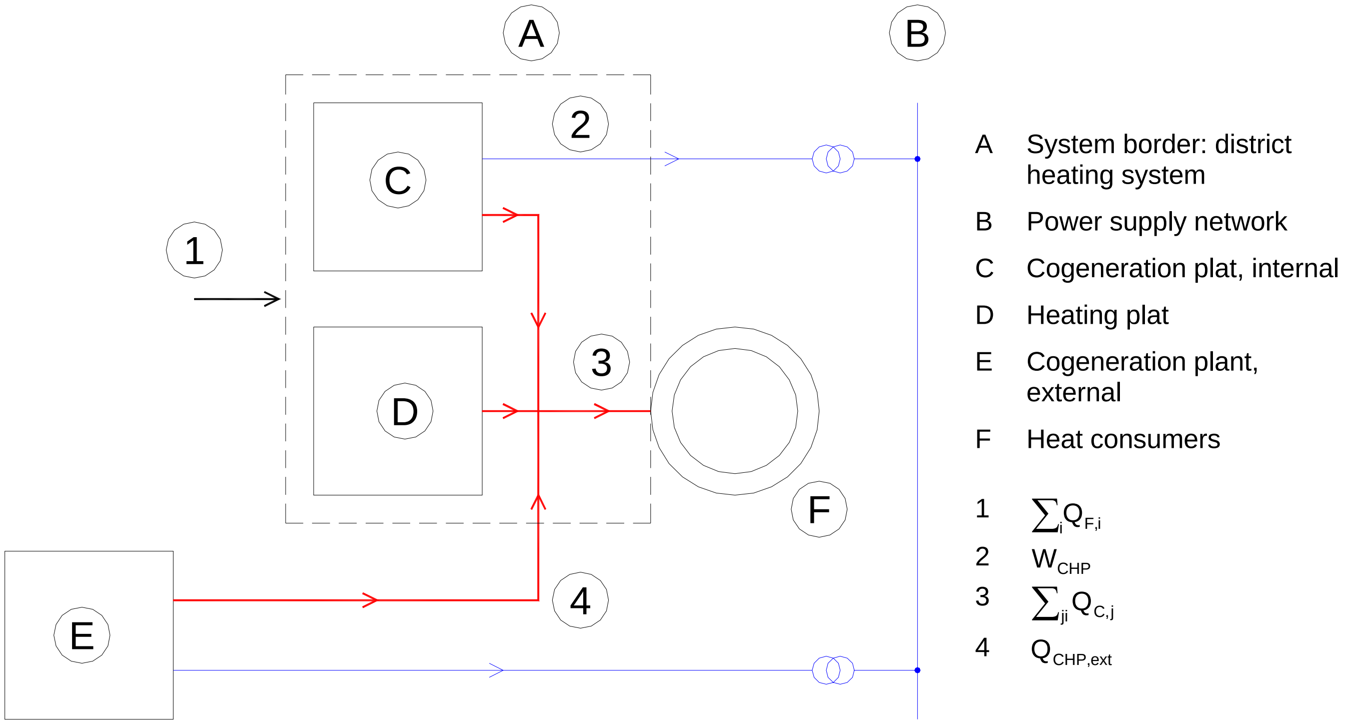



**Figure 2 — Method of the energy balance for an existing district heating system**

The required inputs for the calculation are:

$Q_{F,i}$ fuel input (final energy) to the heating plants and the cogeneration plants within the considered system within the considered time period (usually one year). This energy is measured at the point of delivery

$f_{P,F,i}$ primary energy (resource) factor of the fuel inputs (final energy). Informative values of these factors are given in prEN 15315 or in a national annex.

$W_{CHP}$ electricity production of the cogeneration plants of the considered system within the considered time period

$Q_{CHP,ext}$ heat delivery to the considered system from external cogeneration plants within the considered time period

$\Delta W_{CHP,ext}$ power losses of external cogeneration plants due to heat extraction within the considered time period (relevant only if heat is delivered to the considered system from outside, and this parameter is only applied if $f_{P,CHP,ext}$ is not available)

$f_{P,elt}$ primary energy (resource) factor of electrical power.

$Q_{C,I}$ heat energy consumption measured at the primary side of the building substations of the supplied buildings within the considered time period

$\eta_{HN}$ efficiency of the heating network. Values of $\eta_{HN}$ should be given in a national annex. The values usually range between 0.70 and 0.95.

The output of the calculation is the primary energy (resource) factor $f_{P,DH}$ of the considered district heating system, which yields from equation (2):

$$f_{P,DH} = \frac{\sum_i Q_{F,i} \cdot f_{P,F,i} - W_{CHP} \cdot f_{P,elt}}{\sum_j Q_{C,j}} \qquad (3)$$

**External heat supply to the district heating system**

External heat deliveries to the considered district heating system should be treated in the same way as a fuel input by weighting the external heat delivery $Q_{ext}$ by its primary energy (resource) factor $f_{ext}$.

If cogenerated heat $Q_{CHP,ext}$ is delivered to the considered district heating system and its primary energy factor $f_{P,CHP,ext}$ is not known due to lack of information on some of the inputs of the above calculation, the power loss $\Delta W_{CHP,ext}$ due to the heat extraction of the external cogeneration plant and the efficiency $\eta_{HN}$ of the external heating network weighted by the primary energy factor $f_{P,elt}$ of electrical power can be used instead as appropriate input to equation (3):

$$f_{P,CHP,ext} \cdot Q_{CHP,ext} = f_{P,elt} \cdot \frac{\Delta W_{CHP,ext}}{\eta_{HN}} \qquad (4)$$

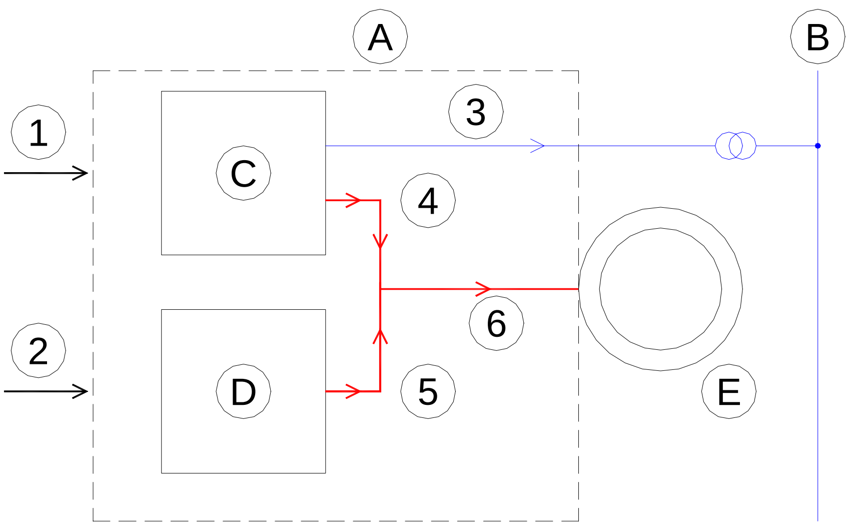
The power losses $\Delta W_{CHP,ext}$ of external cogeneration plants delivering heat to the considered district heating system should be determined from the total power losses of these plants and the relation of the heat delivery to the system to the total heat production of these plants:

$$\Delta W_{CHP,ext} = \Delta W_{CHP,ext,total} \frac{Q_{CHP,ext}}{Q_{CHP,ext,total}} \qquad (5)$$

Calculation examples are provided in annex A.

### 5.1.2 Calculation from design data

For cogeneration systems, the usual design data are used as input for the calculation. The method of calculation is indicated in Figure 3.




A System border: district heating system

B Power supply network

C Cogeneration appliance

D Heat generator

E Heat consumers

1 $Q_{F,CHP} = \frac{W_{CHP} + Q_{CHP}}{\eta_{CHP}}$

2 $Q_{F,HP} = \frac{Q_{HP}}{\eta_{HP}}$

3 $W_{CHP} = \sigma \cdot Q_{CHP}$

4 $Q_{CHP} = \beta \cdot Q_{Gen}$

5 $Q_{HP} = (1-\beta) \cdot Q_{Gen}$

6 $Q_{Gen} = \frac{\sum_j Q_{C,j}}{\eta_{HN}}$

**Figure 3 — Method of energy balance on the basis of design data**

Efficiencies determined according to the appropriate CEN standards should be used:

Combustion heat generator: $$\eta_{HP} = \frac{Q_{HP}}{Q_{F,HP}} \quad (6)$$

Cogeneration appliance: $$\eta_{CHP} = \frac{W_{CHP} + Q_{CHP}}{Q_{F,CHP}} \quad (7)$$

where:

$Q_{F,HP}$ fuel consumption of the combustion heat generator during the considered time period (usually one year)

$Q_{HP}$ heat production of the combustion heat generator measured at the output of the generator during the same time period

$Q_{F,CHP}$ fuel consumption of the cogeneration appliance during the same time period

$W_{CHP}$ power production of the cogeneration appliance measured at the output of the appliance during the same time period

$Q_{CHP}$ Heat production of the cogeneration appliance measured at the output of the appliance during the same time period

Besides the efficiency characteristics of the products, the following design data are required for the calculation:

- $\sigma$, power to heat ratio, relation of power production to heat production of the cogeneration appliance:

$$\sigma = \frac{W_{CHP}}{Q_{CHP}} \quad (8)$$

- $\beta$, relation of heat produced by the cogeneration appliance to the total heat production:

$$\beta = \frac{Q_{CHP}}{Q_{CHP} + Q_{HP}} = \frac{Q_{CHP}}{Q_{Gen}} \quad (9)$$

The efficiency factor of the heat distribution network $\eta_{HN}$ should be evaluated in a national annex. Usual values range between 0.70 and 0.95.

The energy balance of equation (2) becomes:

$$f_{P,DH} \cdot \sum_j Q_{C,j} + f_{P,elt} \cdot W_{CHP} = f_{P,CHP} \cdot Q_{F,CHP} + f_{P,HP} \cdot Q_{F,HP} \quad (10)$$

Solving this equation for $f_{P,DH}$ and replacing all terms by the design data and the product efficiency characteristics, respectively, yields:

$$f_{P,DH} = \frac{(1+\sigma)\cdot\beta}{\eta_{HN}\cdot\eta_{CHP}} \cdot f_{P,CHP} + \frac{1-\beta}{\eta_{HN}\cdot\eta_{HP}} \cdot f_{P,HP} - \frac{\sigma\cdot\beta}{\eta_{HN}} \cdot f_{P,elt} \quad (11)$$

A calculation example is given in annex A.

#### 5.1.3 Auxiliary energy consumption

Auxiliary energy consumption is taken into account by applying only the net power production – i.e. the total power production minus all auxiliary energy consumption, e.g. for pumps – in the above energy balances.

If there is no electricity production in the district heating system, the energy consumption of the auxiliary equipment for heat generation and heat transportation has to be specifically taken into account in the energy balances.

#### 5.1.4 Recoverable heat losses

No losses are recoverable.

#### 5.1.5 Calculation period

It is recommended to use one year as the calculation period. Primary energy factors may be calculated separately for the winter period and the summer period. According to this method, it is even possible to calculate monthly balances, however this is usually too complex.

### 5.2 Energy requirements of a building substation

#### 5.2.1 General

A building substation is characterised by the insulation level of its components. This level is described in EN ISO 12241.

The energy requirement of a dwelling substation is the heat loss of the substation.

Auxiliary power consumption can be neglected.

#### 5.2.2 Heat loss

The heat loss $Q_{BS}$ of a building substation is calculated by:

$$Q_{BS} = H_{BS} \cdot (\Theta_{BS} - \Theta_{amb}) \quad \text{in kWh per year} \quad (12)$$

where:

$H_{BS}$ heat exchange coefficient of the building substation given by equation (13) in kWh/K·a

$\Theta_{BS}$ average temperature of the dwelling substation given by equation (14) in °C

$\Theta_{amb}$ ambient temperature at the location of the building substation in °C

$$H_{BS} = B_{BS} \cdot \Phi_{BS}^{\ 1/3} \quad \text{in kWh/K per year} \quad (13)$$

where:

$B_{BS}$ coefficient (-) depending on the type of building substation and its insulation level. Values for $B_{DS}$ should be given in a national annex. If national values are not available, informative values are given in Table B.1

$\Phi_{BS}$ nominal heat power of the building substation in kW

$$\Theta_{BS} = D_{BS} \cdot \Theta_{P,BS} + (1 - D_{BS}) \cdot \Theta_{S,BS} \quad \text{in °C} \tag{14}$$

where:

$D_{BS}$ coefficient (-) depending on the type of building substation and its control. Values for $D_{BS}$ should be given in a national annex. If national values are not available, informative values are given in Table B.2

$\Theta_{P,BS}$ average heating medium temperature of the primary circuit of the dwelling substation in °C. Typical values should be given in a national annex. If national values are not available, informative values are given in Table B.2

$\Theta_{S,BS}$ average heating medium temperature of the secondary circuit of the dwelling substation in °C, calculated in the same way as for any other type of heat generator (see prEN 15316-4-1)

The above equations are numerical equations. As the unit of the nominal heat power of the dwelling substation is kW, the result of the calculation of the heat loss $Q_{BS}$ is kWh per year.

### 5.2.3 Auxiliary energy consumption

The auxiliary energy consumption is neglected.

### 5.2.4 Recoverable heat losses

If the building substation is located inside the heated space, the total heat losses of the building substation are recoverable.

If the building substation is located in an unheated part of the building, no part of the heat losses of the building substation is recoverable.

# Annex A
# (informative)

# Calculation examples

## A.1 Typical situation of public utilities of a city

The public heat and power supply company of a city operates a cogeneration plant and a heat plant in another part of the city. Natural gas is used as fuel. The system border is the total heat supply area. The following figures were measured during one year:

| | | |
|---|---|---|
| Total heat consumption, measured at the primary side of the dwelling substations: | $\Sigma\ Q_C$ | 350,000 MWh/a |
| Annual gas consumption of the cogeneration plant, measured at the delivery point of the gas: | | 1,050,000 MWh/a |
| Annual gas consumption of the heating plant, measured at the delivery point of the gas: | | 50,000 MWh/a |
| Total gas consumption: | | 1,100,000 MWh/a |
| The unit of the gas consumption refers to the combustion energy (gross calorific), including the condensation enthalpy. Thus, the total gas consumption has to be corrected according to the condensation enthalpy, which is 10 %. Corrected value (net calorific) of the total gas consumption: | $\Sigma\ Q_F$ | 1,000,000 MWh/a |
| Total power production, measured at the input to the public power supply network: | | 350,000 MWh/a |
| Internal power requirements for pumps, etc.: | | 3,000 MWh/a |
| Net power production: | $W_{CHP}$ | 347,000 MWh/a |

No other values of equation (3) apply. The primary energy factor of natural gas is 1.10 and the primary energy factor of electrical power is 2.80. The primary energy factor of the district heating system is determined from equation (3):

$$f_{P,DH} = \frac{\sum_i Q_{F,i} \cdot f_{P,F,i} - W_{CHP} \cdot f_{P,elt}}{\sum_j Q_{C,j}}$$

$$f_{P,DH} = \frac{1{,}000{,}000 \cdot 1.10 - 347{,}000 \cdot 2.80}{350{,}000} \approx 0.37$$

## A.2 Typical situation of an industrial power plant supplying internal requirements and a city nearby

A large industrial complex operates its own power plant mainly for the internal requirements of power, heating and cooling energy. Further, the plant serves a nearby city with heat. The city district heating network is operated by a public enterprise of the city. The system border is the city district heating system.

From the technical data of the power plant and from measurements at the points of delivery, the following data are known:

| | | |
|---|---|---|
| Maximum power capacity of the plant at full condensation operation: | | 350 MW |
| Average power capacity during heat extraction operation: | | 300 MW |
| Power loss due to heat extraction (350 - 300) / 300: | | 16.7 % |
| Total annual power production of the plant: | | 2,200,000 MWh/a |
| Total annual heat extraction of the plant: | | 1,900,000 MWh/a |
| Total annual power loss of the plant (16.7 % of 2,200,000 MWh/a) | | 366,700 MWh/a |
| Total annual heat delivery to the city district heating system: | | 1,600,000 MWh/a |
| Net power loss due to the district heating system (delivered heat / total heat · power loss = 1.600.000 / 1.900.000 · 366.700): | $\Delta W_{CHP,ext}$ | 308,800 MWh/a |
| Total heat consumption within the district heating system: | $\Sigma\ Q_C$ | 1,400,000 MWh/a |

The primary energy factor of the district heating system is determined from equation (3)

$$f_{P,DH} = \frac{\sum_i Q_{F,i} \cdot f_{P,F,i} - W_{CHP} \cdot f_{P,elt}}{\sum_j Q_{C,j}}$$

using equation (4) and (5) and $\eta_{HN} = 0.90$

$$f_{P,CHP,ext} \cdot Q_{CHP,ext} = f_{P,elt} \cdot \frac{\Delta W_{CHP,ext}}{\eta_{HN}} \quad \text{with} \quad \Delta W_{CHP,ext} = \Delta W_{CHP,ext,total} \frac{Q_{CHP,ext}}{Q_{CHP,ext,total}}$$

$$f_{P,DH} = \frac{308{,}800 \cdot 2.80}{0.90 \cdot 1{,}400{,}000} \approx 0.69$$

## A.3 Typical situation of a small heat and power cogeneration system

A small heat and power cogeneration system is planned to supply a new settlement of 100 one-family houses. The design heat load of the settlement is 500 kW and the base load is 50 kW. A gas engine shall be used for heat and power cogeneration. Its heat power is 50 kW, the electrical power is 40 kW and the fuel consumption is 115 kW. The cogeneration module can operate 6,000 hours per year determined from the frequency of the heat loads. The remaining heat is produced by heating boilers. The total heat energy requirement equals 1,400 hours full load operation per year. All efficiency values are based on net calorific values.

| | |
|---|---|
| Efficiency of the cogeneration module: | $\eta_{CHP} = (40 + 50) / 115 = 0.78$ |
| Efficiency of the heating vessels: | $\eta_{HP} = 0.87$ |
| Efficiency of the heating distribution network: | $\eta_{HN} = 0.90$ |
| Power to heat ratio of the cogeneration module: | $\sigma = 40 / 50 = 0.80$ |
| Cogeneration heat to total heat ratio: | $\beta = (50 \cdot 6{,}000) / (500 \cdot 1{,}400) = 0.43$ |

The primary energy factor of the district heating system is determined from equation (11):

$$f_{P,DH} = \frac{(1+\sigma)\cdot\beta}{\eta_{HN}\cdot\eta_{CHP}}\cdot f_{P,CHP} + \frac{1-\beta}{\eta_{HN}\cdot\eta_{HP}}\cdot f_{P,HP} - \frac{\sigma\cdot\beta}{\eta_{HN}}\cdot f_{P,elt}$$

$$f_{P,DH} = \frac{(1+0.80)\cdot 0.43}{0.90\cdot 0.78}\cdot 1.10 + \frac{1-0.43}{0.90\cdot 0.87}\cdot 1.10 - \frac{0.80\cdot 0.43}{0.90}\cdot 2.80 \approx$$

$$\approx 0.97$$

# Annex B
# (informative)

## Building substation performance

**Table B. Coefficient $B_{BS}$ as a function of insulation class and type of network**

| | Insulation class of the components of the dwelling substation according to prEN ISO 12241 | | | |
|---|---|---|---|---|
| Insulation of secondary circuit | 4 | 3 | 2 | 1 |
| Insulation of primary circuit | 5 | 4 | 3 | 2 |
| **Type of network** | **Coefficient $B_{BS}$ [-]** | | | |
| Hot water, low temperature | 3.5 | 4.0 | 4.4 | 4.9 |
| Hot water, high temperature | 3.1 | 3.5 | 3.9 | 4.3 |
| Vapour, low pressure | 2.8 | 3.2 | 3.5 | 3.9 |
| Vapour, high pressure | 2.6 | 3.0 | 3.3 | 3.7 |

**Table B. — Primary temperature $\Theta_{P,BS}$ and coefficient $D_{BS}$ according to the type of dwelling substation**

| Type of dwelling substation | Primary temperature $\Theta_{P,BS}$ (°C) | Coefficient $D_{BS}$ (-) |
|---|---|---|
| Hot water, low temperature | 105 | 0.6 |
| Hot water, high temperature | 150 | 0.4 |
| Vapour, low Pressure | 110 | 0.5 |
| Vapour, high Pressure | 180 | 0.4 |

# Bibliography

GEMIS: Global Emission Model of Integrated Systems, Ökoinstitut, Freiburg, Germany (available free of charges from www.oeko.de/service/gemis/)

CEN/CENELEC Workshop 14 on "Manual for the Determination of CHP Products"

Directive 2001/77/EC on the “Promotion of Electricity Produced from Renewable Energy Sources in the Internal Electricity Market”

Draft Directive COM (2003) 739 on “Energy End-use Efficiency and Energy Services” presented by the Commission in December 2003

Directive 2004/8/EC, “The promotion of cogeneration based on a useful heat demand in the internal energy market and amending Directive 92/42 EEC”