TREES **Training for Renovated Energy Efficient Social housing**

Intelligent Energy Europe

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Section 2 Tools

2.1 Simplified heating load calculation

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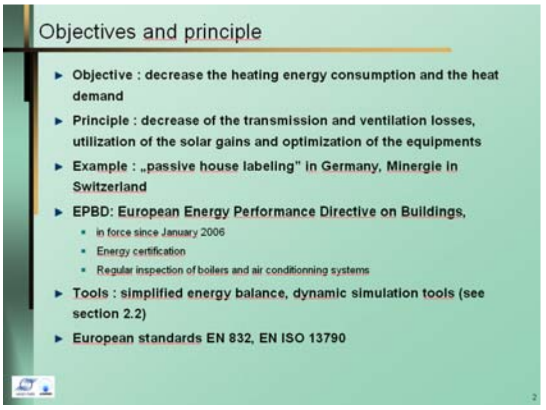
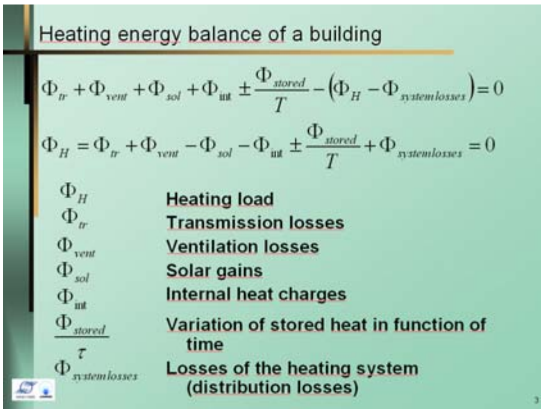


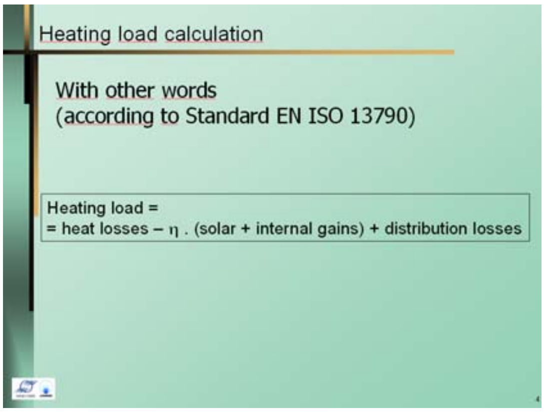
Slide 2

Simplified heating energy demand calculation tools are made to estimate the demand with relative small efforts, within short time and acceptable preciseness (±25%). They are applied for estimating fuel consumption or in certification processes (passive house labelling, EPBD, etc.). For higher level of preciseness or in case of complicated buildings simplified tools are not adequate, dynamic simulation tools are recommended.



Slide 3

Heating load is the amount of heat needed in order to maintain a prescribed indoor air temperature during a period (heating season). It can be calculated for a day, a week, a month or for the whole heating season. The equation shows the different heat flows that determine the heating energy balance of a building. The values are in Watts, for a period their integral should be taken into account (heating load is expressed in Joule or MJ, GJ, kWh).

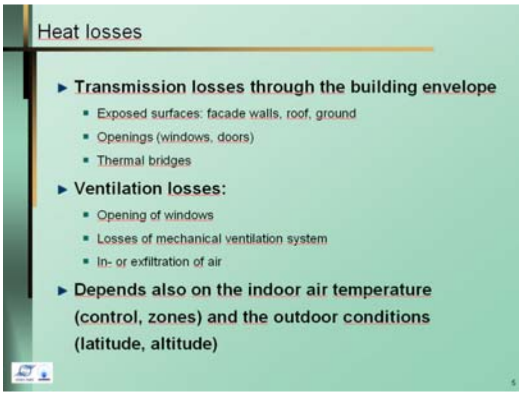


Slide 4

The detailed method of simplified heating load calculation can be found in the Standard EN ISO 13790.

From the equation of slide 3 the heating load can be expressed as the present formula shows: the heating load is the difference between losses and gains. Only a part of the gains can be utilised depending on the thermal mass and the control of the heating system. It is expressed by the η.

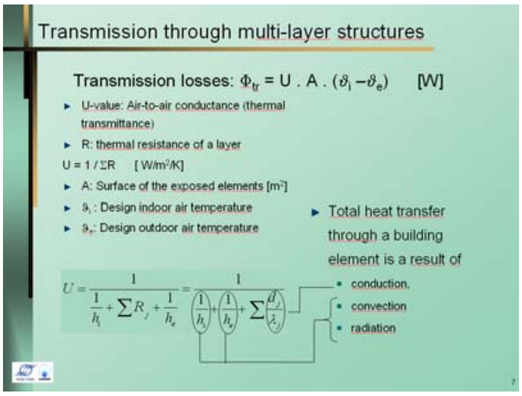
2. Heat losses



Slide 5

Usually the bigger part of the heat losses are caused by transmission: heat flowing through the structures of the building envelope. The other major part is the loss caused by ventilation (fresh air is always needed): it can be spontaneous filtration through air leakages or caused by opening the windows or the ventilation system. The losses mainly depend on the climatic conditions, the insulation level of the building, the air tightness and the HVAC system.

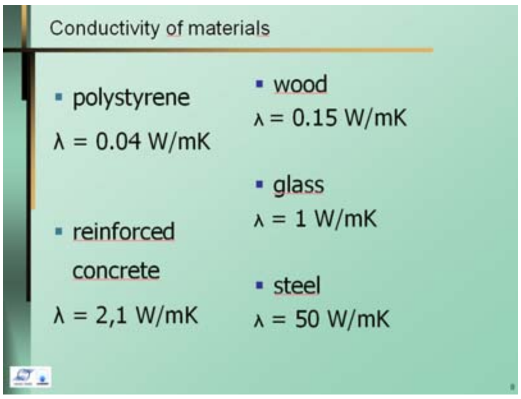
2.1 Transmission losses



Slide 7

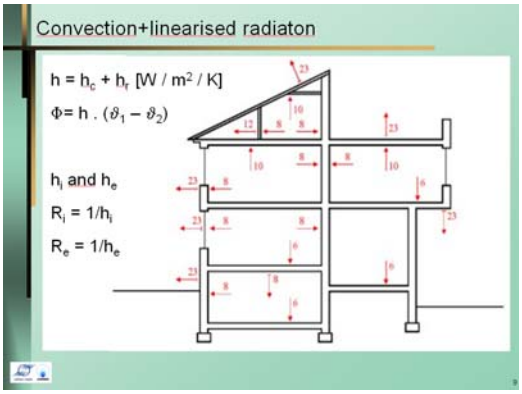
The transmission through a multi-layer structure is the product of the thermal transmittance (U-value), the area and the temperature difference. If a structure is better insulated, the lower the U-value is. U-value depends on the thermal conductance of the layers and the convection in the boundary layers. Simple multi layer structures can be calculated with the formula, for complicated elements (e.g. windows) it is given by the producer.

In many cases thermal resistance (R) is used instead of U-value, because it is more practical to calculate with.



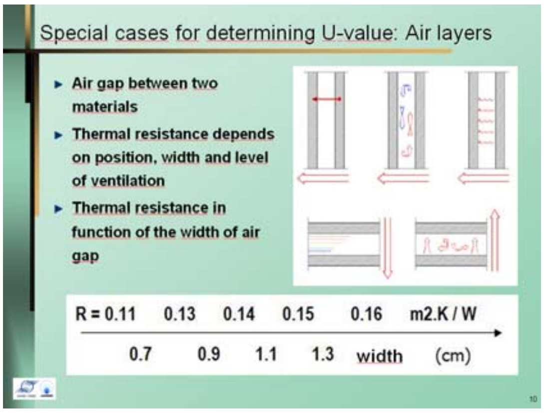
Slide 8

The thermal quality of a material is expressed by its thermal conductance (λ). The lower the λ is, the better the insulation level is. As the figures show the insulation materials, such as polystyrene are more than 1000 times better than steel.



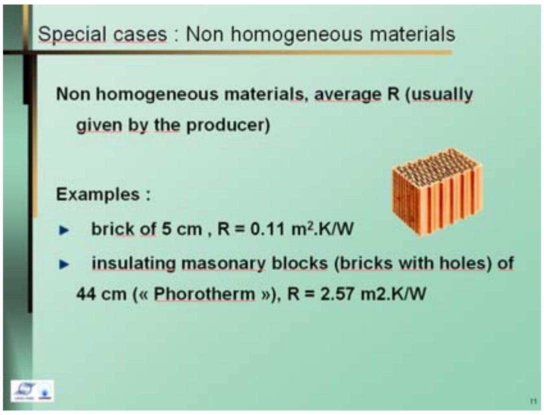
Slide 9

Beside of conduction, heat flow through the building envelope is also determined by convection in the boundary layers. It doesn't depend on the material but other stochastic factors: temperature, wind, air movement, etc. Practically the radiation is also expressed in the h-values, although it is a third way of heat flow.



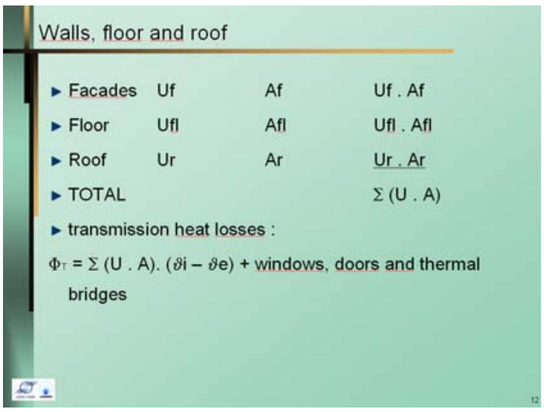
Slide 10

For air layers the formula of the U-value presented in slide 7 doesn't work, because here heat flow is not caused by pure conduction. Depending on the type, thickness and position of the air gap, the U-value can be determined from tables of standards, software tools or books of building physics.



Slide 11

For non homogeneous materials, such as bricks with holes, the formula of the U-value from slide 7 doesn't work, either. Here, product catalogues can help to find the correct U-value.



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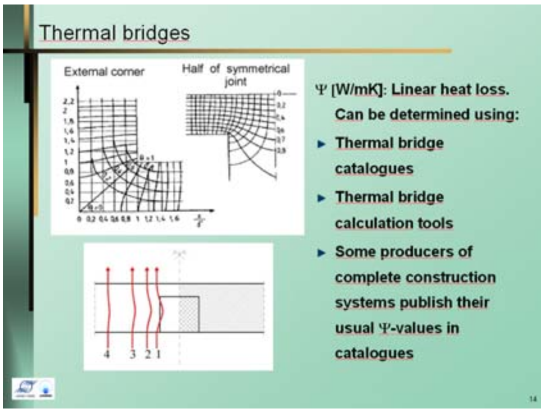
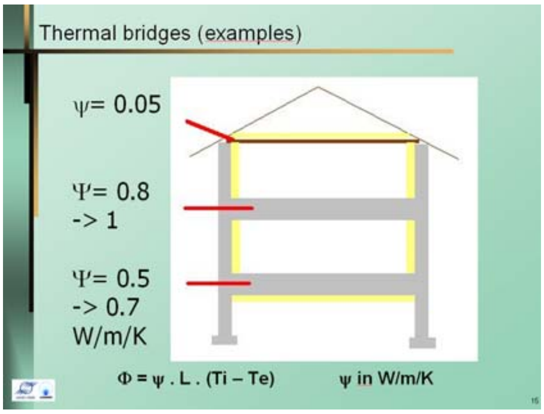
Slide 13
For doors and windows also the producers should provide the U-value. Today, an average new window has a U-value of 1,1-1,4 W/m^{2}K. It is a double glazed window with low-emissivity coating and argon gas filling. With triple glazing and xenon gas filling U-value can be decreased to 0,4 W/m^{2}K. In the case of windows not only the glass, but also the frame and the spacer should be taken into account. $U_{glazing} \neq U_{frame} \neq U_{window}$!

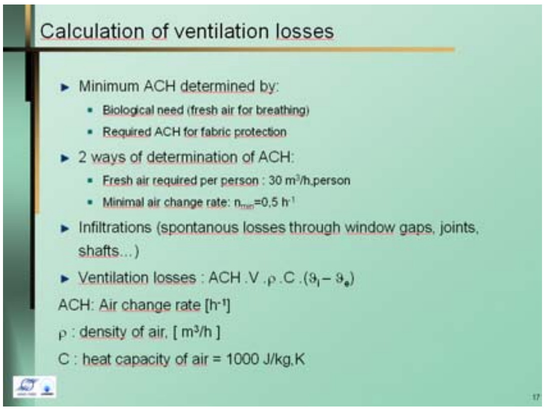


Slide 14
At joints of building elements two- or three-dimensional heat flow develops. In case of good external insulation it increases the heat loss with maximum 5%, but in badly insulated structures it can be 10-200% (the latter is typical for sandwich panels built in the 60s and 70s)! The losses caused by thermal bridges cannot be calculated manually, thermal bridges catalogues or calculation tools are recommended.

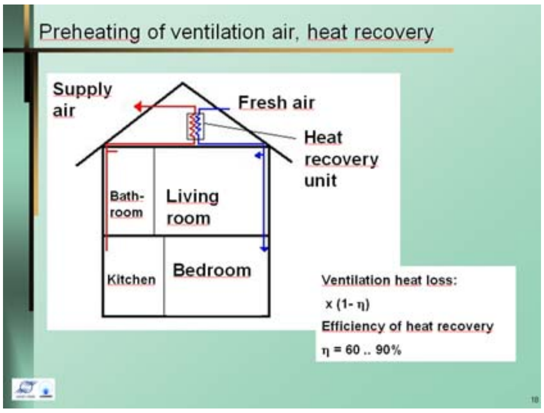


Slide 15
Heat loss through thermal bridges is expressed with the "linear thermal transmittance", the so called Ψ-value (dimension: W/mK). Thermal bridges can be caused by geometric reasons or by non-homogenic materials at a junction (e.g. a reinforced steel pillar or a beam).

2.2 Ventilation losses

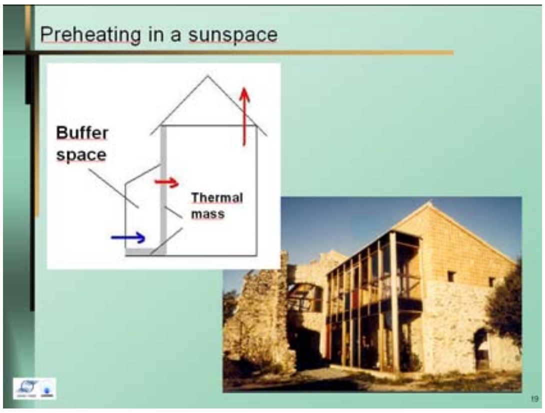


Slide 17
In all buildings there are ventilation losses, because fresh air is needed and it comes from outside. The ventilation heat loss is determined by the air change rate (ACH) that can be determined two ways: from the number of persons or from pre-defined air-change rates given by standards. Ventilation losses depend on the air tightness of the building envelope, the ventilation habit of the occupants and the type and the control of the mechanical ventilation system (if exists).



Slide 18

The ventilation losses can be significantly decreased by a balanced ventilation system with heat recovery. In such a system the fresh air is preheated by the exhaust air in a heat recovery unit (heat exchanger). The efficiency can be between 60 and 90 % depending on the type of the heat exchanger and the air tightness of the building. Electricity consumption of the fans should be taken into account in the overall energy balance of the building.



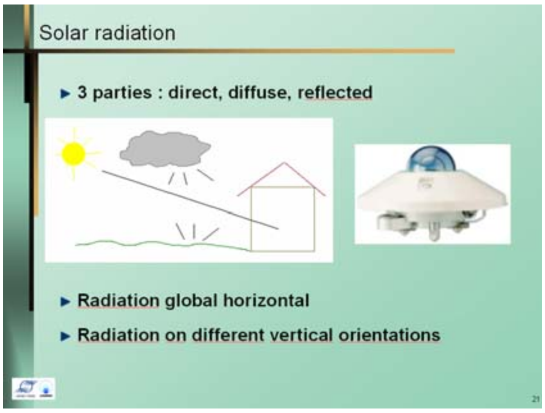
Slide 19

Another way of decreasing ventilation losses is preheating of fresh air in a sun-space. It is a passive way of use of solar energy. Sun space performs as a buffer zone.

Other passive solar measures can be applied to pre-heat fresh air: trombe wall, air-collectors.

3. Heat gains

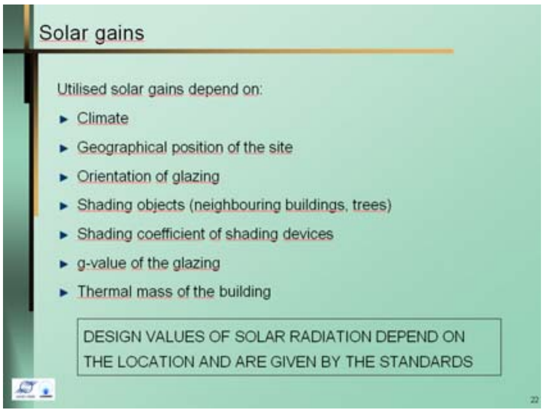
3.1 Solar gains



Slide 21

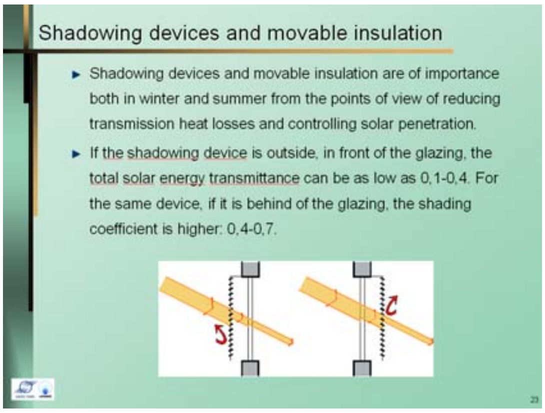
Already slide 19 has shown that there are not only heat losses, but also gains that can be utilised in a conscious way.

Solar radiation comes from the sun during daytime in two ways: direct (clear sky, sunny weather) and diffuse radiation (cloudy weather). Even diffuse radiation causes solar gains due to the greenhouse effect.



Slide 22

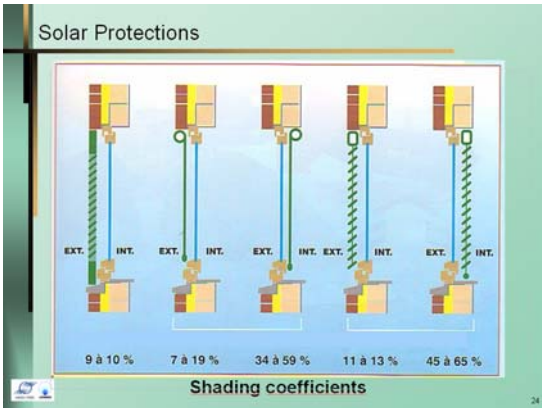
Solar gains depend on the listed factors. Glazing can be characterised by the solar energy transmittance, the so called g-value. It is a figure between 0 and one and represents how many percent of the arriving (perpendicular to the glazing) solar energy can pass through the glazing. Usually a glazing with better (lower) U value has a lower g-value as well, which is a disadvantage in winter. Thermal mass is also an important factor: a heavy building can utilise more solar gain than a lightweight construction.



Slide 23

The solar gains are welcome in winter, but not in summer, therefore solar protection is often needed. External shading devices are usually more efficient than internal ones.

In winter shading devices can be utilised at night, because they decrease the U-value of the window.



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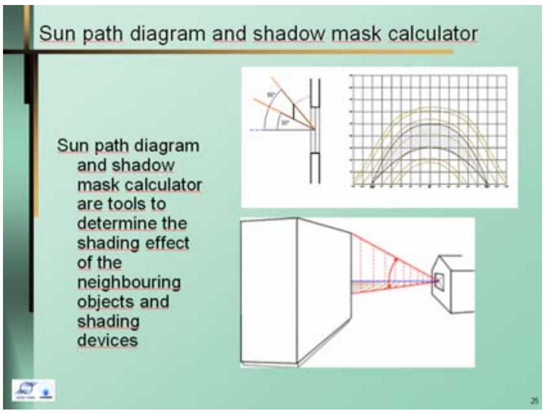
The figure shows the influence of different shading devices on the solar energy transmittance.



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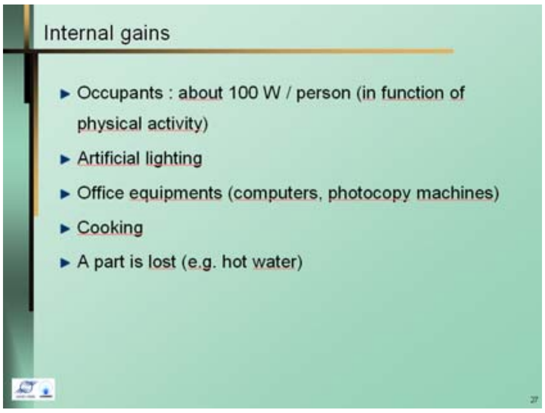
Before taking into account the solar gains we must check when the window is exposed to the sun and when it is in shadow. For this purpose sun-path diagrams and shadow mask calculator can be utilised either manually or using computer tools. The tools can inform us at which days of the year and in which period of the day our window is in shadow.

3.2 Internal gains



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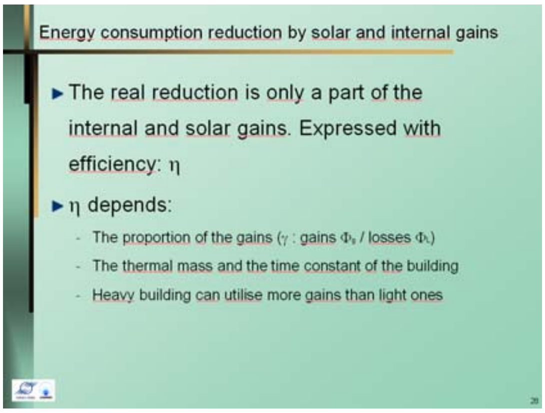
Heat gains are also caused by electric devices (lighting, domestic appliancies), cooking and the occupants. Their effect can be significant especially in office buildings, large kitchens or in crowded public buildings. Although they cause heat gains it is not recommended to increase them, because they are uncontrollable and most of them use electric energy. Their effect can be estimated using tables from books of building physics.



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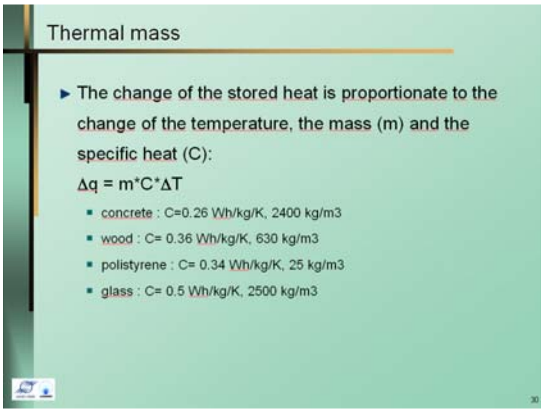
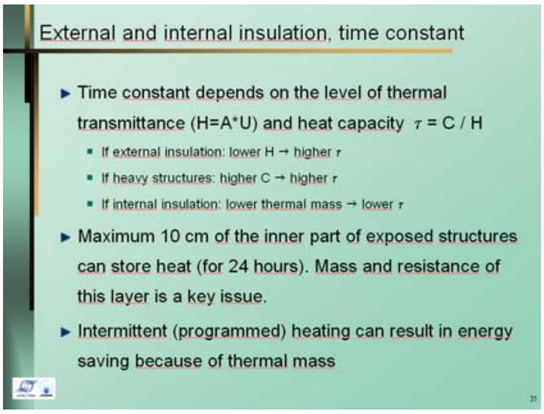
Only a part of the solar and internal gains can be utilised. As they are uncontrollable they can cause overheating even in winter and occupants have to open the window: the gain is lost. If a building has high thermal mass (heavy buildings built with e.g. bricks or concrete) the gains can be store by the structure and released when the losses are higher than the gains (at night). Factors η and γ are explained in the slide.

4. Thermal mass, time constant



Slide 30
The change of the stored heat can decrease the heating load at night, when heat is released from the walls. However in case of intermittent heating the heating up period is longer for a heavy building, because the hevy structures warm up slower.

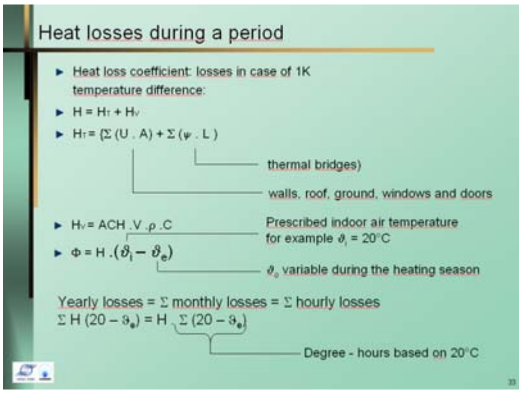


Slide 31

A structure can store more heat for a longer period if the thermal mass of the built-in materials (product of density and specific heat, see slide 30) is higher, or if it is better insulated from outside. External insulation keeps the stored heat inside.

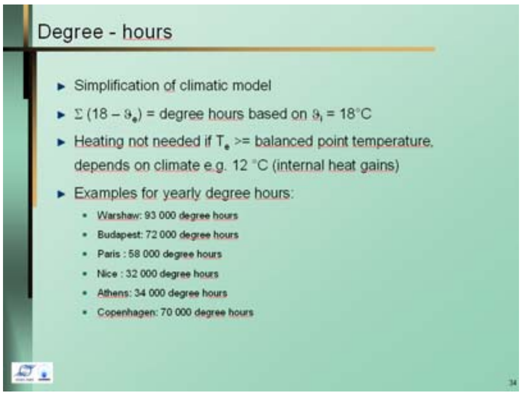
Although the warming up period of the intermittent heating is longer in case of higher time constant, it can save energy, because it cools down slower as well.

5. Heating load calculation for a period



Slide 33

The heat loss coefficient (H) is introduced in order to represent the losses of a building in one factor. Thus, it includes transmission and ventilation losses. “H” is constant during the heating season, it doesn’t depend on the weather, so it can be used for periodic calculations. The actual heat loss is the product of the “H” and the temperature difference between inside and outside.



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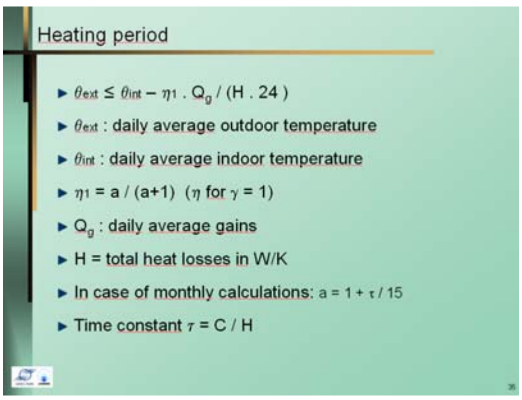
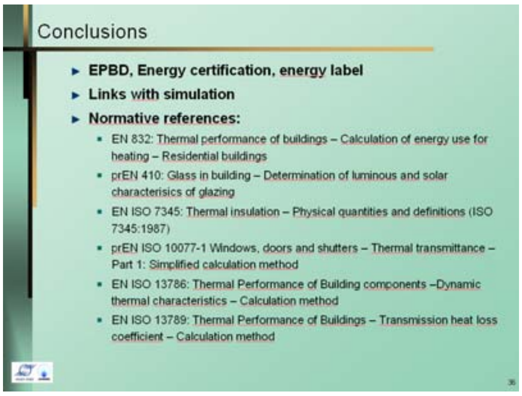
For a period, the product of the “H” and the integral of the temperature difference should be taken into account. This integral is the so called degree-hours that can be determined for each month of the heating season or for the whole season. It strongly depends on the climate as the figures show. Above a certain outdoor temperature (balance point temperature) the gains cover the losses and heating is not needed. These unheated periods are taken out from the degree hours.



Slide 35

A good simplified monthly calculation tool takes the solar gains into account in a right way. It means that the average solar radiation is different in each month, thus not only losses, but also gains are taken into account month by month.

6. Conclusions



Slide 36

Simplified heating load calculation tools are usually computer based tools and can be applied with limitations explained in slide 2. However they are easy to deal with and they are recommended in certain certification processes and energy audits.