

# Primary energy

## HVAC System Design

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## Types of calculation

### Power [W]

- generator sizing
- distribution network sizing
- terminal sizing
- external design conditions (most severe conditions)

### Energy [MJ, kWh]

- annual consumption
- verification of compliance with regulations
- energy certification

# Degree Days

- The degree of severity of the climate of the national territory is determined using the degree days  $DD$
- each municipality is characterized by a value of degree days
- is defined as the sum of the only positive differences between the internal and external average temperatures in the heating season
- the internal temperature is  $\theta_i = 20 \text{ }^\circ\text{C}$

$$DD = \sum_j^{ng} (\theta_i - \theta_{ej})$$

$\theta_i$  internal temperature

$\theta_{ej}$  mean external temperature

$ng$  number of days of heating period

## national territory subdivision

- The national territory is divided into 6 climate zones based on degree days
- the conventional duration of the heating season depends on the climate zone

### climate zones

zone	From DD	To DD	Activation Hours	Start Date	End Date	Municipalities
A	0	600	6	December 1	March 15	2
B	601	900	8	December 1	March 31	157
C	901	1400	November 10	November 15	March 31	989
D	1401	2100	November 12	November 1	April 15	1611
E	2101	3000	October 14	October 15	April 15	4271
F	3001			no limitations		1071

- Decreto 26 giugno 2015. Applicazione delle metodologie di calcolo delle prestazioni energetiche e definizione delle prescrizioni e dei requisiti minimi degli edifici. (decreto requisiti minimi)
- Decreto 26 giugno 2015. Schemi e modalità di riferimento per la compilazione della relazione tecnica di progetto ai fini dell'applicazione delle prescrizioni e dei requisiti minimi di prestazione energetica negli edifici.
- Decreto 26 giugno 2015. Adeguamento del decreto del Ministro dello sviluppo economico, 26 giugno 2009 – Linee guida nazionali per la certificazione energetica degli edifici.

## New decrees

from June 3rd 2026

### DECRETO 28 ottobre 2025

#### MINISTERO DELL'AMBIENTE E DELLA SICUREZZA ENERGETICA

Aggiornamento del decreto 26 giugno 2015, recante «Applicazione delle metodologie di calcolo delle prestazioni energetiche e definizione delle prescrizioni e dei requisiti minimi degli edifici».

## UNI/TS 11300-1

Prestazioni energetiche degli edifici - Parte 1: Determinazione del fabbisogno di energia termica dell'edificio per la climatizzazione estiva ed invernale

## UNI/TS 11300-2

Prestazioni energetiche degli edifici - Parte 2: Determinazione del fabbisogno di energia primaria e dei rendimenti per la climatizzazione invernale e per la produzione di acqua calda sanitaria

## UNI/TS 11300-3

Prestazioni energetiche degli edifici - Parte 3: Determinazione del fabbisogno di energia primaria e dei rendimenti per la climatizzazione estiva

## UNI/TS 11300-4

Prestazioni energetiche degli edifici - Parte 4: Utilizzo di energie rinnovabili e di altri metodi di generazione per riscaldamento di ambienti e preparazione acqua calda sanitaria

## UNI/TS 11300-5

Prestazioni energetiche degli edifici - Parte 5: Calcolo dell'energia primaria e dalla quota di energia da fonti rinnovabili

## UNI/TS 11300-6

Prestazioni energetiche degli edifici - Parte 6: Determinazione del fabbisogno di energia per ascensori e scale mobili

## UNI/TS 11300-1

### Purpose and scope

- The specification 11300-1 defines the national application methods of UNI EN ISO 13790:2008
- is used to determine the thermal energy needs for heating  $Q_{H,nd}$  and for cooling  $Q_{C,nd}$
- applies to the cases provided for by UNI EN ISO 13790:2008:

### use

- design calculation (*design rating*)
- energy assessment of buildings with calculation in standard conditions (*asset rating*)
- energy assessment in particular operating or climatic conditions (*tailored rating*)

# Terms and definitions

## conditioned environment

an enclosed space or compartment that, for the purposes of the calculation, is considered to be heated or cooled to certain regulation temperatures

## Building

is a system made up of external building structures that delimit a space of defined volume, by the internal structures that divide said volume and by all the technological systems and devices that are permanently located inside it; the external surface that delimits a building may border on all or some of these elements: the external environment, the ground, other buildings; the term can refer to an entire building or to parts of a building designed or renovated to be used as separate real estate units

## Thermal zone

Part of the air-conditioned environment maintained at a uniform temperature through the same air-conditioning system

# indoor temperature

## Winter air conditioning

### Heated Environments

- 20 °C for all categories except the following
- 28 °C for category E.6(1)
- 18 °C for category E.6(2) and E.8

### temperature of neighboring buildings

- dependent on intended use
- 20 °C for heated neighboring buildings whose intended use is unknown
- from Appendix A of UNI EN ISO 13789:2008 for unheated adjacent buildings, or from the table of UNI EN 12831

### conditioned environments

The indoor temperature takes the value

- 26 °C for all categories except the following
- 28 °C for category E.6(1)
- 24 °C for category E.6(2)
- 26 °C adjacent buildings

## Thermal Energy Requirements

The procedure leads to calculate the building's requirements for heating and cooling

### heating

$$Q_{H,nd} = Q_{H,ht} - \eta_{H,gn} \times Q_{gn} = (Q_{H,tr} + Q_{H,ve}) - \eta_{H,gn} \times (Q_{int} + Q_{sol})$$

### cooling

$$Q_{C,nd} = Q_{gn} - \eta_{C,is} \times Q_{C,ht} = (Q_{int} + Q_{sol}) - \eta_{C,is} \times (Q_{C,tr} + Q_{C,ve})$$

# Heat balance

winter case

$$Q_{H,nd} = Q_{H,ht} - \eta_{H,gn} \times Q_{gn} = (Q_{H,tr} + Q_{H,ve}) - \eta_{H,gn} \times (Q_{int} + Q_{sol})$$

$Q_{H,nd}$  Heat supplied by the system

$Q_{gn}$  Heat due to free gains

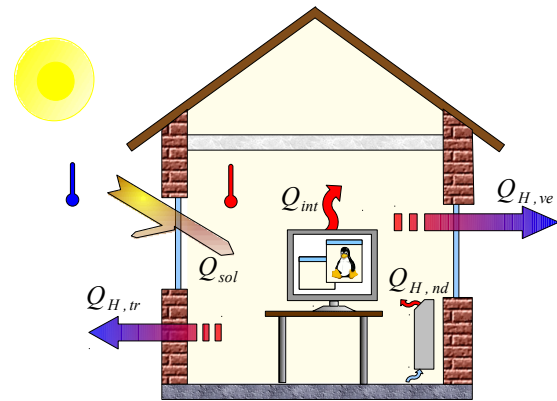
$Q_{H,ht}$  Heat lost by transmission and ventilation

$Q_{H,tr}$  Heat exchanged by transmission with the outside

$Q_{H,ve}$  Heat exchanged by ventilation

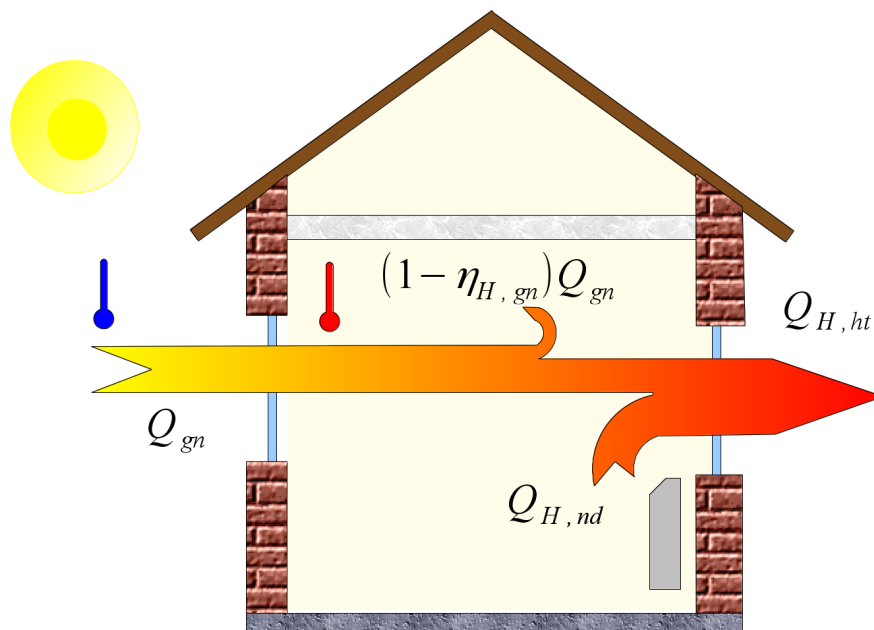
$Q_{sol}$  Heat due to solar loads

$Q_{int}$  Heat from internal loads



# winter energy balance

$$Q_{H,ht} = Q_{H,nd} + \eta_{H,gn} \cdot Q_{gn}$$



# Heat balance

summer condition

$$Q_{C,nd} = Q_{gn} - \eta_{C,is} \times Q_{C,ht} = (Q_{int} + Q_{sol}) - \eta_{C,is} \times (Q_{C,tr} + Q_{C,ve})$$

$Q_{C,nd}$  Heat supplied by the system  
(subtracted)

$Q_{gn}$  Heat due to the free gains

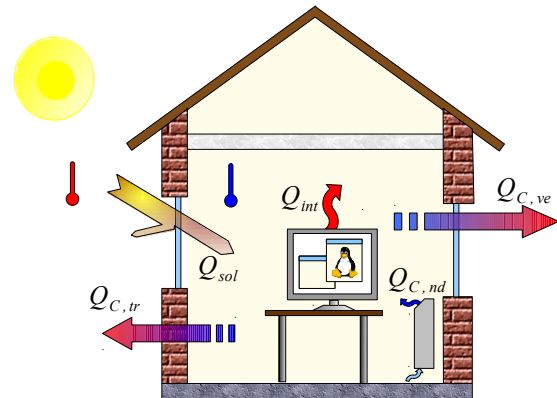
$Q_{C,ht}$  Heat lost by transmission and  
ventilation

$Q_{H,tr}$  Heat exchanged by transmission  
with the outside

$Q_{H,ve}$  Heat exchanged by ventilation

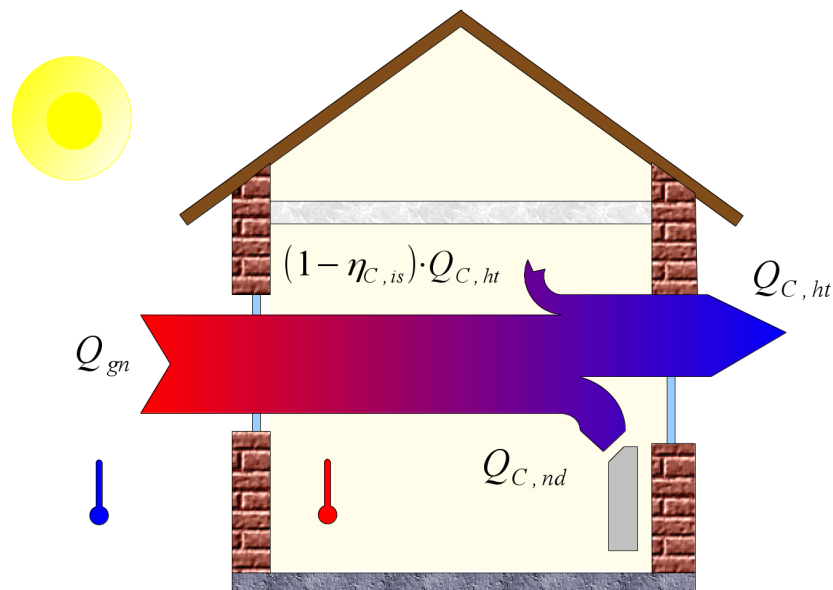
$Q_{sol}$  Heat due to solar loads

$Q_{int}$  Heat from internal loads



# Summer energy balance

$$Q_{gn} = Q_{C,nd} + \eta_{C,is} \times Q_{C,ht}$$



# Building heat exchange calculation

Heat exchanges take the same form for both heating and cooling

## Heating

$$Q_{H,tr} = H_{tr,adj} \times (\theta_{int,set,H} - \theta_e) \times t + \left\{ \sum_k F_{r,k} \Phi_{r,mn,k} \right\} \times t - Q_{sol,op}$$
$$Q_{H,ve} = H_{ve,adj} \times (\theta_{int,set,H} - \theta_e) \times t$$

## Cooling

$$Q_{C,tr} = H_{tr,adj} \times (\theta_{int,set,C} - \theta_e) \times t + \left\{ \sum_k F_{r,k} \Phi_{r,mn,k} \right\} \times t - Q_{sol,op}$$
$$Q_{C,ve} = H_{ve,adj} \times (\theta_{int,set,C} - \theta_e) \times t$$

$H_{tr,adj}$  global heat transfer coefficient for transmission

$\Phi_{r,mn,k}$  extra flux due to infrared radiation towards the sky dome

$F_{r,k}$  shape factor between building component and sky dome

$Q_{sol,op}$  free solar gains on opaque surfaces

# Heat exchange coefficients

$$H_{tr,adj} = H_D + H_g + H_U + H_A$$

$$H_{ve,adj} = \rho_a \times c_a \times \left\{ \sum_k b_{ve,k} \cdot q_{ve,k,mn} \right\}$$

$$q_{ve,k,mn} = f_{ve,t,k} \times q_{ve,k}$$

$q_{ve,k,mn}$  air flow averaged over time

$b_{ve,k}$  temperature correction factor, holds account of the presence of recuperators;

$f_{ve,t,k}$  fraction of time in which the k air flow occurs;

$q_{ve,k}$  flow rate of the k-th air flow.

Skyward radiation is treated as an additional heat loss for opaque structures

$$\Phi_r = R_{se} \times U_c \times A_c \times h_r \times \Delta\theta_{er}$$

$R_{se}$  external resistance

$U_c$  external component transmittance

$A_c$  element area

$h_r$  radiative heat transfer coefficient

$\Delta\theta_{er}$  mean temperature difference between external air and skyward

## Transparent Components

calculation according to UNI EN 10077-1

$$U_w = \frac{A_g U_g + A_f U_f + \Psi_g L_g}{A_g + A_f}$$

$U_g$  transmittance of the glass element

$U_f$  thermal transmittance of the frame

$\psi_l$  transmittance of the spacers

$L_g$  Perimeter length of the glass surface

$A_g$  Glass area

$A_f$  frame area

### predetermined values in appendix

B1 glass transmittance

B2 frame transmittance

B3 windows

# Transparent component

## Shutter contribution

### Shutters

for energy calculation also the increased thermal resistance of shutters is considered

$$U_{w,corr} = U_{w+shut} \times f_{shut} + U_w \times (1 - f_{shut})$$

$U_w$  window transmittance without shutter

$U_{w+shut}$  window transmittance with shutter

$U_{w,corr}$  corrected window transmittance

$f_{shut}$  parameter that takes into account the hourly usage profile and the internal-external temperature difference,  $f_{shut} = 0,6$

## thermal exchange with the ground

- New buildings: UNI EN ISO 13370
- a simplified calculation method is introduced for existing buildings
- the simplified method must be adopted if there are no reliable design data

### simplified method

$$H_g = A \times U_f \times b_{tr,g}$$

$A$  floor area

$U_f$  thermal transmittance of the floor

$b_{tr,g}$  correction factor

Adjacent environment	$b_{tr,g}$
Underground floor	0.45
Underground wall	0.45
Floor on ventilated suspended space	0.80

# Transmission loss coefficient through unheated spaces

$$H_U = L_{iu} \cdot b; \quad b = \frac{H_{ue}}{H_{iu} + H_{ue}}$$

$L_{iu}$  thermal coupling coefficient between heated and unheated space;

$H_{iu}$  heat loss coefficient from heated to unheated space

$H_{ue}$  heat loss coefficient from unheated space to the outside;

## Unheated spaces

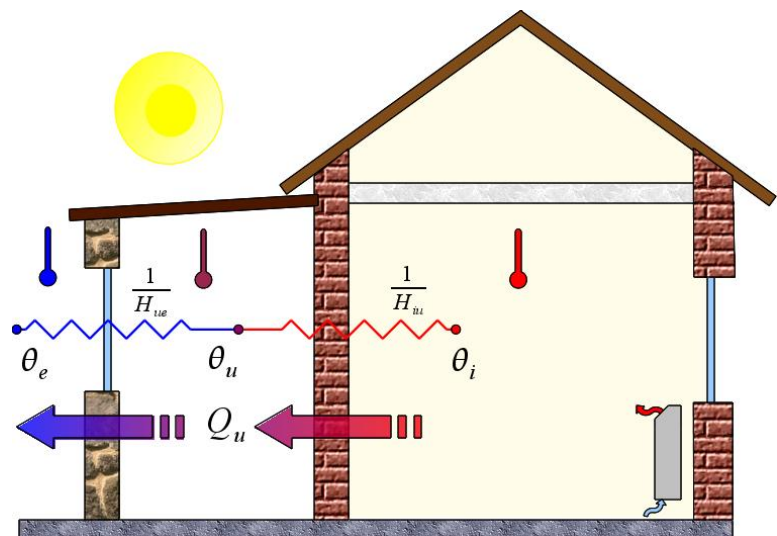
new buildings

### electrical analogy

$$H_U = H_{iu} \times \frac{H_{ue}}{H_{iu} + H_{ue}}$$

$$H_U = H_{iu} \times b_{tr,x}$$

$$b_{tr,x} = \frac{H_{ue}}{H_{iu} + H_{ue}}$$



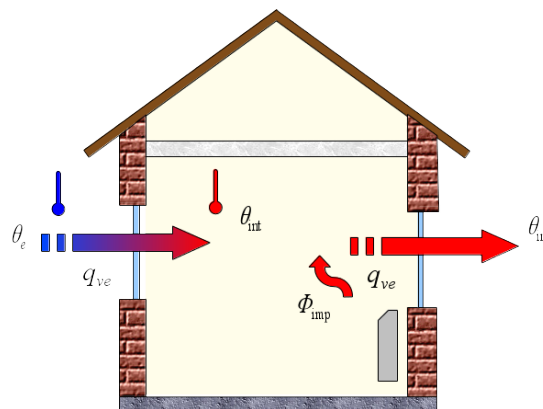
# Unheated spaces

existing buildings

Adjacent space	$b_{tr,x}$
Space	
with one external wall	0.4
without windows with at least two external walls	0.5
with external windows, at least two external walls	0.6
three external walls	0.8
Basement or basement	
without external windows	0.5
with external windows	0.8
Attic	
high ventilation	1.0
other uninsulated roof	0.9
insulated roof	0.7
Internal circulation areas	0.0
Internal circulation areas (opening volume ratio greater than $0.005 \text{ m}^2/\text{m}^3$ )	1.0

Navigation icons: back, forward, search, etc.

# Ventilation



## loss due to ventilation

$$\Phi_V = \dot{m}_{ve} \times (h_{int} - h_e) = \rho_a \times q_{ve} \times (h_{int} - h_e) = \rho_a \times q_{ve} \times c_a \times (\theta_{int} - \theta_e)$$

$h$  enthalpy

$q_{ve}$  volumetric flow rate

$\dot{m}_{ve}$  mass flow rate

$\theta$  temperature

$c_a$  specific heat of air

Navigation icons: back, forward, search, etc.

## Global heat transfer coefficient for ventilation

$$\Phi_V = \rho \times c_a \times q_{ve} \times (\theta_{int} - \theta_e) = H_{ve} \times (\theta_{int} - \theta_e)$$

$$H_{ve} = \rho \times c_a \times q_{ve}$$

## Global heat transfer coefficient for ventilation

$$\Phi_V = \rho \times c_a \times q_{ve} \times (\theta_{int} - \theta_e) = H_{ve} \times (\theta_{int} - \theta_e)$$

$$H_{ve} = \rho \times c_a \times q_{ve}$$

## UNI/TS 11300-1

$$H_{ve,adj} = \rho_a \times c_a \times \left\{ \sum_k b_{ve,k} \times q_{ve,k} \right\}$$

$\rho_a \times c_a = 1200 \text{ J}/(\text{m}^3 \text{ K})$  air volumetric heat capacity

$q_{ve,k,mn}$  averaged airflow rate

$b_{ve,k}$  correction factor if the temperature is  $\neq$  from the outside one

## buildings category E.1 and E.8

$$q_{ve} = q_{ve,0} \times f_{ve,t}$$
$$q_{ve,0} = \frac{n \times V}{3600}$$
$$n = 0.5$$
$$f_{ve,t} = 0.6$$
$$q_{ve} = \frac{0,3 \times V}{3600}$$

## Free heating gains

### internal contributions

$$Q_{int} = \left\{ \sum_k \Phi_{int,mn,k} \right\} \times t + \left\{ \sum_l (1 - b_{tr,l}) \Phi_{int,mn,u,l} \right\} \times t$$

### solar gains

$$Q_{int} = \left\{ \sum_k \Phi_{sol,mn,k} \right\} \times t + \left\{ \sum_l (1 - b_{tr,l}) \Phi_{sol,mn,u,l} \right\} \times t$$

$b_{tr,l}$  reduction factor for unconditioned environment

$\Phi_{int,mn,k}$  internal flux averaged over time

$\Phi_{int,mn,u,l}$  internal flux of the unheated environment averaged over time

$\Phi_{sol,mn,k}$  heat flux of solar origin, averaged over time

$\Phi_{sol,mn,u,l}$  heat flux of solar origin in the unheated environment, averaged over time

# internal contributions

design or standard evaluation

- category E.1(1) and E.1 (2)

$$A_f \leq 120 \text{ m}^2 \quad \Phi_{int} = 7.987 \times A_f - 0.0353 \times A_f^2$$

$$A_f > 120 \text{ m}^2 \quad \Phi_{int} = 450 \text{ W}$$

- other categories according to table

Building category	Destination	Global average contributions [W/m <sup>2</sup> ]
E.1(3)	hotels, guesthouses	6
E.2	offices	6
E.3	hospitals, clinics	8
E.4(1)	meeting rooms, conferences, cinemas	8
E.4(2)	museums	8
E.4(3)	Bars, restaurants	10
E.8	industrial activities	6

Navigation icons: back, forward, search, etc.

## Solar gains

- Solar gain is calculated in the same way for external opaque surfaces and glass
- the only difference is the calculation of the capture area

### solar gain

$$\Phi_{sol,k} = F_{sh,ob,k} A_{sol,k} I_{sol,k}$$

$F_{sh,ob,k}$  reduction factor for external shading

$A_{sol,k}$  effective solar capture area

$I_{sol,k}$  average monthly solar irradiance on the surface

### Warning: unit of measurement

$I_{sol,k}$  must be expressed in W, if the UNI 10349 standard is employed the irradiance is the daily average for the reference month in MJ therefore the value of the standard must be transformed:

$$I_{sol,k} = I_{10349} \times 10^6 / 86400$$

# Area for solar gains

Glass surface

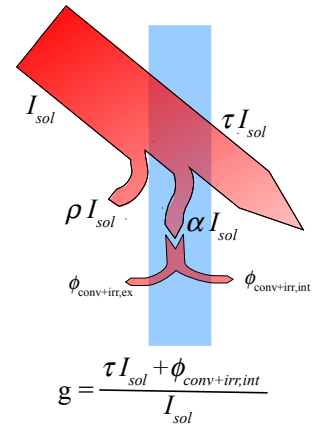
$$A_{sol} = F_{sh,gl} \times g_{gl} \times (1 - F_F) \times A_{w,p}$$

$F_{sh,gl}$  reduction factor for the presence of mobile screens

$g_{gl}$  solar energy transmittance of the glass surface

$F_F$  area fraction relative to the frame

$A_{w,p}$  window compartment area



# Area for solar loads

opaque surfaces

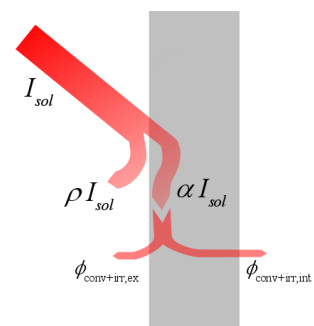
$$A_{sol} = \alpha_{sol,c} \times R_{se} \times U_c \times A_c$$

$\alpha_{sol,c}$  solar absorption factor

$R_{se}$  external surface resistance

$U_c$  thermal transmittance of the component

$A_c$  projected area of the opaque component



## Heating Balance

$$Q_{H,nd} = Q_{H,ht} - \eta_{H,gn} \times Q_{gn} = (Q_{H,tr} + Q_{H,ve}) - \eta_{H,gn} \times (Q_{int} + Q_{sol})$$

$$\gamma_H > 0 \quad \gamma_H \neq 1$$

$$\eta_{H,gn} = \frac{1 - \gamma_H^{a_H}}{1 - \gamma_H^{a_H+1}}$$

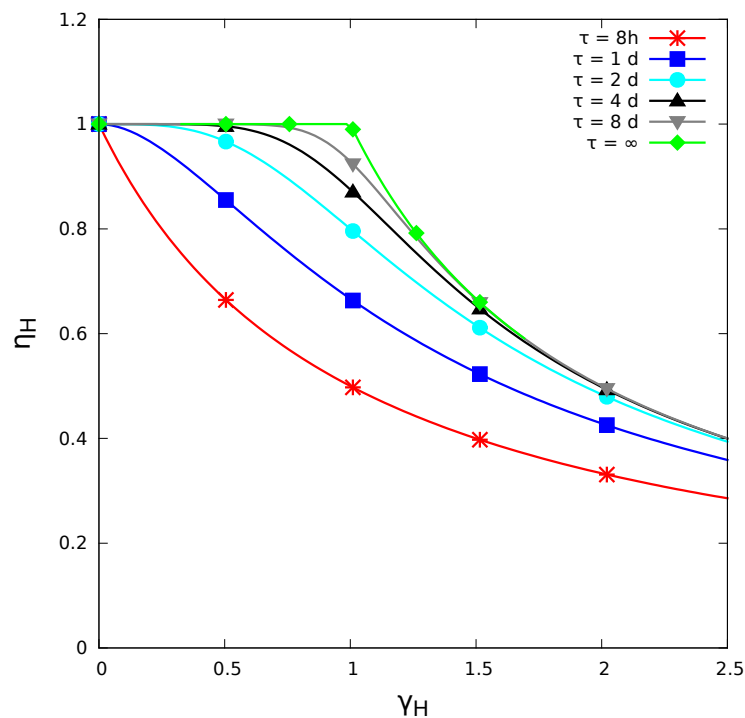
$$\gamma_H = 1$$

$$\eta_{H,gn} = \frac{a_H}{a_H + 1}$$

$$\gamma_H = \frac{Q_{gn}}{Q_{H,ht}}; \quad a_H = a_{H,0} + \frac{\tau}{\tau_{H,0}}; \quad \tau = \frac{C_m}{H_{adj}}$$

- $\tau$  thermal time constant of the zone in hours
- $C$  internal heat capacity of the zone
- $H_{adj}$  corrected global heat transfer coefficient
- for monthly calculation period assume  $a_{H,0} = 1, \tau_{H,0} = 15 \text{ h}$

## gain utilization factor



# Heat capacity

## effective thickness method

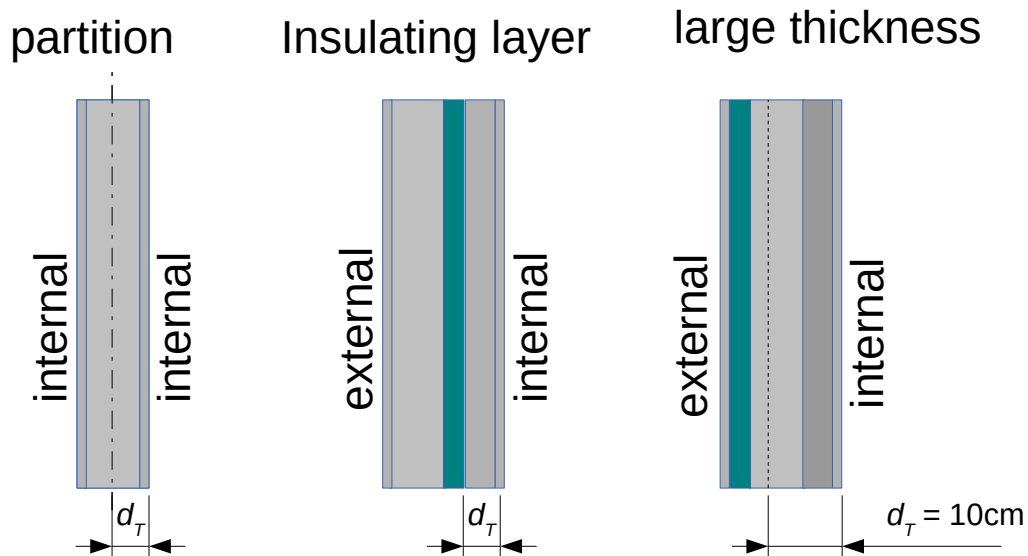
- is a simplified method, it considers the thermal diffusivity
$$\alpha = \frac{\lambda}{\rho \cdot c} = 0.7 \times 10^{-6} \text{m}^2/\text{s}$$
- the minimum value of the effective thickness  $d_T$  is the smallest value among the following:
  - a) half thickness of the component
  - b) the thickness of the materials up to the first layer of insulation
  - c) a maximum depth  $d_T$ , function of the period of temperature variations
- the heat capacity is calculated as

$$\kappa_m = \sum_i \rho_i d_i c_i \quad \text{with} \quad \sum_i d_i = d_T$$

Period of variations	1 hour	1 day	1 week
$d_T$	20 mm	100 mm	250 mm

# Thermal heat capacity

## effective thickness



- useful energy requirement for domestic hot water
- calculates the efficiency and electrical energy requirements of the auxiliaries of heating and DHW systems
- calculates the primary energy requirements for winter air conditioning and DHW production
- applies to new or existing buildings
- applies to
  - heating only
  - mixed or combined for heating and DHW
  - for DHW only

## Utilization subsystems

### Heating

- emission
- regulation
- distribution
- accumulation (external to components)

### DHW

- supply;
- distribution (divided into final distribution and recirculation network where present);
- accumulation (external to system components);
- primary distribution (generator/accumulation circuit).

### Ventilation

- emission;
- distribution (divided into final distribution and recirculation network where present);
- distribution;
- generation (in the independent case).

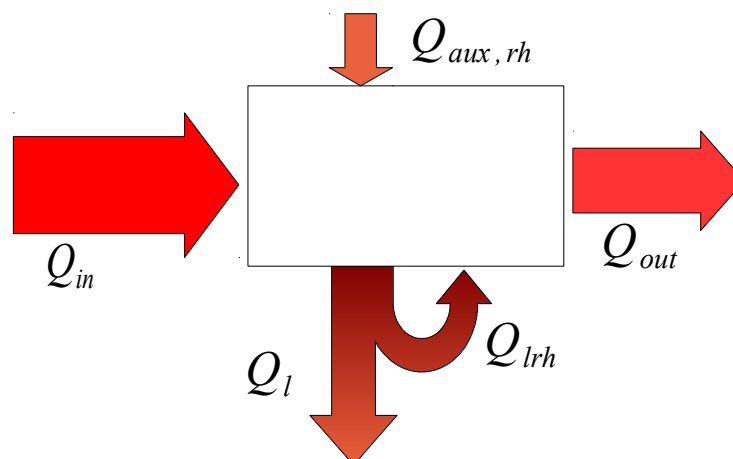
the following thermal energy requirements are considered

- 1) thermal energy requirement for heating and ventilation of the building  $Q_h$
- 2) thermal energy requirement for hot water for sanitary purposes  $Q_w$

## System budget

subsystem budget

$$Q_{in} = Q_{out} + Q_l - (Q_{lrh} + Q_{aux,rh}) \text{ [kWh]}$$



## Loss Types

- non-recoverable: non-recoverable thermal energy (e.g. pipes running outside the building);
- recoverable: thermal energy that can be recovered (e.g. running pipes inside the heated space);
- recovered: fraction of recoverable thermal energy losses that are actually recovered and can therefore be deducted from the useful thermal energy requirement.

# Methods for loss calculation

## calculation methods

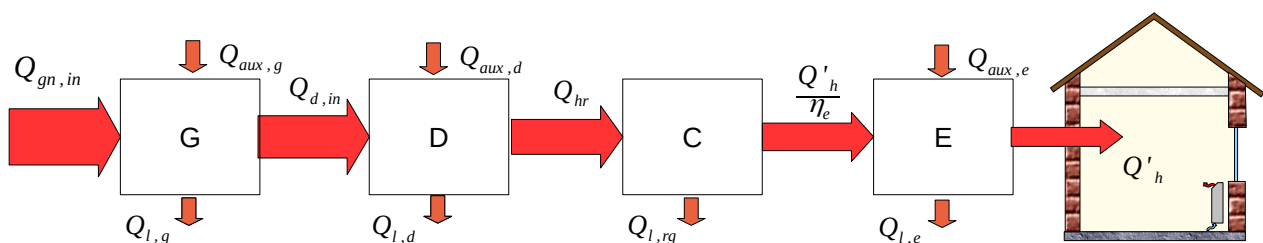
- 1 determination based on tables with pre-calculated data based on the type of system
  - 2 calculation using methods described in the specification
- if method 1, simplified, is used, energy recovery (thermal or electrical) is not considered
  - electrical energy requirements must be calculated separately

The thermal energy demand for heating the building is divided into:

- ideal demand,  $Q_h$  is obtained from UNI/TS 11300-1
- net ideal demand obtained by subtracting the recovered losses (as an example the heat produced by fancoil ventilations, or distribution losses inside heated spaces) from the ideal demand
- effective demand takes into account the emission and control losses, i.e. the thermal energy that the distribution subsystem must introduce into the zones

## Heating subsystems

### Subdivision into subsystems



# Emission losses

## Heating system

- two tables are provided for rooms with heights lower and higher than 4 m respectively
- for rooms with heights higher than 4 m they are influenced by the typology and by a correct installation
- if the above conditions are not verified, it is necessary to operate differently (UNI EN 15316-2-1)
- once the efficiency has been determined, it is possible to compute the losses

## Emission losses

$$Q_{l,e} = Q'_H \times \frac{1 - \eta_e}{\eta_e}$$

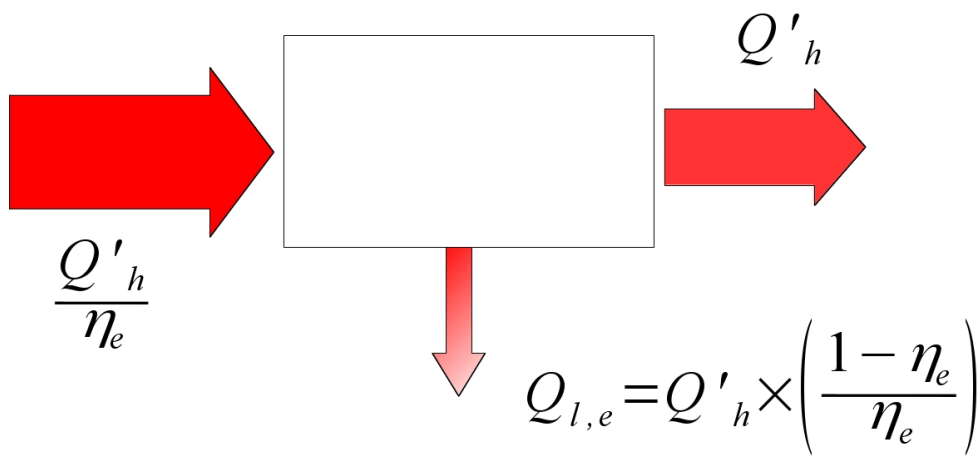
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# Emission efficiency

rooms with height  $\leq 4$ m

Type of delivery terminal	Average annual thermal load W/m <sup>3</sup>		
	< 4	4 – 10	> 10
	$\eta_e$		
Radiators on insulated external wall	0.98	0.97	0.95
Radiators on internal wall	0.96	0.95	0.92
Fan coils referred to $t_{\text{mean water}} = 45^\circ$	0.96	0.95	0.94
Convectors	0.94	0.93	0.92
Vents in hot air systems	0.94	0.92	0.90
Insulated panels embedded in the floor	0.99	0.98	0.97
Panels embedded in the floor	0.98	0.96	0.94
Ceiling embedded panels	0.97	0.95	0.93
Wall panels	0.97	0.95	0.93

Navigation icons: back, forward, search, etc.



## Control subsystem

- table 20 reports values to be used
- for evaluations in actual conditions better values can be used
- form design and standard evaluation table 20
- also in this case the losses are obtained from the efficiency

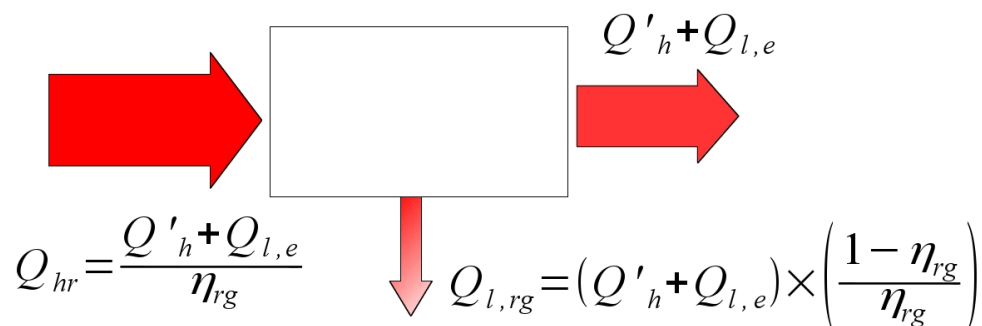
### emission losses

$$Q_{l,rg} = (Q'_H + Q_{l,e}) \times \frac{1 - \eta_{rg}}{\eta_{rg}}$$

# Control efficiency

Type of control	Characteristics	Low thermal inertia systems	High thermal inertia systems	
		Radiators, convectors, fan coils, radiant strips, hot air	panels integrated into building structures and thermally decoupled	panels integrated into building structures and not thermally decoupled
Climate only		$1 - (0.6\eta_u\gamma)$	$0.98 - (0.6\eta_u\gamma)$	$0.94 - (0.6\eta_u\gamma)$
Zone only	On off	0.93	0.91	0.87
	P prop. band 2.0K	0.94	0.92	0.88
	P prop. band 1.0K	0.97	0.95	0.91
	P prop. band 0.5 K	0.98	0.96	0.92
	PI or PID	0.99	0.97	0.93
only for room	On off	0.94	0.92	0.88
	P prop. band 2.0 K	0.95	0.93	0.89
	P prop. band 1.0 K	0.98	0.97	0.95
	P prop. band 0.5K	0.99	0.98	0.97
	PI or PID	0.995	0.99	0.97
zone + climate	On off	0.97	0.95	0.93
	P prop. band 2.0 K	0.97	0.96	0.94
	P prop. band 1.0K	0.98	0.97	0.95
	P prop. band 0.5K	0.99	0.98	0.96
	PI or PID	0.995	0.99	0.97

# control losses



# Distribution subsystem

## Loss calculation

### calculation methods

- 1 using pre-calculated data (table 21)
  - 2 using Appendix A (requires calculation of the distribution network)
- pre-calculated values can be used when the conditions reported are met
  - if method 1 is followed, recoveries due to pumps must not be considered

# Distribution subsystem

## Precalculated data

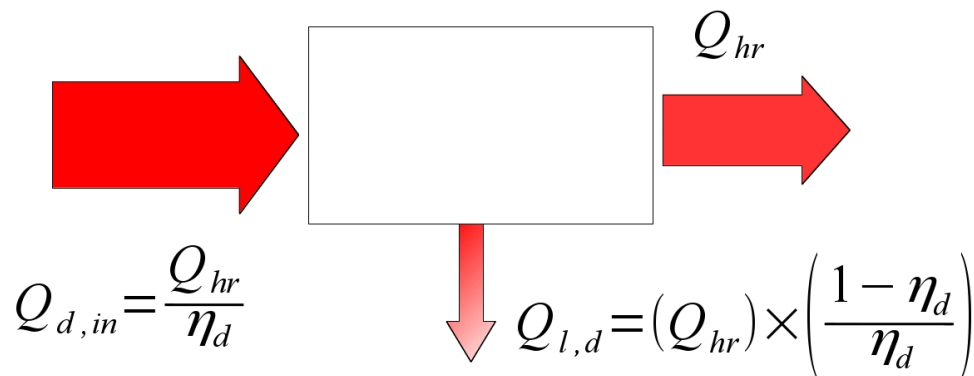
- The values contained therein refer only to the types of networks indicated and can only be used for networks of the types indicated,
- the tables refer to residential typologies (mainly)

### Losses

$$Q_{l,d} = Q_{hr} \times \frac{1 - \eta_d}{\eta_d}$$

$Q_{hr}$  thermal energy requirement at the exit of the distribution segment

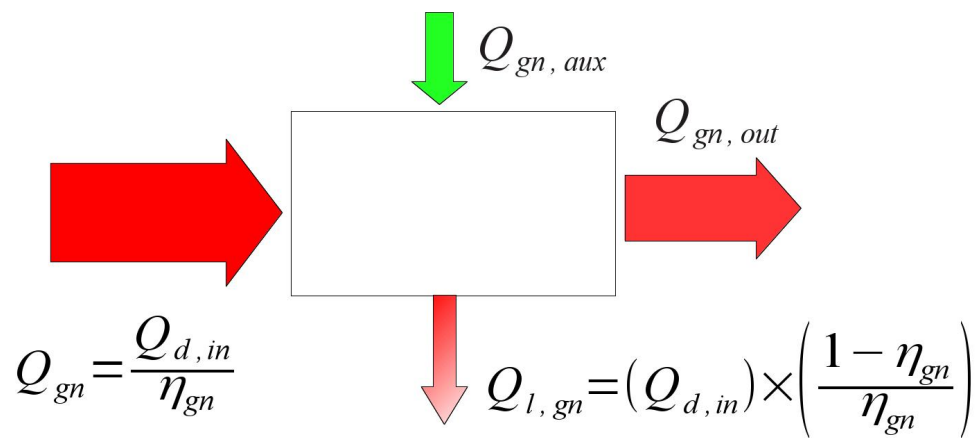




## Generation loss

- 1 Using tables containing pre-calculated values for the most common types of heat generators based on the sizing and installation conditions
- 2 Using calculation methods
  - Calculation method based on the declared efficiencies in accordance with Directive 92/42/EC, with appropriate corrections in relation to the operating conditions;
  - Analytical calculation method
- for design (A1) and standard (A2) assessments, the values listed in the table can be used only if the boundary conditions and the generator typology correspond to those in the tables
- for assessments in actual conditions (A3) I must use the calculation
- if the tables are used, I can calculate the losses as

$$Q_{l,gn} = (Q_{hr} + Q_{l,d}) \times \frac{1 - \eta_{gn}}{\eta_{gn}}$$



## Precalculated generation efficiencies

### Correction factors

- F1 ratio between the installed generator power and the required design power. For modulating generators, F1 is determined with reference to the minimum regulated power.
- F2 outdoor installation
- F3 chimney height greater than 10 m
- F4 average boiler temperature greater than 65 °C under design conditions.
- F5 single-stage generator
- F6 chimney higher than 10 m in the absence of combustion air closure at shutdown (not applicable to premixed)
- F7 return temperature to the boiler in the coldest month

## Table 25

### Atmospheric heat generators B classified \*\* (two stars)

Base value	F1			F2	F3	F4
	1	2	4			
90	0	-2	-6	-9	-2	-2

For generators before 1996 base value 84

For generators classified \* (1 star) base value 88

Base value referred to: two-star boiler, oversizing 1 minimum of modulation, internal installation, chimney less than 10 m high, temperature of flow in design conditions  $< 65^{\circ}\text{C}$

## Table 26

### Type C sealed chamber heat generators for autonomous systems classified \*\*\* (three stars)

base value	F1			F2	F4
	1	2	4		
93	0	-2	-5	-4	-1

Base value referred to: three-star boiler, oversizing 1 modulation, internal installation, chimney less than 10 m high flow in design conditions  $< 65^{\circ}\text{C}$

## Condensing gas heat generators \*\*\*\* (4 stars)

$\Delta T$ fumes - return water to $P_n$	Base value	F1			F2	F5	F7			
		1	1.25	1.5			40	50	60	> 60
< 12°C	104	0	0	0	-1	-3	0	-4	-6	-7
from 12°C up to 24°C	101	0	0	0	-1	-3	0	-2	-3	-4
from > 24°C	99	0	0	0	-1	-2	0	-1	-2	-3

## auxiliary energy

$$Q_{gn,aux} = \frac{W_{aux,Pn} \cdot t_{gn}}{1000} \quad [\text{kWh}]$$

$W_{aux,Pn}$  auxiliary power at nominal condition

in the absence of data, Table B.4 can be used

## Prospetto B.4

$$W_{aux,Pi} = G + H \times \Phi_{Pn}^n \quad [W]$$

Type	power	G	H	n
Condensing generator	$\Phi_{Pn}$	0	45	0,48
	$\Phi_{Pint}$	0	15	0,48
	$\Phi_{Po}$	15	0	0
Blown air generator	$\Phi_{Pn}$	0	45	0,48
	$\Phi_{Pint}$	0	15	0,48
	$\Phi_{Po}$	15	0	0

- knowing the loss terms, primary energy can be calculated
- considers both fossil fuel energy consumed and energy consumed to produce electricity
- conversion factors between different energy vectors

$$Q = f_p \times Q_{gn,IN} + f_{p,el} \times (Q_{gn,aux} + Q_{gn,Po})$$

$Q_{n,P}$  electrical energy absorbed by the circulation pump

$f_{p,el}$  conversion factor electrical energy - primary energy

$f_p$  conversion factor from energy vector to primary energy of the energy vector

## Primary energy conversion factors

Energy vector	$f_{P,nren}$	$f_{P,ren}$	$f_{P,tot}$
Natural gas	1,05	0	1,05
GPL	1,05	0	1,05
Diesel and fuel oil	1,07	0	1,07
Coal	1,10	0	1,10
Solid biomass	0,20	0,80	1,00
Liquid and gaseous biomass	0,40	0,60	1,00
Electricity from the grid	1,95	0,47	2,42
District heating	1,5	0	1,5
Municipal solid waste	0,2	0,2	0,4
District cooling	0,5	0	0,5
Thermal energy from solar collectors	0	1,00	1,00
Electricity: photovoltaic, mini-wind and mini-hydraulic	0	1,00	1,00
Thermal energy from the external environment – free cooling	0	1,00	1,00
External – heat pump	0	1,00	1,00