EDSF Energy Label

for automatic doors

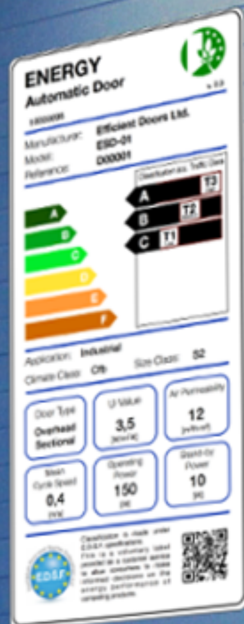
PHYSICAL BASIS EXPLANATION

FAQ Support Document

First Edition 26.06.17

Ref. P0052-00

Introduction



In this document we explain the physical basis for a better understanding of the door energy classification and results, showing the relative weight of the different factors.

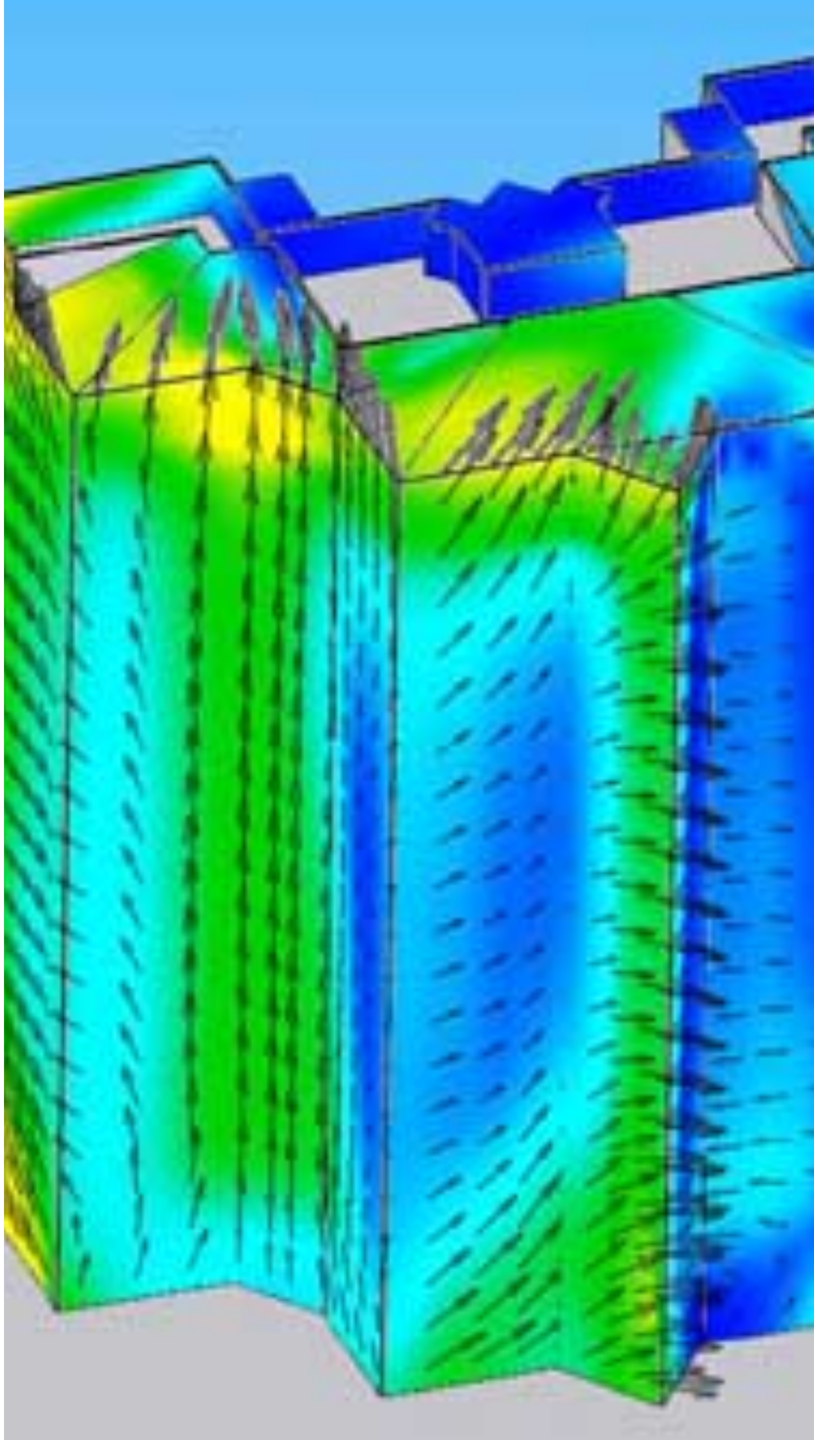
Energy Losses

Energy consumption of buildings is mainly associated with the consumption of **heating and cooling systems**. This is determined by losses through the building **elevations and openings**, represented in large part by **doors**.

Energy Losses

The precise calculation of energy losses in a building due to a door is quite complex, but we use a simplified model for calculation purposes.

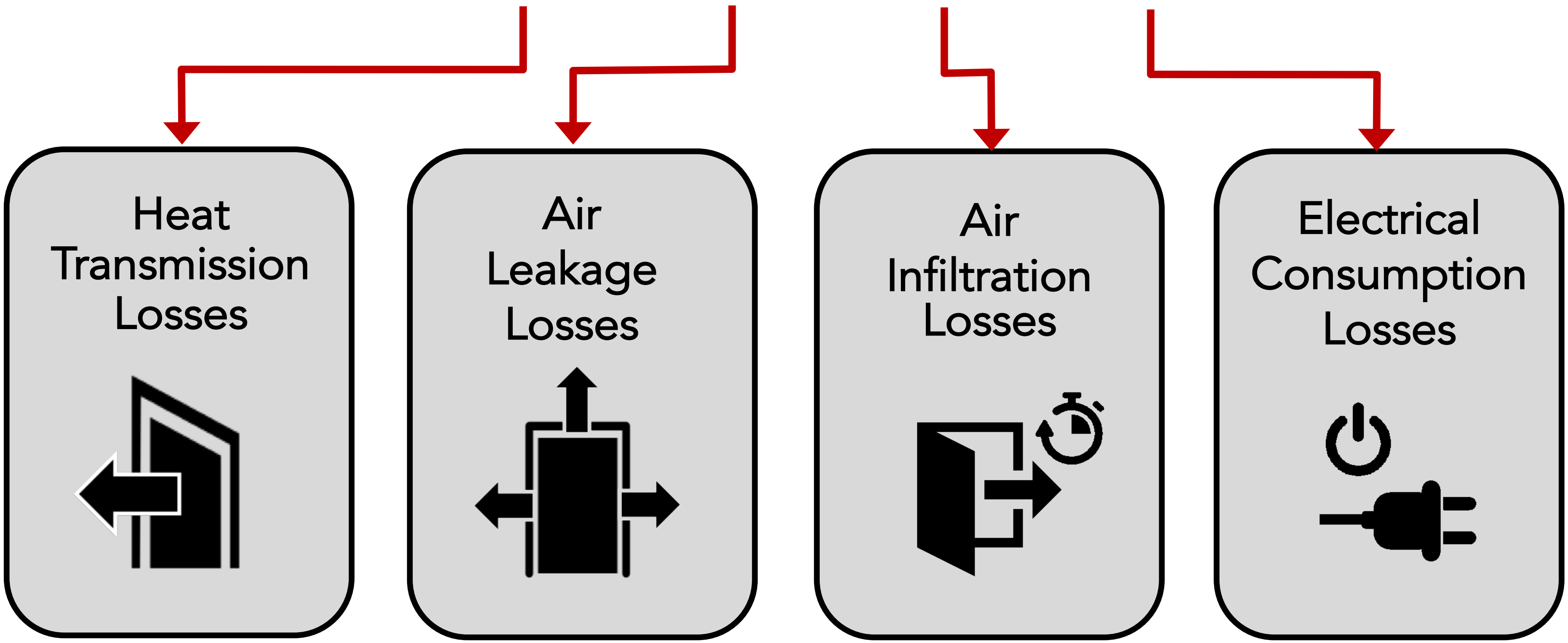
In this document we explain the basis of this simplified model



Energy Losses

These losses in a building due to a door can be summarized in this equation:

$$E = E_t + E_v + E_i + E_e$$



Heat Transmission Losses

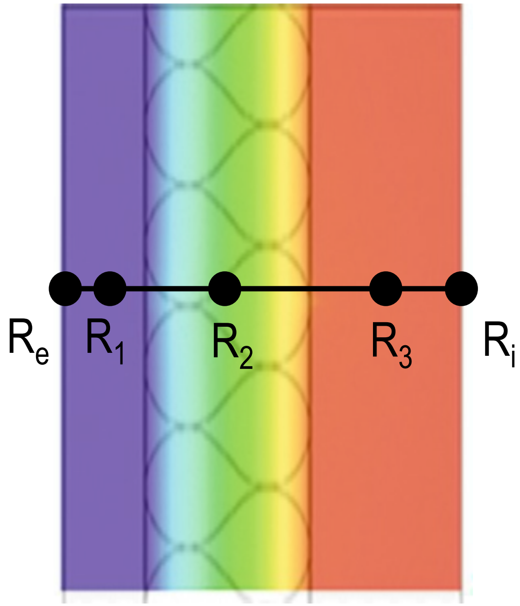
There is a **heat flow** that passes through the door when the door is closed, defined by the following equation:

$$H_t = A \cdot U \cdot (T_i - T_o)$$

- A is the **area** of the door
- T_i and T_o are the inside and outside **temperatures** in the building
- U is the **thermal transmittance**

Heat Transmission Losses

The **thermal transmittance** (also known as U-Value) is the sum of the thermal resistance of the materials of the door leave and internal and external surfaces:



$$U = \frac{1}{\frac{1}{R_e} + \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_i}}$$

- Measured in $W/m^2 \cdot K$
- Detailed calculation should be done according to EN 12428

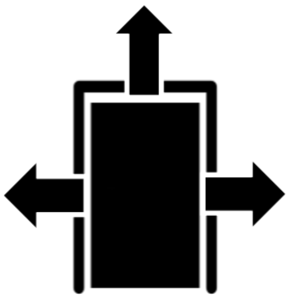
Heat Transmission Losses

The **energy losses per year** due to heat transmission are then calculated:

$$E_t = H_t \cdot h \cdot C_h$$

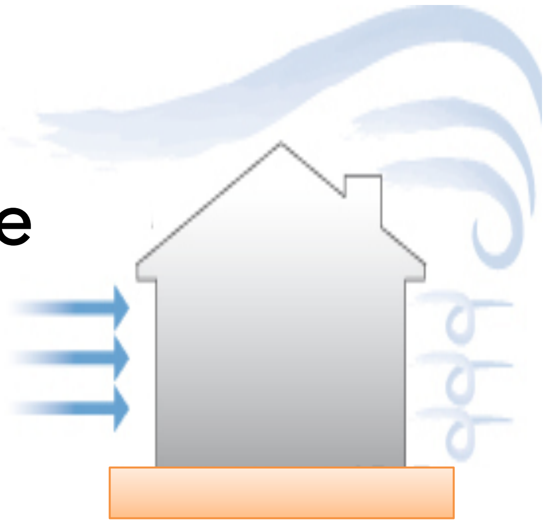
- h is the number of heating/cooling hours per day
- $\mathrm{C_h}$ is the amount of heating/cooling days per year

Air Leakage Losses



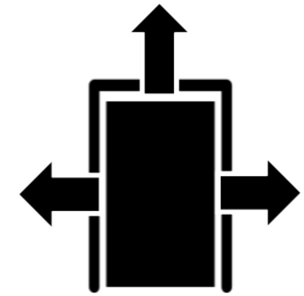
There is a **air flow** that passes through the interstices of the door when it is closed that implies an exchange of heat. The pressure difference between inside and outside can be generated by two factors:

- Wind Pressure



- Chimney Effect

Air Leakage Losses

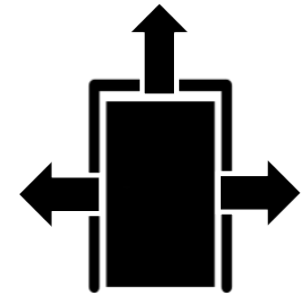


The heat flow that passes through the door due to both effects when the door is closed, defined by the following equations:

$$H_{vL} = C_p \cdot \rho \cdot Q_{vL} \cdot (T_i - T_o)$$

- C_p is the **specific heat** of air
- ρ is the **air density**
- $Q_{vL} = L \cdot A \cdot 1/3600$ is the **air flow**, where:
- L is the **air permeability**

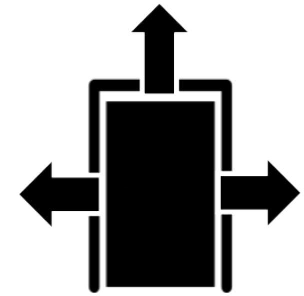
Air Leakage Losses



The **air permeability** of the door depends on the size of the interstices and the pressure difference between outside and inside. It is determined by testing:

- Measured in $m^3/h \cdot m^2$]
- Tests should be done according to EN 12427
- The value should be converted from test pressure difference to calculation pressure

Air Leakage Losses



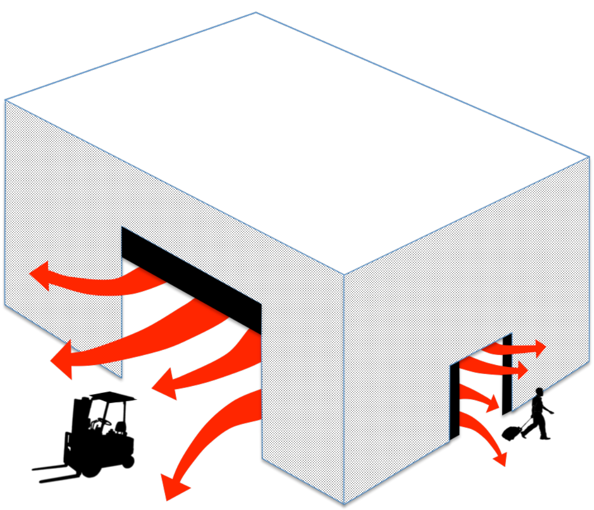
The **energy losses per year** due to air leakage are calculated in the same way than heat transmission:

$$E_{vL} = H_{vL} \cdot h \cdot C_h$$

- h is the number of heating/cooling hours per day
- $\mathrm{C_h}$ is the amount of heating/cooling days per year

Air Infiltration Losses

Also known as ventilation, when the door is open, there is massive **air flow** through the door hole not related to air permeability.



To evaluate the infiltration losses, calculation is made considering heater and cooling operation when inside temperature changes due the massive air exchange during door opening cycles.

Air Infiltration Losses

The heat flow that passes through the door hole is:

$$H_{vI} = C_p \cdot \rho \cdot Q_{vI} \cdot (T_i - T_o)$$

- $Q_{vL} = v \cdot A \cdot C$ is the air flow, where:
- v is wind speed
- C is the flow coefficient, depending on the door size and the building

Air Infiltration Losses

The capacity or power of the heating and cooling system is:

$$H_h = F_h \cdot V$$

- F_h is heating or cooling factor, depending on the system installed
- V is the building volume

Air Infiltration Losses

The **energy losses per year** due to air infiltration are calculated:

$$E_i = [H_{vI} \cdot t_v + H_h \cdot (t_c - t_h)] \cdot n \cdot C_h$$

- t_v is the time to exchange all building air volume
- t_c is the cycle time
- t_h is the time to activate the heating/cooling
- n is the number of cycles per year

If $t_v > t_c$ then $t_v = t_c$ If $H_h > H_{vI}$ then $H_h = H_{vI}$

Air Infiltration Losses

To understand the formula it is important to take into account:

$$E_i = [H_{vI} \cdot t_v + H_h \cdot (t_c - t_h)] \cdot n \cdot C_h$$

- If $t_h < t_c$ then the heating/cooling system takes longer to to compensate the flow losses and the global losses are bigger than if $t_h > t_c$
- t_h is the time to activate the heater/cooler when the inside temperature decreases 1 and it is calculated in reference (1)

Electrical Consumption

The **energy losses** due to air electrical consumption of the door area are calculated:

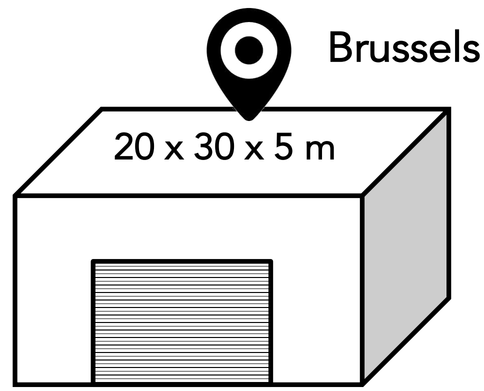
$$E_e = E_{eOP} + E_{eSB}$$

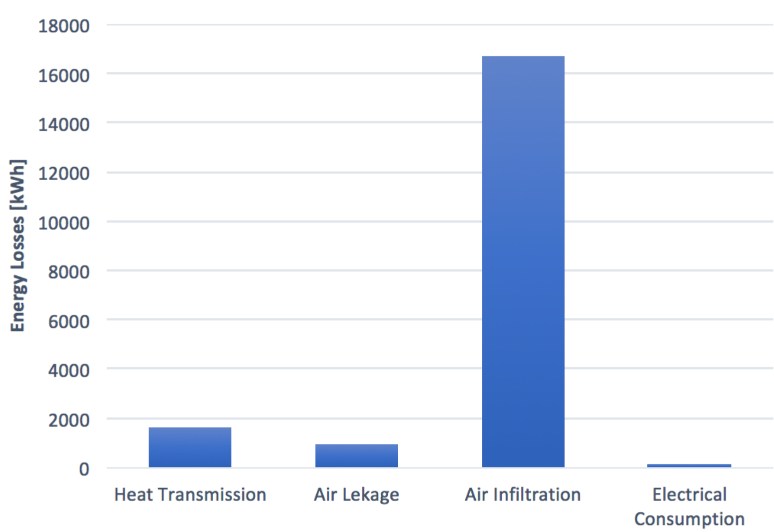
- $\mathrm{E_{eOP}}$ is the operation power consumption during opening cycles
- $\mathrm{E_{eSB}}$ is the stand-by power consumption when the door is closed

Comparing Effects

Example: Sectional Door

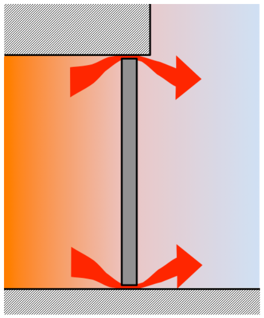
- Door Area = 9 m^2
- Air Permeability = 6 $m^3/h \cdot m^2$
- Opening Cycles per Year = 25.000
- Opening Time per Cycle = 20 s
- Operating Power = 150 W
- Stand-by Power = 10 W





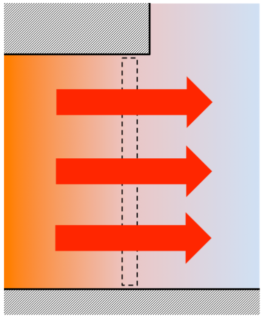
In this medium traffic example infiltration is more than 6 times bigger than the sum of the losses of the rest of effects

Comparing Effects



Example Closed Door Leakage Air Flow

$$Q_{vL} = L \cdot A \cdot \frac{1}{3600} = 5{,}7 \cdot 9 \cdot \frac{1}{3600} = 0{,}014 \text{ m}^3/\text{s}$$



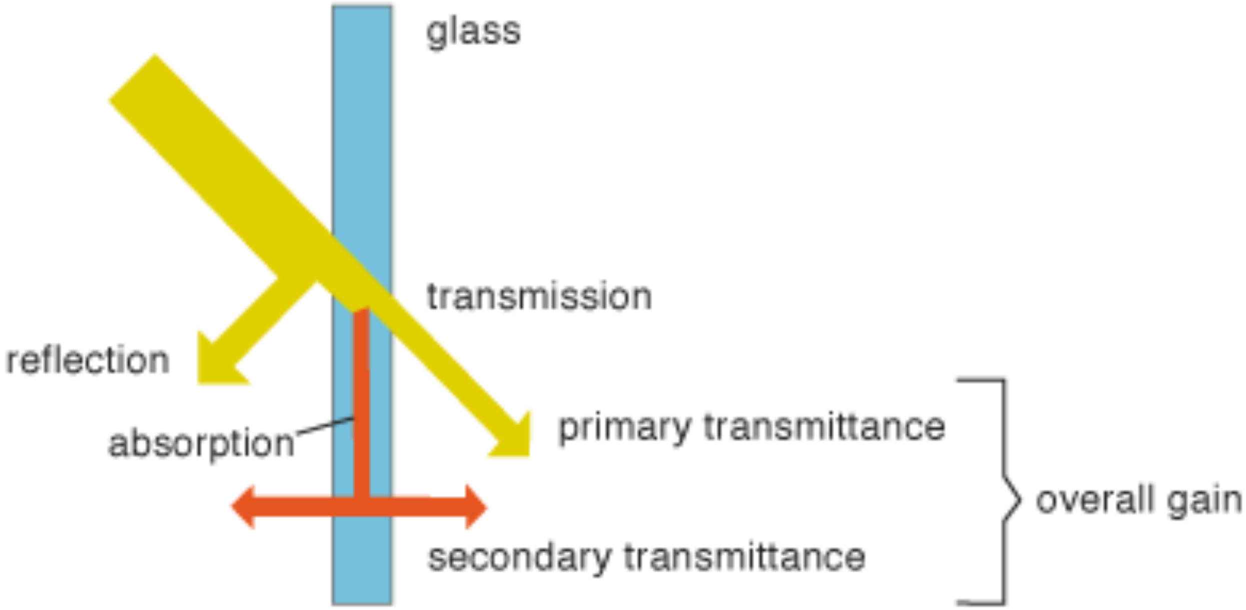
Example Open Door Infiltration Air Flow

$$Q_{vI} = v \cdot A \cdot C = 8{,}4 \cdot 9 \cdot 0{,}5 = 37{,}8 \text{ m}^3/\text{s}$$

The huge difference in flow helps to understand the influence of both effects. In practice, there is a lower difference in energy as the thermal flow is reduced to zero when the inside and outside temperatures are equalized with the ventilation.

About Solar Effect

There are also **energy losses** due solar radiation, but they are excluded in the door classification. Why?



About Solar Effect

The Solar Gain factor g is the % of solar thermal incident energy that is transmitted inside through the wall. It is defined by:

$$g = g_{SH} \cdot g_S$$

- g_S is primary solar factor (without shadings or solar protection system)
- g_{SH} is the shading factor

About Solar Effect

Compared to windows, the factor is lower in doors because:

- g_{SH} is much larger in a door as it is on ground level, usually with setbacks and porches.
- It is a factor to be considered mainly in hot climates, but as we make the balance throughout the year, the global result including shadings is reduced.

References

(1) *CEN/TR 16676:2016 Energy losses by industrial door.*

(2) *V. Liberda, K. Hein and E. Dubbeld d.d., Energy losses by industrial door, 6 may 2010, CEN TC 33 WG 5 Paris.*

(3) *Dr. Gerhard Hausladen, Klaus Klimke, Jakob Schneegans and Timm Rössel, Different door systems in industrial buildings considering energetic, building, climatologic and economic aspects, Technische Universität München.*

(4) *Dott. Ing. Miguel Pérez, Technical Definition of a European Energy Label for Automatic Doors, Third Edition, 2017, EDSF.*

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