National Building Code of Finland, Part D5, Ministry of the Environment, Department of the Built Environment

Calculation of power and energy needs for heating of buildings

Guidelines 2012

DRAFT 28 September 2010

Decree of the Ministry of the Environment on the calculation of energy consumption and heating energy needs for buildings

adopted in Helsinki on … 20

In accordance with the Decision of the Ministry of the Environment, the following guidelines on energy consumption and heating energy needs for buildings to be applied in construction are enacted by virtue of Section 13 of the Land Use and Building Act (132/1999) dated 5 February 1999.

This Decree shall enter into force on 1 January 2012. The previous guidelines may be applied to applications for planning permissions that the authorities receive before the entry into force of this Decree. Previous guidelines shall apply to the calculation of building energy certificates.

Helsinki on this xx day of xxxxxxx 20xx

Housing Minister *Jan Vapaavuori*

Senior Engineer Pekka Kalliomäki

Directive 2010/31/EC of the European Parliament and of the Council (32010L0031); OJ L 153, 18 June 2010, p. 13

D5 NATIONAL BUILDING CODE OF FINLAND
MINISTRY OF THE ENVIRONMENT, Department of the Built Environment

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Calculation of Power and Energy Needs for Heating of Buildings

GUIDELINES 2012

Contents

Explanations, *which are presented in italics across a narrow column, provide additional information and include references to other regulations.*

1

GENERAL

1.1 Scope

1.1.1
The calculation method for monthly levels presented in these guidelines can be used to calculate the energy needs for heating, the net consumption of purchased energy, the energy utilisation index and the heating power for non-cooled buildings or buildings with individual cooled spaces. The method can also be used to calculate the net consumption of purchased energy and the energy utilisation index of all buildings if the heating and cooling net energy needs were calculated using the hourly method.

1.2 Mutual recognition

1.2.1
Whenever information is given in these guidelines in the currently used SFS standards, valid standards of a corresponding level from elsewhere in the European Economic Area or Turkey may be used alongside or instead of them.

1.3 Definitions

1.3.1
For the purposes of these guidelines:

Energy need and consumption (kWh/(m^2 a)) means annual specific needs and consumptions per net heated area.

A building's heating energy need means the energy required to maintain indoor air conditions and heating domestic hot water without system losses and changes. The heating energy need is based on the building's heat losses.

Net heating energy need for ventilation means the heating energy need which arises from heating air after heat recovery to supply air temperature and possibly from heating prior to heat recovery to prevent freezing;

Net heating energy need for domestic hot water means the heating energy need which includes heating cold water to the temperature of domestic hot water consumed;

Net cooling energy need means the net energy needed for cooling spaces and supply air;

Cooling system energy consumption means the energy consumed to produce cooling energy and the electric energy consumption of auxiliary devices. The cooling system energy consumption is calculated from the net cooling energy need, taking into account losses from generating, storing, distributing, and transfer as well as conversions;

Heating system energy consumption means the energy consumed in heating spaces, ventilation, and domestic hot water. The heating system energy consumption is calculated from the net heating energy need, taking into consideration system losses and conversions. System losses are made up of losses from generating, storing, distribution, and transfer of heating energy. Energy conversions, for example, take place in heat pumps and fuel cells. In heating system energy consumption, a distinction is made between electric and heat energy.

Ventilation system energy consumption means the electric energy consumption of blowers and auxiliary devices (pumps, frequency inverters, regulating devices). The heating of supply air is included in the heating system energy consumption.

Energy utilisation index, E-index (kWh/(m^2 a)) means the computed, annual net consumption of purchased energy by a building, weighted by the coefficients of energy types and calculated in accordance with the rules and base values given in these guidelines per net heated area;

Coefficients of energy types (-) mean coefficients of an energy source or type of energy production, multiplied by different types of energy to calculate the energy utilisation index;

A building's consumption of purchased energy means energy delivered into the building from a power grid, a district heating or cooling network, and energy contained in renewable or fossil fuels. Purchased energy includes energy consumed by heating, ventilation and cooling systems, electrical appliances, and lighting, broken down by energy type, with any renewable, self-generated energy already subtracted;

Renewable, self-generated energy means renewable energy generated from renewable energy sources by devices that are part of the building, not including renewable fuels. Renewable, self-generated energy can be energy generated by solar panels and collectors, local wind energy or energy taken from a heat pump's heat source. Renewable fuels are covered as part of renewable purchased energy;

Energy transferred elsewhere means energy transferred away from the building, such as power supplied into the power grid;

Net purchased energy is purchased energy from which energy transferred elsewhere has been subtracted, and

Design temperatures mean indoor and outdoor temperatures on the basis of which heating power needs of buildings have been specified.

1.3.2

The areas of the different components of the building shell are determined according to the overall inner dimensions of the building for the purpose of calculating the building's heating power and heating energy needs.

Floors:

Floor surface areas are calculated using the inner dimensions without subtracting openings or spaces of buildings. Lead-through areas in floors, such as ducts, columns, drains, and water pipes are not subtracted from the floor surface area.

Roofs/ceilings:

Ceiling surface areas are calculated using the inner dimensions of the exterior walls, subtracting the areas of skylights. Lead-through areas in ceilings, such as ducts, flues, and ventilation pipes are not subtracted from the ceiling surface area.

Intermediate floors:

Intermediate floor areas are calculated using the inner dimensions of the exterior walls, without subtracting openings, such as for stairwells.

Exterior walls:
Exterior wall surface areas are calculated using the inner dimensions from the floor surface to the ceiling, subtracting the areas of window and door openings.

Windows and doors:
The surface areas of windows and doors are calculated using the outer dimensions of the frame (outer dimensions of casings). The surface area of a window solution that differs considerably from the facade or roof shape, a dome-shaped skylight or an open smoke exhaust shall be calculated on a case-by-case basis.

1.3.3
Calculating the surface areas of buildings:

Room area, A_{room} [room-m^2]
The room area is the surface area of the room, limited by the wall areas enclosing the room or their imagined continuation. If a room has a slanted or stepped roof, only the area where the roof is at least 1 600 mm from the floor is included in the room area calculation. In such a case, the mean room height of the area above 1 600 mm shall be at least 2 200 mm. The room area does not include the areas of flue groupings, columns, and walls, recessed fireplaces or a built-in brick closet. The calculation of a building's room area is presented in SFS 5139.

Net heated area (m^2) is the sum total of heated storey areas including the inside areas of their exterior walls (which may be calculated as gross heated area less the building surface area of the exterior walls).

1.3.4

The following variables and units will be used in the equations. Degree Celsius is a special name for unit Kelvin (K), which is used to express Celsius temperature values.

A	net heated area, (m^2).
A	surface area of the building shell (including floor), m^2
$A_{\text{solar collector}}$	total surface area of solar collectors, m^2
A_{room}	room surface area of room to be illuminated, room-m^2
A_i	surface area of a building component, m^2
A_{win}	surface area of a window opening (including frame and casing), m^2.
$A_{\text{win, daylight}}$	surface area of a window's daylight opening, m^2
A_{net}	net heated area of a building, m^2
c_p	specific heat capacity of air, kJ/kgK
c_{pv}	specific heat capacity of water, 4.2 kJ/kgK
C_{buil}	building's internal effective heat capacity, Wh/K
E	illuminance of a space, lx.
E	energy utilisation index of a building, kWh/(m^2a)
E_{aux}	annual electric energy consumption of heat pump auxiliary devices (spaces and domestic hot water), kWh.
$E_{\text{aux, DHW}}$	annual electric energy consumption of heat pump auxiliary devices (heating of domestic hot water), kWh.
$E_{\text{aux,spaces}}$	annual electric energy consumption of heat pump auxiliary devices (heating of spaces), kWh.
E_{HP}	annual electric energy consumption of a heat pump for heating spaces and domestic hot water, kWh
$E_{\text{HP, DHW}}$	annual electric energy consumption of a heat pump for domestic hot water, kWh
$E_{\text{HP, spaces}}$	annual electric energy consumption of a heat pump for heating spaces, kWh
$E_{net\text{-}purch}$	building's net consumption of purchased energy, kWh/(m^2a)
E_{purch}	building's consumption of purchased energy, kWh/(m^2a)
e_{spaces}	specific consumption of auxiliary devices, kWh/(m^2a).
f	control factors depending on the lighting control type
$f_{district\ cooling}$	factor for district cooling energy type, -
$f_{district\ heating}$	factor for district heating energy type, -
F_{frame}	frame factor, -
$F_{\text{transmittance}}$	total correction factor for radiant transmittance, -
$f_{fuel,i}$	factor for energy type fuel *i,* -
$F_{\text{side shade}}$	correction factor for shade provided by vertical structures on the side of a window, -
$F_{\text{direction}}$	conversion factor for converting the total solar radiant energy on a horizontal surface to total radiant energy on a vertical surface by compass direction, -
$f_{electric}$	factor for electric energy type, -.
F_{shade}	correction factor for shades, -
F_{curtain}	curtain factor, -.
$F_{\text{top shade}}$	correction factor for shade provided by horizontal structures above a window, -
$F_{\text{environment}}$	correction factor for horizontal shades in the environment, -
g	transmittance factor for total solar radiation through a daylight opening, -.
$G_{\text{radiant, vertical}}$	total solar radiant energy on a vertical surface per area unit, kWh/(m^2unit)
$G_{\text{radiant, horizontal}}$	total solar radiant energy on a horizontal surface per area unit, kWh/(m^2unit)
H	a building's specific heat loss (total specific loss from heating due to conduction, air leakage, make-up air, and supply air), W/K
J	factor, -
k	factor taking into account the collectors' alignment
k	building's utilisation level during operation -
L	total length of incoming and outgoing pipes in an unheated space, m
l_k	length of a linear thermal bridge caused by the joints in building components, m
L_{dhw}	length of the DHW circulation pipe, m
n	number of persons
n_{50}	air leakage value of a building with a 50 Pa pressure difference, 1/h
n_{heater}	number of heaters connected to the circulation pipe for domestic hot water, pcs.
P	plate circumference, m
P_{aux}	electric power of heat pump auxiliary devices, kW
P_e	electric power of a ventilation machine or blower, kW

P_{es}	specific electric power of a ventilation machine or blower, kW/(m^3/s)
P_{dhw}	pump input power of the DHW circulation pipe, W
$P_{pump,i}$	pump power, W
p_s	ratio between the heat output transferred to the air and the blower's electric power, -
$P_{lighting}$	total electric power of the lighting in the space to be illuminated per room surface area, W/room-m^2
q_{50}	air leakage value of the building shell, m^3/(h·m^2)
Q_{solar}	solar radiant energy entering the building through the windows, kWh.
Q_{solar}	solar radiant energy entering the building through the windows, kWh/month
$Q_{solarcol}$	domestic hot water produced using solar collectors, as calculated in chapter 6.5
$q_{solar\ collector}$	energy produced by a solar collector for domestic hot water per collector surface area (Table 6.8),
Q_{ca}	annual cooling energy used by the ventilation machine's cooler battery, kWh/a
Q_{cw}	annual cooling energy used by room units, kWh/a
Q_{person}	heat energy emitted by a person, kWh
Q_i	conductive heat loss through a building component, kWh
Q_{iv}	net heating energy need for ventilation, kWh
$Q_{iv,\ make\text{-}up\ air}$	energy required to heat make-up air, kWh
$Q_{distribution,out}$	heat loss into an unheated space during heat distribution, kWh/a
$q_{distribution\ loss,out}$	specific heat loss into an unheated space during heat distribution, kWh/m,a
$Q_{conduct}$	conduction heat loss through the building shell, kWh
$Q_{cooling}$	heat energy consumption of the cooling system (district cooling), kWh/(m^{2}a)
$Q_{district\ cooling}$	district cooling consumption, kWh/(m^{2}a)
$Q_{district\ heating}$	district heating consumption, kWh/(m^{2}a)
$Q_{make\text{-}up\ air}$	heating of make-up air in a space, kWh
$Q_{suppheat,\ DHW}$	supplemental energy consumed in the heating of domestic hot water, kWh
$Q_{suppheat,\ spaces}$	supplemental energy consumed in the heating of spaces, kWh
$Q_{dhw,\ net}$	net energy need for domestic hot water, kWh
$Q_{dhw,circ}$	DHW circulation pipe heat loss, kWh/a
$Q_{dhw,storage}$	domestic hot water storage heat loss, kWh/a
$Q_{HP,\ heating}$	annual energy consumption for heating spaces and domestic hot water that can be generated by a heat pump, kWh
$Q_{HP,\ heating,\ DHW}$	energy for domestic hot water generated by a heat pump, kWh
$Q_{HP,\ heating,\ spaces}$	energy for heating spaces generated by a heat pump, kWh
$Q_{heating}$	heat energy consumption of the heating system, kWh/(m^{2}a)
$Q_{heating,\ DHW}$	energy consumption for domestic hot water, kWh
$Q_{heating,\ spaces}$	energy consumption for heating spaces, kWh
$Q_{heating,spaces,net}$	net energy need for heating spaces, kWh/a
$Q_{heat\ load}$	a building's heat load, i.e. heat energy released into a building by means other than regulating devices, kWh
$Q_{net\ district\ cooling}$	district cooling energy consumption less the energy supplied to a district cooling network, $Q_{net\ district\ cooling} = Q_{district\ cooling} - Q_{supplied,district\ cooling}$
$Q_{net\ district\ heating}$	district heating energy consumption less the energy supplied to a district heating network, $Q_{net\ district\ heating} = Q_{district\ heating} - Q_{supplied,district\ heating\ network}$
$Q_{fuel,\ i}$	consumption of the energy contained in fuel *i,* kWh/(m^{2}a)
$Q_{int.heat}$	heat loads recovered for heating, kWh
$Q_{electric}$	heat loads from lighting and electric appliances coming into the building, kWh
Q_{space}	heating energy needed for spaces in buildings, kWh
$Q_{supply\ air}$	heating of supply air in a space, kWh
q_v	air flow of a ventilation machine or blower, m^3/s
$q_{v,\ make\text{-}up\ air}$	make-up air flow, m^3/s
$q_{v,\ dhw}$	maximum normal flow of domestic hot water, m^3/s
$q_{v,\ dhw,\ circ}$	design flow of domestic hot water in circulation pipes, m^3/s
$q_{v,\ supply}$	supply air flow, m^3/s
$q_{v,\ air\ leakage}$	air leakage flow, m^3/s
$Q_{air\ leakage}$	energy required to heat air leakage, kWh
SPF_{DHW}	heat pump SPF index for heating domestic hot water-.
SPF_{spaces}	heat pump SPF index for heating spaces, -
t_d	ventilation system mean daily running time ratio, h/24h
t_d	mean daily running time ratio of a building, -
T_{cw}	domestic cold water temperature, °C

T_{dhw}	domestic hot water temperature, °C
t_{dhw}	running time of the domestic hot water circulation pump, h/day
$T_{dhw,\ circ,\ return}$	temperature of the return water in the DHW circulation pipe, °C
T_{recov}	temperature after heat recovery device, °C
$T_{recov,des}$	design temperature after heat recovery device, °C
$t_{pump,i}$	running time of pump i, h
T_{ind}	indoor air temperature, °C
T_{ib}	inblown air temperature, °C
$\hat{T}_u$	difference between annual maximum and minimum temperatures divided by two. K
T_{outd}	outdoor air temperature, °C
$T_{outd,\ des}$	design outdoor air temperature, °C
t_v	mean weekly operating time ratio of a building, -
U_i	thermal transmittance factor of a building component, W/(m^{2}K)
V	air volume of a building, m^3
$W_{ventilation}$	electric energy consumption of the ventilation system, kWh/(m^{2}a)
$W_{cooling}$	electric energy consumption of the cooling system, kWh/(m^{2}a)
$W_{appliances}$	electric energy consumption of household or consumer appliances, kWh/(m^{2}a)
$\mathrm{W}_{\mathrm{appliances}}$	electric energy consumption of appliances, kWh
V_{dhw}	domestic hot water consumption, m^3
$W_{dhw,\ circ}$	specific power of heat loss in a DHW circulation pipe, W/m
$W_{dhw,\ heating}$	specific power of heaters connected to the circulation pipe for domestic hot water, W/pc.
$V_{dhw,\ spec}$	specific consumption of domestic hot water, m^3/m^2 per year
$V_{dhw,\ spec,person}$	specific consumption of domestic hot water, dm^3 per person per year
$W_{heating}$	electric energy consumption of the heating system, kWh/(m^{2}a)
$W_{net\ grid\ electric}$	Grid electric energy consumed less the energy transferred to the grid, $W_{net\ grid\ electric} = W_{grid\ electric} - W_{transf}$
$W_{e\text{-}lighting}$	electric energy consumption of lighting, kWh
W_{grid}	power grid energy consumption, kWh/(m^{2}a)
x	factor, -
α_1	relative share of annual cooling energy generated by process 1
α_2	relative share of annual cooling energy generated by process 2
β_{ac}	system's annual electric energy consumption factor of auxiliary devices
ε_E	annual energy efficiency ratio (EER) of the cooling energy production process
ε_{E1}	EER of production process 1,
ε_{E2}	EER of production process 2.
Φ_{person}	mean heat output of one person, W/person
$\Phi_{room\ heating}$	room heating power need, W
$\eta_{room\ heating}$	efficiency of a room heating system under design conditions
ρ_i	air density, 1.2 kg/m^3
Φ_{iv}	ventilation battery power, W
$\Phi_{conduct}$	conduction heat loss through the building shell, W
$\Phi_{make\text{-}up\ air}$	heating energy required to heat make-up air, W
η_{dhw}	efficiency of a domestic hot water heating system under design conditions, -.
Φ_{dhw}	power required to heat domestic hot water, W
$\Phi_{heating}$	building's heating energy need, W
ε_Q	annual EER of the cooling energy production process.
β_{sca}	factor taking into account the air-side losses (thermal, condensation) of a system
β_{scw}	factor taking into account the water-side losses (thermal) of a system.
Δt	pump running time during a counting cycle, h.
Φ_{space}	heating energy required to heat spaces, W
$\Phi_{supply\ air}$	energy required for heating supply air in a space, W
$\eta_{supply\ air}$	efficiency of a ventilation supply air heating system under design conditions, -.
$\Phi_{supply\ air\ battery}$	heating power need for a ventilation supply air after-heating battery, W
$\Phi_{air\ leakage}$	air leakage heat loss, W
Δt	time period length, h
Δt	time period length, days
β	Luminaire Maintenance Factor,-
γ	heat load to heat loss ratio, -
Δt_{stay}	time of stay, h
η	coefficient of utilisation,-
η_{dhw}	efficiency of domestic hot water transfer, -

$\eta_{heating,spaces}$	heating system’s efficiency in heating spaces,
$\eta_{t, design}$	supply air temperature ratio in heat recovery under design conditions
$\eta_{production}$	efficiency of heating energy production in heating spaces, ventilation, and domestic hot water, -
η_{Φ}	lamp efficacy, lm/W
ρ	air density, 3 kg/m^3
τ	building’s time constant, h
χ_j	additional conductance caused by joints between building components, W/K
Ψ_k	additional thermal bridge conductance caused by joints between building components, W/K
$\Phi_{air\ leakage}$	power required for heating air leakage, W
Φ	conductive heat loss of a building component, W
Φ_{dhw}	power required for heating domestic hot water, kW
$\Phi_{dhw,\ circloss}$	power required by the DHW circulation pipe, kW
$\Phi_{dhw,\ circloss,\ spec}$	specific power required by DHW circulation pipes, kW/m^2
η_{heat}	degree of heat loads recovered by month, -

2

DESCRIPTION OF CALCULATION METHOD

2.1 Calculation principle and limitations of the method

2.1.1
Energy use calculation methods are divided mainly into monthly levels, energy utilisation index methods, simplified hourly levels, and fully dynamic calculation methods. These guidelines present the methods for determining monthly levels, which is suited for calculating the energy efficiency of non-cooled buildings or buildings with only a few cooled spaces.

The method presented in these guidelines is an energy balance method where the energy consumption is calculated on a monthly basis. In the energy balance method, the amount of energy coming into the building equals the outgoing energy in the same month. The annual consumption is the sum of the monthly consumption amounts.

There are three types of source data to be used in the calculation:

- building-specific source data, which can usually be obtained from the building plans;
- operating data for the building and
- the guideline values given in these guidelines, which can be used if more specific data about building components and house technology systems is not available.

Explanation
The method presented in this guideline is a simplified calculation method that takes into consideration the most important factors and building properties affecting energy consumption in Finnish conditions. The method is based mainly on the calculation method presented in Standard SFS-EN 13790. Factors affecting the accuracy of calculation methods are covered in Annex H of Standard SFS-EN 13790.

2.1.2
The calculation takes into account the heating and cooling system heat losses which occur during production, storage, distribution, and transfer; these may include heating pipe and battery losses as well as boiler efficiency. In these guidelines, all losses are treated without a recovery share, meaning that all system losses will be wasted and will not enter the building as heat loads.

The calculation of net cooling energy needs and room temperatures during the summer is not included in the method described in this guideline. They will be calculated with a suitable hourly calculation tool.

2.1.3
In this calculation method, a building is usually treated as one calculation zone. If needed, the building may be divided into calculation zones to correspond to purpose of use and usage times.

2.2 Calculation procedure

2.2.1
In accordance with the calculation method for monthly levels described in this guideline, the net energy consumption of a building is calculated in the phase shown in Figure 2.1.

The energy consumption is calculated by phases as follows:

1. Net heating energy need for space heating and ventilation (chapter 3)
2. Net energy need for heating domestic hot water (chapter 3)
3. Net heating energy need for space cooling and ventilation (chapter 3)
4. Energy consumption of appliances and lighting (chapter 4)
5. Heating system energy consumption (chapter 6)
6. Ventilation system energy consumption (chapter 7)
7. Cooling system energy consumption (chapter 8)
8. Generation of renewable, self-produced energy
9. Building's consumption of purchased energy (chapter 2)
10. Energy supplied elsewhere (chapter 2)
11. Building's net consumption of purchased energy (chapter 2)
12. A building's net consumption of purchased energy weighted by factors for energy type, i.e. E-index (chapter 2)

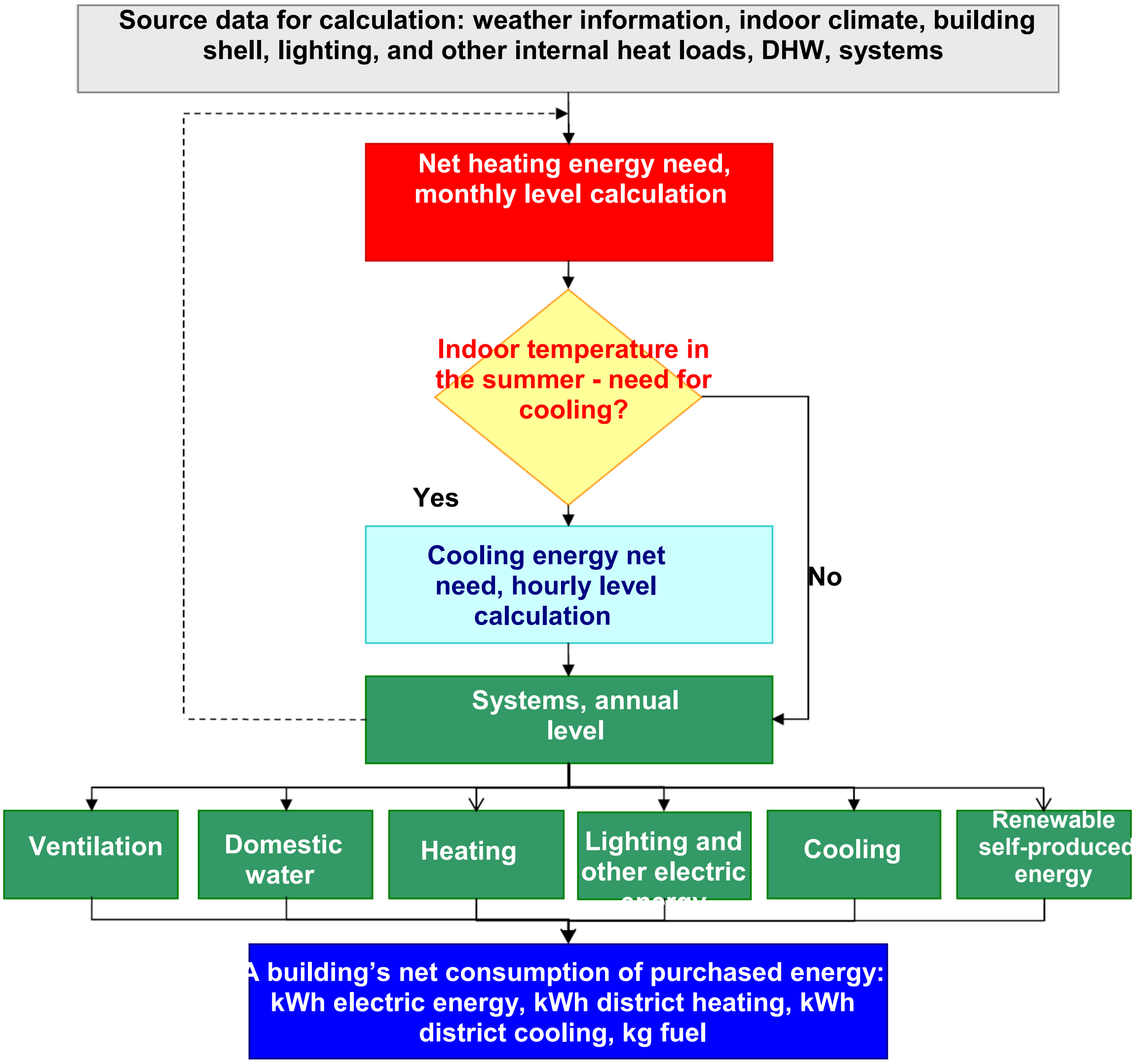


Figure 2.1. Phases for calculating the energy consumption of a building.

2.2.2

The energy consumption is usually calculated on the basis of weather data for the geographic area of the building given in Annex 1.

Explanation

When calculating the energy consumption, weather data that will better represent the average weather *conditions of a location may be used instead of the data in Annex 1.*

2.2.3

The balance limits to be used in the calculation methods for energy consumption are shown in Figure 2.2. The energy need of a building is composed of the heating needs of spaces and ventilation, domestic hot water needs, cooling needs of spaces and ventilation, as well as the electric energy needs of lighting and appliances. The net heating energy need is determined from the heating energy need and the solar radiant energy entering the building, energy recovered from exhaust air and internal heat loads. A heating system brings the energy corresponding to the net heating energy need into spaces, supply air, and domestic hot water. A cooling system brings the energy corresponding to the net cooling energy need into spaces and supply air.

The heating system energy consumption is calculated from the net heating energy need, taking into consideration system losses and conversions. System losses are made up of losses from generating, storing, distribution, and transfer of heating energy. Energy conversions, for example, take place in heat pumps and fuel cells. In heating system energy consumption, a distinction is made between electric and heat energy.

Ventilation system energy consumption includes the electric energy consumption of blowers and auxiliary apparatus (pumps, frequency inverters, regulating devices). The heating of supply air is included in the heating system energy consumption.

The cooling system energy consumption is calculated from the net cooling energy need, taking into account losses from generating, storing, distributing, and transfer as well as conversions.

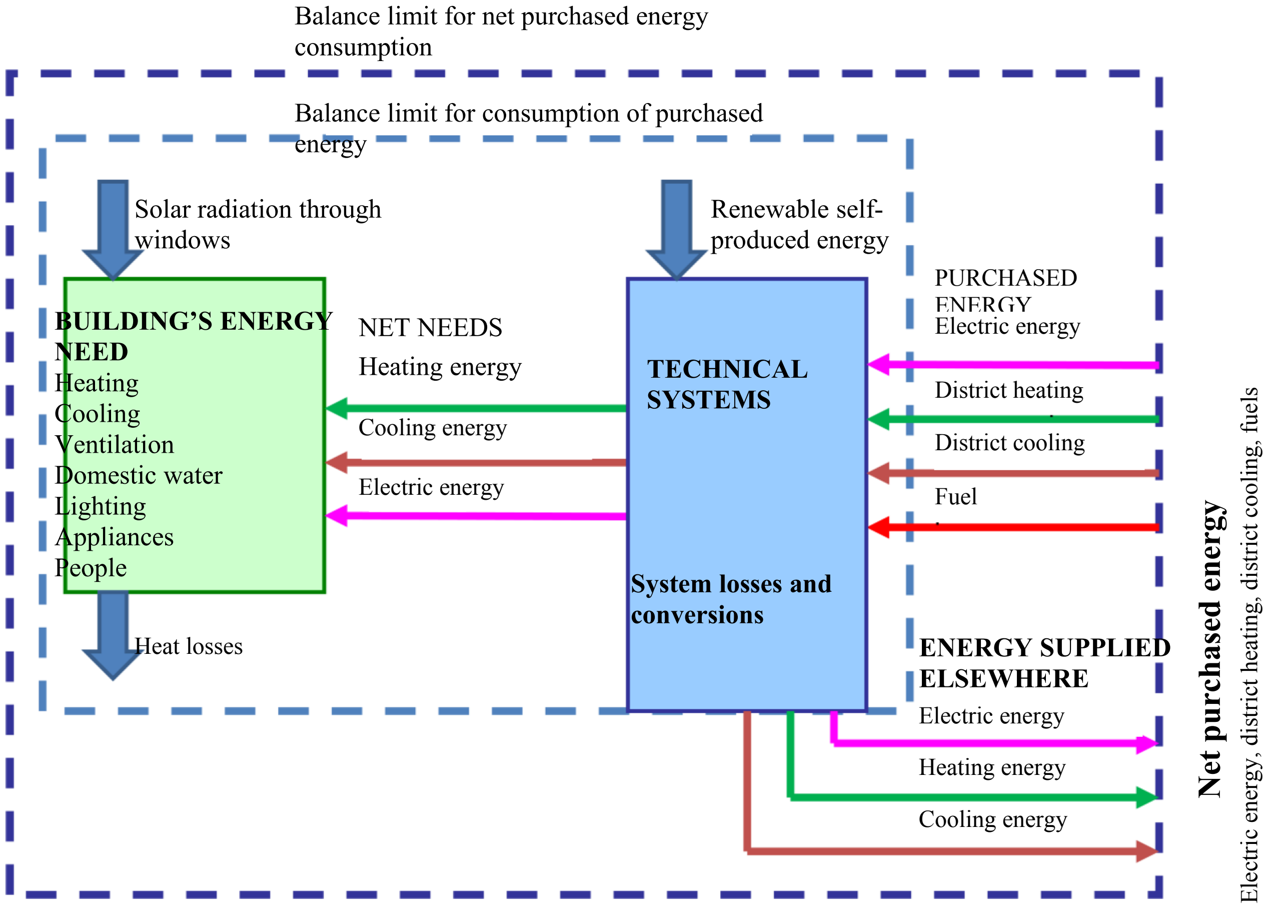


Figure 2.2. A building's balance limit for consumption of purchased energy and how it is derived from net energy needs, the energy consumption of the building's technology systems, renewable self-produced

energy, and other locally produced and energy supplied elsewhere. Renewable self-generated energy can be solar heat, wind or solar electric energy, or energy from a heat pump's heat source.

A building's purchased energy includes energy consumed by heating, ventilation and cooling systems, electrical appliances, and lighting, broken down by energy type, with any renewable, locally generated energy already subtracted.

> ***Explanation***
> *Locally generated energy means energy produced by equipment that is part of the building, such as energy generated from fuels or by heat pumps as well as renewable self-generated energy. Renewable self-generated energy means energy generated by local, renewable sources of energy, such as solar heat, wind or solar electricity. The renewable sources of energy used for this purpose, such as solar radiation or kinetic wind energy are not included in the balance limit of purchased energy.*

The consumption of purchased energy of buildings is calculated using Equation (2.1).

$$E_{purchased} = Q_{heating} + W_{heating} + W_{ventilation} + Q_{cooling} + W_{cooling} + W_{appliances} + W_{lighting} \qquad (2.1)$$

where

E_{purch}	building's consumption of purchased energy, kWh/(m^{2}a)
$O_{heating}$	heat energy consumption of the heating system, kWh/(m^{2}a)
$W_{heating}$	electric energy consumption of the heating system, kWh/(m^{2}a)
$W_{ventilation}$	electric energy consumption of the ventilation system, kWh/(m^{2}a)
$O_{cooling}$	heat energy consumption of the cooling system (district cooling), kWh/(m^{2}a)
$W_{cooling}$	electric energy consumption of the cooling system, kWh/(m^{2}a)
$W_{appliances}$	electric energy consumption of household or consumer appliances, kWh/(m^{2}a)
$W_{lighting}$	electric energy consumption of the lighting system, kWh/(m^{2}a).

The calculation of a building's consumption of purchased energy takes into account the renewable self-generated energy, which has been recovered by the technology systems of the building. Energy supplied elsewhere is also considered in calculating the building's net consumption of purchased energy.

Depending on the types of energy to be used, the building's consumption of purchased energy can be calculated using Equation (2.2).

$$E_{purch} = Q_{district\ heating} + Q_{district\ cooling} + \sum_{i} Q_{fuel} + W_{grid} \qquad (2.2)$$

where

E_{purch}	building's consumption of purchased energy, kWh/(m^{2}a)
$Q_{district\ heating}$	district heating consumption, kWh/(m^{2}a)
$Q_{district\ cooling}$	district cooling consumption, kWh/(m^{2}a)
$O_{fuel,i}$	consumption the energy contained in fuel *i*, kWh/(m^{2}a)
W_{grid}	electric energy consumption, kWh/(m^{2}a).

A building's net consumption of purchased energy is the difference between the purchased energy consumed and energy supplied elsewhere. The net purchased energy consumption of buildings is calculated using Equation (2.3). If no energy is supplied away from the building, the net purchased energy consumption equals the purchased energy consumption.

$$E_{net\text{-}purch} = Q_{net\ district\ heating} + Q_{net\ district\ cooling} + \sum_i Q_{fuel,i} + W_{net\ grid}\,\text{ö} \qquad (2.3)$$

where

$E_{net\text{-}purch}$	building's net consumption of purchased energy, kWh/(m^{2}a)
$Q_{net\ district\ cooling}$	district cooling energy consumption less the energy transferred to a district cooling network, $Q_{net\ district\ heating} = Q_{district\ heating} - Q_{transf,district\ heating}$
$Q_{net\ district\ cooling}$	district cooling energy consumption less the energy transferred to a district cooling network, $Q_{net\ district\ cooling} = Q_{district\ cooling} - Q_{transf,district\ cooling}$
$W_{net\ grid}$	electric energy from the power grid consumed less the electric energy supplied to the grid, $W_{net\ grid} = W_{grid} - W_{supplied}$

Explanation

The possibility of supplying energy to a district heating, district cooling or power grid should be checked with the respective energy undertaking in charge of the network.

The energy utilisation index or E-index is calculated from the building's net purchased energy consumption and the factors for energy types, using Equation (2.4).

$$E = f_{district\ heating}\,\text{ö}\,Q_{net\ district\ heating} + f_{district\ cooling} Q_{net\ district\ cooling} + \sum_i f_{fuel,i} Q_{fuel,i} + f_{electric} W_{net\ grid} \qquad (2.4)$$

where

E	energy utilisation index of the building, kWh/(m^{2}a)
$f_{district\ heating}$	factor for district heating energy type, -
$f_{district\ cooling}$	factor for district cooling energy type, -
$f_{fuel,i}$	factor for energy type i, -
$f_{electric}$	factor for electric energy type, -.

3

NET HEATING ENERGY NEED OF A BUILDING

Calculations in this chapter
Net energy need for space heating
Net ventilation heat energy need
Net domestic hot water heating energy need
Conduction heat losses of the building shell
Energy required for heating air leakages

Minimum source data required for calculations
Surface areas of building components
Thermal transmittance factors of building components
Ventilation air flows
Operating times of the ventilation system
Ventilation system heat recovery temperature ratios

3.1 Net energy need for space heating

The net energy need for space heating Q $_{\text{heating, spaces, net}}$ is calculated using Equation (3.1).

$$Q_{\text{heating, spaces, net}} = Q_{space} - Q_{\text{int.heat}} \tag{3.1}$$

where:

$Q_{\text{heating, spaces, net}}$	net heating energy need for heating spaces in a building, kWh
Q_{space}	heating energy need for heating spaces in buildings, kWh
$Q_{\text{int.heat}}$	heat loads recovered for heating, kWh

The heating energy need for heating spaces Q_{space} is calculated using Equation (3.2).

$$Q_{area} = Q_{conduct} + Q_{air\ leakage} + Q_{supply\ air} + Q_{make\text{-}up\ air} \tag{3.2}$$

where:

Q_{conduct}	conduction heat loss through the building shell, kWh
$Q_{\text{air leakage}}$	air leakage heat loss, kWh
$Q_{\text{supply air}}$	heating of supply air in a space, kWh
$Q_{\text{make-up air}}$	heating of make-up air in a space, kWh

3.2 Conduction heat losses of the building shell

3.2.1

Conduction heat loss through the building shell Q_{conduct} is calculated using Equation (3.3).

$$Q_{conduct} = Q_{exterior\ wall} + Q_{ceiling} + Q_{floor} + Q_{window} + Q_{door} + Q_{thermal\ bridges} \tag{3.3}$$

The heat losses of building components are calculated for each component using Equation (3.4).

$$Q = \sum U_i A_i\ (T_{ind} - T_{outd})\ \Delta t/1000 \tag{3.4}$$

where

Q	conduction heat loss through a building component, kWh
U_i	thermal transmittance factor for a building component, W/(m^{2}K)
A_i	floor area of a building component, m^2
T_{ind}	indoor air temperature, °C
T_{outd}	outdoor air temperature, °C
Δt	time period length, h
1000	factor for converting the denomination to kilowatt hours.

The thermal bridge heat losses caused by joints between building components are calculated using Equation (3.5).

$$Q_{thermal\ bridges} = \left(\sum_k l_k \Psi_k + \sum_j \chi_j\right) (T_{ind} - T_{outd})\ \Delta t/1000 \qquad (3.5)$$

l_k	length of a linear thermal bridge caused by the joints in building components, m
Ψ_k	additional thermal bridge conductance caused by joints between building components, W/(m K)
χ_j	additional conductance caused by joints between building components, W/K

Explanation

The thermal bridges in Equation 3.5 can be calculated in accordance with part C4 of the National Code of Building Regulations of Finland and the Ministry of Environment guide.

Annex 1 shows the outdoor temperatures to be used in heat loss calculation by month and region.

Explanation

Calculating the surface areas of building components is presented in chapter 1.3. The calculation of thermal transmittance is presented in the National Building Code of Finland, Part C4.

3.2.2

If the floor butts directly against the outdoor air, its conduction heat loss is calculated as the temperature difference T_{ind} - T_{outd} according to Equation (3.4). If the floor is above a vented crawl space, the energy conducted through it into the outdoor air shall be calculated in accordance with National Code of Building Regulations of Finland, Part C4, taking into consideration the thermal resistance of the ground and the crawl space.

3.2.3

The monthly heat energy conduction through a floor against the ground ($Q_{ground\ month}$) is calculated using Equation (3.6).

$$Q_{ground,month} = [U_{ap}A_{ap}(T_{ind} - T_{outd}) + J\ P\ \hat{T}_u]\Delta t/1000 \qquad (3.6)$$

where:

$\hat{T}_u$	is the difference between annual maximum and minimum temperatures divided by two	
	in weather zone I	12.9 °C
	in weather zone II	13.0 °C
	in weather zone III	13.6 °C
	in weather zone IV	14.8 °C
P	is the plate circumference, i.e. the sum of the plate sides facing the outdoor air, meaning the length of the plinth insulation, m	

J factor grouping heating energy into the different months; it also depends on the soil type, (W/K). The monthly factor J can be found in Table 3.1.

Table 3.1 *Factor J (W/K).*

Month	Clay, drained sand and gravel, ground frost penetration depth 2.2 m	Silt, soil, fine sand, non-drained sand, and gravel, ground frost penetration depth 3.2 m	Rock, ground frost penetration depth 4.2 m
January	0.078	0.11	0.16
February	0.13	0.20	0.27
March	0.16	0.23	0.31
April	0.13	0.20	0.27
May	0.078	0.11	0.16
June	0	0	0
July	-0.078	-0.11	-0.16
August	-0.13	-0.20	-0.27
September	-0.16	-0.23	-0.31
October	-0.13	-0.20	-0.27
November	-0.078	-0.11	-0.16
December	0	0	0

3.3 Air leakage heat losses

3.3.1

Energy $Q_{\text{air leakage}}$ for heating air flowing in and out of buildings due to leaks is calculated using Equation (3.7).

$$Q_{air\ leakage} = \rho_i c_{pi} q_{v,\ \text{air leakage}} (T_{\text{ind}} - T_{outd}) \Delta t / 1000 \qquad (3.7)$$

where:

$Q_{\text{air leakage}}$	energy required to heat air leakage, kWh
ρ_i	air density, 1.2 kg/m^3
c_{pi}	specific heat capacity of air, 1 000 Ws/(kgK)
$q_{v,\ \text{air leakage}}$	air leakage flow, m^3/s
T_{ind}	indoor air temperature, °C
T_{outd}	outdoor air temperature, °C
Δt	time period length, h
1000	factor for converting the denomination to kilowatt hours.

3.3.2

The air leakage flow $q_{v,\ \text{air leakage}}$ is calculated using Equation (3.8).

$$q_{v,\text{air leakage}} = \frac{q_{50}}{3600 \cdot x} A \qquad (3\ 8)$$

where:

q_{50}	air leakage number of the building shell, m^3/(h m^2)
A	surface area of the building shell (including floor), m^2
x	factor, which is: 35 for one-storey buildings; 24 for two-storey buildings; 20 for three- and four-storey buildings, and 15 for five-storey buildings or higher
3600	factor which converts air flow from unit m^3/h to unit m^3/s.

The building shell air leakage number q_{50} can be assumed as 4 m^3/(h m^2), for the purpose of calculating the heating energy need if the air impermeability is not known. Table 3.2 gives typical air leakage numbers for different air volumes of different buildings.

3.3.3
The building shell air leakage number q_{50} can be calculated using air leakage number n_{50} in Equation (3.9).

$$q_{50} = \frac{n_{50}}{\mathrm{A}} V \qquad (3.9)$$

where:

n_{50}	is the air leakage number of a building with a 50 Pa pressure difference, 1/h
V	air volume of a building, m^3

Table 3.2. *Typical air leakage numbers (n_{50}) for different buildings depending on the construction and execution methods.*

Target air impermeability	Details	Typical n_{50} numbers, 1/h
Good air impermeability	Special care was taken as regards the air impermeability of edges and joints, as well as in carrying out and monitoring the planning and construction work (separate inspection)	Small house **1 ... 3** Apartment building and office building **0.5 ... 1.5**
Medium air impermeability	Standard care was taken as regards air impermeability, as well as in carrying out and monitoring the planning and construction work	Small house **3 ... 5** Apartment building and office building **1.5 ... 3.0**
Weak air impermeability	Hardly any care was taken as regards air impermeability or carrying out and monitoring the planning and construction work	Small house **5 ... 10** Apartment building and office building **3 ... 7**

Explanation

An air leakage flow results from the pressure differences caused by wind and temperature differences. The leakage is affected by the air impermeability of the building shell, the location and height of the building, the ventilation system and its mode of use.

The air leakage flow does not include the air flowing in as the result of the vacuum caused by the ventilation system (make-up air), which is removed through the ventilation system. The effect of make-up air is taken into account in the energy needed for heating ventilation (point 3.4).

In below-ground basement spaces and spaces in the middle of the building, air leakages usually need not be considered.

The volume of air leakage flow in existing buildings can also be estimated using measured data.

3.4 Net heating energy need for ventilation

3.4.1

Using the method presented in this chapter, the net heating energy need for ventilation may only be calculated for cases where the ventilation system is a constant air volume controlled system and the air treatment process is heating only. If the air treatment process includes cooling and humidifying, or if the ventilation is air volume controlled, the energy need must be calculated by other means.

The net heating energy need for ventilation, meaning the heating of supply air in the ventilation machine, is calculated for each ventilation machine using Equation (3.10).

$$Q_{iv} = \rho_i c_{pi}\, t_d\, t_V q_{v,supply}\, (T_{sp} - T_{recov})\, \Delta t/1000 \tag{3.10}$$

where

Q_{iv}	net heating energy need for ventilation, kWh
ρ_i	air density, 1.2 kg/m^3
c_{pi}	specific heat capacity of air, 1000 Ws/(kgK)
t_d	ventilation system's mean daily running time ratio, h/24h
t_v	ventilation system's weekly running time ratio, days/7 days (day=24 h)
$q_{v,\ supply}$	supply air flow, m3/s
T_{ib}	inblown air temperature, °C
T_{recov}	temperature after heat recovery device, °C
Δt	time period length, h
1000	factor for converting the denomination to kilowatt hours.

The supply air temperature after heat recovery is calculated using Equation (3.11)

$$T_{recov} = T_{outd} + \eta_{t,a}\, (T_{ind} - T_{outd}) \tag{3.11}$$

where:

T_{outd}	outdoor temperature, °C
T_{ind}	indoor temperature, °C

The annual efficiency ratio reported for the supply air side may be used for all months. If ventilation is realised with a heat recovery system that does not move heat recovered from exhaust air into the supply air, or if there is no heat recovery, the value for the temperature ratio to be used in Equation (3.10) is 0.

The temperature for inblown supply air can be assumed to be 18 °C if more accurate data is not available. Heat recovery is usually adjusted so that the temperature of the inblown air will not exceed the desired set value. Limiting the waste air temperature (power regulation) will prevent the heat recovery system from freezing. The following guideline values may be used as the minimum temperature to prevent the freezing of waste air, if the performance values of the device are not known:

- In residential buildings, +5 °C for plate heat exchangers and 0 °C for rotary heat exchangers or plate heat exchangers that transfer moisture;
- In other buildings, 0 °C for plate heat exchangers and -5 °C for rotary heat exchangers.

Explanation

Guidelines for determining the annual efficiency in different situations are set out in Ministry of the Environment Bulletin 122.

If the temperature ratios of the product are not available, the typical values given in Table 3.3 may be used for the temperature ratios of different heat exchangers.

Table 3.3 *Values for heat exchangers for ventilation heat recovery temperature ratio η_t, to be used for calculating the annual efficiency of heat recovery on the supply air side.*

Heat exchanger type	Temperature ratio η_t
Heat exchanger with fluid circulation	0.45
Cross-flow heat exchanger	0.55
Counter-flow heat exchanger	0.70
Regenerative heat exchanger	0.75

In large ventilation machines, where the temperature ratios of the heat exchanger are measured in accordance with standard EN 308:1997, the heat of the blower moving the supply air is taken into consideration using Equation (7.3), with temperature difference (T_{ib}-T_{recov}) as the reducing factor.

If the temperature ratio of the supply air has been measured in accordance with standard EN 13141-7, the effect of the blowers heating the supply air is included in the temperature ratio and should not be calculated using the aforementioned equation.

3.4.2
The values presented in Part D3 of the National Code of Building Regulations of Finland may be used for ventilation air flow and running times if more accurate data is not available. In mechanical ventilation systems, the running time ratio td should be chosen according to their actual running times. Weekends and other down-times are considered using factor tv.

Explanation
Regulations on indoor climate and ventilation of buildings are included in Part D2 of the National Code of Building Regulations of Finland.

3.5 Supply and make-up air heating energy needs

3.5.1
The heating of supply air in a space is calculated for each ventilation machine using Equation (3.12).

$$Q_{iv,supply\ air} = \rho_i c_{pi} t_d\ t_V q_{v,supply} (T_{ind} - T_{sp})\ \Delta t/1000 \qquad (3.12)$$

3.5.2
The heating of make-up air in a space is calculated using Equation (3.13).

$$Q_{iv,make\text{-}up\ air} = \rho_i c_{pi} q_{v,make\text{-}up\ air} (T_{ind} - T_{outd})\ \Delta t/1000 \qquad (3.13)$$

where:

$Q_{iv,\ make\text{-}up\ air}$	energy required to heat make-up air, kWh
ρ_i	air density, 1.2 kg/m^3
c_{pi}	specific heat capacity of air, 1 000 Ws/(kgK)
$q_{v,make\text{-}up\ air}$	make-up air flow, m3/s
T_{outd}	outdoor temperature, °C
T_{ind}	indoor temperature, °C
Δt	time period length, h
1000	factor for converting the denomination to kilowatt hours.

The make-up air flow is calculated using Equation (3.14).

$$q_{v,\ make\text{-}up\ air} = \sum t_d\ t_V\ \mathrm{q}_{v,exhaust} - \sum t_d\ t_V\ \mathrm{q}_{v,supply} \tag{3.14}$$

3.6 Energy recovery and ventilation system annual efficiency rate

3.6.1

The energy recovered from ventilation can be calculated using Equation (3.15).

$$Q_{lto} = \sum \rho_i \mathrm{c}_{pi} t_d\ t_V \mathrm{q}_{v,supply}\ (T_{lto} - T_{outd})\ \Delta t/1000 \tag{3.15}$$

The total annual efficiency of ventilation can be calculated using Equation (3.16).

$$\eta_a = \frac{Q_{lto}}{Q_{lto} + Q_{iv,kone} + Q_{iv,tuloilma} + Q_{iv,korvausilma}} \tag{3.16}$$

3.7 Net energy need for heating domestic hot water

3.7.1

The net energy need for heating domestic hot water $Q_{dhw,net}$ is calculated using Equation (3.17).

$$Q_{dhw,\ net} = \rho_v c_{pv} V_{lkv}\ (T_{lkv} - T_{kv})/3600 \tag{3.17}$$

where:

$Q_{hdw,\ net}$	net energy need for domestic hot water, kWh
ρ_v	water density, 1 000 kg/m^3
c_{pv}	specific heat capacity of water, 4.2 kJ/kgK
V_{hdw}	domestic hot water consumption, m^3
T_{dhw}	domestic hot water temperature, °C
T_{cw}	domestic cold water temperature, °C
3600	factor for converting the denomination to kilowatt hours, s/h

The net need includes heating cold water to the temperature of the domestic hot water consumed, not including potential heat losses from the heating device, storage tank or pipe system.

Unless there are good reasons to use different values, the value to be used for the temperature difference between cold and hot water (T_{dhw} - T_{cw}) is 50 °C.

3.7.2

The specific consumptions presented in part D3 of the National Code of Building Regulations of Finland should be used if more accurate data is not available. The consumption of domestic hot water V_{dhw} can be calculated using Equation (3.18) for the calculated specific consumption per person or Equation (3.19) for the calculated specific consumption per surface area. In residential buildings, the values used are usually per-person values and in other buildings, per surface area. If there is apartment-specific metering and billing in a building, the per-person value that can be used is 50 dm^3/person per day and in other cases, 60 dm^3/person per day.

$$V_{lcw} = nV_{dhw, spec,person}\,\Delta t/1000 \tag{3.18}$$

$$V_{lcw} = V_{hdw,\ spec,net}\,\Delta t/365/1000 \tag{3.19}$$

where

V_{dhw}	domestic hot water consumption, m^3
n	number of persons
$V_{dhw,\ spec,\ person}$	domestic hot water consumption, dm^3 per person and day.
Δt	time period length, days
1000	factor for converting the denomination to cubic metres, dm^3/m^3
365	factor for converting the denomination from consumption-per-year to consumption-per-day, days/year
$V_{dhw,spec}$	specific consumption of domestic hot water, m^3/m^2 per year
A_{net}	net heated area of a building, m^2

If the source data for the calculation is the total consumption of domestic water, the share of domestic hot water in residential buildings that can be used is 40 % of the total consumption.

4

ELECTRIC ENERGY CONSUMPTION OF APPLIANCES AND LIGHTING

Calculations in this chapter
The electric energy consumption of appliances in a building less the electric energy used to heat or cool air
Electric energy consumption of lighting

Minimum source data required for calculation
Building type
Building's surface area

4.1 Electric energy consumption of appliances

4.1.1
The electric energy consumption of appliances in a building is the sum of appliance electric energy consumed, less electric energy consumed by lighting and ventilation systems, or electricity used in heating air and cooling spaces. The values presented in Part D3 of the National Code of Building Regulations of Finland may be used for calculating the electric energy consumption of appliances if more accurate values are not available.

4.1.2
If needed, the electric energy consumption of electrical appliances may be calculated for each appliance group based on their specific electric energy consumption.

4.1.3
The electric energy consumption of electrical appliances may also be determined using their specific consumption values in Table 4.1 for residential buildings and in Table 4.2 for office buildings.

Table 4.1 *Typical annual specific electric energy consumption of appliances according to group in residential buildings.*

Appliance group	Apartment building consumption	Small house consumption	Unit
Apartment building sauna	410	-	kWh/apartment
Apartment building laundry facility	67	-	kWh/apartment
Elevator	23	-	kWh/resident
Car parking spaces	150	150	kWh/space
Outside lighting	2	2	kWh/m^2
Apartment appliances			
Stove	340	520	kWh/ea.
Microwave oven	50	55	kWh/ea.
Coffeemaker	70	70	kWh/ea.
Dishwasher	170	250	kWh/ea.
Refrigerator/freezer combo	740	270 (refrigerator)	kWh/ea.
Ice box	330	330	kWh/ea.
Upright freezer	380	380	kWh/ea.
Washing machine	130	240	kWh/ea.

Clothes dryer	300	300	kWh/ea.
TV	200	200	kWh/ea.
Video	95	95	kWh/ea.
PC	80	80	kWh/ea.
Home sauna	8	8	kWh/each time heated

Table 4.2 *Typical annual specific electric energy consumption of appliances according to group in office buildings.*

Appliance group	Specific consumption	Unit
Other locations		
Cafeteria	0.75	kWh/portion
Company sauna	20	kWh/each time heated
Elevator	2 000	kWh/(8-person elevator)
Car parking spaces	150	kWh/space
Outside lighting	2	kWh/brm^2
Office equipment		
Portable PC	24	kWh/ea.
PCs + monitors	430	kWh/ea.
Copiers	1 700	kWh/ea.
Laser printers	400	kWh/ea.

4.2 Electric energy consumption of lighting

4.2.1

The values presented in Part D3 of the National Code of Building Regulations of Finland may be used for the electric energy consumption of lighting.

4.2.2

If the lighting system is known in more detail, the electric energy consumption of lighting may be calculated individually based on lighting needs and solutions.

4.2.3

The electric energy consumption of lighting Wlighting is calculated using Equation (4.1).

$$W_{\text{lighting}} = \Sigma P_{\text{lighting}}\, A_{\text{room}}\, \Delta t\, f/1000 \qquad (4.1)$$

where:

W_{lighting}	electric energy consumption of lighting, kWh
P_{lighting}	total electrical power of the lighting in the space to be illuminated per room surface area, W/room-m^2
A_{room}	surface area of room to be illuminated, room-m^2
Δt	lighting running time (for example, as per Table 4.3), h
f	control factors depending on the lighting control type:

-presence sensor and daylight timer	0.70
-daylight timer	0.80
-presence sensor	0.75
-room-specific switch	0.90
-room-specific switch, separate one for window wall	0.90
-central ON/OFF	1.00

Table 4.3 *Typically running times for building lighting systems* Δt *by building type.*

Building type	Hours per year
Apartment building	550
Row house	550
Small house	550
Office building	2 500
School building	1 900
Store building	4 000
Hotel	5 000
Restaurant	3 500
Sports building	5 000
Hospital	5 000
Other buildings	2 500

4.2.4
Total lighting power per surface area $P_{lighting}$

$$P_{lighting} = \frac{1}{\beta\eta\eta_{\Phi}} E \qquad (4.2)$$

where:

P lighting	total electrical power of the lighting in the space to be illuminated per room surface area, W/room-m^2	
β	Luminaire Maintenance Factor:	
	-clean environment	0.70
	-average environment	0.60
	- filthy environment	0.50
η	coefficient of utilisation:	
	-direct lighting	0.40
	-combined direct/indirect lighting	0.35
	- indirect lighting	0.30
η_{Φ}	lamp efficacy (Table 4.4), lm/W	
E	illuminance of space i, lx.	

The illuminance is the planned illuminance value for a room or a guideline value for illuminance in accordance with standard SFS-EN 12464-1.

Table 4.4 *Lamp efficacy for different lamp types and ranges. Lamp LMF β = 0.70 and coefficient of utilisation η = 0.40 were used in the calculation of power values.*

Lamp type	Lamp efficacy, η_{Φ} lm/W		Power, $P_{lighting}$ W/room-m2			
			Illuminance			
	Typical value	Range	100 lx	300 lx	500 lx	1 000 lx
Light bulb	10	8-12	36	107	179	357
Halogen lamp	12	5 010-24	30	89	149	298

CFL	50	50-85	7.1	21	36	71
Fluorescent lamp	80	50-100	4.5	13	22	45
LED	50	40-100	7.1	21	36	71

5

HEAT LOADS

Calculations in this chapter
Heat energy emitted by people
Heat loads from lighting and electrical appliances
Solar radiant energy entering the building through windows
Heat loads caused by domestic hot water and storage tanks

Heat energy to be recovered from heat loads

Minimum source data required for calculations
Building type
Building’s surface area
Windows
- surface areas by compass direction
- transmittance factor for total solar radiation through windows

Heat losses from spaces in a building (chapter 3)

5.1 Heat load from people

5.1.1
The values presented in Part D3, Table 3 of the National Code of Building Regulations of Finland may be used for heat loads from people W/m^2 if more accurate values are not available.

5.1.2
Instead of the values presented in part D3 of the National Code of Building Regulations of Finland, the heat energy emitted by a person Q_{person} can be calculated according to the length of stay and heat generation power using Equation (5.1).

$$Q_{person} = k\, n\, \phi_{person}\, \Delta t_{stay}/1000 \qquad (5.1)$$

where:

Q_{person}	heat energy emitted by a person, kWh
k	building’s utilisation level during operation, representing the average time people stay in the building,-
n	number of persons, -
ϕ_{person}	mean heat output of one person (not including evaporation heat), W/person
Δt_{stay}	length of stay, h
1000	factor for converting the denomination to kilowatt hours.

5.1.3
70 W can be used as the mean heat power for one person.

5.1.4
The length of stay can be calculated using Equation (5.2).

$$\Delta t_{stay} = \Sigma\, t_d t_v\, \Delta t \qquad (5.2)$$

where:

Δt_{stay}	length of stay, h
t_d	mean daily running time ratio of a building, -
t_v	mean weekly operating time ratio of a building, -
Δt	counting cycle, h

The values presented in Part D3 of the National Code of Building Regulations of Finland may be used for calculating the length of stay if more accurate values are not available.

5.2 Heat load of lighting and electrical appliances

5.2.1

The values presented in Part D3 of the National Code of Building Regulations of Finland may be used in calculating the heat loads of lighting and electrical appliances, where it is assumed that the electric energy consumption of lighting and appliances as a whole goes into the building as a heat load.

Heat loads from lighting and electric appliances coming into the building are calculated using Equation (5.3).

$$Q_{electric} = W_{lighting} + W_{\mathrm{appliances}} \tag{5.3}$$

where:

$Q_{electric}$	heat loads from lighting and electric appliances coming into the building, kWh
$W_{e\text{-}lighting}$	electric energy consumption of lighting, kWh
$W_{appliances}$	electric energy consumption of appliances, kWh

5.3 Solar radiant energy entering the building through windows

5.3.1

Solar radiant energy entering the building through windows (Qsolar) is calculated using Equation (5.4). Radiant energy includes energy entering the building directly through windows and indirectly as heat absorbed by windows.

$$\mathbf{Q}_{solar} = \Sigma G_{radiant,horizontal} F_{direction} F_{transmittance} A_{win}\, g = \Sigma G_{radiant,vertical} F_{transmittance} \mathbf{A}_{win}\, g \tag{5.4}$$

where:

Q_{solar}	solar radiant energy entering the building through the windows, kWh/month
$G_{radiant,\ horizontal}$	total solar radiant energy on a horizontal surface per area unit, kWh/(m^2unit)
$G_{radiant,\ vertical}$	total solar radiant energy on a vertical surface per area unit, kWh/(m^2unit)
$F_{direction}$	conversion factor for converting the total solar radiant energy on a horizontal surface to total radiant energy on a vertical surface by compass direction,-
$F_{transmittance}$	total correction factor for radiation transmittance, -
A_{win}	surface area of a window opening (including frame and casing), m^2
g	transmittance factor for total solar radiation through a daylight opening, -.

The total solar radiant energy ($G_{radiant,\ horizontal}$ and $G_{radiant,\ vertical}$) and the conversion factors for radiant energy ($F_{direction}$) by compass direction and month are presented in Annex 1.

Explanation
The amount of solar radiant energy coming in through windows that can be recovered for heating depends on the surface area of the windows and their direction, window frames, glass properties and curtains, access doors, and other protective structures as well as exterior shade effects, such as other buildings and vegetation.

5.3.3
The total correction factor for radiation transmittance $F_{transmittance}$ is calculated using Equation (5.5)

$$F_{transmittance} = F_{frame}\, F_{curtain}\, F_{shade} \tag{5.5}$$

where:

$F_{transmittance}$ total correction factor for radiation transmittance, -
F_{frame} frame factor, -
$F_{curtain}$ curtain factor, -.
F_{shade} correction factor for shades, -.

Value $F_{transmittance} = 0.75$ may be used as the total correction factor for radiation transmittance if there is no shade or permanent curtains.

5.3.4
Frame factor F_{frame}, which is the ratio between the daylight opening surface area and the window surface area, is calculated using Equation (5.6)

$$F_{frame} = \frac{A_{win,daylightopening}}{A_{win}} \tag{5.6}$$

where:

F_{frame} frame factor, -
$A_{win,\,daylight}$ surface area of a window’s daylight opening, m^2
A_{win} surface area of a window opening (including frame and casing), m^2.

The surface area of window casings and frames (including intermediate frames) is subtracted from the window surface area using the frame factor. Value $F_{frame} = 0.75$ can be used for the frame factor if more accurate data is not available.

5.3.5
Table 5.1 presents typical values for curtain factor $F_{curtain}$.

Table 5.1 Curtain factor $F_{curtain}$ for different curtains and sun shades

Solution	Curtain factor
No curtains	1
Sheer fabric curtains, inside	0.80
Dark fabric curtains, inside	0.75
Coloured fabric curtains, inside	0.70
Light-coloured fabric curtains, inside	0.50
White Venetian blinds between the glass panels	0.3
White Venetian blinds on the inside	0.6
Shutters (lattice) on the outside	0.3

5.3.6

The correction factor for shades F_{shade} is calculated as the product of three correction factors according to Equation (5.7)

$$\mathbf{F}_{shade} = \mathbf{F}_{environment}\,\mathbf{F}_{top\ shade}\,\mathbf{F}_{side\ shade} \tag{5.7}$$

where:

F_{shade}	correction factor for shades, -
$F_{environment}$	correction factor for horizontal shades in the environment (e.g. terrain, surrounding buildings, and trees), - (Table 5.2)
$F_{top\ shade}$	correction factor for shade provided by horizontal structures above a window,- (Table 5.3)
$F_{side\ shade}$	correction factor for shade provided by vertical structures on the side of a window,- (Table 5.4).

Tables 5.2 - 5.4 give the values for shade correction factors by compass direction and shade angles. The shade angles are determined from the window centre to the structure providing the shade. Intermediate values and directions between cardinal points may be determined by interpolation. The values in the tables may be used for all weather zones in accordance with Annex 1 if more accurate data is not available. The values of Tables 5.3 and 5.4 may be used during heating season. The definitions of shade angles are presented in Figure 5.1.

Table 5.2 *Correction factor $F_{environment}$, for shade from the environment for shade angle 45°(15°). For shade angle 0°, the factor is always 1.0 Intermediate values are distributed evenly.*

Month	Direction window is facing		
	North	East and West	South
January	0.95 (0.98)	0.60 (0.86)	0.25 (0.75)
February	0.90 (0.96)	0.50 (0.83)	0.30 (0.76)
March	0.90 (0.96)	0.50 (0.83)	0.40 (0.80)
April	0.80 (0.93)	0.50 (0.83)	0.50 (0.83)
May	0.80 (0.93)	0.55 (0.85)	0.70 (0.90)
June	0.60 (0.86)	0.50 (0.83)	0.75 (0.91)
July	0.70 (0.90)	0.55 (0.85)	0.75 (0.91)
August	0.65 (0.88)	0.40 (0.80)	0.40 (0.80)
September	0.85 (0.95)	0.50 (0.83)	0.45 (0.81)
October	0.90 (0.96)	0.55 (0.85)	0.30 (0.76)
November	0.90 (0.96)	0.60 (0.86)	0.20 (0.73)
December	0.95 (0.98)	0.80 (0.93)	0.20 (0.73)

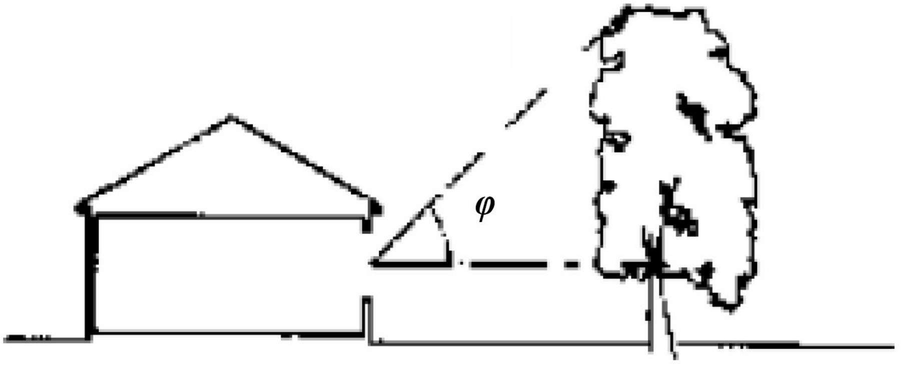
Table 5.3 *Correction factors for top shade during heating season $F_{top\ shade}$*

Angle (α)	Direction window is facing		
	North	East and West	South
0°	1.00	1.00	1.00
10°	0.97	0.98	0.99
20°	0.93	0.95	0.97
30°	0.90	0.92	0.95
40°	0.87	0.88	0.92
45°	0.80	0.81	0.85
60°	0.66	0.65	0.66

Table 5.4 Correction factors for side shade during heating season $F_{side\ shade}$

Angle (β)	Direction window is facing		
	North	East and West	South
0°	1.00	1.00	1.00
10°	0.99	0.97	0.98
20°	0.99	0.94	0.96
30°	0.98	0.90	0.94
40°	0.98	0.87	0.91
45°	0.98	0.82	085
60°	0.98	0.73	0.73

Shade from environment, $F_{environment}$



Shade from the side, $F_{side\ shade}$

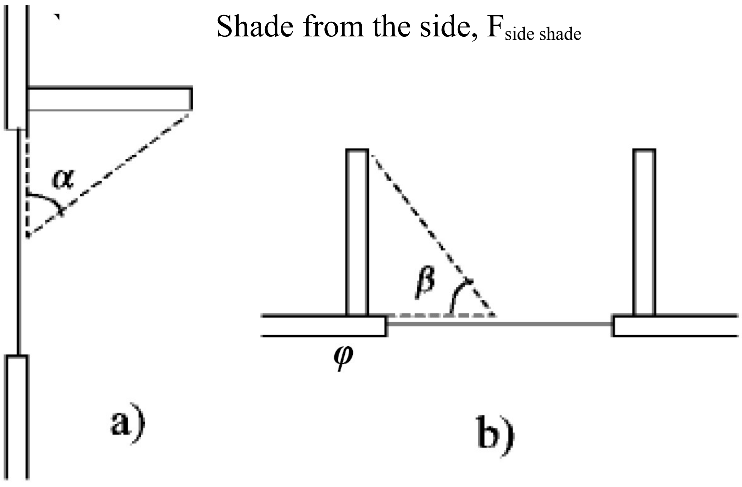


Figure 5.1. Definition of shade angles. Horizontal angle φ refers to shade from terrain and surrounding buildings and trees on a horizontal area, $F_{environment}$. Horizontal shade from above a), refers to factor $F_{topshade}$ and vertical shade on the sides of the window b), which refers to factor $F_{side\ shade}$

5.4 Heat load caused by domestic hot water circulation and storage

The share of heat loss from domestic hot water circulation and storage as calculated in chapter 6.3 that is converted to heat loads is 50 %.

5.5 Energy recovered from heat loads

5.5.1

Heat loads in buildings occur from activities performed in them, especially from lighting and people as well as solar radiant energy coming in through windows; these heat loads can be recovered for heating the buildings. Heat loads can only be recovered on the condition that there is a simultaneous need for heating and that the regulating devices will reduce the generation of other heat by the corresponding amount. The heat load of a building ($Q_{\mathrm{heat\ load}}$) is calculated using Equation (5.8).

$$Q_{heat\ load} = Q_{person} + Q_{electric} + Q_{solar} + Q_{DHW,circ} + Q_{DHW,\mathrm{tank}} \tag{5.8}$$

Heat load energy recovered for heating ($Q_{\mathrm{int.heat}}$), is calculated using Equation (5.9).

$$\mathrm{Q}_{int.heat} = \eta_{\ heat} Q_{heat\ load} \tag{5.9}$$

where

$Q_{\mathrm{int.heat}}$	building’s heat load energy recovered for heating, kWh
η_{heat}	degree of heat loads recovered by month, -
$Q_{\mathrm{heat\ load}}$	a building’s heat load, i.e. heat energy released into a building by means other than regulating devices, kWh
Q_{person}	heat energy emitted by a person, kWh
Q_{electric}	heat loads released into a building from lighting and electrical appliances, kWh
Q_{solar}	solar radiant energy coming into the building through windows, kWh.

The recoverable energy share has been calculated to correspond to average conditions by month.

5.5.2

The interior thermal capacity of the building’s insulation will affect the heat retention of structures. Thus it will affect both the consumption of heating and cooling energy as well as indoor temperatures. The time constant is a variable describing the relative thermal capacity that is independent of the building size; it is the ratio between thermal capacity and specific heat loss. The time constants of a building range from 1-7 days. The building’s thermal capacity is a constant, but the specific heat loss depends, among other things, on the ventilation air flow and is thus variable.

5.5.3

The degree of heat loads recovered (η_{heat}) depends on the ratio (γ) between ($Q_{\mathrm{heat\ load}}$) and heat loss (Q_{space}) as well as the building’s time constant (τ), which is the building’s (space’s) interior effective thermal capacity (C_{build}) ratio to the specific heat loss (H).

5.5.4

The degree of heat loads recovered η_{heat} for basic cases is calculated using Equation (5.10).

$$\eta_{\mathrm{heat}} = \frac{1-\gamma^{a}}{1-\gamma^{a+1}} \tag{5.10}$$

In those special cases where the heat load to heat loss ratio $\gamma = 1$, the degree of recovery is calculated using Equation (5.11).

$$\eta_{heat} = \frac{a}{a + 1} \qquad (5.11)$$

In Equations (5.10) and (5.11), ‘a’ is a numerical parameter that depends on the time constant τ. It is calculated using Equation (5.12).

$$a = 1 + \frac{\tau}{15} \qquad (5.12)$$

5.5.5

Ratio γ is calculated using Equation (5.13).

$$\gamma = \frac{Q_{\text{heat load}}}{Q_{space}} \qquad (5.13)$$

where:

γ	heat load to heat loss ratio, -
$Q_{\text{heat load}}$	a building’s heat load, i.e. heat energy released into a building by means other than regulating devices, kWh
Q_{space}	heat loss of a building’s spaces, kWh

5.5.6

Time constant τ. is calculated using Equation (5.14).

$$\tau . = \frac{C_{buil}}{H} \qquad (5.14)$$

where:

T	building’s time constant, h
C_{build}	building’s interior effective thermal capacity, Wh/K
H	building’s specific heat loss (total specific heat loss due to conduction, heating of air leakage, make-up air, and supply air in a space), W/K

5.5.7

The specific heat loss H of a building is calculated using Equation (5.15).

$$H = \frac{Q_{space}}{(T_s - T_u)\Delta t} 1000 \qquad (5.15)$$

where:

H	specific heat loss of a building, W/K
Q_{space}	heat loss of a building’s spaces, kWh
T_{ind}	indoor air temperature, °C
T_{outd}	outdoor air temperature, °C
Δt	time period length, h
1000	factor used to convert denomination to watts.

5.5.8

The interior effective thermal capacity of a building C_{buil} can be calculated for example in accordance with standards SFS-EN ISO 13786 or SFS-EN ISO 13790. The values $C_{build\ spec}$ in Table 5.5 multiplied by the surface area can be used for interior effective thermal capacity of a building C_{build} if more accurate data is not available. If there are structures with different thermal capacities in a building, the mean thermal capacity of their weighted surface areas may be used.

Table 5.5. Values for effective thermal capacity $C_{build\ spec}$ in different types of furnished buildings

Building type	Sample structures (EW = exterior wall, PW = partition wall, C = ceiling and F = floor)	$C_{build\ spec,}$ Wh/(m^2 K)
	Small houses	
Light-weight construction	EW, PW, C, F light-weight stick-built structures	40
Medium-heavy I	EW, PW, C light-weight stick-built structures, F concrete	70
Medium-heavy II	EW cinder blocks or solid timber, PW, C light-weight stick-built structures, F concrete	110
Heavy construction	EW concrete or brick, PW cinder blocks or brick C, F concrete	200
	Multi-storey apartment buildings	
Light-weight construction	EW, PW, IF light-weight stick-built structures, F concrete	40
Medium	EW light-weight stick-built structures, PW light-weight stick-built structures or concrete, IW concrete, F concrete,	160
Heavy construction	EW concrete, PW cinder block or concrete, IW concrete, F concrete	220
	Office buildings	
Light-weight construction	EW, PW, IF light-weight stick-built structures, F concrete	70
Medium	EW light-weight stick-built structures, PW light-weight stick-built structures or concrete, IW concrete, F concrete,	110
Heavy construction	EW concrete, PW cinder block or concrete, IW concrete, F concrete	160
	Other buildings	
Values from the table can be used, or the effective thermal capacity of a building can be calculated, for example in accordance with Standards SFS-EN ISO 13786 or SFS-EN ISO 13790.		

6

ENERGY CONSUMPTION OF THE HEATING SYSTEM

Calculations in this chapter
Losses from heat distribution and delivery
Losses from domestic hot water and its storage
Electric energy consumption of heating system auxiliary devices
Losses from generating heating energy

Minimum source data required for calculations
net energy need for space heating
net energy need for ventilation heating
net energy need for heating domestic hot water

6.1 General

The energy consumption of a heating system is calculated from the net energy needs for heating spaces, ventilation, and domestic water and by adding to that the losses in the heating system from the delivery point to the heating energy production device. The losses are calculated using the following efficiencies. After that, the effect of the heating energy production device is calculated using its efficiency or coefficient of performance (COP).

6.2 Heating of spaces and ventilation

6.2.1

Energy consumption for heating spaces from heat delivery to heat production Qheating,spaces is calculated using Equation (6.1)

$$Q_{heating,spaces} = \frac{\mathrm{Q}_{\mathrm{heating,space,net}}}{\eta_{\mathrm{heating,spaces}}} + Q_{distribution,out} \qquad (6.1)$$

$\mathrm{Q}_{\mathrm{heating,spaces,net}}$	net energy need for space heating, kWh/a
$\mathrm{Q}_{\mathrm{distribution,out}}$	heat loss into a non-heated room during heat distribution, kWh/a
$\eta_{\mathrm{heating,spaces}}$	heating system efficiency in heating spaces, -

The efficiency of the heating system in heating spaces $\eta_{\mathrm{heating,spaces}}$ takes into account losses from heat delivery, regulation, temperature layers, and heat distribution. The guideline values for heat distribution efficiency are presented in Table 6.1; they can be used if more accurate data is not available.

Heat losses into a non-heated space during distribution $\mathrm{Q}_{\mathrm{distribution,out}}$ for the time period under consideration are calculated using Equation (6.2)

$$Q_{distribution,out} = q_{distribution\ losses,out} L \qquad (6.2)$$

$\mathrm{q}_{\mathrm{distribution\ losses,out}}$	heat loss into a non-heated room during heat distribution, kWh/m,a
L	combined length of supply and return pipes in a non-heated space, m

Table 6.2 presents guideline values for specific heat losses to determine the heat loss of heat distribution pipes in a non-heated space; these values can be used if more accurate data is not available. The values in the table apply to a transfer pipe between a single building and the heat production unit. Heat losses of pipes in a larger area must always be calculated using a suitable method.

6.2.2

In calculating the heat energy consumption for ventilation, the efficiency of the ventilation machine battery can be assumed to be 1.0, in which case $Q_{heating,vent}.= Q_{iv}$.

The electric energy consumption of heating system auxiliary devices, such as circulation pumps, regulating devices etc., W_{spaces} is calculated using Equation (6.3)

$$W_{spaces} = e_{spaces}A \tag{6.3}$$

e_{spaces}	specific consumption of auxiliary devices (Table 6.1), kWh/(m^{2}a).
A	net heated area, (m^2).

Table 6.1 Guideline values for annual efficiencies for heat distribution and delivery systems and electric energy consumption of auxiliary devices. The efficiencies were determined using a proportional regulator (P=2°C), except for electric heaters, which were determined using an electronic regulator.

Heating solution	Efficiency η_{spaces}	Electric e_{spaces}, kWh/(m^{2}a)
Water radiator 45/35 °C		
insulated distribution pipes	0.89	2
non-insulated distribution pipes	0.84	
Water radiator 70/40 °C		
insulated distribution pipes	0.87	2
non-insulated distribution pipes	0.81	
Water radiator 90/70 °C		
insulated distribution pipes	0.86	2
non-insulated distribution pipes	0.77	
Water radiator 70/40 °C with manifold		
	0.80	2
Water radiator 45/35 °C with manifold		
	0.83	2
Hot-water floor heating system 40/30 °C		
building butts against ground	0.84	2.5
building butts against a crawl space	0.78	
building butts against outdoor air	0.75	
building butts against warm space	0.89	
Roof heating (electric)		
building butts against outdoor air	0.86	1
building butts against warm space	0.88	1
Window heating (electric)		
window Ug value 0.8 W/m^{2}K	0.83	1
window Ug value 1.0 W/m^{2}K	0.80	1
Ventilation heating		
blown in from an interior wall	0.89	1
Electric heater		
	0.94	1
Electric floor heating		
building butts against ground	0.87	1
building butts against a crawl space	0.82	1
building butts against outdoor air	0.79	1
building butts against warm space	0.91	1

Table 6.2 Guideline values for specific heat loss for heat distribution pipes in non-heated spaces.

		Specific heat loss
		$q_{\text{distribution losses,out}}$, kWh/m,a
Small house	**Buried distribution pipes**	
	- insulated	60
	Distribution pipes in a semi-warm space1)	
	- non-insulated	150
	- insulated	25
	Distribution pipes in outdoor air	
	- insulated	35
Other building	**Buried distribution pipes**	
	- insulated	85
	Distribution pipes in a semi-warm space1)	
	-non-insulated	250
	- insulated	30
	Distribution pipes in outdoor air	
	- insulated	50

1) Temperature of semi-warm space is 15 °C.

6.3 Heating of domestic hot water

The energy consumption for heating domestic hot water from heat production to water point $Q_{\text{heating,dhw}}$ is calculated using Equation (6.4)

$$Q_{heating,dhw} = \frac{Q_{hdw,net}}{\eta_{hdw}} + Q_{dhw,\ storage} + Q_{dhw,\ circulation} \tag{6.4}$$

$Q_{\text{dhw,net}}$	net energy need for domestic hot water, kWh/a
η_{dhw}	efficiency of domestic hot water transfer, -
$Q_{\text{dhw,storage}}$	loss from domestic hot water storage, kWh/a
$Q_{\text{dhw,circ}}$	loss from domestic hot water circulation, kWh/a

6.3.1

The efficiency of domestic hot water transfer includes the losses from domestic hot water distribution pipes. If more accurate data is not available, the building type-specific values given in Table 6.3 can be used for the efficiency of domestic hot water transfer. The table contains efficiencies for different levels of insulation. The insulation thickness is given relative to the diameter D of the circulation pipe. Here, an insulation thickness of 0.5D means that the thickness is half the diameter of the pipe to be insulated; 1.5D means insulation with a thickness of 1.5 times the pipe diameter.

Table 6.3. Efficiency of domestic hot water transfer

η_{dhw}CirculationNo circulationBuilding typenon-insulatedin a housing pipeinsulated, basic level2)insulated, better3)Single small house, row houses, and cluster homes0.960.750.850.890.92Apartment building0.970.760.860.900.94Apartment building, metering1)0.970.760.860.900.94Office building0.880.690.780.820.85Store building0.870.680.770.810.84Commercial lodging building0.970.760.860.900.94School and day-care building 0.890.700.790.830.86Sports centre0.980.770.870.910.95Hospital0.940.740.840.880.91 1) Apartment-specific water metering for cold and hot water2) Basic level of insulation means a minimum insulation thickness of 0.5D, where D is the pipe diameter 3) Better level of insulation means a minimum insulation thickness of 1.5D, where D is the pipe diameter

6.3.2

If more accurate data is not available, the values given in Table 6.3b, which are based on heat loss power of a domestic hot water tank, can be used for the loss from domestic hot water storage.

Table 6.3b. Loss from domestic hot water storage.

Storage tank volume, l	Storage tank heat loss, kWh/a	
	40 mm insulation	100 mm insulation
50	440	220
100	640	320
150	830	420
200	1 000	500
300	1 300	650
500	1 700	850
1 000	2 100	1 100
2 000	3 000	1 500
3 000	4 000	2 000

6.3.3

For systems with domestic hot water circulation, the circulation pipe heat loss can be calculated using pipe length and constant heat loss. The guideline value for the specific power of the circulation pipe heat loss to be used is 40W/m if more accurate data is not available. If the insulation level of the circulation pipe is known, the values given in Table 6.4 may be used. Heat loss $Q_{\text{dhw, circ}}$ (kWh/a) is calculated using Equation (6.5).

$$Q_{dhw,circ} = \frac{W_{hdw,circ}}{1000} L_{dhw} t_{dhw} 365 + W_{dhw,\text{ heating}} n_{heating\ device} \tag{6.5}$$

where:

$W_{\text{dhw, circ}}$	specific power of DHW circulation pipe heat loss, W/m
L_{dhw}	length of the DHW circulation pipe, m
t_{dhw}	running time of the domestic hot water circulation pump, h/day

$W_{dhw, heating}$ specific power of heaters connected to the circulation pipe for domestic hot water, W/pc.
$n_{heating\ device}$ number of heaters connected to the circulation pipe for domestic hot water, pcs.

The values given in Table 6.4 may be used for the specific power of DHW circulation pipe heat loss. The table contains heat loss specific power values depending on the insulation level of the DHW circulation pipe. The insulation thickness is given relative to the diameter D of the circulation pipe. Here, an insulation thickness of 0.5D means that the thickness is half the diameter of the pipe to be insulated; 1.5D means insulation with a thickness of 1.5 times the pipe diameter. If heating dryers are connected to the DHW circulation pipe but their quantity is not known, +40 W/m should be added to the circulation pipe heat loss specific power. If the number of heating devices is known but more accurate data is not available, 200 W can be used as the power value of one heating device.

Table 6.4. Specific power of DHW circulation pipe heat loss and connected heating devices.

Insulation level	DHW circulation pipe heat loss specific power
No data available	40 W/m
0.5D	10 W/m
1.5D	6 W/m
Housing pipe	15 W/m
Housing pipe +0.5D	8 W/m
Housing pipe +1.5D	5 W/m
Specific power of heating devices	
Quantity not known	Add +40 W/m to DHW circulation pipe heat loss specific power
Quantity known	200 W/pc.

If accurate data on the length of the DHW circulation pipe is not available, the building type-specific values given in Table 6.5 can be used for the specific length of the circulation pipe. The length of the circulation pipe can be determined by multiplying the specific length with the net heated area of the building.

Table 6.5. Length of circulation pipe

Building type	Circulation pipe specific length, m/m^2
Single small house, row houses, and cluster homes	0.043
Apartment building	0.043
Apartment building, metering[1)]	0.043
Office building	0.020
Store building	0.020
Commercial lodging building	0.043
School and day-care building	0.020
Sports centre	0.020
Hospital	0.043
[1)] Apartment-specific water metering for cold and hot water	

6.3.4
The energy consumption of the DHW circulation pipe can be calculated using Equation (6.6).

$$W_{dhw,pump} = P_{dhw,pump}\, t_{dhw,pump} \frac{365}{1000} \qquad (6\ 6)$$

where:

P_{dhw} pump input power of the DHW circulation pipe, W

t_{dhw} running time of the domestic hot water circulation pump, h/day.

6.4 Heating system energy consumption

6.4.1

The heating system energy consumption is composed of heating energy $Q_{heating}$ and electric energy $E_{heating}$ consumption, which are calculated separately. The heating system heat energy consumption $Q_{heating}$ is calculated without considering the heating energy generated by heat pumps, using Equation (6.7)

$$Q_{heating} = \frac{Q_{heating,spaces} + Q_{heating,iv} + Q_{heating,hdw} - Q_{solar}}{\eta_{production}} \qquad (6.7)$$

where

η_{prod} efficiency of heating energy production in heating spaces, ventilation, and domestic hot water (Tables 6.6 and 6.7), -

Q_{solar} domestic hot water produced using solar collectors, as calculated in chapter 6.5.

Heating energy produced by heat pumps is calculated according to Equation 6.6.

If part of the heating is electric heat, it must be calculated separately from other heating energy and presented together with the electric energy consumed by auxiliary devices as part of the electric energy consumption of the heating system.

Table 6.6 Guideline values for efficiencies and electric energy consumption of boilers and district heating distribution centres of different small houses, row houses, and cluster homes.

	Standard	Condensation	Condensation	Pellet	Wood boiler	Electric	
Month	Oil/gas	Oil	Gas	Boiler	Energy storage	Boiler	District heating
1	0.86	0.92	0.98	0.76	0.78	0.94	0.96
2	0.86	0.92	0.98	0.75	0.78	0.93	0.96
3	0.83	0.89	0.94	0.72	0.71	0.90	0.95
4	0.79	0.85	0.91	0.68	0.75	0.86	0.93
5	0.72	0.79	0.84	0.61	0.69	0.79	0.91
6	0.67	0.73	0.78	0.56	0.55	0.74	0.91
7	0.68	0.74	0.78	0.56	0.67	0.74	0.91
8	0.67	0.73	0.78	0.56	0.57	0.74	0.91
9	0.73	0.79	0.84	0.61	0.67	0.79	0.91
10	0.80	0.86	0.91	0.69	0.76	0.87	0.94
11	0.83	0.90	0.95	0.73	0.74	0.91	0.95
12	0.85	0.91	0.97	0.75	0.79	0.93	0.96
Annual efficiency	**0.81**	**0.87**	**0.92**	**0.70**	**0.73**	**0.88**	**0.94**
Electric (kWh/m2a)	**0.99** (1 **0.59** (2	**1.07**	**0.68**	**0.77**	**0.38**	**0.02**	**0.6**

1) **Oil**

2) Gas

Table 6.7 Guideline values for efficiencies and electric energy consumption of boilers and district heating distribution centres of other (larger) buildings.

	Standard	Condensation	Condensation	Pellet	wood boiler	
Month	Oil/gas	Oil	Gas	Boiler	Energy storage	District heating
1	0.92	0.97	1.03	0.83	0.84	0.98
2	0.92	0.97	1.03	0.83	0.84	0.98
3	0.91	0.96	1.02	0.82	0.83	0.98
4	0.88	0.93	0.99	0.76	0.80	0.95
5	0.78	0.83	0.88	0.61	0.71	0.88
6	0.68	0.73	0.77	0.48	0.60	0.83
7	0.67	0.71	0.76	0.47	0.59	0.82
8	0.67	0.72	0.77	0.48	0.61	0.83
9	0.77	0.82	0.87	0.60	0.72	0.88
10	0.88	0.93	0.99	0.77	0.82	0.96
11	0.91	0.96	1.02	0.82	0.83	0.98
12	0.92	0.97	1.03	0.84	0.84	0.99
Annual efficiency	**0.90**	**0.95**	**1.01**	**0.80**	**0.82**	**0.97**
Electric (kWh/ m^{2}a)	**0.24** (1 **0.11** (2	**0.25**	**0.12**	**0.13**	**0.25**	**0.07**

1) **Oil**
2) Gas

6.4.2

The annual efficiency of slow heat release fireplaces can be assumed to be 0.60 if more accurate data is not available.

6.5 Heating domestic hot water with solar collectors

Heating domestic hot water with solar energy is calculated by multiplying the values in Table 6.8 with the surface area of the collectors and taking into consideration the correction factor for direction, Equation (6.8). The solar energy share of the domestic hot water heating energy must not exceed 30 % in the calculation.

$$Q_{solar} = q_{solar\ collector}\, A_{solar\ collector}\, k \qquad (6.8)$$

where:

$q_{solar\ collector}$	energy produced by a solar collector for domestic hot water per collector surface area (Table 6.8), kWh/m^2,a
$A_{solar\ collector}$	total surface area of solar collectors, m^2
k	factor taking into account the direction the collectors are facing (Table 6.9)

Table 6.8 Energy produced by solar collectors per collector surface area, used for heating domestic hot water.

Zone/location	$q_{solar\ collector}$ kWh/m^2,a
I / Helsinki	156
II / Jyväskylä	139
III/Sodankylä	125

The table figures apply to collectors with an inclination angle of 30-70 degrees from the horizontal. For other inclination angles, the table value must be multiplied by 0.8.

Table 6.9. Values for factor k, which takes into account collector direction.

Direction	k
south/southeast/southwest	1
east/west	0.8
north/northeast/northwest	0.6

If the planned solution deviates considerably from the assumptions below, a different, acceptable method should be used.

The values in the table are based on the following assumptions:

- •Domestic water consumption 200 litres/day (+50 ºC; transfer/distribution heat losses 30 % (50 litres/ person/day)
- •Collector surface area 10 m^2 (2.5 m^2/person; 1 m^2/20 litres DHW consumption)
- •Collector efficiency (η_0) for perpendicular radiation without effect of temperature difference 60 %
- •Tank size 500 litres (50 litres/1 m^2 per collector surface; 2.5 x daily water consumption) (the calculation is based on a design where the maximum monthly production of 85 % of the heating need is solar energy; at the annual level, 28 % of the energy need for DHW is met by solar energy)
- The tank and collector circulation loop losses were calculated using the values for poor insulation

The electric energy consumption of solar heating system pumps is calculated as

$$W_{solar,pumps} = \Sigma(P_{pump,i}\ t_{pump,i}) \qquad (6.9)$$

where:

$P_{pump,i}$ is the power of individual pump i, W
$t_{pump,i}$ running time of pump i, h

If details of the planned values are not known, the planned values for pump power can be calculated using Equation 6.10

$$P=50\ W + 5^{*}A_{solar\ collector} \qquad (6.10)$$

where:

$A_{solar\ collector}$ is the surface area of the collectors connected to the circulation loop, m^2

A pump running time of 2 000 h/a may be assumed if more accurate data is not available. The pump running time is assumed to correspond to the monthly radiant energies.

Energy that could be stored from the pumps' electric energy will not be considered in calculating the heating need of a building.

6.6 Heat pumps

6.6.1

The simple calculation method for heat pumps can be used to calculate the electric energy consumption of a heat pump used for heating, the energy generated for heating spaces and domestic hot water, as well as supplemental energy needed for heating spaces and domestic hot water.

The electric energy consumption of a heat pump consists of the energy consumed in generating heating energy and the electric energy consumption of auxiliary devices. The electric energy consumption of a heat pump is calculated using the energy generated for heating spaces or domestic hot water as well as the pump's annual mean COP (SPF index), which is defined in more detail in a separate guide.

The calculation methods for supplemental heating energy presented in chapter 6.6.2 (Tables 6.10-6.11) and the sample values for SPF indexes presented in chapter 6.6.3 (Tables 6.14-6.16) assume that the lowest running temperature for the air-source heat pump is -20°C. It is also assumed that air-source and ground-source heat pumps will alternately heat domestic water and spaces, primarily heating domestic water. It is assumed that exhaust air heat pumps which heat water and spaces will heat spaces and domestic water simultaneously. If these assumptions do not apply in the case to be calculated, it should be calculated more accurately using a different method.

6.6.2

The heating energy for spaces and domestic hot water generated by heat pumps as well as the share of supplemental heating energy needed may be calculated using Tables 6.10-6.13, a guide published by the Ministry of the Environment or another method.

The heating energy share generated by air-source and ground-source pumps can be estimated using Tables 6.10-6.12, if the pump's nominal output Φ_{hpn} ratio to the building's designed output for heating spaces $\Phi_{heatmax}$ is known (relative heat output: $\Phi_{hpn}/\Phi_{heatmax}$). The nominal output of heat pumps Φ_{hpn} in Tables 6.10-6.12 are given for test conditions laid down in Standard SFS EN 14511-2, with outdoor air temperature +7°C and indoor air temperature 21°C for air-source heat pumps; for ground-source heat pumps, the temperatures is 0°C at the collection pipe system; the heat distribution network return water temperature is 35°C. In addition, the heat distribution network temperature level, the ratio between space and water heating energy, and the effect of Finland's weather zones on the supplemental heating energy need can be estimated using Tables 6.10-6.12.

The share of heating energy generated by exhaust air heat pumps can be estimated using Table 6.13 if the space heating energy consumption $Q_{heating,spaces}$ is known. Table 6.13 can also be used to estimate the effect of the waste air temperature from exhaust air heat pumps on the share of heating energy to be produced by the heat pump.

The supplemental heating energy need for all aforementioned heat pump types can be estimated using Tables 6.10-6.13, based on the relative share of heating energy to be specified, which is the ratio between space and water heating energy generated by the pump Q_{hp} and the building's total space and water heating energy Q_{tot} (relative heating energy: Q_{hp} / Q_{tot}).

Table 6.10. A ground-source heat pump's relative heat energy share (Q_{hp}/Q_{tot})*, arranged in a table with the relative thermal output (*Φ_{hpn}/Φ_{totmax}*), the ratios of space and water energy (*Φ_{heat}/Φ_{dhw}*), the max. temperatures of return water, and different weather zones. The heat pump's nominal output* Φ_{hpn} *is given at operating point* T_{liquid} / T_{return} *0/35 °C.*

Φ_{hpn}/Φ_{totmax}	Φheat/ dhw	Weather zone: I-II				Weather zone: III				Weather zone: IV			
		T_m, °C				T_m, °C				T_m, °C			
		30	40	50	60	30	40	50	60	30	40	50	60
0.3	0.5	0.39	0.39	0.39	0.39	0.38	0.38	0.38	0.38	0.36	0.36	0.36	0.36
	1	0.47	0.47	0.47	0.47	0.46	0.46	0.46	0.46	0.44	0.44	0.44	0.44
	2	0.62	0.60	0.58	0.56	0.60	0.58	0.56	0.54	0.44	0.54	0.52	0.51
	4	0.68	0.65	0.62	0.59	0.67	0.63	0.60	0.58	0.63	0.59	0.56	0.54
0.4	0.5	0.52	0.52	0.52	0.52	0.51	0.51	0.51	0.51	0.48	0.48	0.48	0.48
	1	0.67	0.66	0.65	0.64	0.65	0.64	0.63	0.62	0.61	0.60	0.59	0.59
	2	0.78	0.75	0.72	0.70	0.76	0.73	0.70	0.68	0.59	0.69	0.67	0.64
	4	0.84	0.79	0.76	0.73	0.82	0.77	0.73	0.70	0.78	0.73	0.69	0.66
0.5	0.5	0.65	0.65	0.65	0.65	0.63	0.63	0.63	0.63	0.61	0.61	0.61	0.61
	1	0.82	0.80	0.78	0.76	0.80	0.78	0.76	0.74	0.77	0.74	0.73	0.71
	2	0.90	0.87	0.84	0.81	0.89	0.85	0.82	0.79	0.71	0.81	0.78	0.75
	4	0.92	0.89	0.86	0.83	0.91	0.88	0.84	0.81	0.89	0.84	0.80	0.76
0.6	0.5	0.81	0.80	0.79	0.78	0.79	0.78	0.77	0.76	0.75	0.74	0.74	0.73
	1	0.92	0.90	0.88	0.86	0.91	0.88	0.86	0.84	0.88	0.85	0.82	0.80
	2	0.95	0.93	0.91	0.89	0.95	0.92	0.90	0.87	0.80	0.90	0.86	0.83
	4	0.96	0.94	0.92	0.90	0.96	0.93	0.91	0.88	0.95	0.91	0.88	0.85
0.7	0.5	0.92	0.90	0.88	0.87	0.90	0.88	0.87	0.86	0.87	0.85	0.84	0.83
	1	0.97	0.95	0.94	0.92	0.96	0.95	0.93	0.91	0.95	0.92	0.90	0.88
	2	0.98	0.96	0.95	0.93	0.98	0.96	0.94	0.92	0.88	0.95	0.92	0.90
	4	0.98	0.97	0.95	0.94	0.98	0.96	0.95	0.93	0.98	0.95	0.93	0.90
0.8	0.5	0.97	0.96	0.95	0.94	0.97	0.95	0.94	0.93	0.95	0.93	0.91	0.90
	1	0.99	0.98	0.97	0.96	0.99	0.97	0.96	0.95	0.98	0.96	0.95	0.93
	2	0.99	0.98	0.97	0.96	0.99	0.98	0.97	0.95	0.99	0.97	0.95	0.95
	4	0.99	0.98	0.97	0.96	0.99	0.98	0.97	0.95	0.99	0.98	0.96	0.94

Table 6.11. An air-source (air-water) heat pump's relative heat energy share (Q_{hp}/Q_{tot})*, arranged in a table with the relative thermal output (Φ_{hpn}/Φ_{totmax}), the ratios of space and water energy (Φ_{heat}/Φ_{dhw}), the max. temperatures of return water, and different weather zones. The heat pump's nominal output Φ_{hpn} is given at operating point $T_{outdoor}$ / T_{return} 7/35 °.*

Φ_{hpn}/Φ_{totmax}	Φheat/Φdhw	Weather zone: I-II				Weather zone: III				Weather zone: IV			
		T_m, °C				T_m, °C				T_m, °C			
		30	40	50	60	30	40	50	60	30	40	50	60
0.3	0.5	0.33	0.33	0.33	0.33	0.31	0.31	0.31	0.31	0.28	0.28	0.28	0.28
	1	0.39	0.39	0.39	0.39	0.37	0.37	0.37	0.37	0.33	0.33	0.33	0.33
	2	0.49	0.48	0.47	0.46	0.46	0.45	0.44	0.44	0.40	0.39	0.39	0.38
	4	0.56	0.54	0.52	0.50	0.53	0.51	0.49	0.48	0.46	0.44	0.43	0.41
0.4	0.5	0.44	0.44	0.44	0.44	0.42	0.42	0.42	0.42	0.38	0.38	0.38	0.38
	1	0.52	0.52	0.52	0.52	0.50	0.50	0.49	0.49	0.44	0.44	0.44	0.44
	2	0.63	0.61	0.60	0.58	0.60	0.58	0.57	0.56	0.52	0.51	0.50	0.49
	4	0.68	0.65	0.63	0.61	0.64	0.62	0.60	0.58	0.56	0.54	0.52	0.51
0.5	0.5	0.54	0.54	0.54	0.54	0.52	0.52	0.52	0.52	0.47	0.47	0.47	0.47
	1	0.65	0.64	0.64	0.63	0.62	0.61	0.61	0.60	0.55	0.54	0.54	0.53
	2	0.73	0.71	0.69	0.68	0.70	0.68	0.66	0.64	0.61	0.60	0.58	0.57
	4	0.78	0.75	0.72	0.70	0.74	0.71	0.68	0.66	0.64	0.62	0.60	0.58
0.6	0.5	0.64	0.64	0.64	0.64	0.62	0.62	0.62	0.61	0.55	0.55	0.55	0.55
	1	0.75	0.74	0.72	0.72	0.72	0.70	0.69	0.69	0.64	0.63	0.62	0.61
	2	0.82	0.79	0.77	0.75	0.78	0.76	0.74	0.72	0.69	0.67	0.65	0.64
	4	0.84	0.82	0.80	0.77	0.81	0.78	0.76	0.73	0.71	0.69	0.66	0.64
0.7	0.5	0.73	0.73	0.73	0.73	0.70	0.70	0.70	0.70	0.63	0.63	0.63	0.63
	1	0.83	0.81	0.80	0.78	0.79	0.78	0.76	0.75	0.71	0.69	0.68	0.67
	2	0.87	0.85	0.83	0.82	0.84	0.82	0.80	0.78	0.75	0.73	0.71	0.69
	4	0.89	0.87	0.85	0.83	0.86	0.84	0.81	0.79	0.76	0.74	0.72	0.70
0.8	0.5	0.81	0.80	0.80	0.79	0.80	0.80	0.79	0.78	0.72	0.71	0.71	0.70
	1	0.88	0.87	0.85	0.84	0.86	0.85	0.84	0.82	0.77	0.76	0.74	0.73
	2	0.90	0.89	0.88	0.86	0.88	0.86	0.85	0.84	0.79	0.77	0.76	0.74
	4	0.91	0.90	0.88	0.87	0.88	0.87	0.85	0.84	0.79	0.77	0.76	0.74

Table 6.12. An air-source (air-air) heat pump's relative heat energy share (Q_{hp}/Q_{tot}) *arranged in a table with the relative thermal output (Φ_{hpn}/Φ_{totmax}) in relation to different weather zones. The heat pump's nominal output $_{hpn}$ is given at operating point $T_{outdoor}/T_{indoor}$ + 7/21°C.*

	Weather zone		
	I-II	III	IV
0.3	0.54	0.51	0.44
0.4	0.66	0.62	0.53
0.5	0.75	0.71	0.61
0.6	0.81	0.78	0.68
0.7	0.85	0.83	0.73

Table 6.13. An exhaust air heat pump's relative heat energy share (Q_{hp}/Q_{tot}) *arranged in a table in relation to heating energy consumption of spaces at different waste air temperatures.*

	T_{waste}, °C		
	1	3	5
50	0.95	0.90	0.84
100	0.72	0.66	0.60
150	0.56	0.51	0.46
200	0.46	0.41	0.37

The heating energy to be generated by a heat pump, taking into consideration the energy needed for supplemental heating, is calculated using Equations (6.11) and (6.12).

$$Q_{HP,heating,spaces}= Q_{heating,spaces}-Q_{suppheat,spaces} \tag{6.11}$$

where:

$Q_{HP,\ heating,\ spaces}$	energy for heating spaces generated by a heat pump, kWh
$Q_{heating,\ spaces,\ net}$	energy consumption for heating spaces, kWh
$Q_{supp,\ spaces}$	supplemental energy consumed in the heating of spaces, kWh

If the heat pump is used to heat ventilation supply air, this energy consumption is added in Equation (6.1) to the building's total space and water heating energy consumption $Q_{heating,spaces}$.

$$Q_{HP,\ heating,\ DHW} =Q_{heating,\ DHW}- Q_{suppheat,\ DHW} \tag{6.12}$$

where:

$Q_{HP,\ heating,\ DHW}$	energy for heating DHW generated by a heat pump, kWh
$Q_{heating,\ DHW}$	energy consumption for domestic hot water, kWh
$Q_{supp,DHW}$	supplemental energy consumed in the heating of domestic hot water, kWh.

The space and water heating energy consumption ($Q_{heating,spaces}$ and $Q_{heating,DHW}$) are calculated using Equation (6.1) and (6.4).

6.6.3

In calculating the electric energy consumption for heating, the heat pump is only considered for the time periods it is running. The electric energy consumption of a heat pump used for heating $E_{HP,heating}$ can be calculated using equation

$$E_{HP,heating} = Q_{HP,heating,spaces}/ SPF_{spaces} +Q_{HP\ heating,\ DHW} / SPF_{DHW} \tag{6.13}$$

where:

SPF_{spaces}	heat pump SPF index for heating spaces, -
SPF_{DHW}	heat pump SPF index for heating domestic hot water-.

An air-source (air-air) heat pump's electric energy consumption is calculated as per Equation (6.13), using only the heating energy consumption of those spaces that are affected by the heat pump. In that case, the heating energy consumption of those spaces must be calculated separately.

If more accurate data is not available, the SPF-index values from Tables 6.14-6.16 may be used in Equation (6.13) for the different heat pump types. The SPF-index values are the same for weather zones I and II. Tables 6.14-6.15 show that the temperature level of the heat distribution network affects heat pump performance. If the temperature level of the heat distribution network rises, the heat pump performance will drop and the SPF index will be lower. The heat pump performance also depends on the temperature level of the heat source; for example, the outdoor temperature will affect the SPF-index of air-source heat pumps (Table 6.14).

If the heat distribution network temperature levels presented in Tables 6.14-6.15 do not correspond to the temperature levels of the network for which the calculation is performed, the intermediate values for the SPF-index presented in the table may be determined by interpolation.

The use of a ground-source heat pump for cooling a building will raise the ground temperature and reduce the risk of the ground freezing in the long term. Thus using a ground-source heat pump for cooling will, in the long run, improve the pump's operating conditions for heating as well.

Table 6.14. SPF-indexes for air-source heat pumps

Air-source heat pumps max. temperature (return water) °C	SPF-index		
	Weather zones		
	I-II	III	IV
Air-air	2.8	2.8	2.7
Air-water *(heating of spaces)*			
30	2.8	2.8	2.7
40	2.5	2.5	2.4
50	2.3	2.3	2.2
60	2.2	2.1	2.0
Air-water *(heating of domestic water)*			
60	1.8	1.6	1.3

Table 6.15. SPF-indexes for ground-source heat pumps

Ground-source heat pump max. temperature (return water) °C	SPF-index	
	Annual mean temperature of the collection pipe system, °C	
	-3	+3
Space heating		
30	3.4	3.5
40	3.0	3.1
50	2.7	2.7
60	2.5	2.5
DHW heating		
60	2.3	2.3

Table 6.16. Exhaust air heat pump combined SPF-indexes for heating spaces and domestic hot water if the exhaust air temperature is 21 °C.

Exhaust air heat pump	SPF-index
Waste air min. temperature	
+1	2.1
+3	2.0
+5	1.9

The SPF-index of heat pumps may be calculated more accurately using the method presented in the Ministry of the Environment guide or other suitable method, such as using product data that were measured using the test methods of standards SFS EN 255-3 or SFS EN 14511-3 or otherwise verified by suitable means. The COP to be used in determining the SPF-index of a heat pump must take into consideration energy that might be used for thawing and for the heat pump's auxiliary devices, such as regulators and blowers, as well as the pumps' electric energy consumption as presented in Standard SFS EN 14511-3.

The electric energy consumption of auxiliary devices that are not included in the measured values of the COP, such as the collection pipe system in some devices, and the electric energy consumption of pumps in distribution pipe systems, must be considered separately when calculating the SPF-index.

The SPF-index values to be used in Equation (6.4), calculated separately for heating spaces and domestic hot water, are calculated using Equations (6.14) and (6.15)

$$SPF_{spaces} = \frac{Q_{\text{HP, heating, spaces}}}{E_{\text{HP, spaces}} + E_{\text{aux, spaces}}} \tag{6.14}$$

where:

$Q_{\text{HP, heating, spaces}}$	annual energy for heating spaces generated by a heat pump, kWh
$E_{\text{HP, spaces}}$	annual electric energy consumption of a heat pump for heating spaces, kWh
$E_{\text{aux, spaces}}$	annual electric energy consumption of heat pump auxiliary devices (heating of spaces), which is not included in the measured values of the heat pump's COP, kWh.

$$SPF_{DHW} = \frac{Q_{\text{HP, heating, HDW}}}{E_{\text{HP, HDW}} + E_{\text{aux, HDW}}} \qquad (6.15)$$

where:

$Q_{\text{HP, heating, DHW}}$	annual energy for heating DHW generated by a heat pump, kWh
$E_{\text{HP, DHW}}$	annual electric energy consumption of a heat pump for domestic hot water, kWh
$E_{\text{aux, DHW}}$	annual electric energy consumption of heat pump auxiliary devices (domestic hot water), which is not included in the measured values of the heat pump's COP, kWh.

A combined SPF-index for heating spaces and domestic hot water is calculated using Equation (6.16).

$$SPF_{spaces+DHW} = \frac{Q_{\text{HP, heating}}}{E_{\text{HP}} + E_{\text{aux}}} \qquad (6.16)$$

where:

$Q_{\text{HP, heating}}$	annual energy consumption for heating spaces and domestic hot water that can be generated by a heat pump, kWh
E_{HP}	annual electric energy consumption of a heat pump for heating spaces and domestic hot water, kWh
E_{aux}	annual electric energy consumption of heat pump auxiliary devices (heating of spaces and DHW), which is not included in the measured values of the heat pump's COP, kWh.

Since the electric energy consumption of a heat pump blower is included in the SPF-index, the blower's electric energy consumption need not be considered in calculating the electric energy consumption of the ventilation system, if the building ventilation machine is equipped with an exhaust air heat pump.

The annual electric energy consumption of heat pump auxiliary devices E_{aux}, which is not included in the measured values of the heat pump's COP, is calculated using Equation (6.17).

$$E_{aux} = P_{aux}\,\Delta t \qquad (6.17)$$

where:

P_{aux}	electric power of heat pump auxiliary devices, kW
Δt	pump running time during a counting cycle, h.

7

VENTILATION SYSTEM ENERGY CONSUMPTION

Calculations in this chapter
Specific electric power of a ventilation system
Energy consumption of a ventilation system
Heating of supply air in the blower

Minimum source data required for calculations
Electric power of the ventilation machines
Air flows of the ventilation machines

7.1
The electric energy consumption of blowers or ventilation machines is calculated using Equation (7.1), as the product of specific power, air flow, and running time.

$$W_{ventilation} = \Sigma P_{es}\, q_v\, \Delta t \qquad (7.1)$$

where:

$W_{ventilation}$	electric energy consumption of the ventilation machine or blower, kWh
P_{es}	specific electric power of a ventilation machine or blower, kW/(m^3/s)
q_v	air flow of a ventilation machine or blower, m^3/s
Δt	running time of a ventilation machine or blower during a counting cycle, h.

If needed, the effect of controlled ventilation should be calculated separately using suitable methods. In planning the ventilation system, the specific power should not exceed 2.0 kW(m^3/s) (mechanical supply air and exhaust air system) or 1.0 kW(m^3/s) (mechanical exhaust air system).

7.2
The specific power of the ventilation system is calculated using Equation (7.2).

$$P_{es} = \frac{P_e}{q_v} \qquad (7.2)$$

where:

P_{es}	specific electric power of a ventilation machine or blower, kW/(m^3/s)
Pe	electric power of a ventilation machine or blower, kW
q_v	air flow of a ventilation machine or blower, m^3/s

Explanation
The pressure loss of the ventilation system and the blower efficiency will affect the ventilation system's specific power. The greater of the non-charged exhaust air flow or the supply air flow during the running time is used to calculate the specific power of the ventilation machine.

7.3

The temperature of the blower's air flow is calculated using Equation (7.3)

$$\Delta T = \frac{P_{es} p_s}{\rho c_p} = \frac{P_e p_s}{\rho c_p q_v} \qquad (7.3)$$

where:

pind	ratio between the heat output transferred to the air and the blower's electric power, -
p	air density, kg/m^3
cp	specific heat capacity of air, kJ/kgK

The values in Table (7.1) are used for ratio p_s.

Table 7.1 Ratio between the heat output transferred to the air and the blower's electric power, p_s

Blower motor placement	ps
In the air flow	1.0
Not in the air flow	0.6
Placement not known	0.8

If required source data is not available, an assumed value of 0.5 K should be used.

8

COOLING SYSTEM ENERGY CONSUMPTION

Calculations in this chapter
Electric energy consumption of the cooling system
Electric energy consumption of the cooling system's auxiliary devices

Minimum source data required for calculations
Annual cooling energy used by the ventilation machine's cooler battery
Annual cooling energy used by room units

The cooling energy required for cooling spaces in a building is brought into the spaces by an air flow, water flow or both simultaneously, Figure 8.1. The energy consumption of the cooling system comprises the energy for producing cooling energy (compressor unit, water tower, etc.) and the electric energy consumption of the auxiliary devices.

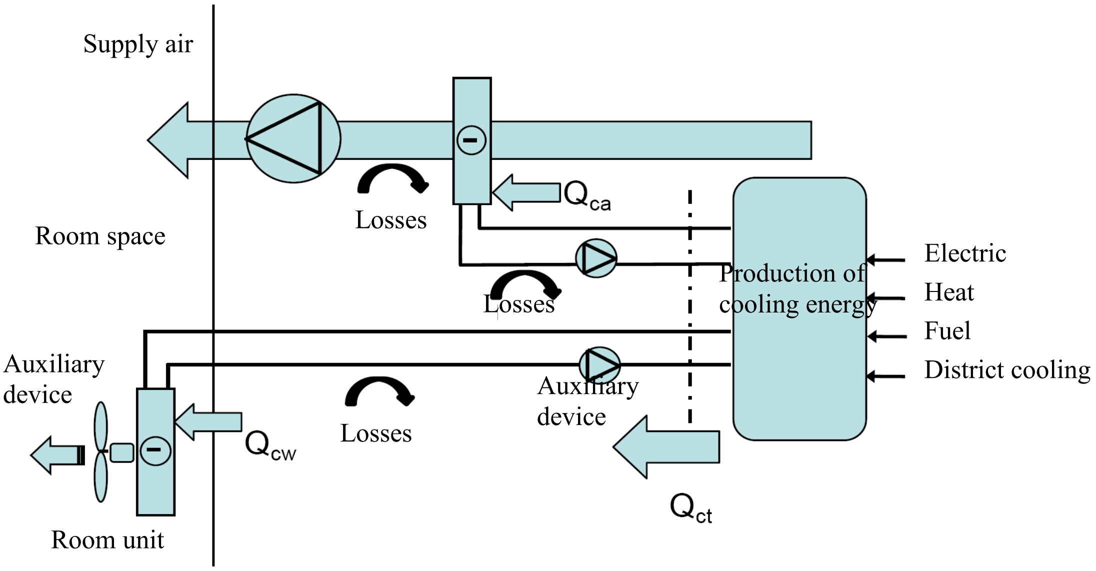


Figure 8.1 Principle diagram of a cooling system

The annual energy consumption of the cooling system is estimated based on the annual cooling energy of the ventilation cooling battery Q_{ca}, the cooling energy of the room units Q_{cw}, and the properties of the cooling system. The annual energies mentioned are calculated in connection with the cooling energy need of spaces, using a suitable energy simulation program and maximum time intervals of one hour. The annual cooling energy generated by a cooling system Q_{ct} equals

$$Q_{ct} = (1+\beta_{sca})\, Q_{ca}+(1+\beta_{scw})\, Q_{cw} \qquad (8.1)$$

Q_{ca}	annual cooling energy used by the ventilation machine's cooler battery, kWh/a
Q_{cw}	annual cooling energy used by room units, kWh/a
β_{sca}	factor taking into account the air-side losses (thermal, condensation) of a system
β_{scw}	factor taking into account the water-side losses (thermal) of a system.

Depending on the calculation method (program), the annual cooling energy used by the ventilation machine's cooler battery includes the energy needed to condense air humidity in the battery (wet battery) or not (dry battery). This must be taken into consideration when using the loss factors in Table 8.2. If the annual cooling energy consumed by the cooler battery includes the energy required for condensing, the value for factor β_{sca} in Table 8.2 to be used is the one not including the effect of condensing. However, if condensing is not included in the battery's energy consumption, it must be taken into consideration by using the appropriate factor.

The annual electric energy need E_{sys} (kWh/a) of a system that uses electric energy to produce cooling energy (not including the electric energy for auxiliary devices) is calculated using equation

$$E_{sys} = \frac{Q_{ct}}{\varepsilon_E} \tag{8.2}$$

ε_E annual energy efficiency ratio of the cooling energy production process.

Correspondingly, the annual energy need of a system using heating or cooling energy (absorption cooling or district cooling) is calculated using the following equation:

$$Q_{sys} = \frac{Q_{ct}}{\varepsilon_Q} \tag{8.3}$$

ε_Q annual energy efficiency ratio (EER) of the cooling energy production process.

The annual EER of a cooling energy production process is defined as the ratio between the annual amount of cooling energy produced and the annual amount of energy used by the process. The energy used in the production process thus contains the pump energy for condensing, condenser blower energy, cooling tower blower energy, etc. and other energy used directly in the cooling process.

Guideline values for the annual EER are presented in Table (8.1) and for loss factors in Table (8.2). Manufacturer's verified performance data may be used in lieu of the guideline values.

Table 8.1 **Annual EERs for the cooling energy production process**

Cooling energy production method	ε_E	ε_Q
Compressor-refrigerant unit, air condenser	2.5	-
Compressor-refrigerant unit, water condenser	3	
Independent system, refrigerant (dry)	5	-
Independent system, cooling tower (wet)	7	-
Independent system, buried pipes (vertical)	30	-
Split systems	3	-
District cooling (heat exchanger)	-	1
Absorption cooling	-	0.7

Table 8.2	Guideline values for cooling loss factors		
Cooling return water temperature	β_{sca} [1)]	β_{sca} [2)]	β_{scw}
7 C	0.3	0.6	0.2
10 C	0.2	0.5	0.15
15 C	0.1	0.2	0.1

1) Does not include condenser losses
2) Includes condenser loss

If cooling energy in a building is produced by two different processes, such as by an independent system and a supplemental compressor unit, the annual energy need of the system is calculated using Equation

$$E_{sys} = \alpha_1 \frac{Q_{ct}}{\varepsilon_{E1}} + \alpha_2 \frac{Q_{ct}}{\varepsilon_{E2}} \quad (8.4)$$

α_1	relative share of annual cooling energy generated by process 1,
α_2	relative share of annual cooling energy generated by process 2, (a1 + a2 = 1.0)
ε_{E1}	EER of production process 1,
ε_{E2}	EER of production process 2.

In addition to the above, systems use electric energy for pumps, blowers, and other auxiliary devices in the delivery and distribution of cooling energy. The pumping energy needed for cooling energy distribution and the energy needed to boost cooling energy delivery is included in the electric energy consumption of auxiliary devices, such as the blower energy of a blower convector. Not included in the electric energy consumption of auxiliary devices is the blower energy used in the air transfer of ventilation or air-conditioned air or the energy used in the cooling energy production process. The electric energy consumption of auxiliary devices depends on the system type and is calculated using equation

$$E_{ac} = \beta_{ac} Q_{ct} \quad (8.5)$$

β_{ac} system's annual electric energy consumption factor of auxiliary devices

Guideline values for consumption factors are given in Table (8.3). Data obtained with a more accurate method may be used in lieu of the guideline values.

Table 8.3 Guideline values for electric energy consumption factors for cooling system auxiliary devices

Cooling system	$\boldsymbol{\beta}_{ac}$
Chilled-water system, chilled beam	0.06
Chilled-water system, blower convector	0.08
Air-cooled system, IMS system	0.05

9

HEATING POWER

Calculations in this chapter
Heating power needs of buildings
Heat output conducted through buildings
Power required for heating air leakages
Power required for heating supply air in a space
Power required for heating make-up air
Heater battery power of ventilation machines
Power required for heating domestic water

Minimum source data required for calculations
Surface areas of building components
Thermal transmittance factors of building components
Air volume of a building
Ventilation air flows
Temperature ratios of ventilation heat recovery under design conditions
Normal flow of domestic hot water
Heating system efficiencies

9.1 Heating power needs of buildings

9.1.1
The heating power needs of buildings are usually calculated room-specifically, thus allowing the room-specific calculation of heating power needs and the design and selection of appropriate heating devices.

The heating power need of buildings depends primarily on the conduction heat losses of buildings, air leakages, and ventilation. The heating power need is calculated using the design outdoor temperature of the location (Annex 1). If the outdoor air needed for ventilation is brought in directly from outside or at low temperatures, the required power must be considered when designing the room-specific heaters. The after-heating of supply air in the ventilation machine is considered in the design of the heater battery of the ventilation machine.

The heating power need of a building is the sum of the room-specific, simultaneous heating power needs, plus the possible power needed for heating supply air (depending on the ventilation system), plus the power needed for heating DHW at the same time.

The effects of internal heat sources on the power needs will be considered only if they are significant and continuous. Likewise, solar radiant heat is not considered in calculating the power need. The thermal capacity of buildings is considered in the calculation of the design heating output for non-continuous heating.

The design of the heat generating devices may deviate from the calculated heating power need. For example, in systems with storage tanks, the daily energy can be brought into the tank or storage structures within several hours. The power is thus multiplied in regards to the continuous heating power need. On the other hand, large power peaks of domestic hot water may be supplied from the storage tank, in which case the storage can be reheated slowly for the next use using very little power.

For devices used in periodic and part-time heating, the design depends heavily on the power need at the time heating returns, which is affected by the return heating time, the structures’ thermal capacity (solidity), the permitted temperature drop, and the length of the heating period.

9.1.2

Heating power need of a building Φ_{heating} is calculated by adding the simultaneous power needs using Equation (9.1).

$$\Phi_{\text{heating}} = \frac{\phi_{\text{room heating}}}{\eta_{\text{room heating}}} + \frac{\phi_{\sup plyairbattery}}{\eta_{\sup plyair}} + \frac{\phi_{hdw}}{\eta_{hdw}} \qquad (9.1)$$

where:

Φ_{heating}	building's heating energy need, W
$\Phi_{\text{room heating}}$	room heating power need, W
$\Phi_{\text{supply air battery}}$	heating power need for a ventilation supply air after-heater battery, W
Φ_{dhw}	power required to heat domestic hot water, W
$\eta_{\text{room heating}}$	efficiency of a room heating system under design conditions, -.
$\eta_{\text{supply air}}$	efficiency of a ventilation supply air heating system under design conditions, -.
η_{dhw}	efficiency of a domestic hot water heating system under design conditions, -.

The efficiencies of heating systems can be defined using the method described in chapter 6. If the systems' efficiencies are not known at the time of design, 0.9 may be used as the efficiency value. However, the efficiency value used for direct electric heating of indoor air or supply air is usually 1.0.

9.1.3

The heating energy need for heating spaces | space is calculated using Equation (9.2)

$$\Phi_{space} = \Phi_{cond} + \Phi_{air\ leakage} + \Phi_{supply\ air} + \Phi_{make\text{-}up\ air} \qquad (9.2)$$

where:

Φ_{space}	heating power required to heat spaces, W
Φ_{conduct}	conduction heat loss through the building shell, W
$\Phi_{\text{air leakage}}$	air leakage heat loss, W
$\Phi_{\text{supply air}}$	power for heating supply air in a space, W
$\Phi_{\text{make-up air}}$	power for heating make-up air in a space, W

9.2 Conductive heat loss of the building shell

9.2.1

The conductive heat loss of the building shell is the sum of the conductive heat losses of exterior walls, windows, exterior doors, ceiling, floor, and thermal bridges.

Heating power for conduction cond is calculated using Equation (9.3)

$$\Phi_{conduct} = \Phi_{exterior\ wall} + \Phi_{ceiling} + \Phi_{floor} + \Phi_{window} + \Phi_{door} + \Phi_{thermal\ bridges} \qquad (9.3)$$

The heat losses of building components are calculated for each component using equation (9.4).

$$\Phi = \Sigma U_i A_i \, (T_{IND} - T_{outd,\ design}) \qquad (9.4)$$

The thermal bridge heat losses caused by joints between building components are calculated using Equation (9.5).

$$\Phi_{thermal\ bridges} = (\Sigma_k l_k \Psi_k + \Sigma_j \chi_j)(T_{ind} - T_{outd}) \qquad (9.5)$$

where

Φ	conductive heat loss of a building component, W
U_i	thermal transmittance factor for a building component, W/(m^{2}K)
A_i	floor area of a building component, m^2
T_{ind}	indoor air temperature, °C
$T_{outd\ design}$	design outdoor air temperature, °C
l_k	length of a linear thermal bridge caused by the joints in building components, m
Ψ_k	additional thermal bridge conductance caused by joints between building components, W/(m K)
χ_j	additional conductance caused by joints between building components, W/K

The outside temperature for the design situation is selected depending on the location according to the weather data table in Annex 1.

9.2.2
When calculating the room-specific heating power, the power escaping into adjacent rooms must be added to the conduction heating power, if applicable. The power escaping into adjacent rooms is calculated according to Equation (9.3), using the coefficients of thermal transmittance between building components from the specific heat loss calculation and for the temperature difference, the difference between the spaces' indoor temperatures.

9.2.3
The conduction power through the floor is calculated using Equation (9.3), if heat conduction through the floor is mainly into the outdoor air. If the air temperature below the floor is always the same as the outdoor temperature, the actual outdoor temperature must be used for the design.

9.2.4
If the crawl space under the floor is partially closed off, so that ventilation openings take up no more than 0.8 % of the floor surface area, the design temperature to be used is the annual mean temperature less 2 °C.

9.2.5
The heat output conducted into the ground is calculated using Equation (9.3). In this case, the sum of the values for structures and ground calculated in accordance with Part C4 of the National Code of Building Regulations of Finland shall be used as the coefficient of thermal transmittance. The design outdoor temperature to be used is the mean temperature plus 2 °C. The surface area is the floor area that is in direct contact with the ground.

9.3 Power required for heating air leakages

9.3.1
The power required for heating air leakages $\Phi_{air\ leakage}$ is calculated using Equation (9.6).

$$\Phi_{air\ leakage} = \rho_i c_{pi} q_{v,\ air\ leakage}(T_{ind} - T_{outd,design}) \qquad (9.6)$$

where:

$\Phi_{air\ leakage}$	power required for heating air leakages, W
ρ_i	air density, 1.2 kg/m^3
c_{pi}	specific heat capacity of air, 1 000 Ws/(kgK)
$q_{v,\ air\ leakage}$	air leakage flow, m^3/s
T_{ind}	indoor air temperature, °C
$T_{outd\ design}$	design outdoor air temperature, °C

9.3.2
If there are good reasons to assume that the building is exceptionally airtight or leaking air, the air leakage must be estimated separately. In below-ground basement spaces and spaces in the middle of the building, air leakages usually need not be considered.

9.4 Power required for heating supply air in a space

9.4.1
Power required for heating supply air in a space $\Phi_{\text{supply air}}$ is calculated using Equation (9.7).

$$\Phi_{\textit{supply air}} = \rho_{\mathrm{i}}\, c_{\mathrm{pi}}\, q_{\mathrm{v,\ supply\ air}} (T_{\mathrm{ind}} - T_{ib}) \tag{9.7}$$

where:

$\Phi_{\text{supply air}}$	power required for heating supply air in a space, W
ρ_{i}	air density, 1.2 kg/m^3
c_{pi}	specific heat capacity of air, 1 000 Ws/(kgK)
$q_{\mathrm{v,\ air\ leakage}}$	air leakage flow, m^3/s
T_{ind}	indoor air temperature, °C
T_{ib}	inblown air temperature, °C

9.5 Power required for heating make-up air

9.5.1
The power required for heating make-up air $\Phi_{\text{make-up air}}$ is calculated using Equation (9.8).

$$\Phi_{\textit{make-up air}} = \rho_{\mathrm{i}}\, c_{\mathrm{pi}} q_{\mathrm{v,\ make\text{-}up\ air}} (T_{ind} - T_{outd,design}) \tag{9.8}$$

where:

$\Phi_{\text{make-up air}}$	power required for heating make-up air, W
ρ_{i}	air density, 1.2 kg/m^3
c_{pi}	specific heat capacity of air, 1 000 Ws/(kgK)
$q_{\mathrm{v,\ air\ leakage}}$	air leakage flow, m^3/s
T_{ind}	indoor air temperature, °C
$T_{\mathrm{outd,\ design}}$	design outdoor air temperature, °C

9.5.2
The make-up air volume is calculated using Equation (9.9).

$$q_{\textit{make-up air}} = q_{\mathrm{v,exhaust}} - q_{\mathrm{v,supply}} \tag{9.9}$$

9.6 Heater battery power of ventilation machines

9.6.1
In calculating the power need, planned air flows should be used, but at least air flows specified in Part D2 of the National Code of Building Regulations of Finland. The power of heating devices need not be designed to consider temporary boosts, such as stove exhaust hoods in small houses, in the maximum exhaust air flow.

Power to be recovered from exhaust air and used to heat supply air is calculated by considering the efficiency of the heat recovery device at design temperature, including the operation of the recovery device's freeze protection, potential changes in air flows, as well as usable electric power from the supply air blower.

The effect of the exhaust air heat pump on the ventilation heating power need is calculated separately, taking into consideration what the recovered heat will be used for.

9.6.2

The heating power required for the ventilation system of the whole building is calculated for each ventilation machine
using Equation (9.10).

$$\Phi_{vent} = \rho_i c_{pi} q_{v,\,supply}(T_{ib} - T_{recov,\,design}) \tag{9.10}$$

where

Φ_{iv}	power of ventilation heater battery, W
ρ_i	air density, 1.2 kg/m3
c_{pi}	specific heat capacity of air, 1 000 Ws/(kgK)
$q_{v,supply}$	supply air flow, m3/s
T_{ib}	inblown air temperature, °C
$T_{recov,\,design}$	temperature after heat recovery device, °C

The supply air temperature after heat recovery is calculated using Equation (9.11)

$$T_{recov,design} = T_{outd,design} + \eta_{t,design}\,(T_{ind} - T_{outd,design}) \tag{9.11}$$

where:

$T_{outd,design}$	design outdoor air temperature, °C.
$\eta_{t,design}$	supply air temperature ratio in heat recovery under design conditions
T_{ind}	indoor temperature, °C

9.6.3

In calculating the heating power, a deterioration of the exhaust air temperature ratio must be taken into consideration, for example by by-passing the heat recovery so that the heat exchanger will not freeze. The manufacturer's stated and verified value should be used as the waste air temperature value for the design situation. If a manufacturer's value is not available, the limit temperature values to prevent freezing to be used in the power need calculation are: 0 °C in dry office spaces and +5 °C in normal residential buildings, manufacturer, freeze protection, and usage conditions permitting.

If heat recovery is able to raise the supply air temperature above the supply air temperature set value, the value obtained in Equation (9.10) will be negative. In that case, the power need for the supply air after-heater battery will be 0 W.

Explanation

A potentially lower temperature ratio resulting from the freeze protection of the heat recovery device is calculated using bulletin 122 of the Ministry of the Environment.

9.7 Power required for heating domestic water

9.7.1

The power required for heating domestic water is calculated in accordance with Part D1 of the National Code of Building Regulations of Finland, using the building-specific flows specified for domestic hot water. If applicable, the heat loss of the circulation pipes should be added to the power need. Usually, the heat loss of the circulation pipes is small compared to the overall power need for domestic hot water.

The power required for heating domestic hot water is calculated using Equation (9.12).

$$\Phi_{dhw} = \rho_v c_{pv} q_{v,\,dhw}(T_{dhw} - T_{cw}) + \Phi_{dhw,circloss} \qquad (9.12)$$

where:

Φ_{dhw}	power required for heating domestic hot water, kW
ρ_v	water density, 1 000 kg/m^3
c_{pv}	specific heat capacity of water, 4.2 kJ/kgK
$q_{v,\,dhw}$	maximum normal flow of domestic hot water, m^3/s
T_{dhw}	domestic hot water temperature, °C
T_{cw}	domestic cold water temperature, °C
$\Phi_{dhw,circloss}$	power required by the DHW circulation pipe, kW

Unless there are good reasons to use different values, the value to be used for the temperature difference between cold and hot water $(T_{dhw} - T_{cw})$ is 50 °C.

9.7.2

If the domestic hot water is heated in a water tank, the charging power of the tank is usually lower than the power needed for heating water under design flow conditions. The tank's charging power and storage capacity are usually designed to correspond a day's consumption. The tank heat losses must be considered when designing the charging power.

If applicable, the power need for DHW calculation should include the circulation pipe heat loss; the heating power need is calculated using Equation (9.13) or (9.14).

$$\Phi_{dhw,circloss} = \Phi_{dhw,circloss,\,spec} A \qquad (9.13)$$

$$\Phi_{cw,\,circloss} = \rho_v c_{pv} q_{v,\,dhw,\,circ}\,(T_{dhw} - T_{dhw,\,circ,\,return}) \qquad (9.14)$$

where:

$\Phi_{dhw,circloss}$	power required by the DHW circulation pipe, kW
$\Phi_{dhw,circloss,\,spec}$	specific power required by DHW circulation pipes, kW/m^2
A	net heated area of a building, m^2
$q_{v,\,dhw,\,circ}$	designed flow of domestic hot water in circulation pipes, m^3/s
T_{dhw}	domestic hot water temperature, °C
$T_{dhw,\,circ,\,return}$	temperature of the return water in the DHW circulation pipe, °C

Unless there are good reasons to use different values, the value to be used for the temperature difference between hot water and return water from HDW circulation $(T_{dhw} - T_{dhw,\,circ,\,return})$ is 5 °C.

Unless it can be proven otherwise, the specific power need for heating domestic hot water in residential and similar buildings is 0.002 kW/m^2, if no dryer battery is connected to the circulation pipes. If a dryer battery is connected to the circulation pipes, the specific power value to be used is 0.004 kW/m^2. In other types of buildings, the specific power is half of that of residential buildings.

10

ELECTRIC ENERGY PRODUCED BY A PHOTOVOLTAIC SYSTEM

Calculations in this chapter
Electric energy produced by solar cells (PV cells)

Minimum source data required for calculations
Cell surface area, alignment and inclination angle, maximum power coefficient, information about installation method, radiation on the horizontal

10.1 Electric energy produced by a photovoltaic system

The electric energy $E_{s,pv,out}$ [kWh/year] produced by a photovoltaic system connected to a building may be calculated using this method, which follows the method in Standard SFS EN 15316-4-6:2007, having an Annex with national factors and table values.

The method only applies when calculating the electric energy produced photovoltaic systems integrated in buildings; the method does not cover the transfer, distribution, and storage of electric energy.

The electric energy of photovoltaic cells is calculated using Equation (10.1)

$$E_{s,pv,out} = \frac{E_{sol} \cdot P_{\max} \cdot F_{\text{usage}}}{\mathrm{I}_{\text{ref}}} \qquad (10.1)$$

where:

E_{sol} is	the annual radiant energy directed at photovoltaic cells [kWh/m^2,a]
P_{max}	maximum electric power produced by photovoltaic cells whose cells produce in reference radiation (I_{ref}=1 kW/m^2, at reference temperature 25 °C) [kW]
F_{usage}	performance factor for the usage scenario [-]
I_{ref}	reference radiation [1 kWh/m^2]

The solar radiation directed at the cells during a year is calculated using Equation (10.2).

$$E_{sol} = E_{sol,hor} \, F_{position} \qquad (10.2)$$

where:

$E_{sol,hor}$ is	the annual amount of total solar radiant energy directed at a horizontal area which is dependent on the building location [kWh/m^2,a]. From Table 10.1.
$F_{position}$	correction factor for photovoltaic cell direction and inclination angle [-]. From Table 10.2.

The maximum electric power Pmax produced by the photovoltaic cells is the device's tested power under standard conditions. The method is described in standard EN61829. If a test result is not available, Pmax is calculated using Equation (10.3).

$$P_{max} = K_{max} \, A \qquad (10.3)$$

where:

K_{max} is the maximum power coefficient, which depends on the solar cell type. [kW/m^2] From Table 10.3.

A surface area of the photovoltaic cell (without frame)

The performance factor for the usage scenario F_{usage} takes into consideration factors in the photovoltaic cell's environment, such as the conversion of direct current to alternating current, and the effects of cell operating temperature and cell installation.

The method does not take into account the shading from the environment and buildings, and if it occurs, it is considered by correcting factor F_{usage}, the amount of the shade relative to the total cell surface area $(1-A_{shade}/A_{total\ area})$

The potentially required supplemental energy consumption by the photovoltaic cells is not calculated separately, and the energy produced by the photovoltaic cells includes the net energy only.

Potential heat energy produced by or recovered from the photovoltaic cells will not be considered in the building's energy balance calculation.

The correction factor Fposition for compass direction and inclination angle is calculated using Equation (10.4)

$$F_{position} = F_1 F_2 \tag{10.4}$$

where F_1 is the factor for the compass direction
where $_F2$ is the factor for inclination angle

Table 10.1 F_1 is the factor for the compass direction (-).

Facing	F1
south/southeast/southwest	1
east/west	0.8
north/northeast/northwest	0.6

Table 10.2 F_2 is the factor for inclination angle (-)

Inclination angle	Factor
<30°	1
30°...70°	1.2
>70°	1

Table 10.3. Maximum power coefficient K_{max}, which depends on the photovoltaic cell type (kW/m^2

Photovoltaic cell type	Maximum power coefficient K_{max} kW/m^2
Monocrystalline silicon cells *	0.12...0.18
Multicrystalline silicon cells *	0.10...0.16
Thin-film silicon cells	0.04...0.08
Other thin-film cells	0.035
Thin-film $CuInGaSe_2$ solar cell	0.105
Thin-film CdTe solar cell	0.095
* Packing density >80 %	

Table 10.4. Performance factor for the usage scenario F_{usage}[-]

Installation method for the photovoltaic cell	Performance factor for the usage scenario F_{usage}[-]
Module without ventilation	0.70
Module with light ventilation	0.75
Module with heavy ventilation or mechanical ventilation	0.80

ANNEX 1

Weather information used in calculating energy consumption

The energy consumption can be calculated using the weather data in this Annex. Finland is divided into four weather zones. The weather zones are shown in Figure Ll.l. The borders between zones III and IV have been drawn more accurately compared with the previous division, in order to better match the mean distribution of annual mean temperatures in Finland. The mean outdoor air temperatures and solar radiant energy in the weather zones (Tables L1.2 - L1.4) are based on measurements during test years performed at meteorological observing stations at Helsinki-Vantaa airport (weather zones I and II), Jyväskylä airport (weather zone III) and the Finnish Meteorological Institute in Sodankylä (weather zone IV). Design and mean outdoor air temperatures (Table L1.1.) are presented separately for weather zones I and II. The data of weather zone II are based on weather observations by Jokioinen weather station. The standard heating need index (S17) is helpful when comparing the heating needs in test years with the heating needs in other years or of other locations.

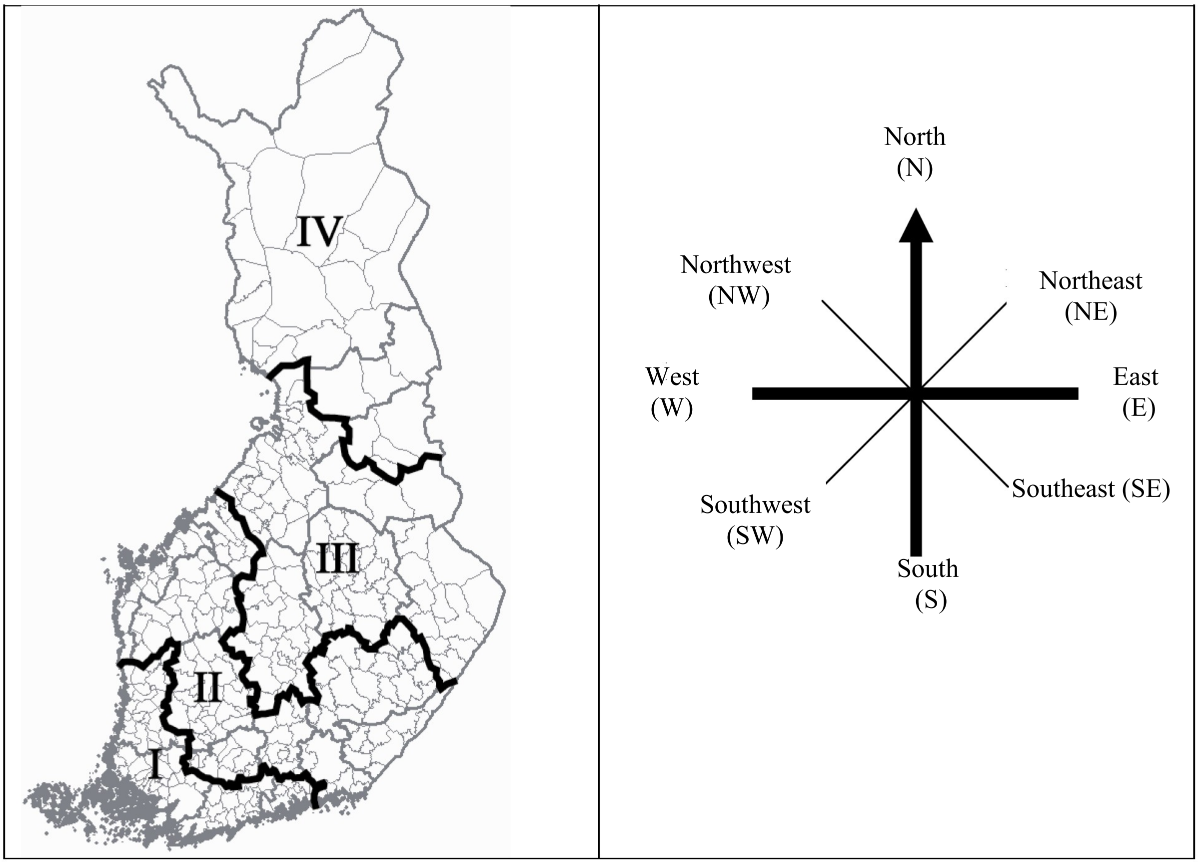


Figure L1.1. Weather zones.

Table L1.1. *Design and mean outdoor air temperatures in different weather zones.*

Weather zone	Design outdoor air temperature, °C	Mean annual outdoor air temperature, °C
I	-26	5.4
II	-29	4.7
III	-32	3.3
IV	-38	-0.3

Table L1.2. Weather data by month for weather zones I and II. Helsinki-Vantaa.

Month	Mean outdoor air temperature, T_{out}, °C	Total solar radiant energy on a horizontal $G_{radiant,\ horizontal}$, kWh/m^2	Heating need index S17, Kd used for standardisation
January	-3.97	**6.2**	650
February	-4.50	**22.4**	602
March	-2.58	**64.3**	607
April	4.50	**119.9**	354
May	10.76	**165.5**	117
June	14.23	**168.6**	9
July	17.30	**180.9**	0
August	16.05	**126.7**	31
September	10.53	**82.0**	161
October	6.20	**26.2**	331
November	0.50	**8.1**	495
December	-2.19	**4.4**	595
Year total	5.57	**975**	3 952

Total solar radiant energy on vertical surfaces facing different directions, $G_{radiant,\ vertical}$, kWh/m^2

Month	N	NE	E	SE	S	SW	W	NW
January	**6.2**	**4.7**	**3.8**	**9.5**	**12.9**	**9.5**	**3.8**	**4.7**
February	**17.3**	**13.8**	**15.6**	**31.0**	**41.4**	**30.9**	**15.6**	**14.0**
March	**40.3**	**38.1**	**48.5**	**75.1**	**89.5**	**69.4**	**43.7**	**36.9**
April	**43.9**	**56.3**	**79.9**	**101.1**	**107.3**	**101.6**	**80.6**	**56.8**
May	**57.8**	**82.1**	**112.8**	**123.3**	**116.0**	**117.5**	**104.5**	**76.3**
June	**70.6**	**87.9**	**109.6**	**109.9**	**101.6**	**110.9**	**111.2**	**89.1**
July	**66.3**	**91.1**	**118.8**	**123.1**	**115.5**	**128.6**	**122.7**	**91.2**
August	**50.0**	**66.4**	**91.8**	**106.0**	**100.4**	**92.8**	**78.8**	**61.1**
September	**32.9**	**37.5**	**56.5**	**83.9**	**100.5**	**87.3**	**59.3**	**38.1**
October	**17.9**	**15.6**	**17.5**	**28.3**	**37.0**	**30.0**	**18.8**	**15.7**
November	**7.2**	**5.5**	**5.1**	**12.3**	**16.8**	**12.3**	**5.1**	**5.6**
December	**4.2**	**3.2**	**2.6**	**8.4**	**11.8**	**8.8**	**2.9**	**3.2**
Year total	**414.6**	**502.2**	**662.5**	**811.9**	**850.7**	**799.6**	**647.0**	**492.7**

Conversion factor $F_{direction}$ converts the total solar radiant energy on a horizontal surface to total radiant energy on a vertical surface by compass direction

Month	N	NE	E	SE	S	SW	W	NW
January	**0.995**	**0.757**	**0.609**	**1.531**	**2.080**	**1.519**	**0.605**	**0.759**
February	**0.774**	**0.618**	**0.700**	**1.387**	**1.854**	**1.381**	**0.700**	**0.624**
March	**0.627**	**0.592**	**0.754**	**1.169**	**1.392**	**1.079**	**0.679**	**0.574**
April	**0.366**	**0.470**	**0.666**	**0.843**	**0.895**	**0.847**	**0.672**	**0.474**
May	**0.349**	**0.496**	**0.681**	**0.745**	**0.701**	**0.710**	**0.632**	**0.461**
June	**0.419**	**0.521**	**0.650**	**0.652**	**0.602**	**0.658**	**0.659**	**0.528**
July	**0.367**	**0.503**	**0.657**	**0.681**	**0.639**	**0.711**	**0.679**	**0.504**
August	**0.395**	**0.524**	**0.725**	**0.837**	**0.793**	**0.732**	**0.622**	**0.482**
September	**0.401**	**0.457**	**0.689**	**1.023**	**1.225**	**1.064**	**0.723**	**0.465**
October	**0.683**	**0.595**	**0.670**	**1.081**	**1.412**	**1.144**	**0.718**	**0.598**
November	**0.888**	**0.683**	**0.632**	**1.519**	**2.068**	**1.519**	**0.633**	**0.686**
December	**0.920**	**0.697**	**0.571**	**1.850**	**2.615**	**1.942**	**0.637**	**0.697**
Year total	**0.425**	**0.515**	**0.679**	**0.833**	**0.872**	**0.820**	**0.663**	**0.505**

Table L1.3. Weather data by month for weather zone III. Jyväskylä.

Month	Mean outdoor air temperature, Tout, °C	Total solar radiant energy on a horizontal $G_{\text{radiant, horizontal}}$, kWh/m^2	Heating need index S17, Kd used for standardisation
January	-8.00	**5.4**	775
February	-7.10	**20.1**	675
March	-3.53	**51.9**	637
April	2.42	**102.9**	437
May	8.84	**171.4**	210
June	13.39	**159.1**	60
July	15.76	**158.2**	22
August	13.76	**113.9**	78
September	9.18	**71.1**	218
October	4.07	**25.3**	401
November	-1.76	**7.3**	563
December	-5.78	**3.2**	706
Year total	3.44	**890**	4 782

Total solar radiant energy on vertical surfaces facing different directions, $G_{\text{radiant, vertical}}$, kWh/m^2

Month	N	NE	E	SE	S	SW	W	NW
January	**6.0**	**4.5**	**3.1**	**6.5**	**9.0**	**6.8**	**3.3**	**4.5**
February	**16.4**	**12.8**	**15.6**	**34.4**	**46.3**	**33.5**	**15.1**	**12.8**
March	**38.7**	**35.2**	**37.9**	**55.1**	**69.8**	**60.2**	**42.1**	**36.1**
April	**46.1**	**54.5**	**73.5**	**93.6**	**99.1**	**89.5**	**70.0**	**53.6**
May	**68.9**	**91.3**	**122.6**	**132.4**	**123.4**	**124.5**	**115.0**	**88.5**
June	**72.7**	**87.1**	**105.4**	**108.0**	**103.3**	**107.5**	**103.6**	**85.0**
July	**65.1**	**81.4**	**106.2**	**115.0**	**109.4**	**111.6**	**104.5**	**82.6**
August	**48.0**	**57.0**	**74.5**	**91.7**	**98.3**	**94.5**	**77.3**	**58.1**
September	**30.6**	**34.2**	**51.8**	**77.7**	**91.6**	**76.1**	**50.1**	**33.4**
October	**15.3**	**13.6**	**18.5**	**33.1**	**42.5**	**32.1**	**17.6**	**13.3**
November	**6.9**	**5.3**	**4.9**	**10.7**	**14.6**	**10.7**	**4.9**	**5.3**
December	**3.3**	**2.5**	**1.6**	**3.3**	**4.4**	**3.2**	**1.6**	**2.5**
Year total	**418.0**	**479.4**	**615.6**	**761.5**	**811.7**	**750.2**	**605.1**	**475.7**

Conversion factor $F_{direction}$ converts the total solar radiant energy on a horizontal surface to total radiant energy on a vertical surface by compass direction

Month	N	NE	E	SE	S	SW	W	NW
January	**1.094**	**0.833**	**0.568**	**1.189**	**1.651**	**1.256**	**0.610**	**0.824**
February	**0.817**	**0.636**	**0.778**	**1.712**	**2.306**	**1.670**	**0.750**	**0.639**
March	**0.747**	**0.678**	**0.730**	**1.063**	**1.346**	**1.160**	**0.811**	**0.696**
April	**0.448**	**0.530**	**0.715**	**0.910**	**0.963**	**0.870**	**0.681**	**0.521**
May	**0.402**	**0.533**	**0.715**	**0.773**	**0.720**	**0.726**	**0.671**	**0.517**
June	**0.457**	**0.547**	**0.662**	**0.679**	**0.649**	**0.675**	**0.651**	**0.534**
July	**0.412**	**0.514**	**0.671**	**0.727**	**0.692**	**0.705**	**0.661**	**0.522**
August	**0.422**	**0.500**	**0.654**	**0.805**	**0.863**	**0.830**	**0.679**	**0.510**
September	**0.430**	**0.481**	**0.729**	**1.093**	**1.288**	**1.071**	**0.705**	**0.470**
October	**0.604**	**0.535**	**0.729**	**1.305**	**1.675**	**1.268**	**0.695**	**0.523**
November	**0.937**	**0.717**	**0.665**	**1.459**	**1.984**	**1.458**	**0.665**	**0.719**
December	**1.015**	**0.762**	**0.503**	**1.006**	**1.352**	**0.997**	**0.500**	**0.765**
Year total	**0.470**	**0.539**	**0.692**	**0.856**	**0.912**	**0.843**	**0.680**	**0.535**

Table L1.4. *Weather data by month for weather zone IV. Sodankylä.*

Month	Mean outdoor air temperature, Tout, °C	Total solar radiant energy on a horizontal $G_{\text{radiant, horizontal}}$, kWh/m^2	Heating need index S17, Kd used for standardisation
January	-13.06	**1.4**	932
February	-12.62	**13.6**	830
March	-6.88	**48.0**	740
April	-1.56	**121.0**	557
May	5.40	**128.1**	337
June	13.03	**154.2**	115
July	14.36	**146.4**	30
August	12.06	**94.5**	138
September	6.6	**63.7**	308
October	0.15	**16.6**	522
November	-6.78	**3.0**	714
December	-10.08	**0.2**	839
Year total	0.05	**791**	6 063

Total solar radiant energy on vertical surfaces facing different directions, $G_{\text{radiant, vertical}}$, kWh/m^2

Month	N	NE	E	SE	S	SW	W	NW
January	**1.4**	**1.1**	**0.7**	**1.1**	**1.4**	**1.1**	**0.7**	**1.1**
February	**13.2**	**10.2**	**9.4**	**19.8**	**27.6**	**21.0**	**10.2**	**10.1**
March	**38.0**	**33.2**	**36.4**	**57.9**	**74.6**	**60.6**	**38.6**	**33.5**
April	**59.0**	**70.8**	**100.8**	**134.9**	**146.7**	**127.8**	**93.7**	**67.9**
May	**63.8**	**79.8**	**97.6**	**99.5**	**91.4**	**91.1**	**85.9**	**71.7**
June	**78.7**	**90.5**	**106.7**	**106.3**	**101.2**	**105.9**	**106.0**	**89.9**
July	**69.7**	**84.0**	**104.0**	**111.2**	**107.9**	**104.2**	**94.4**	**77.4**
August	**44.1**	**50.7**	**62.8**	**77.0**	**84.9**	**83.4**	**68.4**	**52.1**
September	**25.5**	**31.0**	**51.8**	**80.2**	**92.7**	**74.5**	**46.1**	**28.7**
October	**12.8**	**10.2**	**11.8**	**23.8**	**31.2**	**22.8**	**11.2**	**10.4**
November	**3.1**	**2.4**	**1.8**	**4.0**	**5.5**	**4.2**	**1.9**	**2.4**
December	**0.2**	**0.2**	**0.1**	**0.2**	**0.2**	**0.2**	**0.1**	**0.2**
Year total	**409.5**	**464.1**	**583.9**	**715.9**	**765.3**	**696.8**	**557.2**	**445.4**

Conversion factor $F_{direction}$ converts the total solar radiant energy on a horizontal surface to total radiant energy on vertical surfaces facing in different directions

Month	N	NE	E	SE	S	SW	W	NW
January	**1.000**	**0.750**	**0.479**	**0.764**	**1.014**	**0.764**	**0.479**	**0.750**
February	**0.966**	**0.749**	**0.686**	**1.451**	**2.025**	**1.540**	**0.745**	**0.744**
March	**0.792**	**0.691**	**0.759**	**1.205**	**1.554**	**1.262**	**0.804**	**0.698**
April	**0.488**	**0.585**	**0.833**	**1.115**	**1.213**	**1.056**	**0.774**	**0.561**
May	**0.498**	**0.623**	**0.762**	**0.777**	**0.714**	**0.711**	**0.671**	**0.560**
June	**0.511**	**0.587**	**0.692**	**0.689**	**0.657**	**0.687**	**0.687**	**0.583**
July	**0.476**	**0.574**	**0.710**	**0.759**	**0.737**	**0.712**	**0.644**	**0.528**
August	**0.467**	**0.536**	**0.665**	**0.814**	**0.898**	**0.883**	**0.724**	**0.551**
September	**0.400**	**0.487**	**0.813**	**1.259**	**1.454**	**1.169**	**0.724**	**0.451**
October	**0.774**	**0.618**	**0.710**	**1.435**	**1.883**	**1.375**	**0.673**	**0.625**
November	**1.026**	**0.780**	**0.576**	**1.299**	**1.819**	**1.375**	**0.625**	**0.776**
December	**0.955**	**0.727**	**0.455**	**0.727**	**0.955**	**0.727**	**0.455**	**0.727**
Year total	**0.518**	**0.587**	**0.738**	**0.905**	**0.968**	**0.881**	**0.704**	**0.563**

Guideline information

NATIONAL BUILDING CODE OF FINLAND
Situation as of xx.xx.20xx in accordance with the information on the date of issue of this Decree xx.xx.20xx
(updated Table of Contents www.ymparisto.fi)

A	GENERAL PART		
A1	Supervision of construction work	Regulations and Guidelines	2006
A2	Building designers and plans	Regulations and Guidelines	2002
A4	Maintenance manual for the care and use of buildings	Regulations and Guidelines	2000
A5	Plan notations	Regulations	2000
B	STRENGTH OF STRUCTURES		
B1	Structural safety and loads	Regulations	1998
B2	Loadbearing structures	Regulations	1990
B3	Foundations	Regulations and Guidelines	2004
B4	Concrete structures	Guidelines	2005
B5	Structures of lightweight concrete blocks	Guidelines	2007
B6	Light gauge steel structures	Guidelines	1989
B7	Steel structures	Guidelines	1996
B8	Brick structures	Guidelines	2007
B9	Structures of concrete blocks	Guidelines	1993
B10	Timber structures	Guidelines	2001
C	INSULATION		
C1	Sound insulation and noise abatement in buildings	Regulations and Guidelines	1998
C2	Moisture	Regulations and Guidelines	1998
C4	Thermal insulation in a building	Guidelines	2012
D	HEPAC AND ENERGY MANAGEMENT		
D1	Water supply and drainage installation for buildings	Regulations and Guidelines	2007
D2	Indoor climate and ventilation of buildings	Regulations and Guidelines	2012
D3	Energy management in buildings	Regulations and Guidelines	2012
D4	HEPAC drawings	Guidelines	1978
D5	Calculation of power and energy needs for heating of buildings	Guidelines	2007
D5	Calculation of power and energy needs for heating of buildings	Guidelines	2012
D7	Efficiency requirements for boilers	Regulations	1997
E	STRUCTURAL FIRE SAFETY		
E1	Structural fire safety in buildings	Regulations and Guidelines	2002
E2	Fire safety of production and warehouse buildings	Guidelines	2005
E3	Small chimneys	Guidelines	2007
E4	Fire safety of garages	Guidelines	2005
E7	Fire safety of ventilation installations	Guidelines	2004
E8	Masonry fireplaces	Guidelines	1985
E9	Fire safety of boiler rooms and fuel stores	Guidelines	2005
F	GENERAL BUILDING PLANNING		
F1	Barrier-free building	Regulations and Guidelines	2005
F2	Safety in use buildings	Regulations and Guidelines	2001
G	HOUSING PLANNING AND BUILDING		
G1	Housing design	Regulations and Guidelines	2005