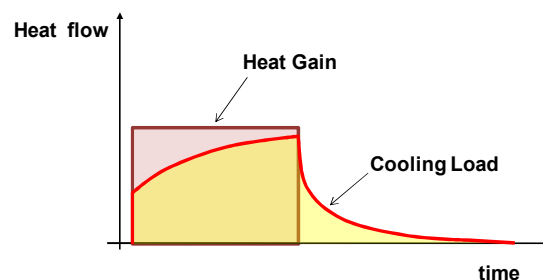


Simplified dynamic calculation methods: cooling load, method of the equivalent temperature, overview on the quasi-steady state method, schematic of cooling systems

Heat gain and cooling load

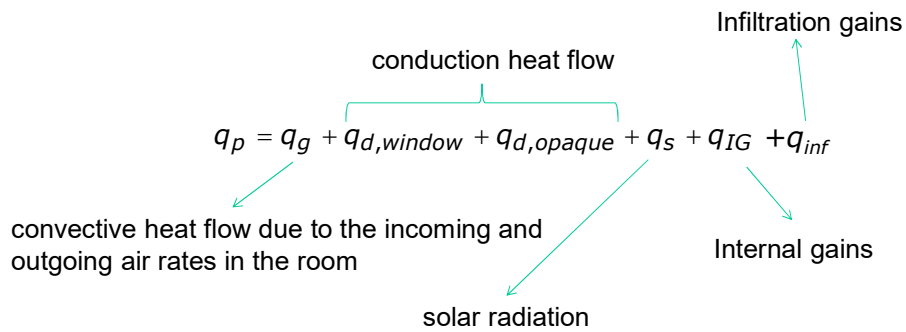
These models are based on the shift in time of the heat gain which occurs in a certain time step due to the thermal inertial of the building structures.

The cooling load is the effective load considering the effect of the building structures in terms of thermal inertia as storage and later released of the thermal energy embedded in the structures



Method based on equivalent difference temperature

For each hour of the day, the following equation can be written:



Ventilation gain:

$$q_g = G_a c_p (t_{imm} - t_i)$$

Infiltration gain:

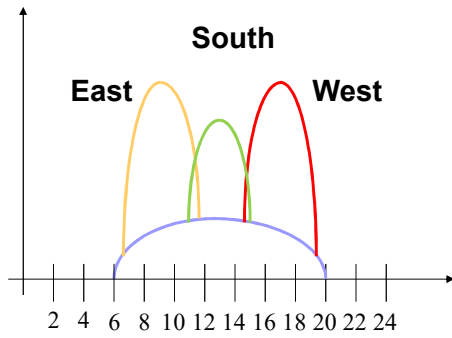
$$q_{inf} = G_a c_p (t_e - t_i)$$

Windows are supposed to have no capacity:

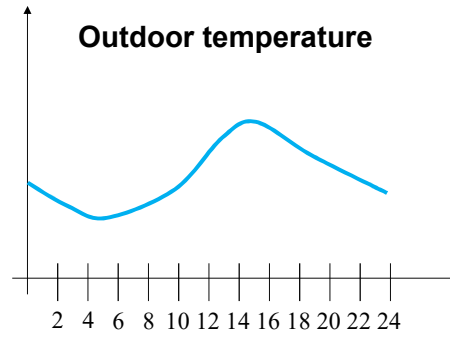
$$q_{d,window} = \sum_{k=1}^f U_k S_k (t_e - t_i)$$

Cooling load of opaque structures

Solicitation: sol-air temperature



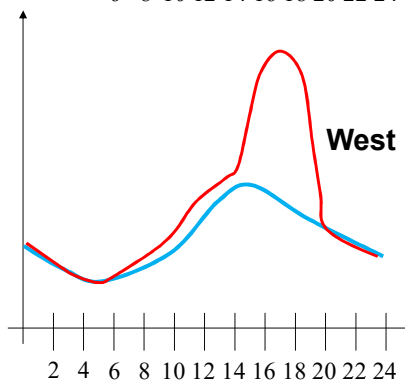
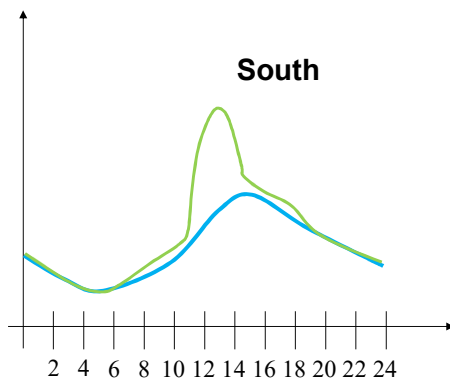
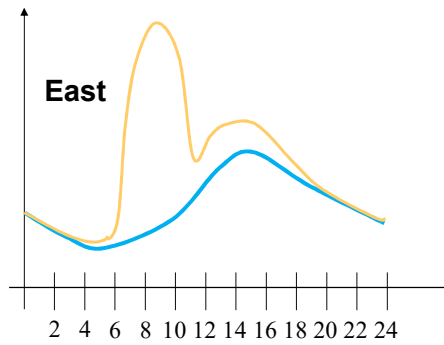
Solar radiation in the different orientations (clear sky conditions)

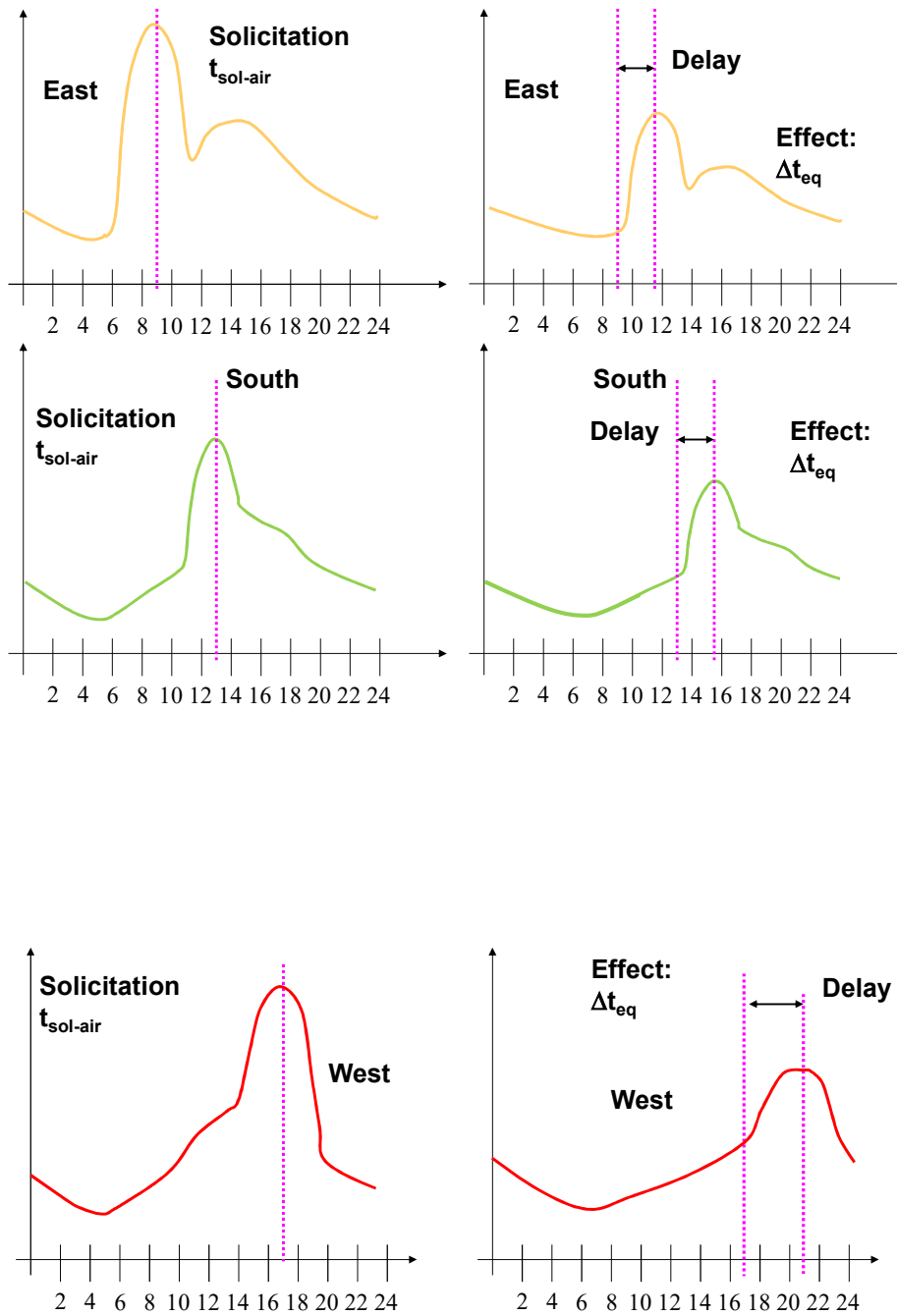


Outdoor air temperature

Sol-air temperature:

$$t_{sol-air} = t_a + a \cdot I \cdot f_h / h_c$$



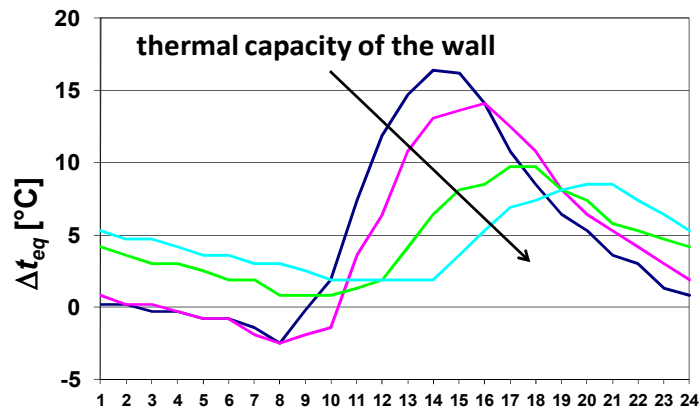


Depending on the orientation and colour of the wall, on the hour of the day and on the specific mass of the wall per surface area (m_f):

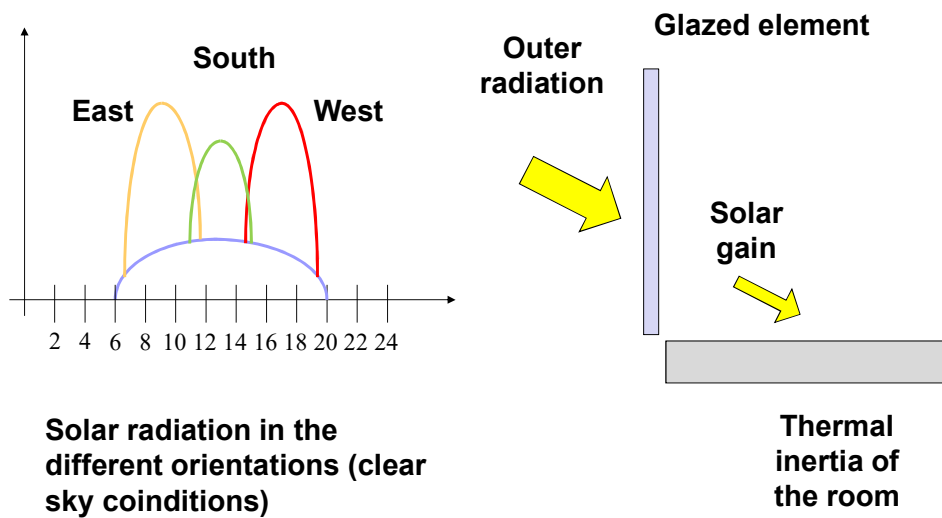
$$q_{d,opaque} = \sum_{i=1}^0 U_i S_i \Delta t_{eq,i}$$

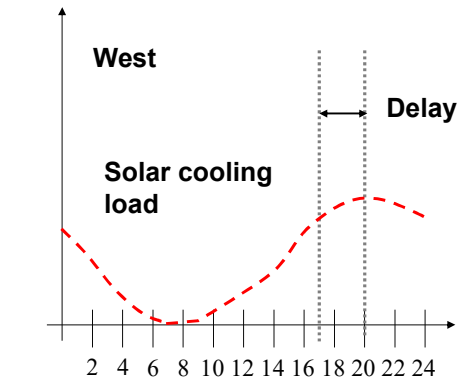
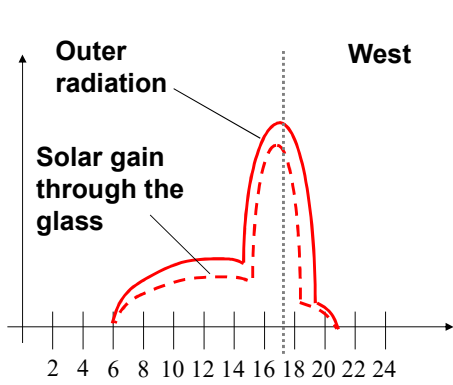
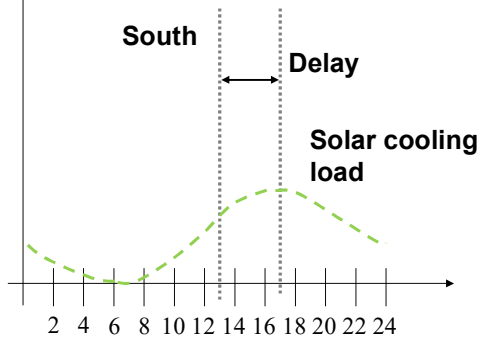
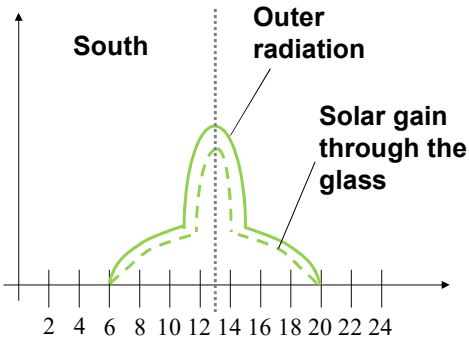
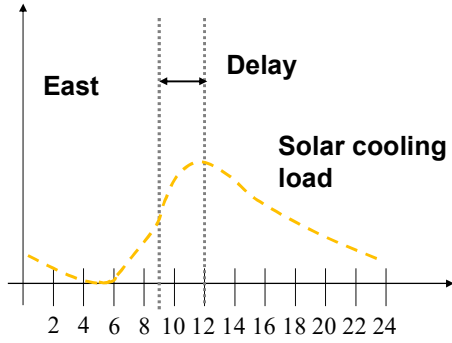
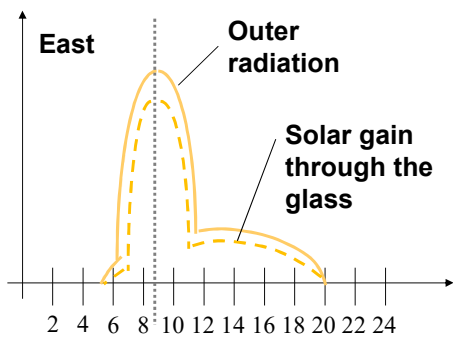
$$m_f = \sum_q \rho_q S_q$$

The $\Delta t_{eq,i}$ is the equivalent temperature difference and it includes the sol-air temperature and the shift in time of the thermal capacity of the wall

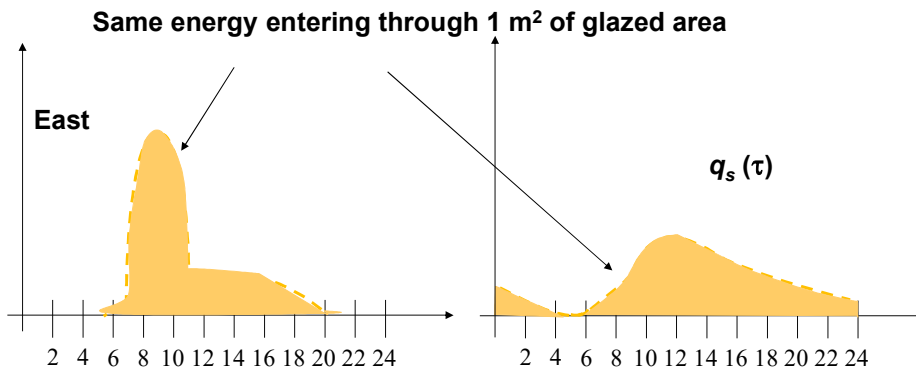
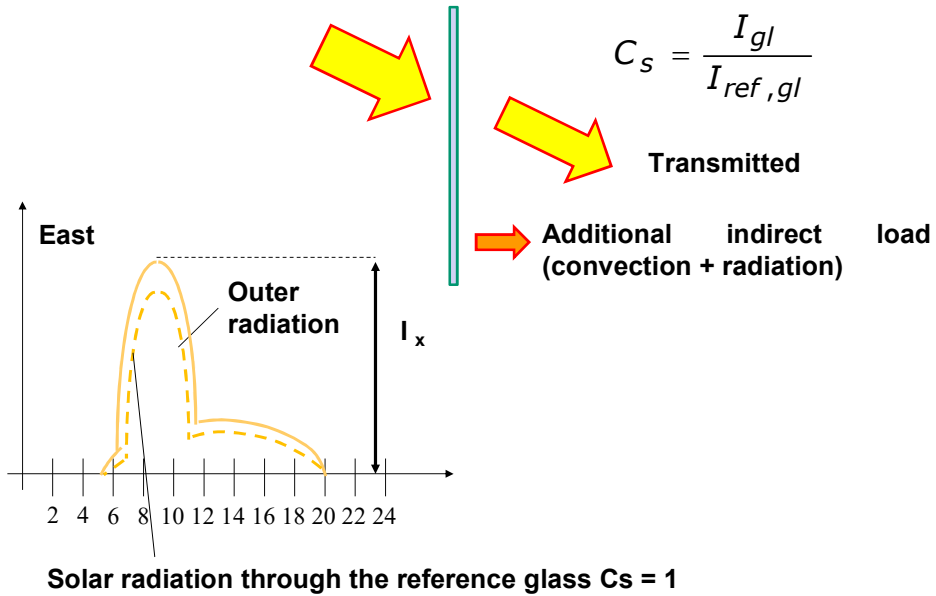


Solar cooling load from glazed elements





It is the ratio between the solar factor of the analyzed glass and solar factor of a reference one (clear glass, 3 mm):



Solar cooling load (q_s): evaluated for each orientation as a function of the thermal inertia of the room (hour by hour).

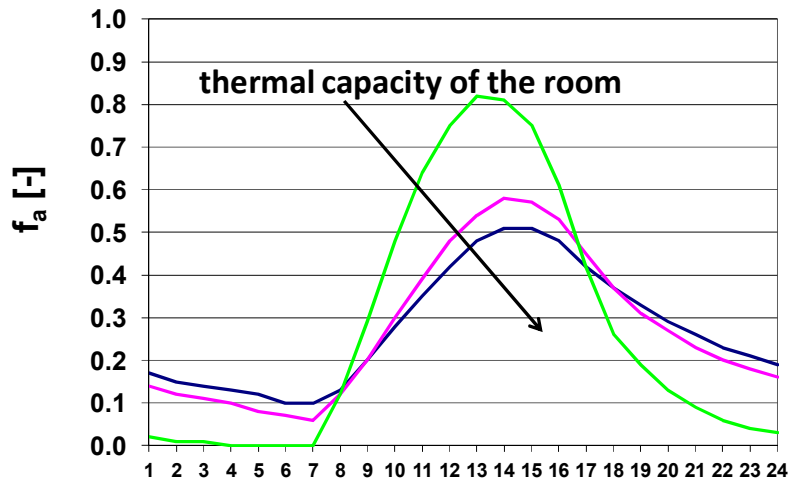
Attenuation factor: $f_a(\tau) = \frac{q_s(\tau)}{I_x}$ Referred to the maximum incident solar radiation for the considered orientation

Considering the area of the glass and the actual characteristics of the glass (C_s):

$$q_s(\tau) = S I_x f_a(\tau) C_s$$

The effect of solar radiation through glazing components:

$$q_s = \sum_{k=1}^f S_k I_{x,k} f_{a,k} C_{s,k}$$



The thermal capacity of the room M_R is calculated as:

$$M_R = \frac{\sum_j m_{f,j} S_j + 0.5 \cdot \sum_r m_{f,r} S_r}{S_f}$$

Floor area

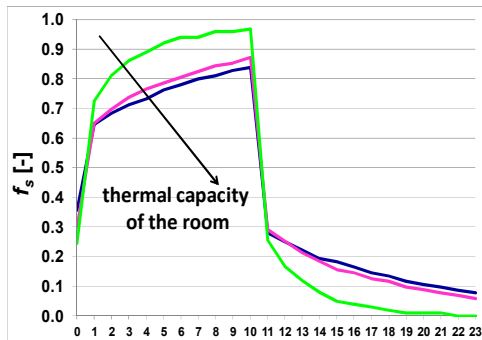
The thermal inertia of the j -th generic wall facing outside has to be considered as a whole, while the r -th internal wall is counted for half of the thermal capacity

Internal gains:

convective and radiant gains are considered together

$$q_{IG} = \sum_j f_{s,j} (q_{I,j} + q_{C,j})$$

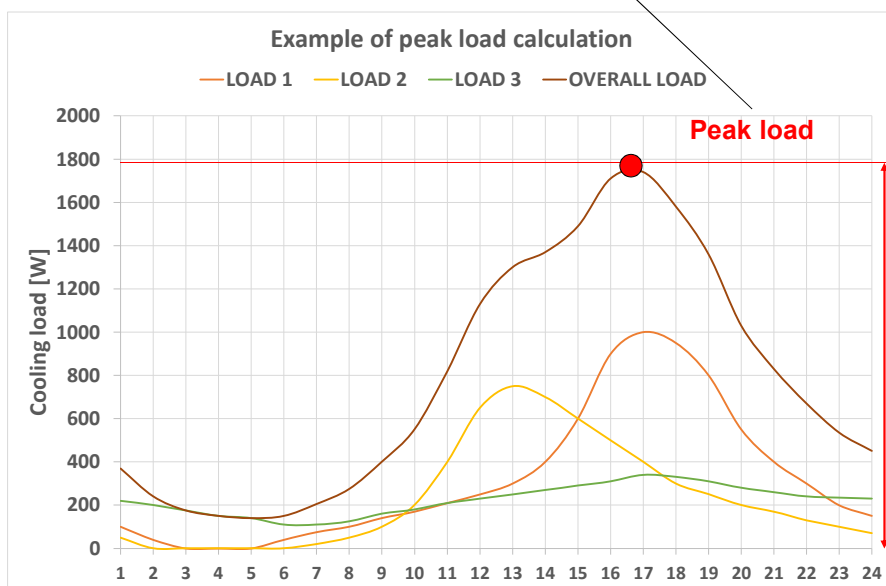
internal gain storage factor



The storage factor begins (time step 0) when the internal gain starts

Peak load evaluation

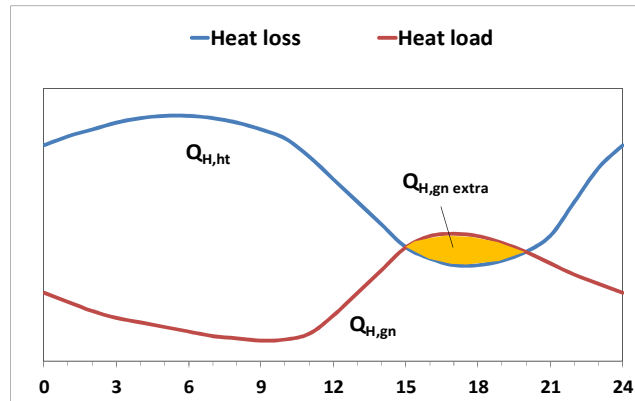
Maximum value of the overall load



Overview on the quasi-steady state method

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

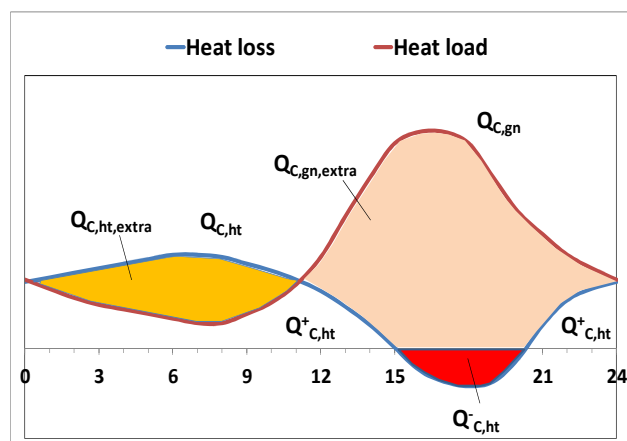
Heating



$$\eta_{H,gn} = \frac{Q_{H,gn} - Q_{H,gn,extra}}{Q_{H,gn}}$$

Cooling

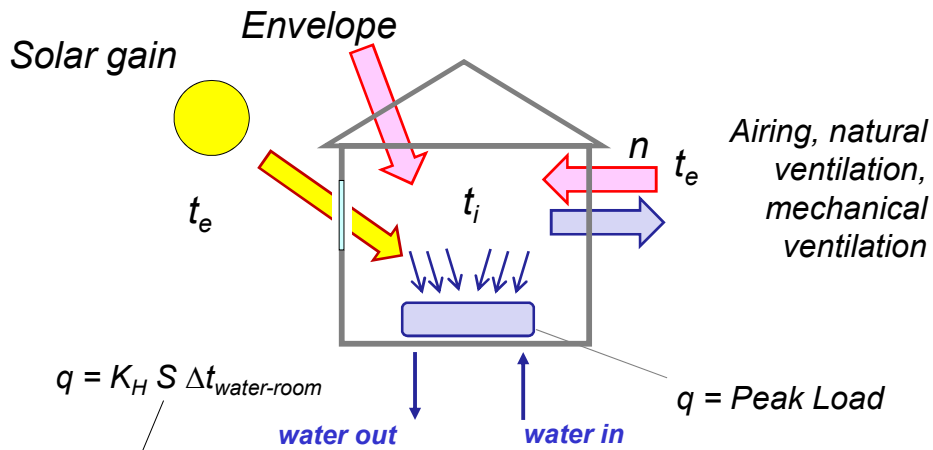
$$Q_{C,nd} = Q_{C,gn} - \eta_{C,ht} \cdot Q_{C,ht}$$



$$\eta_{C,ht} = \frac{Q_{C,ht} - Q_{C,ht,extra} - |Q_{C,ht}^-|}{Q_{C,ht} - |Q_{C,ht}^-|}$$

Types of HVAC systems

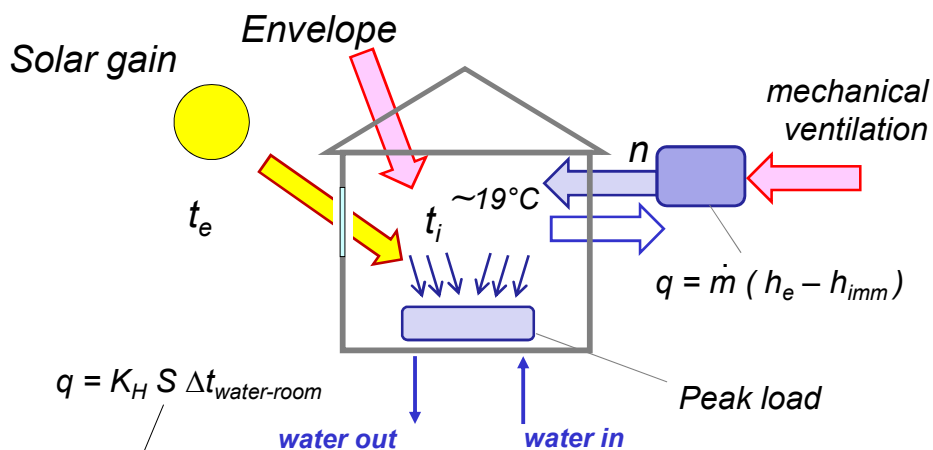
1. Water based cooling



- Type and size of the emission system
- Average water temperature in the emission system (dehumidification needed)

Types of HVAC systems

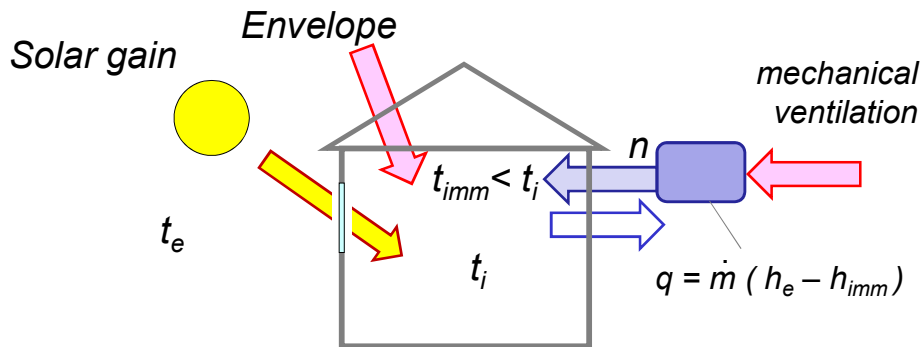
2. Air and water based cooling



- Type and size of the emission system
- Average water temperature in the emission system

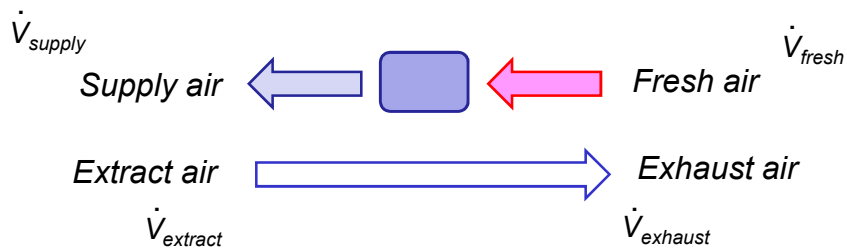
Types of HVAC systems

3. Full air cooling



The air enters the room with lower temperature (t_{imm}) than t_i . Depending on the flow rate and t_{imm} , there are 2 possible solutions.

1) No recirculation: $\dot{V}_{fresh} = \dot{V}_{supply} \cong \dot{V}_{exhaust}$



2.) With recirculation: $\dot{V}_{fresh} < \dot{V}_{supply} \cong \dot{V}_{extract}$

