USER GUIDE
«HEATY»
BUILDING HEAT LOAD CALCULATOR

0. INTRODUCTION

1. «Heaty» is a building heat load calculator implementing the "standard method" set out in the **European standard EN 12831-1:2017**. This method covers a steady-state calculation of the design heat load of a building, of the separate building entities (e.g. apartments) within this building and of individual heated spaces within each of the building entities. «Heaty» is to be used in conjunction with EN 12831-1 in order to be able to perform the calculations with the correct user input data.

2. Heat loss from a building will depend on **climatic conditions** and therefore it will vary with geographic location and with the time of year.
The purpose of a design heat load calculation is to determine the heat loss under extreme, yet probable, weather conditions at a given geographic location. These exterior "design conditions", especially the external design temperature at the location, can be looked up in separate national annexes that European countries provide to supplement or override the "core" standard EN 12831-1.

3. Besides external temperature, heat loss from a building will also depend on **internal temperatures** within the building. Indeed, it's the temperature difference between interior and exterior that drives the heat through the building envelope.
Heated spaces may have different desired temperatures, e.g. 20 °C in a living room and 24 °C in a bathroom. Table B.14 of EN 12831-1 shows a list of different kind of heated spaces along with their default internal design temperature (this table can be overridden in a national annex, see e.g. table NA.2 of the Belgian national annex NBN EN 12831-1 ANB:2020).

4. The heat loss from a heated space isn't necessarily directly towards the outdoor environment (exterior). A heated space at design conditions may also lose heat to other adjacent heated spaces that have lower internal design temperature (or gain heat from adjacent spaces with higher internal design temperature), to adjacent unheated spaces, to adjacent building entities, to neighboring buildings or to the ground (if the floor is in contact with the ground). The design temperatures to select for adjacent unheated spaces, building entities, buildings, and the ground are covered in the standard (see §6.3.2.5, Table 7) or can be looked up in the appropriate national annex.

5. The total design heat load of a heated space, a building entity or building is composed of:

– **transmission heat loss** through building elements that enclose the heated space, building entity or building;
– **ventilation and infiltration heat loss** as colder exterior air is brought into heated spaces, either purposefully for hygienic ventilation or unintentionally through openings and cracks in the building envelope due to wind and/or stack effect;
– **additional heating-up power** to attain the desired internal temperature within a given time period after a temperature setback.

6. The calculation procedure of the standard method considers the building as a hierarchical or tree-like structure. At the top of the hierarchy (or the root of the tree) is the **building**.

A building can have one or more **building entities** (e.g. apartments in an apartment building).

Each building entity usually has one **ventilation zone**, but it is possible that there a more. EN 12831-1 defines a ventilation zone as "a group of rooms that are air-connected by design, either directly or indirectly (through other rooms in between)" and it further notes that, by design, there is no air transfer possible between ventilation zones.

Each ventilation zone within a building entity has several **heated spaces** (and unheated spaces) that are ventilated by the same ventilation system.

A heated space is enclosed by **building elements** (walls, windows, doors, floor, ceiling, or roof). EN 12831-1 makes a distinction between different categories of building elements:

- building elements between the heated space under consideration and the exterior;
- building elements between the heated space and an adjacent heated space;
- building elements between the heated space and an adjacent unheated space or neighboring building;
- building elements between the heated space and the ground;
- building elements between the heated space and an adjacent building entity.

1. CALCULATION OF DESIGN TRANSMISSION HEAT LOSS

1. Transmission heat loss is the heat flow leaving a heated space through the building elements that enclose it.

2. Each category of building elements has two basic properties in common:

- area A [m^2]
- thermal transmittance U [W/(m^2.K)]

Multiplication of these two properties gives us the basic transmission heat transfer coefficient H [W/K] of the building element, i.e. the transmission heat loss through the building element per unit temperature difference.

This basic coefficient is then refined by applying correction factors or terms. E.g. a blanket additional thermal transmittance ΔU_{TB} [W/(m^2.K)] may be added to the thermal transmittance U to account for thermal bridges in case of a building element that separates a heated space from the exterior. The resulting transmission heat transfer coefficient can then still be multiplied by a correction factor $f_{U,k}$ to take into account the influence of building part qualities and meteorological conditions.

3. A noteworthy feature of the calculation method presented in EN 12831-1 is that the transmission heat transfer coefficients of building elements are temperature adjusted. This means that the actual transmission heat transfer coefficient is multiplied with a temperature adjustment factor, so that the transmission heat loss through any building element becomes the product of the temperature adjusted transmission heat transfer coefficient of the building element and the difference between the internal design temperature of the heated space and the external design temperature, regardless of the actual temperature difference across the building element being considered.

4. The most involved transmission heat transfer coefficient to calculate is that of building elements in direct contact with the ground. Firstly, the "equivalent thermal transmittance" $U_{equiv,k}$ of the building element in contact with the ground must be calculated. This result is then multiplied with the floor area, a correction factor $f_{GW,k}$ that takes the influence of ground water into account, a correction factor $f_{\theta ann}$ that takes the annual variation of the external temperature into account, and finally the temperature adjustment factor $f_{ig,k}$.

\# **TABLE 1**
Overview of the input parameters that «Heaty» needs in order to calculate the transmission heat transfer coefficient for each type of building element

Symbol in EN 12831-1	Symbol in «Heaty»	Description
Building element directly to exterior EN 12831-1 §6.3.2.2		
A_k	A	surface area of the building element
U_k	U	thermal transmittance of the building element
ΔU_{TB}	dU_tb	blanket additional thermal transmittance for thermal bridges; see EN 12831-1, Annex B.2.1 for default values or NBN EN 12831-1 ANB:2020 NA.5.1
$f_{U,k}$	f_U	correction factor for the influence of building part qualities and meteorological conditions; see EN 12831-1, Annex B.2.2 for default values or NBN EN 12831-1 ANB:2020 NA.5.2

Table 1 continued...

Symbol in EN 12831-1	Symbol in «Heaty»	Description
Building element to adjacent heated space within the same building entity EN 12831-1 §6.3.2.3 + §6.3.2.5		
A_k	A	surface area of the building element
U_k	U	thermal transmittance of the building element
$\theta_{int,a}$	T_adj	temperature of the adjacent heated space, i.e. the internal design temperature of the adjacent heated space
Building element to adjacent unheated space or neighboring building EN 12831-1 §6.3.2.3 + §6.3.2.5		
A_k	A	surface area of the building element
U_k	U	thermal transmittance of the building element
f_1	f1	adjustment factor for the difference between the temperature of an adjacent space and the external design temperature; see EN 12831-1, Annex B.2.4 for default values – optional parameter: if left empty, T_adj will be used.
	T_adj	temperature of the unheated space if known or temperature of neighboring building (= annual mean external temperature if greater than 5 °C else 5 °C or see NBN EN 12831-1 ANB:2020 NA.5.6)
Building element in contact with the ground EN 12831-1 §6.3.2.4		
A_k	A	surface area of the building element
U_k	U	thermal transmittance of the building element
$f_{\theta ann}$	f_dT_an	correction factor taking into account the annual variation of the external temperature; see EN 12831-1, Annex B.2.3 for default values or NBN EN 12831-1 ANB:2020 NA.5.3
$f_{GW,k}$	f_gw	correction factor taking into account the influence of ground water; see EN 12831-1, Annex B.2.3 for default values or NBN EN 12831-1 ANB:2020 NA.5.3
A_G	A_g	area of the floor slab; see EN 12831-1, Annex E

Table 1 continued...

Symbol in EN 12831-1	Symbol in «Heaty»	Description
P	P	exposed periphery of the floor slab; see EN 12831-1, Annex E
ΔU_{TB}	dU_tb	blanket additional thermal transmittance for thermal bridges; see EN 12831-1, Annex B.2.1 for default values or NBN EN 12831-1 ANB:2020 NA.5.1
z	z	depth of the top edge of the floor slab below ground level
Building element adjacent to building entity EN 12831-1 §6.3.2.3 + §6.3.2.5		
A_k	A	surface area of the building element
U_k	U	thermal transmittance of the building element
θ_u	T_adj	internal temperature of the adjacent building entity considered to be unheated; see EN 12831-1, Annex D or NBN EN 12831-1 ANB:2020 AN.5.4 and AN.5.6 for default values

NOTES:

The equivalent thermal transmittance $U_{equiv,k}$ of a building element in contact with the ground is calculated by «Heaty» behind the scenes according to the formulas in Annex E of EN 12831-1.

The temperature adjustment factor for each type of building element is calculated by «Heaty» behind the scenes according to EN 12831-1 §6.3.2.5.

In heated spaces with heigh ceilings (≥ 4 m), the temperature adjustment factor also takes into account the difference between the internal design temperature of the heated space and the mean surface temperature of a building element (see EN 12831-1 §6.3.8.2). In order to be able to calculate the mean surface temperature of a building element, «Heaty» needs some more information about the heated space (see TABLE 2). If the height of the room is less than 4 m, it is assumed that the mean surface temperature of a building element equals the internal design temperature of the heated space.

TABLE 2

Overview of the input parameters that «Heaty» needs in order to calculate the design transmission heat loss of a heated space

Symbol in EN 12831-1	Symbol in «Heaty»	Description
$\theta_{int,i}$	T_i_d	internal design temperature of the heated space
h_k	h_r	mean height of the heated space above floor level; if there are significantly differing floor levels in a room, the area-weighted mean floor height may be set as floor level
$h_{occup,i}$	h_occ	height of the occupied zone in the room; see EN 12831-1, Annex B.2.6
$G_{\theta,air,i}$	gT_a	air temperature gradient of the heat emission system in the room; see EN 12831-1, Annex B.2.6, Table B.3
$\Delta\theta_{surf,k}$	dT_s	correction term to allow for differing air and surface temperatures (e.g. increased floor or wall temperatures due to illumination, radiant heaters, floor heating); see EN 12831-1, Annex B.2.6, Table B.3

5. Once the heat transfer coefficients of the building elements enclosing each of the heated spaces within a building entity can be calculated, «Heaty» will also be able to calculate the design transmission heat loss of the building entity by first calculating and then taking the sum of:

1. the transmission heat loss through building elements of heated spaces directly in contact with the exterior,
2. the transmission heat loss through building elements of heated spaces that are in contact with adjacent unheated spaces or a neighboring building,
3. the transmission heat loss through building elements of heated spaces that are in contact with adjacent building entities, and
4. the transmission heat loss through building elements of heated spaces that are in direct contact with the ground.

6. Once the heat transfer coefficients of all building elements enclosing the heated spaces within the whole building can be calculated, «Heaty» will also be able to calculate the design transmission heat loss of the entire building, by first calculating and then taking the sum of:

1. the transmission heat loss through building elements of heated spaces directly in contact with the exterior,
2. the transmission heat loss through building elements of heated spaces that are in contact with adjacent unheated spaces or neighboring buildings, and
3. the transmission heat loss through building elements of heated spaces that are in direct contact with the ground.

It should be noted that «Heaty» does the calculations in a dynamic way: each time the configuration of the hierarchical building structure is altered, e.g. by adding a new heated space, the entire building structure is immediately updated.

2. CALCULATION OF DESIGN VENTILATION HEAT LOSS

1. Within the “standard method” of EN 12831-1 a general calculation model is included for the design ventilation heat loss applicable to the most common ventilation systems (natural or mechanical, fan-assisted ventilation, balanced or unbalanced ventilation, taking additional combustion air into account e.g. in case of open flue heaters in rooms). The method also incorporates any infiltration through leakages in the building envelope. The calculation procedure is laid out in paragraph 6.3.3.3 of the standard.

2. While the standard’s calculation method for the design transmission heat loss is fairly easy to grasp, this is not quite the case for the calculation of the design ventilation heat loss. It takes numerous, intermediate steps, using some undocumented or empirical formulas, to finally get at the design ventilation heat loss of a heated space. In Annex A of this user guide a schematic overview of the calculation steps is presented. Each formula of standard EN 12831-1 is represented by a “black box” with the input variables on the left side and the output of the formula on the right side of the block.

The chain of calculation steps takes a start at step 1 and moves to each of the following steps until step 12 is reached. At this final step the outcome is the design ventilation heat loss of the heated space we are looking for. The output at certain intermediate steps may be used as an input to several of the following steps as is indicated in the overview.
The user input variables marked yellow in the overview are valid at the level of the ventilation zone. User input variables marked light-blue are valid at the level of the heated space. Input variables marked orange are calculated by «Heaty» and don't need to be entered by the user.
Default values, tables or methods to determine the user input parameters are given in the informative annexes to the standard or may be given in a separate national annex. It is mentioned in the overview where information about the values of specific input parameters can be found in the standard.

- Step 1: the air volume flow rate through ATDs in the ventilation zone is calculated based on a pressure difference of 50 Pa between indoor and outdoor.

- Step 2: an adjustment factor is calculated that takes the additional pressure difference into account due to unbalanced ventilation.

- Step 3: the air volume flow into the ventilation zone due to additional infiltration is calculated, being the sum of (1) the infiltration air volume flow through leakages in the building envelope at 50 Pa, which can be measured using an air tightness measurement ("blower door test") of the building, and (2) the separate air volume flow through the ATDs at 50 Pa as determined in the 1st step. This sum is then adjusted by the product of the adjustment factor calculated in the 2nd step and the volume flow factor.

- Step 4: the total external air volume flow through the building envelope (including any ATDs) of the ventilation zone is calculated, being the sum of (1) the difference between ventilation exhaust (including any combustion air) and supply air, i.e. the net airflow provided by the ventilation system, and (2) the air volume flow due to additional infiltration calculated in step 3.

- Step 5: the authority (the share) of the ATDs in the total air volume through the building envelope is determined. With this parameter, the air volume flow through the building envelope is divided into two components:

– in step 6 the external air volume flow through leakages in the building envelope into the ventilation zone is determined, and

– in step 7 the external air volume through ATDs is determined.

- Step 8: the total external air volume flow into the ventilation zone due to infiltration through leakages in the building envelope (step 6) and through ATDs (step 7) is distributed across the heated spaces that are part of the ventilation zone. The distribution depends on the ratio of the considered room envelope area to the ventilation zone envelope area and also depends on the ratio of the design air volume flow through ATDs in the room under consideration to the design air volume flow through all ATDs of the ventilation zone.

- Step 9: the external air volume flow through the envelope of only the heated space under consideration is deduced based on a combination of (1) the additional infiltration air volume flow into the ventilation zone determined in step 3, (2) the total air volume flow through the building envelope of the ventilation zone determined in step 4 and (3) the external air volume flow into the heated space through leakages and ATDs determined in step 8.

- Step 10: the “technical” air volume flow into the heated space is determined. It is the maximum of the ventilation air volume flow that flows into the heated space (supply air and transfer air) and the ventilation air volume flow that flows out of the heated space (exhaust air and combustion air).

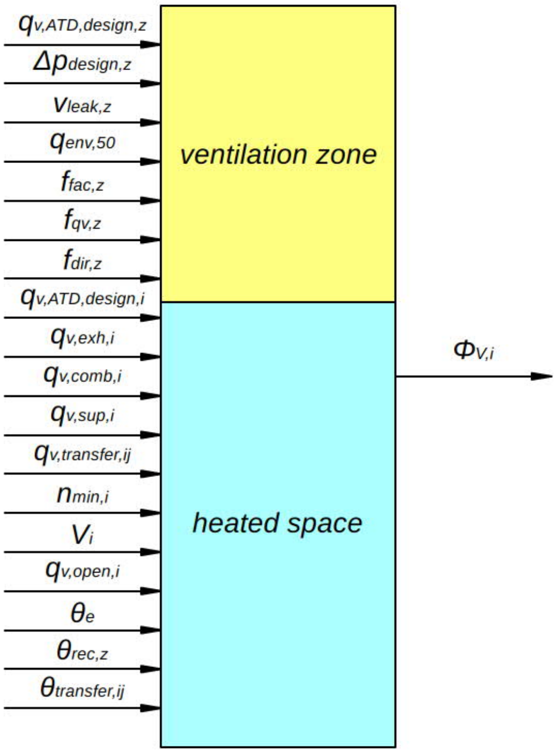
Air volume flow through any ATDs or through leakage openings in the building envelope is excluded from the technical air volume flow, as it is included in the air volume flow calculated in the 8th step, from which the external air volume flow through the envelope of the heated space is then deduced in step 9.

• Step 11: the minimum required ventilation air volume flow needed to sustain adequate air quality in the room is determined.

• Step 12: the design ventilation heat loss is calculated from the air volume flows calculated in step 9 to step 11 (the external air volume flow through the envelope, the “technical” air volume flow and the minimum required ventilation air volume), and additionally the possible air volume flow through any large openings if present in the heated space.

The formula for calculating the design ventilation heat loss contains three terms:
The first term considers the sum of the external air volume flow through the envelope of the heated space and the air volume flow that may enter through any large openings into the heated space. It also considers the difference between the minimum air volume flow required to sustain air quality and the technical air volume flow determined in step 10. The formula then takes the greatest of these two flows. This air volume flow is considered as the air volume flow that enters the heated space directly from the exterior, which is multiplied with the temperature difference between the internal air temperature of the heated space and the external design temperature.
The second term considers the air volume flow that is supplied to the heated space by the ventilation system through air inlets (not ATDs) in the heated space, which is multiplied with the temperature difference between the internal air temperature of the heated space and the supply air temperature after the heat recovery device (if present).
The third term considers the air volume flow entering the heated space from another, adjacent space (=air transfer), which is multiplied with the temperature difference between the internal air temperature of the heated space and the internal air temperature in the other space.

3. The schematic overview shown in Annex A can be reduced into one single “black box” with on the left side the user input parameters that «Heaty» needs in order to be able to calculate the design ventilation heat loss of a heated space.



The user input parameters at the level of a ventilation zone will be shared by all heated spaces that belong to this ventilation zone.

 # TABLE 3
Overview of the input parameters that «Heaty» needs at the level of the ventilation zone in order to calculate the design ventilation heat loss of a heated space

Symbol in EN 12831-1	Symbol in «Heaty»	Description
$q_{v,ATD,design,z}$	V_ATD_d	design air volume flow of the ATDs in the zone; see EN 12831-1, Annex B.2.12
$\Delta p_{design,z}$	dp_ATD_d	design pressure difference of the ATDs in the zone; see EN 12831-1, Annex B.2.12
$v_{leak,z}$	v_leak	pressure exponent; see EN 12831-1, Annex B.2.13
$q_{env,50}$	q_env_50	air permeability (or air change rate) at a pressure difference of 50 Pa between interior and exterior (cf. air tightness measurement) with any ATDs closed or sealed; see EN 12831-1 §6.3.3.4 and EN 12831-1, Annex B.2.10
$f_{fac,z}$	f_fac	adjustment factor for the number of (wind) exposed facades of the zone; see EN 12831-1, Annex B.2.15

Table 3 continued...

Symbol in EN 12831-1	Symbol in «Heaty»	Description
$f_{qv,z}$	f_V	volume flow factor of the zone; see EN 12831-1, Annex B.2.11
f_{dir}	f_dir	factor for the orientation of the zone; see EN 12831-1, Annex B.2.14
f_{iz}	f_iz	ratio between the minimum air volume flow of a single heated space and the air volume flow of the entire zone; see EN 12831-1, Annex B.2.9; this parameter will actually be used by «Heaty» to calculate the design ventilation loss of the entire ventilation zone

NOTES:

The abbreviation ATD stands for "Air Terminal Device" and is defined by EN 12831-1 as an air out- or inlet that allows air transfer between external air and internal air (external ATD) or between separate rooms (internal ATD). Within the specific context of the standard, the term refers only to passive devices (e.g. air grilles) allowing air flow through a building element; it does not include the air outlets and inlets of a mechanical, fan-assisted ventilation system.

If the design volume flow of each single ATD or for each room with ATDs is known, the design volume flow for the ventilation zone $q_{v,ATD,design,z}$ is simply the sum of the design volume flows $q_{v,ATD,design,i}$ of the rooms that are part of the ventilation zone.
Should only the total design volume flow for the ventilation zone $q_{v,ATD,design,z}$ be known in advance, the design volume flow of a room with ATDs $q_{v,ATD,design,i}$ can be estimated with:

$$q_{v,ATD,design,i} = \frac{V_i}{\sum_i V_i} q_{v,ATD,design,z} \tag{1}$$

V_i in the numerator is the internal volume of the room under consideration, while the denominator is the sum of the internal volumes of all rooms with ATDs in the ventilation zone.

If neither of both design flows should be known in advance, the design volume flow for the ventilation zone can be estimated with:

$$q_{v,ATD,design,z} = 0{,}3\left[1/hr\right]V_z \tag{2}$$

with V_z the total internal volume of the zone, i.e. the sum of the internal volumes of all rooms in the ventilation zone, with or without ATDs.

The air volume flow through an ATD will depend on the pressure difference across the ATD. For design calculations it may be assumed that the pressure difference at which the design volume flow passes through an ATD ($\Delta p_{design,z}$) is equal to 4 Pa (see EN 12831-1, Annex B.2.12).

The pressure exponent $v_{leak,z}$ allows to calculate the air volume flow through an ATD at pressure differences that deviate from the design value. The default value for the pressure exponent is 0,67 (see EN 12831-1, Annex B.2.13).

The air permeability $q_{env,50}$ is a measure of the air tightness of a building and of course will have an influence on the ventilation heat loss of a building. This quantity can be measured in case of an existing building by an air tightness measurement (“blower door test”), otherwise a reasonable default design value should be selected: see EN 12831-1, Annex B.2.10.

 # TABLE 4
Overview of the input parameters that «Heaty» needs at the level of the heated space in order to calculate the design ventilation heat loss of a heated space

Symbol in EN 12831-1	Symbol in «Heaty»	Description
$q_{v,ATD,design,i}$	V_ATD_d	design air volume flow of the ATDs in the room; see EN 12831-1, Annex B.2.12
$q_{v,exh,i}$	V_exh	exhaust air volume flow from the heated space
$q_{v,comb,i}$	V_comb	air volume flow exhausted from the heated space that has not been included in the exhaust air volume flow of the ventilation system; typically, but not necessarily, combustion air if an open flue heater is present

Table 4 continued...

Symbol in EN 12831-1	Symbol in «Heaty»	Description
$q_{v,sup,i}$	V_sup	supply air volume flow into the heated space
$q_{v,transfer,ij}$	V_trf	transfer air volume flow into the heated space if there is internal air transfer from one space to another
$n_{min,i}$	n_min	minimum air change rate required for the heated space for reasons of air quality/hygiene and comfort; see EN 12831-1, Annex B.2.10, Table B.7
V_i	V_r	internal volume of the heated space
$q_{v,open,i}$	V_open	external air volume flow into the heated space through “large openings”; see EN 12831-1, Annex G
$\theta_{rec,z}$	T_sup	temperature of the supply air volume flow into the heated space after passing heat recovery (see EN 12831-1 §6.3.3.7) or after passive preheating; in case of active preheating, which requires power from a heat generator, it should be the temperature of the air before preheating
$\theta_{transfer,ij}$	T_trf	temperature of the transfer air volume flow into the heated space from another space; in case the room height of the other space is less than 4 m, it is equal to the internal design temperature of the other space, otherwise, it is equal to the mean air temperature of the other space (see EN 12831-1 §6.3.8.3)
$\Delta\theta_{rad}$	dT_rad	correction factor to allow for differing air and operative temperatures; see EN 12831-1, Annex B.2.6 – this parameter is used by «Heaty» to calculate the mean internal air temperature in the heated space if its room height is greater than or equal to 4 m

NOTES:

The air volume flows $q_{v,ATD,design,i}$, $q_{v,exh,i}$, $q_{v,sup,i}$ and $q_{v,transfer,ij}$ can be present with a mechanical ventilation system. Two categories of mechanical ventilation systems are in widespread use:

1. Mechanical exhaust ventilation systems: fresh, exterior air enters a “dry” room (living room, bedroom,...) through ATDs ($q_{v,sup,i}$ = 0, but $q_{v,ATD,design,i}$ > 0).

This air is then transferred through internal ATDs towards “wet” rooms (toilet, bathroom, kitchen,...) in the ventilation zone ($q_{v,transfer,ij} > 0$), where it is extracted through air outlets by a fan-driven exhaust system, that discharges the “dirty” room air back into the outdoor atmosphere ($q_{v,exh,i} > 0$).

2. Mechanical supply and exhaust ventilation systems: fresh, exterior air is blown into “dry” rooms by a fan-driven supply air system ($q_{v,sup,i} > 0$ and $q_{v,ATD,design,i} = 0$). This air is then transferred through internal ATDs towards “wet” rooms (toilet, bathroom, kitchen,...) in the ventilation zone ($q_{v,transfer,ij} > 0$), where it is extracted through air outlets by the aid of a fan-driven exhaust system, that discharges the “dirty” room air back into the outdoor environment ($q_{v,exh,i} > 0$).

“Large openings” are defined by EN 12831-1 as openings that are kept open for significant periods over the day on a regular basis; usually, but not necessarily, doors or gates (e.g. in logistics and industrial halls). A method for estimating the external air volume through large openings is explained in annex G of EN 12831-1.

To retrieve the supply air temperature after heat recovery in a mechanical supply and exhaust ventilation system, one must know the efficiency of the heat recovery under externa design conditions ($\eta_{rec,z}$). If the heat recovery efficiency $\eta_{rec,z}$ is known, the supply air temperature to the heated spaces in the zone can be estimated as:

$$\theta_{rec,z} = \theta_e + \eta_{rec,z}\left(\theta_{exh,z} - \theta_e\right) \tag{3}$$

with $\theta_{exh,z}$ the temperature of the exhaust air at the inlet of the heat recovery device, which can be estimated with:

$$\theta_{exh,z} = \frac{\sum_i \left(q_{v,exh,i} \cdot \theta^*_{int,i}\right)}{\sum_i q_{v,exh,i}} \tag{4}$$

with $\theta^*_{int,i}$ the mean internal air temperature of the considered room.

The temperature difference that drives the ventilation heat loss depends on the mean internal air temperature of the heated space, which can be assumed equal to the internal design temperature of the heated space if the room height is less than 4 m. Otherwise, the mean internal air temperature of the heated space is to be determined according to §6.3.8.3 of EN 12831-1. In the calculation a correction term $\Delta\theta_{rad}$ is taken into account that represents the temperature difference between the operative room temperature (i.e. the room temperature as sensed by a human and that also includes the influence of radiative interaction and air velocity in the room) and the actual room air temperature. Its value depends on the type of heat emission system: see EN 12831-1, Annex B.2.6, table B.3.

When this correction term, together with the air temperature gradient, the room height and the height of the occupied zone (see already table 2), is handed over to «Heaty», the program is able to calculate the mean internal air temperature of the room.

Note that, if $\theta_{transfer,ij}$ applies to an adjacent space whose room height is 4 m or higher, the mean internal air temperature in that space needs to be calculated by the user himself.

4. Once the design ventilation heat loss of all the heated spaces in a ventilation zone can be calculated, the total design ventilation heat loss of the ventilation zone can be calculated by «Heaty» at the same time. As already mentioned before, «Heaty» performs the calculations dynamically: each time the configuration of the hierarchical building structure is altered, the complete calculation procedure is repeated. In the same manner, when all ventilation zones within the building are configured, the final design ventilation heat loss of the building entities and the entire building will also be known. In other words, the user only has to enter the necessary input data at the level of the heated spaces and the ventilation zones in the building; «Heaty» continuously updates the calculation results for the entire building structure.

3. CALCULATION OF ADDITIONAL HEATING-UP POWER

1. EN 12831-1 points out that oversizing the heat generator should be avoided due to higher energy consumption (higher standby losses, more on/off-cycles,...) and therefore, that it is highly recommended that the heating-up power or the acceptable period of time required for the heating-up is agreed between contractor and client.
Nevertheless, intermittently heated spaces can require additional heating-up power to attain the desired internal design temperature after a temperature setback within a given time period.

2. EN 12831-1 presents under Annex F a simplified approach to estimate the heating-up power. Two methods are presented: one based on the length of the setback period, the other based on the temperature drop during setback.

The first method is applicable if all of the following conditions are fulfilled:

– the building has a high standard of thermal insulation,
– the room height is small (≤ 3,5 m),
– the temperature drop during setback is limited to 5 K (by means of temperature control).

If these conditions are not met or when the temperature drop during setback is known, the second method is to be used.

In the first method four parameters, viz. setback or disuse period, air change rate during setback, thermal storage capacity of the building mass and required heating-up time, determine the specific heating-up power (i.e. the thermal power per unit of floor area): see EN 12831-1, Annex F, Table F.1. A grey marked cell in the table indicates that for the selected parameters the internal temperature will very likely drop by 5 K or more and a high specific power results. Values that exceed 100 W/m² are indicated with >100; in such cases the additional heating-up power will likely be at least of the same magnitude as the design heat load without additional heating-up power and alternative options should be considered, like allowing more time for heating-up.

Otherwise, the additional heating-up power may surely lead to oversizing of the heat generator.

In the second method, the setback or disuse period is replaced by the temperature drop during setback. The other three parameters remain. From Table F.2 the estimated specific heating-up power can be read for a specific selection of the four parameters.
In case the temperature drop during setback is unknown, it can be estimated using formula F.1 in Annex F.

3. Once the specific heating-up power of a heated space is determined, it can be passed to «Heaty» –user input parameter q_hu–, which will calculate the additional heating-up power required for this heated space based on its floor area.

4. When all heated spaces in the building entities and the building are configured, the final extra heating-up power for the building entities and the building will also be determined at the same time by «Heaty».

4. HOW TO USE «HEATY»

Climate data

The first thing to do when you start a new project, is to set the climate data for the specific geographical location by clicking the button «Set Climate Data...». A dialog window appears in which three parameters must be set:

1. T_e_d: the external design temperature
2. T_e_an: the annual average external temperature
3. T_e_min: the average minimal external temperature during the coldest month

Building up the hierarchical building structure

At startup of the program there is only a building item at the top of the tree view panel:

- You can modify the name of this building, by entering a name in the «Edit name» entry in the control panel on the left side of the window and pressing the Enter- or Return-key.

- You can add a building entity under the building, by entering a name for the building entity in the entry «Add building entity» and pressing the Enter- or Return-key.

- If you select the building entity in the tree view, another panel «Building Entity» will become visible at the left side of the main window, allowing you to edit the name of the building entity or to add a ventilation zone under the building entity. It is also possible to remove the building entity from the building by clicking the button «Delete Building Entity». This will remove the whole building entity including its children from the tree.

- To add a ventilation zone to the building entity, enter a name for it in the entry «Add ventilation zone» and press the Enter- or Return-key.
  A dialog will appear in front of the main window, where you can enter the values for the user input parameters of the ventilation zone. Where possible reasonable default values are suggested according to EN 12831-1. If the «Submit»-button is clicked, the ventilation zone will be added to the tree under the building entity that was previously selected.

- When the ventilation zone is selected in the tree view, another panel «Ventilation Zone» now becomes visible at the left side of the main window. Within this panel there is a button that allows you to modify the currently selected ventilation zone, should you have made a mistake when setting the user input parameters. Another button allows you to remove the ventilation zone and all of its children from its building entity.

– In the same way as before, a heated space can be added to the ventilation zone. Enter a meaningful name for the heated space in the entry «Add heated space» and press the Enter- or Return-key.
  A dialog will appear in front of the main window, where you can enter the values for the user input parameters of the heated space and where you can define the building elements that enclose the heated space.

– To add a building element to a heated space, choose the appropriate tab and fill in the user input parameters. Click the «Add»-button to add the building element to the heated space. The added building elements are shown in a list. Should you have made a mistake when configuring one of the building elements, it can be selected in the list and deleted by clicking the «Delete»-button, which also removes it from the heated space. To re-add this building element without the mistake, it should be completely reconfigured first and then added again by clicking the «Add»-button.
  When all building elements are added to the heated space and all user input parameters of the heated space are entered, you can click the «Submit»-button to add the heated space to the currently selected ventilation zone and the dialog will close.

– When you click a heated space in the tree view, another panel «Heated Space» will become visible on the left side of the main window. There you can change the name of the currently selected heated space, click the button «Modify Heated Space...» to go back to the input dialog, or click the button «Delete Heated Space» to remove it from the tree.

Project menu

From the project menu you can:

– start with a new project
– open an existing project
– save the current project

– export the current project as a CSV-file that can be opened in any spreadsheet program
– set your preferences
– leave the program

Preferences

When «Preferences» is selected in the project menu, a dialog comes up that allows you to change the default paths were projects and export files are stored and allows you to change the default units of the quantities that are used throughout the program.

Units

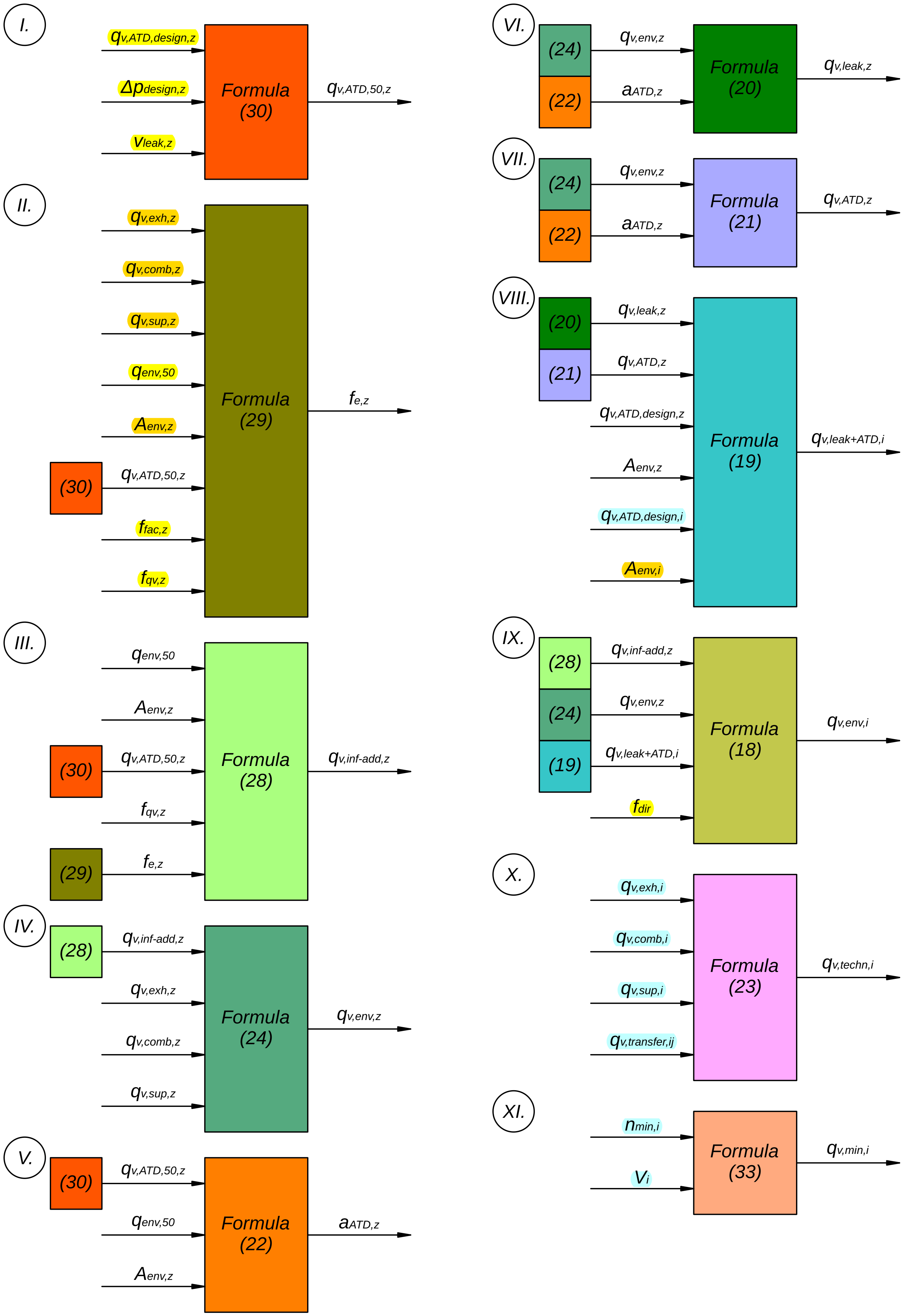
«Heaty» uses a software library called «Pint» for working with units. To keep things simple at the programming side, «Heaty» has retained the way in which units are entered in «Pint». The most important thing to notice is the power operator, which is indicated by `**`; e.g. m^2 is entered as `m ** 2`.

Besides using the default units that can be set under «Preferences», it is also possible to enter other equivalent units for the quantities in the input dialogs used for setting climate data, configuring a ventilation zone or heated space.

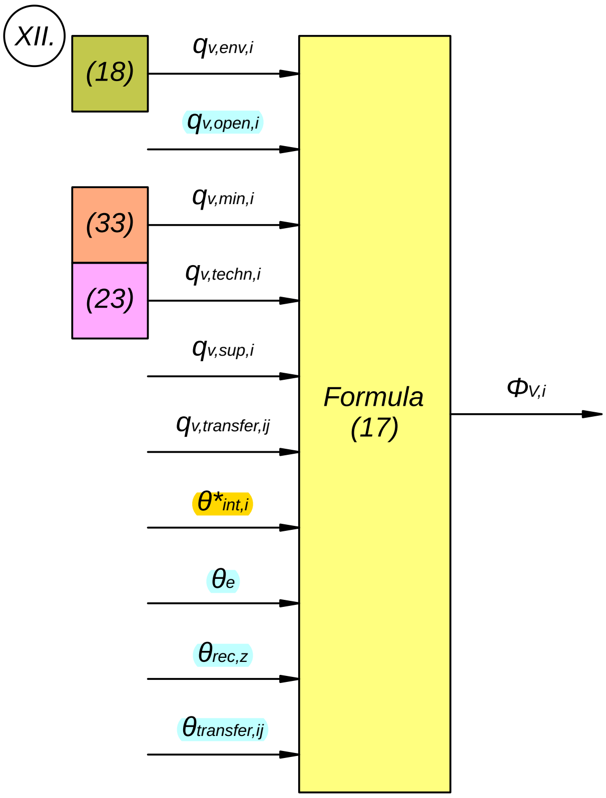
* * *

ANNEX A

Schematic overview of the calculation of the design ventilation heat loss of a heated space according to EN 12831-1, §6.3.3.3



ANNEX A


XII.
(18)
(33)
(23)
$q_{v,env,i}$
$q_{v,open,i}$
$q_{v,min,i}$
$q_{v,techn,i}$
$q_{v,sup,i}$
$q_{v,transfer,ij}$
$\theta^*_{int,i}$
θ_e
$\theta_{rec,z}$
$\theta_{transfer,ij}$
Formula (17)
$\Phi_{V,i}$

ANNEX A

Symbol	Meaning	Default values / Calculation
$q_{v,ATD,design,z}$	design air volume flow of the ATDs in the ventilation zone	Annex B.2.12
$\Delta p_{design,z}$	design pressure difference of the ATDs in the ventilation zone	Annex B.2.12
$v_{leak,z}$	pressure exponent	Annex B.2.13
$q_{v,ATD,50,z}$	air volume flow into the ventilation zone through ATDs @ 50 Pa	
$q_{v,exh,z}$	exhaust air volume flow from the ventilation zone	
$q_{v,comb,z}$	combustion air volume flow into the ventilation zone	
$q_{v,sup,z}$	supply air volume flow into the ventilation zone	
$q_{env,50}$	specific air permeability of the envelope @ 50 Pa	Annex B.2.10
$A_{env,z}$	envelope surface of the zone	
$f_{fac,z}$	adjustment factor for the number of exposed facades	Annex B.2.15
$f_{qv,z}$	volume flow factor	Annex B.2.11
$f_{e,z}$	adjustment factor taking into account the additional pressure difference due to unbalanced ventilation	
$q_{v,inf\text{-}add,z}$	air volume flow through additional infiltration into the ventilation zone	
$q_{v,env,z}$	external air volume flow into the ventilation zone through the building envelope	
$a_{ATD,z}$	ATD authority of the ATDs in the zone	
$q_{v,leak,z}$	external air volume flow into the ventilation zone through leakages	
$q_{v,ATD,z}$	external air volume flow into the ventilation zone through ATDs	
$q_{v,ATD,design,i}$	design air volume flow of the ATDs in the room	Annex B.2.12
$A_{env,i}$	envelope of the room	
$q_{v,leak+ATD,i}$	external air volume flow into the room through leakages and ATDs	
$f_{dir,z}$	orientation factor	Annex B.2.14
$q_{v,env,i}$	external air volume flow into the room through the envelope	
$q_{v,exh,i}$	exhaust air volume flow from the room	
$q_{v,comb,i}$	combustion air volume flow exhausted from the heated space	
$q_{v,sup,i}$	supply air volume flow of the room	
$q_{v,transfer,ij}$	transfer air volume flow into the room from an adjacent room	
$q_{v,techn,i}$	technical air volume flow of the room	
$n_{min,i}$	minimum air change rate of the room	Annex B.2.10
V_i	internal air volume of the room	
$q_{v,min,i}$	minimum air volume flow of the room	
$q_{v,open,i}$	external air volume flow through large openings in the building envelope for the room	Annex G
$\theta^{*}_{int,i}$	internal air temperature of the room	
θ_e	external design temperature	
$\theta_{rec,z}$	temperature of the supply air into the zone after passing heat recovery if any	
$\theta_{transfer,ij}$	temperature of the transfer air from an adjacent room into the room	
$\Phi_{V,i}$	ventilation heat loss of the room	