

Ventilation for buildings — Calculation of room temperatures and of load and energy for buildings with room conditioning systems

ICS 91.140.30

National foreword

This British Standard is the UK implementation of EN 15243:2007.

With respect to the Energy Performance of Buildings Directive (EPBD) requirements, attention is drawn to the text of the fourth paragraph of the EN foreword. This recognizes at the present time that, if there is a conflict, existing national regulations take precedence over any requirements set out in this standard.

The UK participation in its preparation was entrusted to Technical Committee RHE/2, Ventilation for buildings, heating and hot water services.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

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Lüftung von Gebäuden - Berechnung der Raumtemperaturen, der Last und Energie für Gebäuden mit Klimaanlage

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Foreword

This document (EN 15243:2007) has been prepared by Technical Committee CEN/TC 156 "Ventilation for buildings", the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by February 2008, and conflicting national standards shall be withdrawn at the latest by February 2008.

This standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association (Mandate M/343), and supports essential requirements of EU Directive 2002/91/EC on the energy performance of buildings (EPBD). It forms part of a series of standards aimed at European harmonisation of the methodology for the calculation of the energy performance of buildings. An overview of the whole set of standards is given in CEN/TR 15615, Explanation of the general relationship between various CEN standards and the Energy Performance of Buildings Directive (EPBD) ("Umbrella document").

Attention is drawn to the need for observance of EU Directives transposed into national legal requirements. Existing national regulations with or without reference to national standards, may restrict for the time being the implementation of the European Standards mentioned in this report.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

Clauses 13 and 14 of this standard deal with the calculation of the energy demand of HVAC systems, specifically in connection with the Energy Performance Rating in connection with the Energy Performance of Buildings Directive. The calculation of the building energy demand that has to be met is dealt with in prEN ISO 13790 "Thermal Performance of Buildings – Calculation of energy use for space heating and cooling" – this information is input data for the procedures addressed in this standard. Calculation methods satisfying this standard may also be used for other purposes, (for example, for system sizing). These are covered by Clauses 1 to 12 of the standard. Users of calculation methods should exercise care in ensuring that the need for appropriate modifications are considered and, if necessary, implemented for other applications.

The standard has an unusual large portion of informative annexes in terms of number and size. This is due to the fact that the area covered by this standard is highly dependent on the system solutions, which exist in a large number of variations, and therefore many issues can only be shown in an exemplary way and experts in the different countries would not agree in putting this generally in normative way. Also, due to the different approaches taken in the different countries for the implementation of the EPBD, different solutions should be possible in parallel and the normative part can only be general. Nevertheless, the standard intends to give room for documentation of specific solutions, in order to provide information in enough depth, to make common parts and difference transparent for possible closer harmonisation in future.

1 Scope

The scope of this European Standard is:

- To define the procedure how the calculation methods to determine the temperatures, sensible loads and energy demands for the rooms shall be used in the design process.
- To describe the calculation methods to determine the latent room cooling and heating load, the building heating, cooling, humidification and dehumidification loads and the system heating, cooling, humidification and dehumidification loads.
- To define the general approach for the calculation of the overall energy performance of buildings with room conditioning systems.
- To describe one or more simplified calculation methods for the system energy requirements of specific system types, based on the building energy demand result from prEN ISO 13790, and to define their field of application.

A general framework standard is given which imposes an hourly calculation for all cases which cannot be covered by simplified methods, and gives requirements on what has to be taken into account. Input and output data are defined.

The target audience of this standard is twofold:

- Designers of HVAC systems, which are given an overview of the design process with the relevant references to the different involved standards (Clauses 5 to 12).
- Developers of regulations and tools, which find requirements for calculation procedures to be used for the energy requirements according to the EPBD (Clauses 13 and 14).

The idea followed by this standard is, that for the detailed approach one single calculation method is used for the different room related purposes such as room temperature calculation, room cooling and heating load calculation, and room energy calculation. This means, for the building type envisaged (buildings with room conditioning systems) it is an alternative to simplified calculation methods such as heating load according to EN 12831 and heating energy according to prEN ISO 13790. This standard does not describe any detailed methods for the sensible room based calculations. For this it refers to the relevant standards EN ISO 13791, EN ISO 13792, EN 15255 and EN 15265.

This standard specifies simplified methods and describes the necessary functionality of methods for the calculation of standardized annual energy consumption by systems providing temperature control, mechanical ventilation and humidity control in existing and new buildings. For brevity, these are described as HVAC systems. These systems may provide any or all of these services, including heating, cooling, air filtration, humidification or dehumidification. For the air side calculations of air based systems it refers to EN 15241. Systems providing heating but no other services are covered by EN 15316. These boundaries are, however, not kept strictly in the informative annexes, because some of the shown example calculations follow a holistic approach and this separation is therefore not always possible.

The standard specifically relates to demand calculations needed for Energy Performance Rating in connection with the Energy Performance of Buildings Directive.

These installations may include:

- Emission, distribution, storage and generation for cooling.
- Emission, distribution and heat exchanger for heating if these functions are performed using an air conditioning system; all heating functions performed by direct heating or using water as a heat transport medium are treated in other standards.

The calculation of cooling and heating energy demand within buildings is dealt with by prEN ISO 13790 and is a required input. This standard only addresses these issues to the extent that HVAC systems have an influence on the loads.

The boundaries and relations between the covered areas are shown in Figure 1.

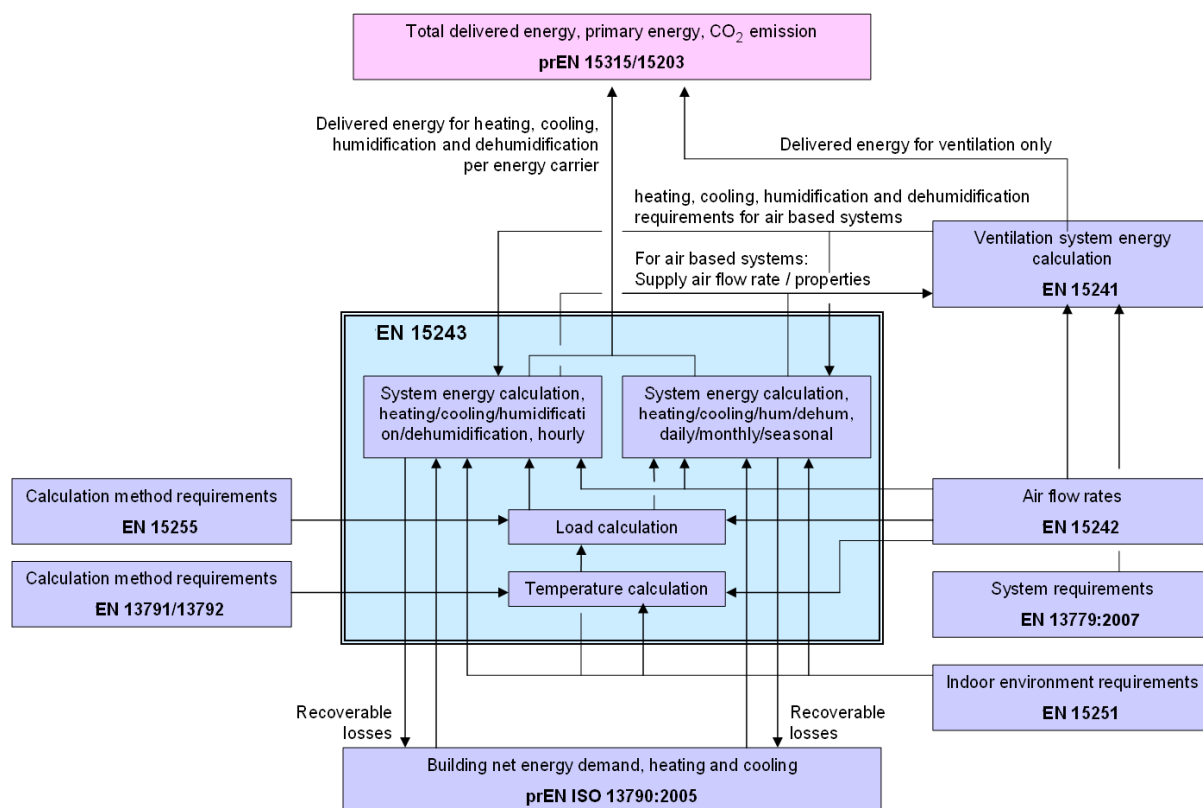


Figure 1 — Chart showing the relations to other standards related to the EPBD

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.

EN 13779, *Ventilation for non-residential buildings — Performance requirements for ventilation and room-conditioning systems*

EN 15026, *Hygrothermal performance of building components and building elements — Assessment of moisture transfer by numerical simulation*

EN 15241, *Ventilation for buildings — Calculation methods for energy losses due to ventilation and infiltration in commercial buildings*

EN 15242:2007, *Ventilation for buildings — Calculation methods for the determination of air flow rates in buildings including infiltration*

EN 15251, *Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics*

EN 15255:2007, *Thermal performance of buildings — Sensible room cooling load calculation — General criteria and validation procedures*

EN 15316-2-1, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 2-1: Space heating emission systems*

EN 15377-3, *Heating systems in buildings — Design of embedded water based surface heating and cooling systems — Part 3: Optimizing for use of renewable energy sources*

prEN ISO 13790, *Energy performance of buildings — Calculation of energy use for space heating and cooling (ISO/DIS 13790:2005)*

EN ISO 13792, *Thermal performance of buildings — Calculation of internal temperatures of a room in summer without mechanical cooling — Simplified methods (ISO 13792:2005)*

prEN ISO 15927-2, *Hygrothermal performance of buildings — Calculation and presentation of climatic data — Part 2: Hourly data for design cooling load (ISO/DIS 15927-2:2007)*

EN ISO 15927-4, *Hygrothermal performance of buildings — Calculation and presentation of climatic data — Part 4: Hourly data for assessing the annual energy use for heating and cooling (ISO 15927-4:2005)*

3 Terms and definitions

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

3.1

room

enclosed space or part of an enclosed space

3.2

room heating load

daily profile of the energy flow rate which must be added to a room under design conditions in order to keep its comfort conditions within a defined range

3.3

room cooling load

daily profile of the energy flow rate which must be extracted from a room under design conditions in order to keep its comfort conditions within a defined range

3.4

room sensible cooling load

daily profile of the energy flow rate which must be extracted from a room under design conditions in order to keep its temperature (air temperature or operative temperature) within a defined range

3.5

room latent cooling load

daily profile of the energy flow rate which must be extracted from a room under design conditions in order to keep its humidity below a defined limit

3.6

basic room sensible cooling load

daily profile of the energy flow rate which must be extracted from a room under design conditions in order to keep its air temperature at a constant value

3.7

room latent heating load

daily profile of the energy flow rate which must be added to a room under design conditions in order to keep its humidity above a defined limit

3.8

room conditioning system

system able to keep a comfort conditions in a room within a defined range

NOTE Air conditioning as well as surface based radiative systems are included.

3.9

zone

group of rooms forming part of a building, assigned to a system

3.10

zone cooling load

daily profile of the energy flowrate to be extracted from a zone

NOTE It is calculated by superposition of the room cooling load profiles

3.11

zone heating load

daily profile of the energy flowrate to be added to a zone for heating purposes

NOTE It is calculated by superposition of the room heating load profiles

3.12

zone humidification load

daily profile of the energy flowrate to be added to a zone for humidification purposes

NOTE It is calculated by superposition of the room humidification load profiles

3.13

system

set of HVAC components which provides heating, cooling, humidification and dehumidification energy to a zone in order to meet the comfort conditions in the rooms

NOTE The system boundaries are at the emission/extraction of heat and/or conditioned air to the rooms, the envelope of the system (leakage and/or heat transfer) and the energy delivered to the system in form of fuel and/or electricity. Intermediate boundaries may be necessary for calculation purposes

3.14

system cooling load

daily profile of the energy flowrate to be extracted from a system under design conditions taking into account the system impact

3.15

system heating load

daily profile of the energy flowrate to be added to a system under design conditions which meets the zone heating load, taking into account the system impact

3.16

system cooling capacity

maximum heat extraction flowrate of a system under specified conditions

3.17

system heating capacity

maximum heat addition flowrate of a system under specified conditions

3.18

room cooling energy demand

energy amount to be extracted from the room in order to keep its comfort conditions within a defined range throughout the year under typical meteorological conditions

3.19

room heating energy demand

energy amount to be added to the room in order to keep its comfort conditions within a defined range throughout the year under typical meteorological conditions

3.20

system cooling energy demand

energy amount to be extracted from the system in order to keep its intended operating conditions throughout the year under typical meteorological conditions

3.21

system heating energy demand

energy amount to be added to the system in order to keep its intended operating conditions throughout the year under typical meteorological conditions

3.22

HVAC system

system providing temperature control, mechanical ventilation and humidity control in a building

3.23

turn over temperature

outside temperature when no heating or cooling demand exists within a building, also known as the 'free temperature' of the building

Definitions of system types are given in Table 1, Table 2 and Annex C.

4 Symbols and abbreviations

NOTE The symbols of Annex E and Annex F are not taken into account in the lists below, since they origin from different national documents and do not follow the same rule.

Table 1 — Symbols and units

symbol	Name	Unit
A	Area	m^2
a	Humidity production	kg/s
c	Specific heat capacity	$\text{J kg}^{-1}\text{K}^{-1}$
E	Delivered energy or energyware	J
EIR	Energy input ratio	-
EER	Energy efficiency ratio	-
F	Frequency	-
f	Fraction or factor	-
f_w	Weighting factor	-
Q	Thermal energy	J
q_m	Mass flow rate	kg.s^{-1}
W	Auxiliary electrical energy	J
x	Absolute humidity	kg/kg dry air
θ	Temperature	$^{\circ}\text{C}$
θ_{ii}	initial internal temperature	$^{\circ}\text{C}$
$\delta\theta_{vs}$	spatial variation of temperature	K
$\delta\theta_{vt}$	control accuracy	K
ρ	Density	kg/m^3

Table 2 — Indices

symbol	Name
a	Air
aux	auxiliary
c	Cooling
d	Distribution
dem	Demand
e	Emission
entr	Entering
f	Floor
g	Generation
h	Heating
hum	Humidifier
i	Internal
ii	Initial internal
loss	Losses
la	interaction
in	input to subsystem
prim	Primary
r	Refrigerant
recirc	Recirculation
s	Storage
sat	Saturation
sea	Seasonal
sens	Sensible
start	At starting time
tot	Total
out	output of subsystem
w	Water
(E)	Electricity – indicating the fuel type for delivered energy
(G)	Gas – indicating the fuel type for delivered energy
(O)	Oil – indicating the fuel type for delivered energy

5 General approach

The general approach for the calculation procedure of a building with a room conditioning system is shown in Figure 2.

The first step is to define whether a humidity control is necessary or not. If so, there is a cooling and/or humidification requirement, and the latent room cooling and heating load has to be calculated.

If no humidity control is required, it has to be decided whether cooling is necessary or not. An optional step for this is a room temperature calculation. It can be done for some specifically chosen rooms.

If no cooling is required, the project is out of the scope of this standard and can be treated according to the heating related standards EN 12831, prEN ISO 13790 and the different parts of EN 15316.

If cooling is required, a next optional step is a basic room cooling load calculation. This optional calculation is done with constant comfort conditions and gives a basic value which can serve for comparison with different system solution values. It can give help in the system and control choice decision.

If an envisaged system is not adequate to meet the basic room heating and cooling loads, modifications may be considered on the building envelope and construction.

After the choice of the system, an appropriate room cooling and heating load calculation shall be performed. This is the base for sizing the room based cooling equipment such as air volume flow rate, chilled ceiling power, fan coil power, radiator power, embedded system power etc. It generally consists of three parts:

- Room sensible cooling load.
- Room cooling load due to room based ventilation.
- Room latent cooling load.

The load due to room based ventilation only occurs and has to be taken into account, when there is room based ventilation such as natural ventilation through windows or vents or room based mechanical ventilation.

The latent room cooling load has been taken into account in the beginning, when the humidity of a room has to be controlled. But the latent gains have an influence on the local or central equipment also in the other cases (uncontrolled dehumidification by cooling coils).

The zone load calculation, which is done by superposition of the room load profiles, gives then the base for the sizing of central cooling equipment.

Economic and/or energy considerations may be the reason for an equipment sizing which does not cover all the load cases. In this case, a further room temperature calculation may be performed to show the consequences of this undersizing.

With a chosen and sized central equipment, yearly energy calculations can be performed in order to optimise the system. Iterations may include building modifications, a new system and control choice and/or a new equipment sizing.

An outline for a “best procedure” for this general approach is given in Annex A.

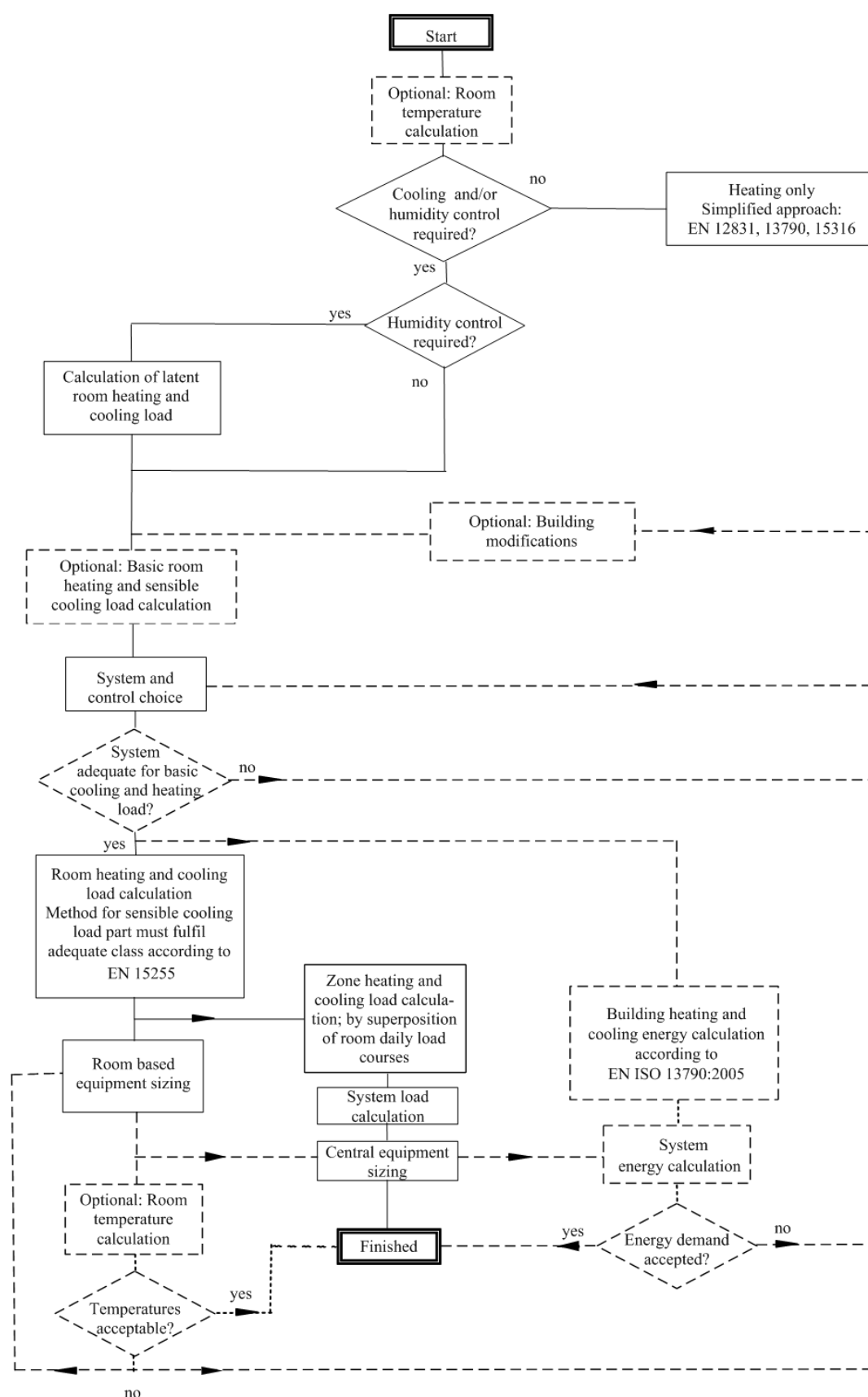


Figure 2 — Flow chart for general approach (all dotted steps and loops are optional)

6 Room temperature calculation without room conditioning system

6.1 Choice of rooms

Typical rooms representing different building areas shall be chosen.

Annex B gives a proposal for a possible procedure to choose rooms.

6.2 Calculation method

The method used to perform the room temperature calculation shall comply with the requirements given in EN ISO 13792. Compliance with EN ISO 13791 can be decided on a national basis.

6.3 Boundary conditions

6.3.1 Climatic data

The climatic data used for the room temperature calculation shall be calculated and presented according to prEN ISO 15927-2 or EN ISO 15927-4. The choice of the type of data and the duration of the period considered is defined on a national basis.

6.3.2 Internal loads

The assumptions on internal loads shall be determined on a national basis. The following values shall be considered on an hourly basis for the whole period considered:

- Lighting.
- Occupants.
- Equipment.

In the absence of prescribed values they shall be agreed with the customer.

6.3.3 Window opening

The effect of openable windows shall be calculated according to EN 15242.

6.3.4 Acceptable comfort conditions

The level of temperatures considered as acceptable and the tolerable frequency of exceeding are defined on a national basis. Requirements are given in EN 15251.

7 Room cooling load calculation

7.1 Basic sensible room cooling load calculation

The basic room cooling load calculation is performed under constant comfort conditions for a convective system with unlimited maximum cooling power. The used calculation method shall fulfil the requirements of class A1 defined in EN 15255.

7.2 System dependent sensible room cooling load calculation

The room cooling load calculation shall be performed by using a method which fulfils the requirements of the appropriate class according to EN 15255:2007, Tables 4 and 5.

7.3 Latent room cooling load calculation

In the most general case, the room based latent load is determined by a full moisture balance of the room, including effects of moisture transport in building components and furniture. In this case the calculation is equal to the calculation of the room humidification and dehumidification energy demand for a certain time step, described in 13.2.

A simplified approach is to neglect storage effects in building components and furniture, which leads to a pure room air moisture balance. This depends on:

- The water mass entering and leaving the room (input)
- The humidity internal gains water (input)

A part of the load may be covered by room based equipment. This can be taken into account according to Annex H.

7.4 Boundary conditions

7.4.1 Definition of room conditions (temperature, humidity, tolerances)

Assumptions on room conditions are defined on a national basis in accordance with EN 15251.

7.4.2 Climatic data

The climatic data used for the cooling load calculation shall be calculated and presented according to prEN ISO 15927-2.

7.4.3 Internal loads

General requirements on information on internal loads are given in EN 13779.

7.4.4 Ventilation rates

The air flow rates for ventilation purposes are defined according to EN 15242.

8 Room heating load calculation

8.1 Calculation procedure

The same calculation procedure as for the system dependent room cooling load calculation shall be used.

8.2 Climatic data

The climatic data used for the cooling load calculation shall be calculated and presented according to EN ISO 15927-4.

8.3 Ventilation rates

The air flow rates for ventilation purposes are defined according to EN 15242.

9 Room based equipment sizing

Room based equipment used to meet the room heating and cooling load (fan coils, chilled ceilings, split chillers etc., but also supply air flow rates and conditions) shall be sized according to common engineering knowledge and manufacturer's information. The influence of the equipment size on the system energy consumption, e.g. due to operation conditions and/or part load behaviour, shall be considered.

10 Zone load calculation

The zone cooling and heating load is found by superposition of the daily profiles of the room cooling and heating loads. It is not adequate to add up non coincident hourly peak load values.

11 System heating and cooling load calculation

No specific method can be given for the system heating and cooling load. It is highly dependent on the chosen system. It shall be performed according to common engineering rules, taking into consideration all the relevant processes. For air based systems this generally involves psychrometric calculations.

12 Central system equipment sizing

Central equipment used to meet the system heating and cooling load (air handling units, chillers etc.) shall be sized according to common engineering knowledge and manufacturer's information. The influence of the equipment size on the system energy consumption, e.g. due to operation conditions and/or part load behaviour, shall be considered.

13 Room and building energy calculation

13.1 General

The calculation of cooling and heating energy demand within buildings is described in prEN ISO 13790. The result of this calculation is an input for the system energy demand calculation described in Clause 14. Building related issues are only addressed to the extent that HVAC systems have an influence on the building energy demand.

13.2 Humidification and dehumidification energy demand

In the most general case, the room based latent energy demand in a certain time step is determined by a full moisture balance of the room, including effects of moisture transport in building components and furniture. This is a complex calculation, the mechanisms of which are described in EN 15026. In many cases, the calculation of the room latent load can be simplified. Two approaches are possible:

- The storage effect in building components and furniture is neglected. The latent load is then determined by a pure room air moisture balance. This leads to an overestimation of the room and exhaust air humidity. The humidity balance depends on:
 - The water mass entering and leaving the room (input)
 - The humidity internal gains water (input)
 - The condensation on the coil of room based equipment (output)

Energy demand due to humidification and dehumidification for local emitters may occur intentionally or as a side effect of cooling. A calculation method is given in Annex H.

- The storage effect in building components and furniture as well as the moisture sources in the room are neglected and the moisture content of the exhaust air is assumed to be equal to the one of the supply air. This leads to an underestimation of the room and exhaust air humidity and can be desired in cases with equipment, the performance of which depends on the exhaust air humidity, and for which the simplified calculation approach shall be on the safe side.

13.3 Relation to system energy calculation methods

According to prEN ISO 13790, building energy demand calculation methods are divided into detailed and simplified categories.

System behaviour calculation methods can be divided in hourly, monthly, seasonal, and annual categories. The main distinction is between hourly methods and methods using larger time steps. Table 3 shows a classification of combinations of calculation methods.

Table 3 — Classification of building vs system calculation methods

		System calculation	
		Hourly	Monthly, seasonal, annual
Building Calculation	Hourly	BhSh	BhSm
	Monthly, seasonal	BmSh	BmSm

Type BhSh

This configuration makes it possible to take into account hourly interactions between building behaviour and system behaviour. It is the case for example for VAV system where the air flow depends on the cooling demand, or for latent load which are difficult to calculate on a monthly basis.

Type BmSh

In this case the system behaviour is calculated based on hourly values before the building calculation is performed. This can be done when the system behaviour is not dependent on the building behaviour. It can be for example for systems reacting mainly to outdoor climate (for example combination of outdoor air temperature and humidity). Some assumptions can also be used e.g. relating for example indoor temperature to outdoor temperatures.

Type BmSm and BhSm

In this case the system behaviour is calculated by averaged monthly, seasonal or annual values, using in general statistical analysis based on hourly calculation for typical climates, configurations etc.. It can also be done directly if the system is simple enough to neglect the interaction with both outdoor climate and the building behaviour.

A commonly used category of system calculation method is based on the frequency distribution of hourly outdoor air temperature and/or humidities. This can be combined with either hourly or monthly/seasonal building calculations, thus belong to category BhSh or BmSh.

14 System energy calculation

14.1 General approach

14.1.1 System structure and boundaries

The general structure of the system and calculation is given in Figure 3. Heating and cooling systems have in general a parallel structure. Heating and cooling function may be combined in emitter and distribution components (ducts, fan coil units) and also in generation (split systems for heating and cooling; reversible cooling machines). In most systems distribution of heat and cold is performed by both water and air. Heat and cold are transferred from water to air using heat exchangers in the air conditioning plant or at the emitters, using for instance induction units, terminal reheat units or radiators. The structure is worked out in more detail for different systems in 14.1.2.

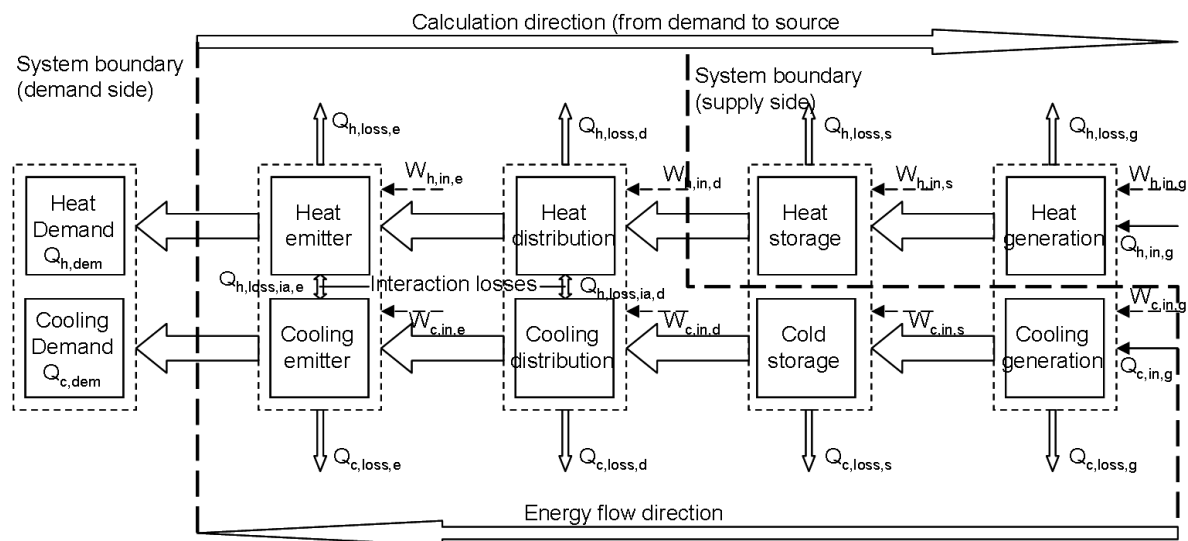


Figure 3 — General HVAC system structure and energy flows The system boundary includes contributions from EN 15241 in case of all air systems, see 14.2.4.2

System boundaries for the scope of this standard are indicated in the figure. For the demand side the system boundary is between the emitters and the demand; for cooling the system boundary is at the right side of the cooling generation. For heating the system boundary may be at different places, depending on system type. Heat generation and storage are always outside the system boundary (indicated). Also hot water distribution and emitter (radiator) components are outside the system boundary. Only the air-conditioning emitter and distribution components are within the system boundary. For practical reasons also interaction losses between all heat and cold distribution and emitter components are within the scope of the standard. In Annex C boundary layers are worked out in more detail.

14.1.2 Energy calculation structure

Each sub-system may have losses and auxiliary power use. Heat and cold generators consume fuel or power. Emitter and distribution components may also have interaction losses, due to simultaneous heating and cooling, mixing of heat and cold flows, etc.

Over a given period the delivered energy $Q_{h,in,g}$ for heating and $Q_{c,in,g}$ for cooling is given by:

$$Q_{h,in,g} = Q_{h,dem} + Q_{h,loss,e} + Q_{h,loss,ia,e} + Q_{h,loss,d} + Q_{h,loss,ia,d} + Q_{h,loss,s} + Q_{h,loss,g} \quad (1)$$

and:

$$Q_{c,g,in} = Q_{c,dem} + Q_{c,loss,e} + Q_{c,loss,ia,e} + Q_{c,loss,d} + Q_{c,loss,ia,d} + Q_{c,loss,s} + Q_{c,loss,g} \quad (2)$$

In some installations, different energyware may be used for heating or cooling generation, for example:

- Heating installation using electricity for a compressor heat pump and gas for additional boilers.
- Cooling installation using gas for a sorption cooler and electricity for a compressor cooler.

In these cases the delivered energy shall be calculated separately for the different energywares, for example $Q_{h,in,g}(E)$, $Q_{h,in,g}(G)$, $Q_{h,in,g}(O)$ for delivered energy using electricity, gas or oil.

Total auxiliary electricity consumption $W_{h,in,tot}$ for heating and $W_{c,in,tot}$ for cooling is given by:

$$W_{h,in,tot} = W_{h,in,e} + W_{h,in,d} + W_{h,in,s} + W_{h,in,g}$$

and:

$$W_{c,in,tot} = W_{c,in,e} + W_{c,in,d} + W_{c,in,s} + W_{c,in,g}$$

where:

$Q_{h,in,g}$	delivered energy (fuel consumption) for heating in Joule
$Q_{h,dem}$	building heat demand in Joule
$Q_{h,loss,e}$	emitter heat loss in Joule
$Q_{h,loss,ia,e}$	emitter heat loss, due to interaction with cooling system, in Joule
$Q_{h,loss,d}$	distribution heat loss in Joule
$Q_{h,loss,ia,d}$	distribution heat loss, due to interaction with cooling system, in Joule
$Q_{h,loss,s}$	storage heat loss in Joule
$Q_{h,loss,g}$	generation heat loss in Joule
$Q_{c,in,g}$	delivered energy (fuel consumption) for cooling in Joule
$Q_{c,dem}$	building cooling demand in Joule
$Q_{c,loss,e}$	emitter cold loss in Joule
$Q_{c,loss,ia,e}$	emitter cold loss, due to interaction with heating system, in Joule
$Q_{c,loss,d}$	distribution cold loss in Joule
$Q_{c,loss,ia,d}$	distribution cold loss, due to interaction with heating system, in Joule
$Q_{c,loss,s}$	storage cold loss in Joule
$Q_{c,loss,g}$	generation cold loss in Joule
$W_{h,in,tot}$	total auxiliary energy consumption for heating in Joule
$W_{h,in,e}$	heat emitter auxiliary energy consumption in Joule
$W_{h,in,d}$	heat distribution auxiliary energy consumption in Joule
$W_{h,in,s}$	heat storage auxiliary energy consumption in Joule
$W_{h,in,g}$	heat generation auxiliary energy consumption in Joule
$W_{c,in,tot}$	total auxiliary energy consumption for cooling in Joule
$W_{c,in,e}$	cooling emitter auxiliary energy consumption in Joule
$W_{c,in,d}$	cooling distribution auxiliary energy consumption in Joule
$W_{c,in,s}$	cold storage auxiliary energy consumption in Joule
$W_{c,in,g}$	cooling generation auxiliary energy consumption in Joule

In Figure 4 the basic energy flow scheme for a subsystem is given, including the energy flow symbols.

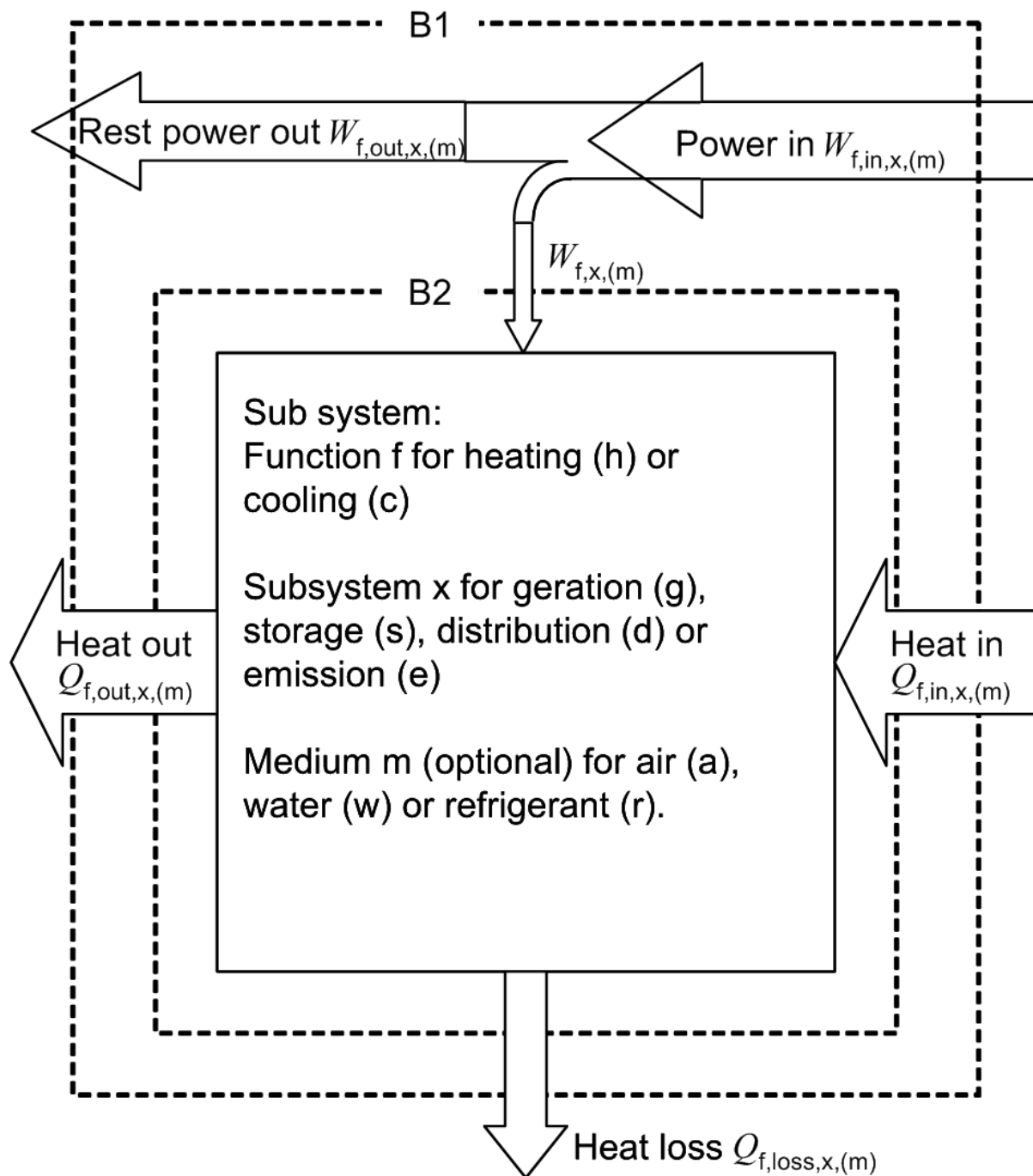


Figure 4 — Subsystem energy flows

This information can be passed to prEN 15203 and prEN 15315 for conversion to primary energy and CO₂ emission and for assessment or further calculations.

14.1.3 Calculation methods

The system energy calculation can be done simplified or detailed.

- Simplified or implicit methods operate with longer periods of time – typically monthly or daily – and use parametric descriptions of HVAC system operation, rather than represent the actions of

HVAC systems directly. As a result, they generally require fewer calculations to be carried out when applied to a building. However, the performance of many air-conditioning (and some heating) systems is non-linear or discontinuous with load or outdoor conditions. In these situations, the development of adequate parametric descriptions may be a considerable task in the development of a simplified or implicit procedure.

- Detailed or explicit methods aim to provide algorithms that directly reflect the timestep by timestep operation of each important component and each important mechanism within the system. Commonly, an energy calculation is carried out using hourly timesteps that represent a complete year¹. Procedures that represent a year by a lesser number of days, but carry out an explicit calculation for those days are here considered to be detailed or explicit methods.

This standard allows different routes to determine system energy performance:

- For both simplified and detailed methods an overview of required functionality of calculation methods is given.
Calculation methods require a kind of verification to show the required functionality is available. In Annex F the EDR-method is described that might be used for this verification.
Calculation methods satisfying this functionality required by this standard may also be used for other purposes, (for example, for system sizing). They are the content of the Clause 1 to 12.
Users of calculation methods should exercise care in ensuring that the need for appropriate modifications are considered and, if necessary, implemented for other applications.
- For the simplified method several calculation procedures for energy consumption and system losses are given, requiring different levels of knowledge about the installation parameters. Alternative methods are allowed.
- For the detailed method little calculation procedures can be given due to the fact that there is a large variety of systems and variations. This clause now only contains procedures to assess the effect of the emitter on the sensible and latent load.

Before going through these clauses first a system overview is given below to illustrate the basic structure and system boundaries for different HVAC systems.

14.1.4 HVAC System Overview

In Table 4a an overview of HVAC systems is given. In Table 5 these systems are described in more detail, both in a function table and in system schemes, including an indication of system boundaries for the components treated in this standard. Table 4b gives an overview of ventilation-only systems. The calculation of the latter is covered by EN 15241.

¹ Many air-conditioning (and heating) system components have characteristic timescales shorter than this so, strictly speaking, hourly timesteps include some generalizations that we characterize as implicit.

Table 4a — HVAC system overview

Code	System name	Does not always include heating provision and may be used with separate heating system (including room heaters which may be within terminals)	Does not include integral provision of ventilation and may be used with separate (cooled) ventilation system
A	All-air systems		
A1	Single duct system (including multi-zone)		
A2	Dual duct system		
A3	Single duct, Terminal reheat		
A4	Constant Volume (with separate heating)	✓	
A5	Variable Air Volume (with separate heating)	✓	
B	Water-based systems		
B1	Fan coil system, 2-pipe	✓	✓
B2	Fan coil system, 3-pipe		✓
B3	Fan coil system, 4-pipe		✓
B4	Induction system, 2-pipe non change over	✓	
B5	Induction system, 2-pipe change over		
B6	Induction system, 3-pipe		
B7	Induction system, 4-pipe		
B8	Two-pipe radiant cooling panels (including chilled ceilings and passive chilled beams)	✓	✓
B9	Four-pipe radiant cooling panels (including chilled ceilings and passive chilled beams)		✓
B10	Embedded cooling system (floors, walls or ceilings)		✓
B11	Active beam ceiling system	✓	✓
B12	Heat pump loop system	□	✓ □
C	Packaged Air Conditioning Units		
C1	Room units (including single duct units)	✓	✓
C2	Direct expansion single split system	✓	✓
C3	Direct expansion multi split system (including variable refrigerant flow systems)	✓	✓

Some systems usually provide heating or ventilation within an integrated system. Others (identified in the columns) normally require separate provision of these services.

In some cases (notably A5, B4 and C1) the separate heating may take the form of electric heaters within room terminals.

Where ventilation is provided separately, this is considered in this standard as an additional HVAC system and a calculation procedure shall be capable of handling both types of system (and multi-system buildings) satisfactorily.

Table 4b - Ventilation Systems Overview

Code	System name	Heat recovery possible from exhaust air	Use of regenerative energy possible ^a	Air heating possible
E	Exhaust air system (exhaust air fan assisted)			
E1	Central fan ^b without heat pump			
E2	Central fan ^b with heat pump	✓		
E3	Single room ^c fan without heat pump			
BAL	Balanced system (supply air and exhaust air fan assisted)			
BAL1	Central system ^b without heat recovery		✓	✓
BAL2	Central system ^b with heat exchanger	✓	✓	✓
BAL3	Central system ^b with heat pump	✓	✓	✓
BAL4	Central system ^b with heat exchanger and heat pump	✓	✓	✓
BAL5	Single room ^c unit without heat recovery			✓
BAL6	Single room ^c unit with heat exchanger	✓		✓
S	Supply air system (supply air fan assisted)			
S1	Central system ^b without regenerative energy			✓
S2	Central system ^b with regenerative energy		✓	✓
S3	Single room unit ^c without regenerative energy			✓
^a for example ground to air heat exchanger or solar air collector				
^b systems for dwellings or residential buildings				
^c fans or units for single rooms				

14.2 Required functionality of detailed and simplified calculation methods

14.2.1 General

In this clause the required functionality for both detailed and simplified calculation methods including the heating and cooling demand calculation are discussed. General principles and requirements are listed in 14.2.2. The following section, 14.2.3, addresses verification of procedures and 14.2.4 summarises a number of simplified procedures for handling some of the mechanisms that need to be addressed. These are described in more detail in informative annexes or in other standards.

14.2.2 General principles and reporting of procedure

- The system is modelled using models for all subsystems. In Figure 4 the basic energy flow scheme for a subsystem is given. The basic system structures are given in the “system overview”.
- Using a detailed method requires semi-dynamic models, often static component models assuming average values for all variables like temperatures and flows. In reality the variable values and controls may be more dynamic so in the model losses due to these dynamics should be taken care of.
- Table 5 shows which mechanisms are important for which HVAC system types. Energy calculation methods should address all the mechanisms that are relevant to the system types being considered. The documentation accompanying each calculation method shall report how each mechanism is represented. Different degrees of calculation complexity will be appropriate for different applications. Annex D contains recommendations for appropriate levels of treatment and refers to other relevant annexes and standards.

14.2.3 Verification of building and HVAC system calculation methods

14.2.3.1 General

This section describes a procedure for “verifying” whether or not a particular calculation procedure is appropriate to a particular application. In effect, it is a process of sequential “filtering” of options. Calculation methods can be eliminated if they fail to meet particular criteria. Surviving the process does not guarantee satisfactory performance under all possible conditions, although it does reduce the likelihood of unsatisfactory performance.

If sufficient reference data are available the Energy Diagnosis Reference (EDR) described in Annex F (informative) can be used.

14.2.3.2 Background

A vast number of calculation methods for predicting the energy performance of buildings is available. They differ in scope, in complexity of calculation and in the quantity of input data required. In practice, even methods of similar scope and complexity often yield different results even when identical input data are used.

At a national level, a single calculation method may be demanded. In this case the procedure can be used as part of the selection process for that method. Alternatively, a number of different methods may be acceptable, in which case the procedure can be used as part of the acceptance procedure.

This standard covers only calculations relating to HVAC systems. In practice, integrated methods that combine calculation of building energy demand and HVAC system energy consumption will often be used. The principles described below are equally applicable in this case.

For the Energy Performance Certification of Buildings, key requirements are:

- Credibility. The mechanisms should be technically sound and the results of the calculation shall be plausible.
- Discrimination. The rating should be better for systems and buildings that are clearly more energy-efficient.
- Repeatability. Different users should get essentially the same results for the same building.
- Transparency. It should be straightforward to check the data used and the execution of the procedure.

For design purposes – and especially for system sizing, over-heating risk and high-cost decisions – additional factors come into play. In particular the implications of uncertainty and any bias in the results will need to be considered in conjunction with a risk assessment and the selection of appropriate safety margins.

14.2.3.3 Procedure

Step 1. Define required characteristics and check that the method appears to provide them

The first step is to define the necessary and desirable characteristics of the calculation methods. This includes requirements related to:

- Output: for example, whether both heating and cooling consumptions are required; whether the output is annual energy demand or design load (and under what conditions).
- Scope: for example, what types of system can be covered.
- Applicability: for example the requirements for Energy Performance Certification noted above.

Different priorities may exist for different classes of building. The Dutch EDR process illustrates one way of structuring this aspect of the process.

Possible calculation methods should be inspected to check that they do not lack any of these essential features. This check can be carried out by inspection of user guides, theoretical background papers etc but it is preferable to also apply each method to a few simple buildings. It is difficult to assess many of the non-technical requirements without such initial application testing. At this step, it is not usually possible to test accuracy – though the cause of obviously improbable results should be investigated.

Table 5 lists important technical features that affect the energy consumption of different types of HVAC system. Some calculation procedures may not adequately handle all these features, in which case their application should be restricted to applications that exclude the possible use of systems for which the absent features are important.

Table 5a — Important technical features that affect the energy consumption of different types of HVAC system

Mechanism	System type																			
	All-air systems					Water-based systems												Packaged Air Conditioners		
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	C1	C2	C3
Within-room mechanisms																				
Room heat balance and temperature	Part of building demand calculation – not HVAC system calculation																			
Room moisture balance and moisture content	Part of building demand calculation – not HVAC system calculation																			
Definition of zones and ability to combine room demands into zonal demands	✓□	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Combination of room conditions into zonal return air state	✓□	✓	✓	✓	✓				✓	✓	✓	✓								
Contribution to room demands from separate ventilation / base cooling system						✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓
Contribution to room demands from heat gains or losses from pipes and ducts	✓□	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				
Impact of proportional band on energy supplied	✓□	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Impact of dead band on energy supplied	✓□	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Mechanism	System type																			
	All-air systems					Water-based systems												Packaged Air Conditioners		
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	C1	C2	C3
Effect of open-loop control or averaging of sensors	✓□	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Effect of absence of interlock between heating and cooling					✓		✓		✓				✓		✓	✓		✓	✓	✓
Distribution: terminal issues																				
Energy penalties from hot/cold mixing or reheat systems	□	✓	✓		✓	✓		✓	✓		✓									
Terminal auxiliary energy.					✓	✓	✓	✓								✓	✓	✓	✓	✓
Effect of sensible heat ratio of terminal (<i>and risk of condensation</i>)						✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓
Lack of local time control	✓□	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓				✓
Heat gains and losses from pipes and ducts <i>Includes AHUs and other air-handling components</i>	✓□	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			

BS EN 15243:2007
EN 15243:2007 (E)

Mechanism	System type																			
	All-air systems					Water-based systems												Packaged Air Conditioners		
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	C1	C2	C3
Duct system air leakage <i>Includes AHUs and other air-handling components</i>	☐	✓	✓	✓	✓				✓	✓	✓	✓								
Refrigerant pipework heat losses																	✓	✓	✓	✓
Fan and pump energy pickup	✓☐	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
Heat recovery provision	✓☐	✓	✓	✓	✓															
Distribution systems: operation																				
Latent demand calculation at central (zonal) plant <i>(includes dewpoint control plus reheat)</i>	✓☐	✓	✓	✓	✓															
Adiabatic spray cooling	✓☐	✓	✓	✓	✓															
Additional demands produced by hot deck:cold deck mixing systems	✓☐	✓																		
Impact of mixing of return water temperature in 3-pipe systems							✓				✓									

Mechanism	System type																			
	All-air systems					Water-based systems												Packaged Air Conditioners		
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	C1	C2	C3
Wastage due to changeover in 2-pipe systems						✓				✓			✓							
Impact of variable ventilation air recirculation <i>Typically CO2 controlled – total air flow unchanged</i>	✓ □	✓	✓	✓	✓															
Impact of air-side free cooling	✓ □	✓	✓	✓	✓															
Distribution systems: auxiliary energy																				
Auxiliary energy use by fans and pumps (other than in terminals)	✓ □	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
Cold and heat generation																				
Cold generator (chiller) part-load performance (including multiple installations and over-sizing)	✓ □	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Water-side free cooling						✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
Thermosyphon operation	✓ □	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			

BS EN 15243:2007
EN 15243:2007 (E)

Mechanism	System type																			
	All-air systems					Water-based systems												Packaged Air Conditioners		
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	C1	C2	C3
Impact on chiller performance of central heat rejection equipment <i>Includes cooling towers, dry coolers etc. Included in overall performance of packaged systems</i>	✓ ☐	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
Auxiliary energy use by central heat rejection equipment <i>Included in overall performance of packaged systems</i>	✓ ☐	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
Heat generator (boiler) part-load performance (including multiple installations and over-sizing)	✓ ☐	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Auxiliary energy use by heat generators <i>Includes gas boosters, fuel pumps etc Included in overall performance of packaged systems</i>	✓ ☐	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			
Energy use for humidification	✓ ☐	✓	✓	✓	✓															

Mechanism	System type																			
	All-air systems					Water-based systems												Packaged Air Conditioners		
	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	C1	C2	C3
Bivalent systems <i>Includes boiler + CHP; condensing boiler + non-condensing boiler; heat pump + top-up; evaporative cooling + chiller...</i>	✓ ☐	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 5b - Important technical features that effect the energy consumption of different types of ventilation systems

Mechanism	System type											
	Exhaust air system			Balanced system						Supply air system		
	E1	E2	E3	BAL1	BAL2	BAL3	BAL4	BAL5	BAL6	S1	S2	S3
Room heat balance and temperature	Part of building demand calculation											
Definition of zones and ability to combine room demands into zonal demands	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Combination of room conditions into zonal return air state		✓			✓	✓	✓		✓			
Impact of heat recovery from exhaust air and use for supply air preheating					✓	✓	✓		✓			
Impact of use regenerative energy					✓	✓	✓				✓	
Impact of air heating				✓	✓	✓	✓	✓	✓	✓	✓	✓
Impact of demand-dependent air flow	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Impact of control	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Contribution to room demands from heat gains or losses from ducts	✓	✓		✓	✓	✓	✓			✓	✓	
Contribution to room demands from heat losses from storage		✓				✓	✓					
Contribution to room demands from heat gains or losses from generation and air heating		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Auxiliary energy use by fans	✓	✓		✓	✓	✓	✓			✓	✓	
Heat gains and losses from ducts	✓	✓		✓	✓	✓	✓			✓	✓	
Duct system air leakage	✓	✓		✓	✓	✓	✓			✓	✓	
Auxiliary energy use by pumps		✓				✓	✓					
Heat losses from storage		✓				✓	✓					
Auxiliary energy use by fans and control	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Energy use by heat pump		✓				✓	✓					
Energy use by air heating				✓	✓	✓	✓	✓	✓	✓	✓	✓
Energy use by defrosting operation					✓	✓	✓		✓			
Heat losses from heat pump		✓				✓	✓					
Heat losses from heating				✓	✓	✓	✓	✓	✓	✓	✓	✓
Heat pump part-load performance		✓				✓	✓					

Step 2. Verification of calculation accuracy

There are several techniques for verifying calculation methods, none of which can completely guarantee accuracy in all conditions. The main ones are shown in Table 6. The application of verification techniques is decided on a national basis. If a verification technique is used, the results obtained shall be stated.

Table 6 — Verification techniques

Technique	Method	Strengths	Weaknesses
Theory checking	Equations are checked	* Ensures that appropriate theory has been applied.	* Requires expert knowledge and judgement about appropriate theory
Code checking	Computer code is checked line by line	* Ensures that equations have been correctly implemented * Ensures that data are correctly processed	* Only possible by experts * Only possible for open programs * Slow and time consuming * Only practicable for simple algorithms
Analytic tests	Predictions for simple situations are compared with analytic solutions	* Tests correct processing by input interface, program, and output interface * Exact answer known, so absolute accuracy can be determined	* There are very few situations for which analytic solutions can be produced * Analytic solutions not possible for building-like spaces * May be difficult to isolate testable algorithms from program * Cannot test whole program
Inter-model comparisons	Prediction are compared with those from other methods supplied with equivalent data	* Relatively easy to undertake and, in principle, can cover any building situation * Can test whole program * By carefully sequencing tests, sensitivity to design changes can be compared	* Tests for consistency between models rather than for absolute accuracy. If one model is out of line with the remainder, this may indicate poor performance – alternatively, it may indicate more accurate modelling
Empirical validation	Prediction are compared to detailed measurements in real buildings (Predictions should be made without knowledge of actual performance – that is, blind)	* In principle, the most powerful validation technique as it compares prediction with reality	* Difficult to carry out convincingly because it is very difficult and time-consuming to obtain measurements of adequate accuracy. In practice, this means that data are from unoccupied simple buildings.
Statistical validation	Predictions for many buildings are compared to energy consumption measurements	* The most directly relevant verification for existing buildings	* There are many uncontrolled variables, especially in occupied buildings, so the verification is of a combination of calculation method and data set. * The results are specific to the combination of building type of the sample, * In practice, there are large variations that are not explained by the calculation method

Depending on the application, verification may be in terms of quantitative values (typically energy consumptions) or in terms of a ranking of different situations.

At present it is not possible to provide a useful range of analytic, inter-model or empirical tests for complete HVAC systems.

14.2.4 Calculation procedures: Information in other standards

14.2.4.1 General

Calculation procedures for some of the mechanisms included in Table 5 are already addressed in other CEN Standards. Informative examples procedures for other mechanisms are contained in annexes to this standard.

14.2.4.2 All air systems

For air based systems not controlled to react on the room loads (such as constant volume flow rate systems or purely time dependent multi stage systems with outdoor reset supply temperature control) the calculation method is defined in EN 15241.

If the system is designed to be controlled according to the room/building heating/cooling demand (e.g. VAV systems or room dependent supply temperature control), the room/building load dependent variables are calculated from the room energy balance as follows.

Two possibilities of room or zone temperature control are considered:

1) air supply temperature control: A local coil situated in the supply air flow is controlled by the room sensor. In this case the air flow rate is defined at the AHU level. In the heating season, the airflow will be in general higher than the one required for hygienic purposes. A recirculation air ratio can then be associated to it in order to save energy.

2) air volume control: A local grille controls the air flow rate. In this case the supply air temperature is defined at the AHU level. The local supply air flow rate cannot be less than the one required for hygienic purposes, and will generally be higher. A procedure to calculate it is given in EN 15242:2007 (Annex C).

Once the heating demand or the cooling demand of the room is known:

For case 1: In a heating situation and as the local coil has no impact on the AHU behaviour, it is possible to consider the coil as a standard emitter directly situated in the room.

In a cooling situation and if the AHU is only devoted to one zone, the supply air set point temperature is modified according to the cooling demand. If not, the calculation method requires to be adapted.

For case 2: the local required air flow rate is calculated according to the cooling demand.

The calculation of all air side processes for the system energy requirements is then done according to EN 15241, taking into account the respective values for the room/building load dependent parameters.

In order to allocate the system energy demand to the purposes of a system, it may be adequate to make the distinction between the "basic system" which provides ventilation only, and a (fictitious) "peak system", which only covers the room conditioning purposes. In that case, the calculation is done twice: once for the "basic system" and once for the complete system as described above. The difference between the two is the "peak system" energy demand. An example of such an approach is in E.2.

14.2.4.3 Separate heating systems

If the heating demand of the building is covered by a separate system independent from the cooling and ventilation system (e.g. radiator or floor heating system), the heating system calculation is performed according to EN 15316-2-1 or EN 15377-3.

14.2.4.4 Night ventilation (mechanical or natural)

The calculation of the air flow rates for natural ventilation is performed according to EN 15242. These are considered in the building energy demand calculations according to prEN ISO 13790.

14.2.4.5 Cooling systems embedded in construction components

The energy performance of the embedded system itself is defined by EN 15377-3. The distribution losses of the system connecting to and serving the embedded system can be treated according to Annex J and Annex K.

14.3 Simplified system losses and energy demand calculation methods

14.3.1 General remarks

In simplified methods component losses or efficiencies are given for each component or for groups of components. The calculation direction of Figure 3 is followed: emission, distribution, storage and generation. The methods presented here are not prescriptive but are optional. Other methods may be used if the required functionality is taken into account.

14.3.2 Emission losses

14.3.2.1 Basis of the method

The internal temperature is affected by:

- the spatial variation due to the stratification, depending on the emission system,
- the temporal variation depending on the capacity of the control device to assure a homogeneous and constant temperature.

The internal temperature θ_i , taking into account the emission system, is calculated by the following formula:

$$\theta_i = \theta_{i0} + \delta\theta_{vs} + \delta\theta_{vt}$$

With:

- θ_{i0} initial internal temperature,
- $\delta\theta_{vs}$ spatial variation of temperature,
- $\delta\theta_{vt}$ control accuracy.

These internal temperatures are used in the calculations instead of the initial room temperature.

Remarks:

The spatial and temporal variations of the temperature can depend on the thermal load. In the absence of sufficient data, these variations are not taken into account in this version.

Example values for emission losses are given in Annex G.

14.3.3 Emission auxiliary energy demand calculation

For some room based equipment, a calculation method for the auxiliary energy demand is described in Annex L.

14.3.4 Calculation of cold water distribution

A possible method for the calculation of distribution losses is given in Annex K.

The principles for the calculation of the auxiliary energy use by pumps etc. are described in Annex J.

14.3.5 Humidification and dehumidification energy demand

The energy demand for humidification and dehumidification occurring in the air handling unit is treated in EN 15241.

A calculation method for the auxiliary energy for humidification is given in J.4.3

14.3.6 Cold generation and chiller energy performance

The calculation of cold generator and chiller energy performance is treated in Annex I. A calculation method for the auxiliary energy demand of heat rejection equipment is given in Annex M.

14.3.7 Example calculation procedures

Different methods are possible. 3 examples are given in Annex E.

14.4 Detailed system losses and energy demand calculation method

14.4.1 General remarks

No complete method can yet be given due to the number of systems and variations. All methods shall take into account the functional requirements discussed in 14.2.

14.4.2 Climatic data

The climatic data used for the energy calculation shall be calculated and presented according to EN ISO 15927-4.

Annex A (informative)

Best procedure for design process

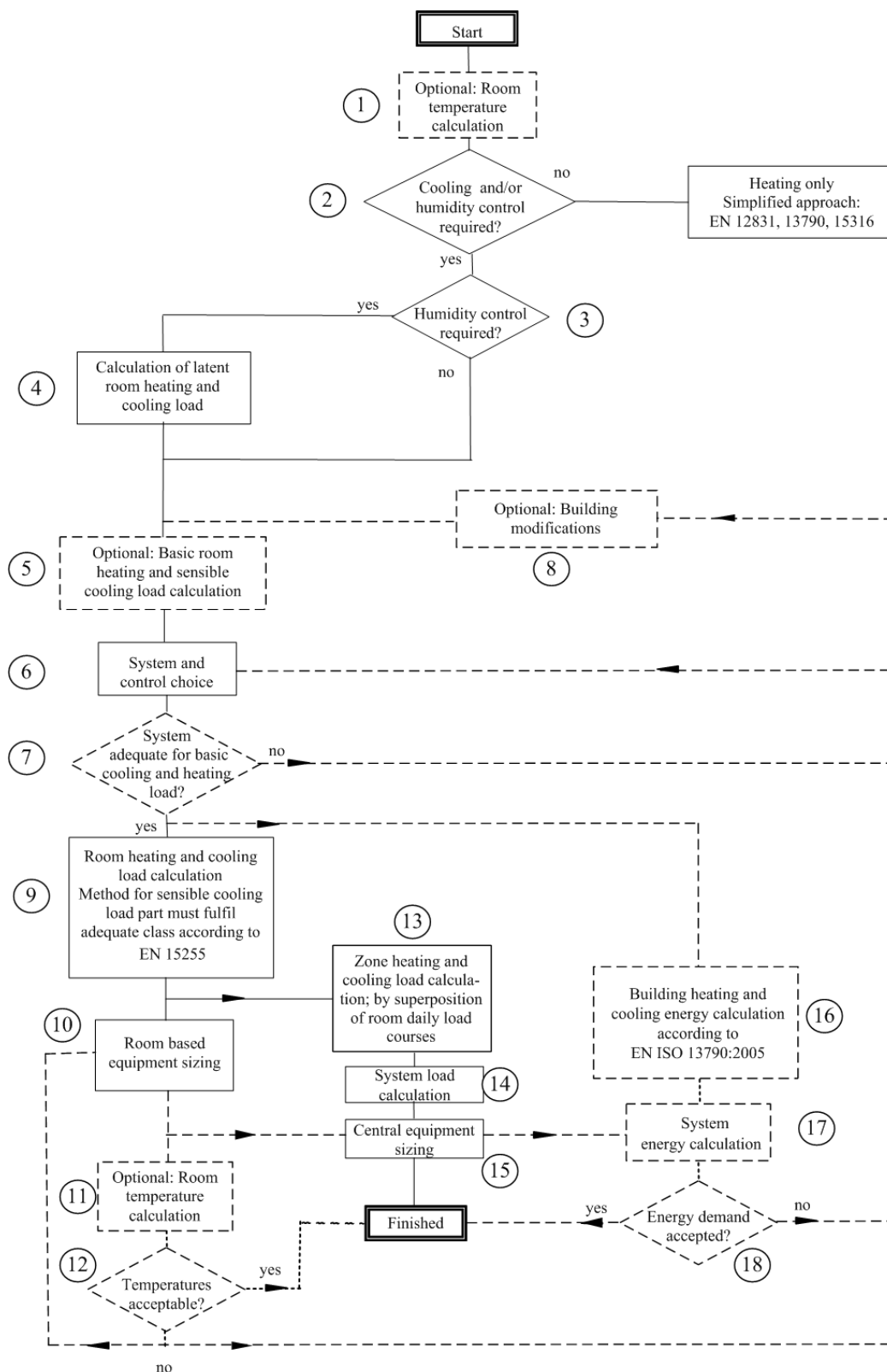


Figure A.1 — Flowchart with numbers for explanations

The recommended “best procedure” involves the following steps, which are related to the numbers given in Figure A1.

- 1) Perform room temperature calculation according to Clause 6 for selected rooms.
- 2) Decide whether either cooling or humidity control or both are required
- 3) If 1 = “yes”: Define range of humidity in rooms. Calculation of latent heating and cooling load according to 7.2
- 4) Perform basic cooling load calculation according to 7.2
- 5) Choose system type and control strategy.
- 6) Decide whether chosen system type and control strategy is adequate for basic load. If “no”: ->8, or redo choice of system type and control (-> 6).
- 7) Propose modifications on building envelope and structure to responsible people, and redo steps 4 to 6
- 8) Perform system dependent heating and cooling load calculation according to 7.3
- 9) Size room based equipment: such as air volume flow rate, chilled ceiling power, fan coil power, radiator power, embedded system power etc.
- 10) Perform room temperature calculation in case of intentionally undersized equipment.
- 11) Decide whether temperatures acceptable. If “no” redo room based equipment sizing (12a - > 10) or propose building envelope and structure modifications (12b -> 8)
- 12) Perform zone load calculations according to Clause 10.
- 13) Perform system load calculation according to Clause 11.
- 14) Size central equipment, may be influenced by room based equipment sizing.
- 15) Perform building energy demand calculation according to Clause 13
- 16) Perform system energy demand calculation according to Clause 14
- 17) Decide whether energy demand acceptable. If “no”: Propose building envelope and structure modifications (-> 8) or redo choice of system type and control (-> 6)

Annex B (informative)

Proposed procedure for choice or typical rooms for temperature calculation

- Divide the building into the lowest possible number of areas with spaces of the same or enough similar operation and construction, and with the same orientation;
- Pick from these areas those with a ratio of more than 10 % of the total building area for which air conditioning is envisaged;
- Pick from these areas all those with orientations in the sectors between E - SE and SW - W;
- If an area found is equal to a space, the modelled zone is this space;
- if an area consists of several spaces (the more frequent case), the modelled zone is the one of these spaces, which represents best the whole group of spaces.
- Areas with orientations out of the sectors defined above have to be treated in the same way,
 - if overheating occurs in the zones mentioned above,
 - if there is a group with harder operational conditions (higher internal gains).

Annex C (informative)

System overview

Index	System name	Heat/cold generation	Air distribution system						Central air conditioning		Water distribution system	Central water conditioning		Emission		Decentral heat/cold generation & distribution
		central/decentral	Number of supply ducts	Air quantity	Pressure	Velocity	Central return air	Air recirculation	Summer / cooling control	Winter / heating control	Type	Cold water / control	Warm water / control	Apparatus	Local control	
A	All-air systems															
A1	Single duct system (including multi-zone)	C	1	>Ventilation	HP/LP	H/L	yes	yes	Cooling, central control	Heating, central control	2 pipe ww	6-12?	Heating curve	Anemostat & radiator (opt)	Thermostatic (rad)	---
A2	Dual duct system	C	2	>Ventilation	HP/LP	H/L	yes	yes	Cooling (control?)	(Pre-) heating (control?)	2 pipe ww	6-12?	Heating curve	Anemostat & radiator (opt)	Thermostatic mixing chamber & thermostatic (rad)	---
A3	Single duct, Terminal reheat	C	1	>Ventilation	LP	L	yes	yes	Cooling, fixed setpoint.	Preheating, fixed setpoint	2 pipe ww	---	Heating curve	Convector	Thermostatic	---
A4	Constant Volume (with separate heating)	C	1	>Ventilation	HP/LP	H/L	yes	yes	Cooling, fixed setpoint.	Preheating, fixed setpoint	2 pipe ww	6-12?	Heating curve	VAV unit & radiator (opt)	Thermostatic (rad)	---
A5	Variable Air Volume (with separate heating)	C	1	>Ventilation	HP/LP	H/L	yes	yes	Cooling, fixed setpoint.	Preheating, fixed setpoint	2 pipe ww	6-12?	Heating curve	VAV unit & radiator (opt)	Flow & thermostatic (rad)	---
B	Water-based systems															
B1	Fan coil system, 2-pipe	C	1	Ventilation	LP	L	yes	Option	Cooling, fixed setpoint.	Preheating, fixed setpoint	2 pipe cw (S), ww (W)	6-12 ?	Heating curve	Fan coil unit	Thermostatic	---

Index	System name	Heat/cold generation	Air distribution system						Central air conditioning		Water distribution system	Central water conditioning		Emission		Decentral heat/cold generation & distribution
		central/decentral	Number of supply ducts	Air quantity	Pressure	Velocity	Central return air	Air recirculation	Summer / cooling control	Winter / heating control	Type	Cold water / control	Warm water / control	Apparatus	Local control	
B2	Fan coil system, 3-pipe	C	1	Ventilation	LP	L	yes	Option	Cooling, fixed setpoint.	Pre-heating, fixed setpoint	1 pipe ww, 1 pipe cw, common return ww/cw	6-12?	Heating curve	Fan coil unit	Thermostatic (2x)	---
B3	Fan coil system, 4-pipe	C	1	Ventilation	LP	L	yes	Option	Cooling, fixed setpoint.	Pre-heating, fixed setpoint	2 pipe ww, 2 pipe cw	6-12?	Heating curve	Fan coil unit	Thermostatic (2x)	---
B4	Induction system, 2-pipe non change over	C	1	Ventilation	HP	H	yes	Option	Pre-cooling, curve	Heating, heating curve	2 pipe cw	6-12?	Heating curve	Induction unit	Thermostatic	---
B5	Induction system, 2-pipe change over	C	1	Ventilation	HP	H	yes	Option	Cooling, fixed setpoint.	Pre-heating, fixed setpoint.	2 pipe cw (S), ww (W)	6-12?	Heating curve	Induction unit	Thermostatic	---
B6	Induction system, 3-pipe	C	1	Ventilation	HP	H	yes	Option	Cooling, fixed setpoint.	Pre-heating, fixed setpoint	1 pipe ww, 1 pipe cw, 1 common return ww/cw	6-12?	Heating curve	Induction unit	Thermostatic (2x)	---
B7	Induction system, 4-pipe	C	1	Ventilation	HP	H	yes	Option	Cooling, fixed setpoint.	Pre-heating, fixed setpoint	2 pipe ww, 2 pipe cw	6-12?	Heating curve	Induction unit	Thermostatic (2x)	---
B8	Two-pipe radiant cooling panels (including chilled ceilings) and passive chilled beam	C	1	Ventilation	HP	H	yes	Option	Cooling, fixed setpoint.	Pre-heating, fixed setpoint.	2 pipe cw (S), ww (W)	Cooling curve or fixed 6-12 for air cooling	Heating curve	Active ceiling for heating/cooling	Thermostatic	---
B9	Four-pipe radiant cooling panels (including chilled ceilings) and passive chilled beams	C	1	Ventilation	HP	H	yes	Option	Cooling, fixed setpoint.	Pre-heating, fixed setpoint.	2 pipe ww, 2 pipe cw	Cooling curve or fixed; 6-12 for air cooling?	Heating curve	Active ceiling for heating/cooling	Thermostatic (2x)	---

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Index	System name	Heat/cold generation	Air distribution system						Central air conditioning		Water distribution system	Central water conditioning		Emission		Decentral heat/cold generation & distribution
		central/decentral	Number of supply ducts	Air quantity	Pressure	Velocity	Central return air	Air recirculation	Summer / cooling control	Winter / heating control	Type	Cold water / control	Warm water / control	Apparatus	Local control	
B 10	Embedded systems	C	1	Ventilation	LP	L	yes	no	Air: precooling, fixed setpoint; Water: central control	Air: preheating, fixed setpoint; Water: central control	2 pipe cw/hw	Cooling curve or intermittent	Heating curve	Embedded pipes for heating/cooling	no	---
B 11	Active beam ceiling system	C	1	Ventilation	LP	L	yes	no	Air: precooling, fixed setpoint; Water: central control	Air: preheating, fixed setpoint; Water: central control	2 pipe cw/hw	Cooling curve or intermittent	Heating curve	Active ceiling for heating/cooling plus fan	Thermostatic	---
B12	Heat pump loop system	C / D	1	Ventilation	LP	L	yes	no	Pre-cooling, fixed setpoint.	Pre-heating, fixed setpoint.	---	6-12?	Heating curve	Anemostat & DX internal unit	Thermostatic control of DX unit	rev. heat pump with water distribution system
C	Packaged Air Conditioners															
C1	Room units & single duct ventilation	C / D	1	Ventilation	LP	L	yes	no	Pre-cooling, fixed setpoint.	Pre-heating, fixed setpoint.	---	6-12?	Heating curve	Anemostat & packaged unit	Thermostatic control of DX unit	Room unit with chiller or rev. heat pump
C2	Single split system & single duct ventilation	C / D	1	Ventilation	LP	L	yes	no	Pre-cooling, fixed setpoint.	Pre-heating, fixed setpoint.	---	6-12?	Heating curve	Anemostat & DX-internal unit	Thermostatic control of DX unit	DX external unit (rev. heat pump) & coolant pipes
C3	Multi-split system & single duct ventilation	C / D	1	Ventilation	LP	L	yes	no	Pre-cooling, fixed setpoint.	Pre-heating, fixed setpoint.	---	6-12?	Heating curve	Anemostat & DX internal unit	Thermostatic control of DX unit	DX external unit (rev. heat pump) & coolant pipes