A, B, C, D VENTILATION SYSTEMS: COMPARISON

ATIC-ULg Ventilation day
19/11/2015

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- Introduction - Key figures
- Definitions
- Classification of ventilation systems
- Simulation
- Conclusions

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Objectives of the presentation

- Brief overview of ventilation systems

  Definition, classification, advantages and drawbacks

- Introduction of some innovative technologies presented today

  Framework of the day

- Conclusion related to the use of ventilation systems

  Presentation of some simulation results

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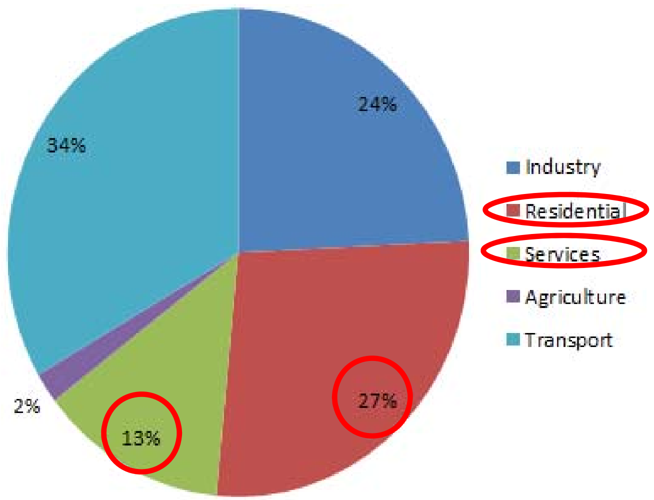
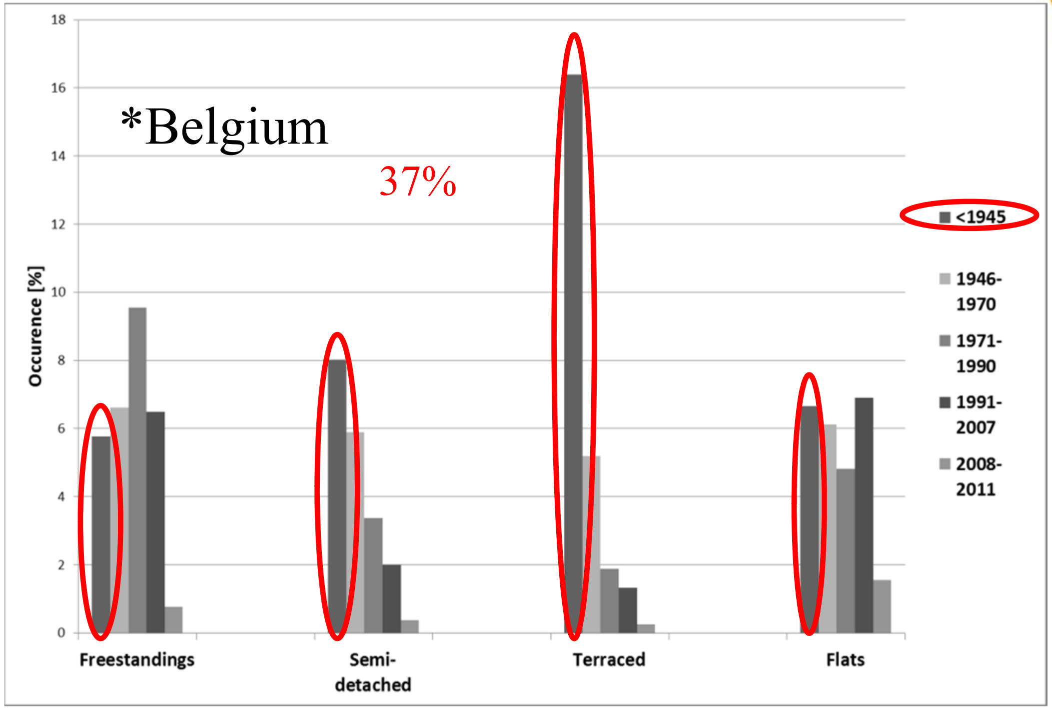
Key figures



Final energy consumption by sector in 2011 (Europe of 27)



*Labothap (2015)

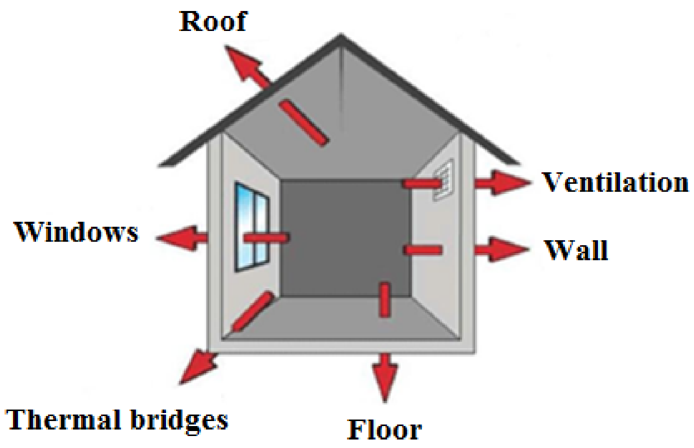
Retrofit rates: 1% per year in most of the EU countries, 0.8% in Belgium,…

Introduction

First retrofit options to be considered for existing residential buildings are the improvement of the **thermal insulation** and **air tightness**.

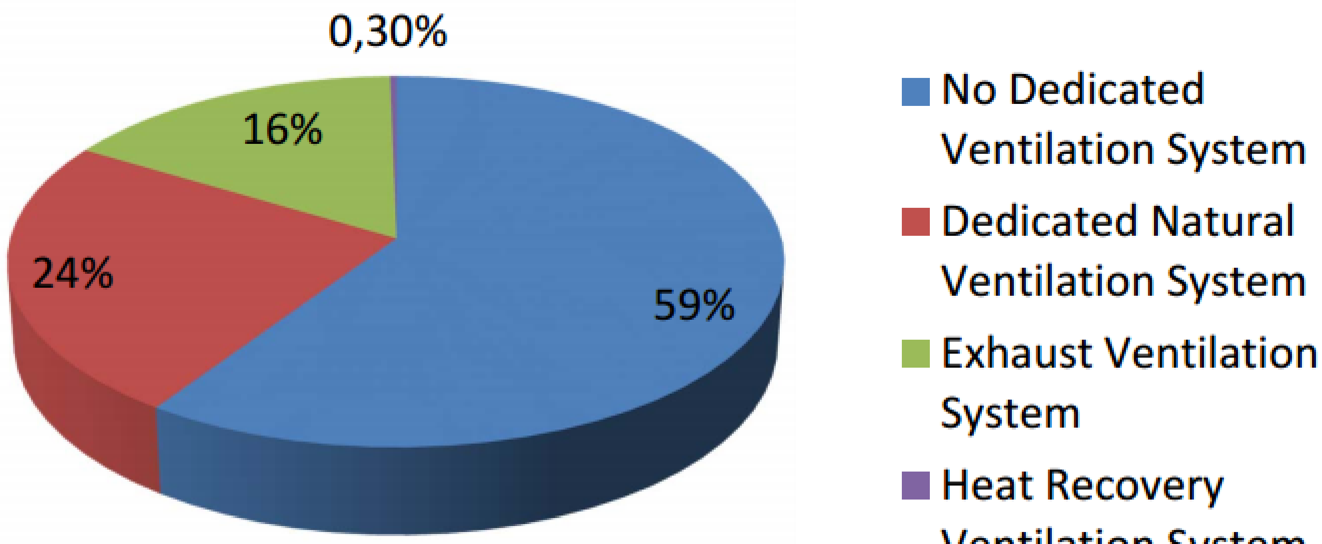
This represents a **high potential of energy savings… but also a potential reduction of Indoor Air Quality (IAQ).**

Improving the building envelope tends to **increase the relative part of the energy consumption due to ventilation.** Many studies estimates the total energy losses due to ventilation between **20% and 50%** (in building with a high thermal insulation).



Key figures

Residential Ventilation Installed



Ecodesign Lot 10 Study and Supplementary Study, FGK, 2010

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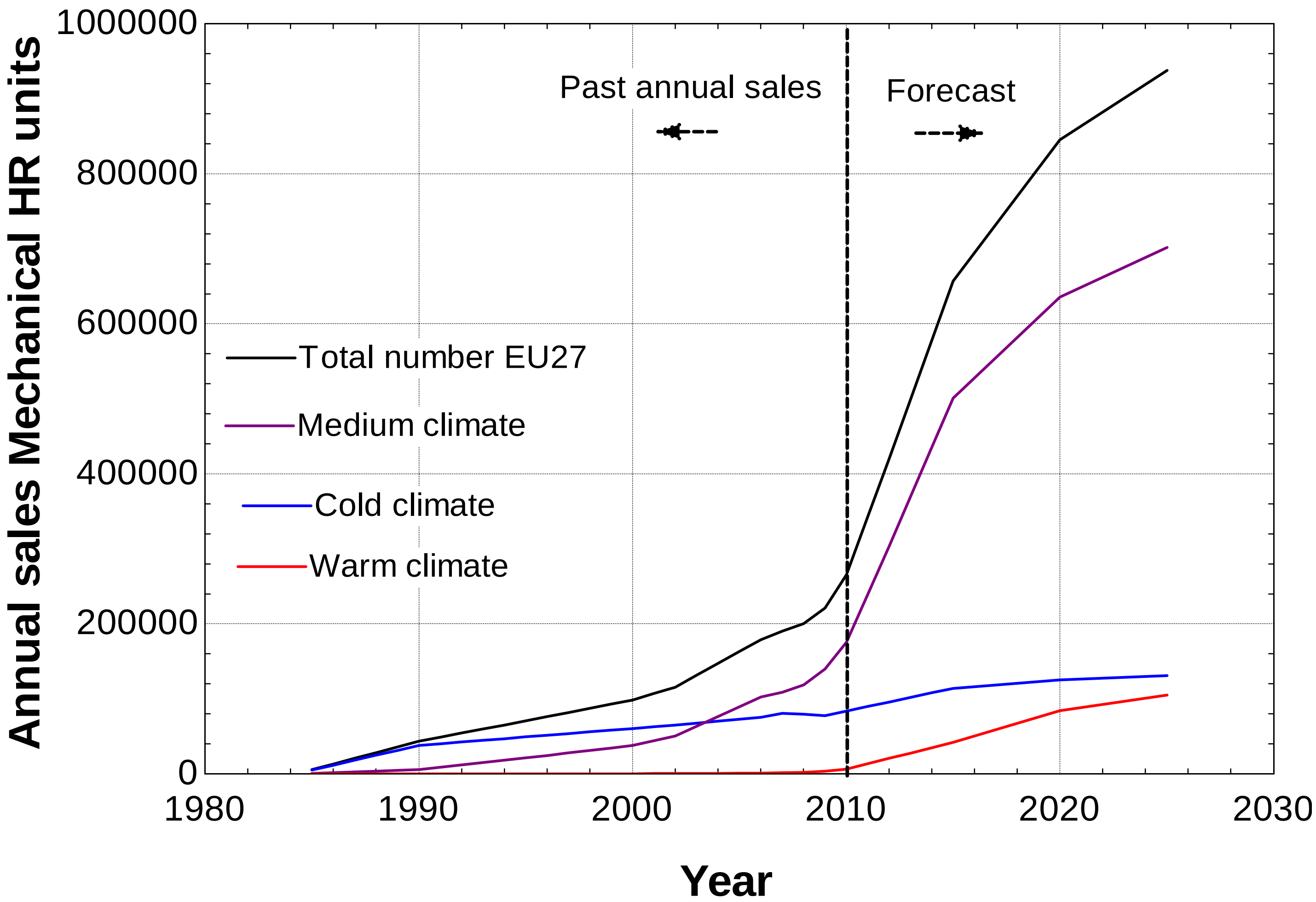
Key figures



EU27 Forecast and Market trends (Ecolot design (2012))

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Key figures

Seppanen (2012) showed an important changement in the ventilation market in **Belgium**:

- **Before 2007**, only **0.68%** of buildings are equipped with mechanical ventilation systems;

- **5%** of buildings constructed during years **2007 and 2008** are equipped with mechanical ventilation systems;

- **40%** of buildings **constructed after 2008** are equipped with mechanical ventilation systems.

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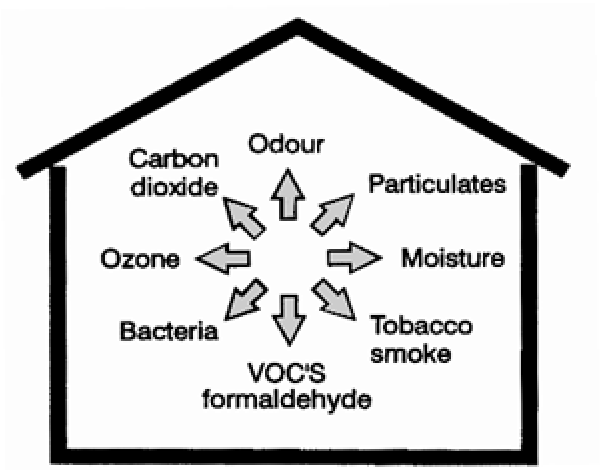
Definitions

- ✓ Aeraulic has an influence on at least 4 fields of the building (Morel et Gnansounou, 2007):
  - o The Indoor Air Quality (IAQ) → **Occupants' health**
  - o Heat losses→ **Energy consumption**
  - o Internal and superficial condensation issues→ **Building sustainability**
  - o **Thermal comfort**



- o Building is a selective protection against outdoor conditions: the sun, the rain, the wind… but indoor conditions are also polluted by:
  - ✓ Human: CO_2, H_2O, metabolic heat, bio-organic et inorganic effluents, bacteria, tobacco smoke
  - ✓ Human activity (kitchen, bathrooms,…)
  - ✓ …

⇨ Need of air renewal

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Definitions

Air exchange *of outdoor air with air already in a building can be divided into two broad classifications:* ***ventilation*** *and* ***in/ex-filtration****.*

- ***Ventilation*** *is intentional introduction of air from the outside into a building; it is further subdivided into natural and mechanical ventilation:*

  Mechanical *(or* ***forced****) ventilation is the intentional movement of air into and out of a building using fans and intake and exhaust vents.*

  Natural ventilation *is the flow of air through open windows, doors, grilles, and other planned building envelope penetrations, and it is driven by natural and/or artificially produced pressure differentials.*

- ***Infiltration*** *is the flow of outdoor air into a building through cracks and other unintentional openings and through the normal use of exterior doors for entrance and egress. Infiltration is also known as air leakage into a building.* ***Exfiltration*** *is leakage of indoor air out of a building through similar types of openings. Like natural ventilation, infiltration and exfiltration are driven by natural and/or artificial pressure differences.*

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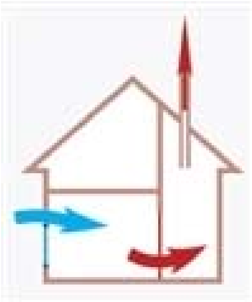
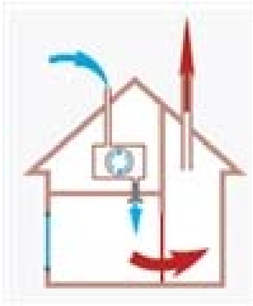
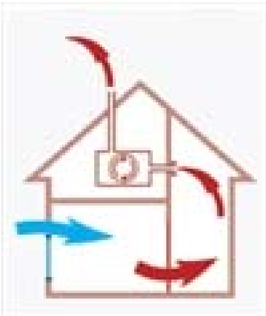
Classification of ventilation systems

System A	System B
 Natural ventilation	 Mechanically supplied ventilation
System C	**System D**
 Mechanical extracting ventilation	 Mechanically supplied and extracting ventilation

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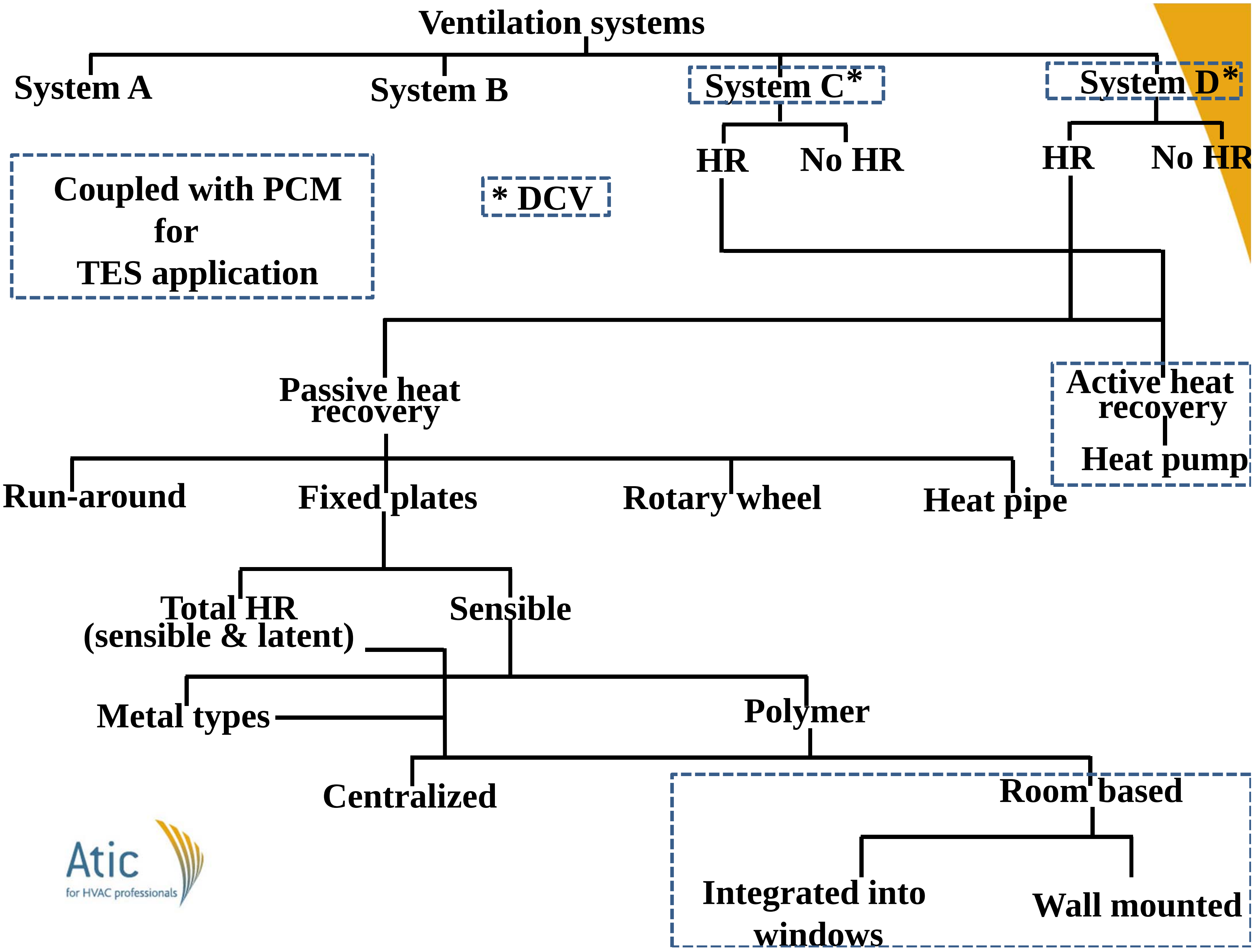
	Criteria	System A	System B	System C	System D
CONCEPTION	Renovation case	Simple to install	No always suitable for renovation	Can be installed in new and retrofitted buildings	No suitable for renovation
	Envelope air tightness	Need a good envelope air tightness	Need a really good envelope air tightness	Need a really good envelope air tightness	Need a “perfect” envelope air tightness
	Complexity	Need controlled supply orifice and vertical extracting duct	Quite simple	Quite simple	System more complex
	Ducting	Need space for air extracting duct	Need space for vertical air extracting duct and for supply ducts	Need a set of air extracting ducts	Need set of air extracting and supplying ducts
IAQ	Air filtration	No air treatment allowed	Supply air can be filtered	Supply air can not be filtered	Air can be filtered and treated (T, RH)
	Gaz leaks (ground)	Risk if the building is depressurized	Over pressurization of the building reduces risks	Depressurization can allow for gaz draught from the ground	No risks because some rooms can be overpressurized
NOISE	Sound transmission	Controlled supply orifice allows for noise transmission from outdoor	Good sound attenuation except if the air supplying duct are not well installed	Controlled supply orifice allows for noise transmission from outdoor	Sound transmission is limited if well designed
	Sound generation	No sound generation	Sound generation due to air supplying fans	Sound generation due to air extracting fans	Sound generation due to air extracting and air supplying fans

	Criteria	System A	System B	System C	System D
CONTROL	Supplied air flow rate	Dependent on the natural phenomena and the wind	Supplied air flow rates are controlled	No control on the supplied air flow rates per room	Supplied air flow rates are controlled
	Extracted air flow rate	Dependent on the natural phenomena and the wind	No control on the extracted air flow rates per room	Extracted flow rates are controlled	Extracted air flow rates are controlled
	Flow rates management	Control supplied orifice but flow rates are never perfectly known	Only the supplied air flow rate is really controlled	Only the extracted air flow rate is really controlled	System really suitable for controlled flow rates and an automatic regulation
	Maintenance	Little maintenance for the components of the system	Regular maintenance	Regular maintenance	Regular maintenance (inspection and cleaning)
ENRGY	Recovered heat	No recovered heat	No recovered heat	Active heat recovery	Passive and active heat recovery
	Electrical consumption	No electrical consumption	Electrical consumption	Electrical consumption	Electrical consumption
COST	Global cost	Installation quite simple	Quite expensive	Exploitation cost OK	System expensive, especially if no recovered heat



Ventilation systems
System A
System B
System C*
System D*
HR
No HR
HR
No HR
Coupled with PCM for TES application
* DCV
Passive heat recovery
Active heat recovery
Heat pump
Run-around
Fixed plates
Rotary wheel
Heat pipe
Total HR (sensible & latent)
Sensible
Metal types
Polymer
Centralized
Room based
Integrated into windows
Wall mounted
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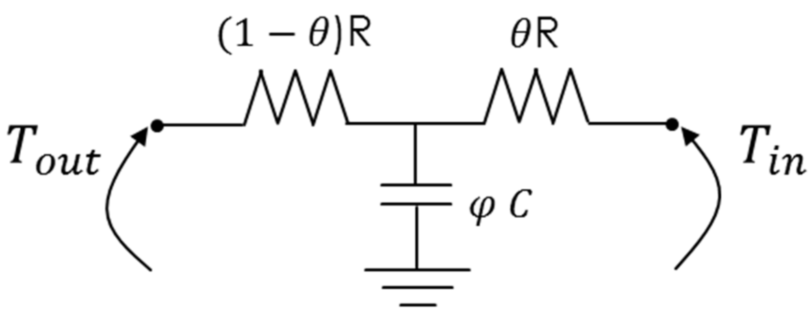
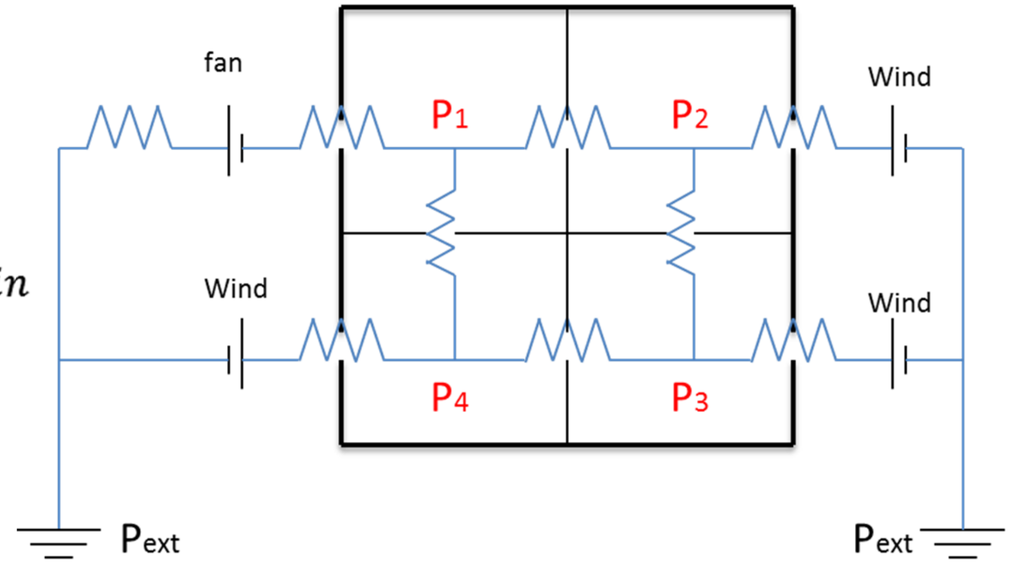
Annual performances: numerical simulation

Global thermo-aeraulic building model*

Thermal behavior

Airflow building network

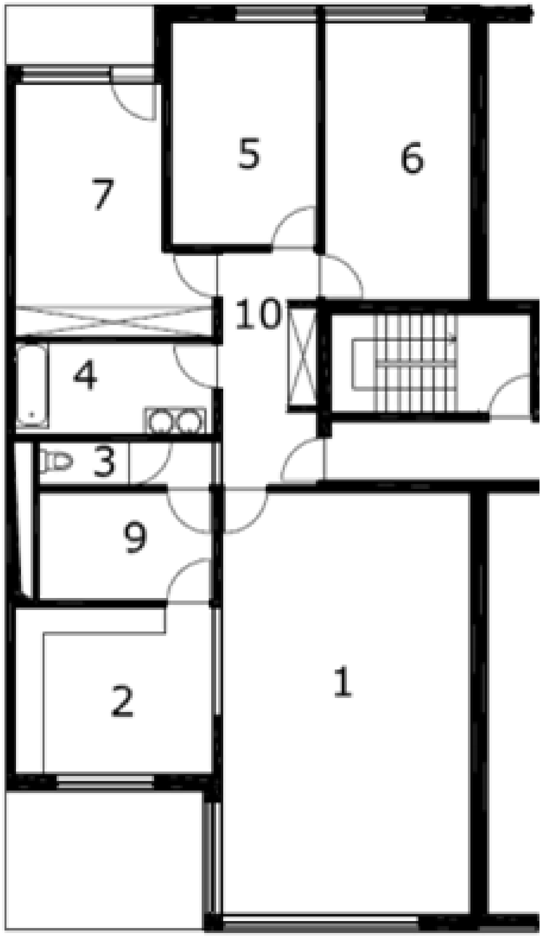




*Model developed by Ulg in Modelica language
Available in open-access

Annual performances: numerical simulation

Investigated apartment



- Floor Area: 121 m²
- External Walls U-value: parameter
- Windows U-value: parameter
- Infiltration Rate (50 Pa): parameter
- Nominal Ventilation Rate: 286 m³/h
- Occupancy profile: 4 people from 4PM to 8AM
- DHW tank Volume: 200 l
- Set-Point Temperature for DHW: 55°C
- Inside Set-Point Temperature: 18 & 21°C

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Annual performances: numerical simulation

3 constructive characteristics

Old building

$$U_{wall} = 1.6 \left[\frac{W}{m^2K}\right]$$

$$U_{window} = 5 \left[\frac{W}{m^2K}\right]$$

$$Ach_{50Pa} = 6 \left[\frac{vol}{h}\right]$$

Massive structure
(Brick wall)

Retroffited building

$$U_{wall} = 0.46 \left[\frac{W}{m^2K}\right]$$

$$U_{window} = 3.5 \left[\frac{W}{m^2K}\right]$$

$$Ach_{50Pa} = 2.4 \left[\frac{vol}{h}\right]$$

Massive structure
(Brick wall + external insulation)

New building

$$U_{wall} = 0.24 \left[\frac{W}{m^2K}\right]$$

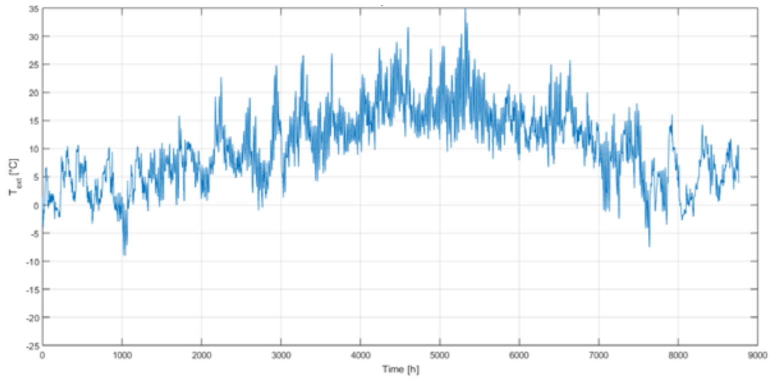
$$U_{window} = 1.8 \left[\frac{W}{m^2K}\right]$$

$$Ach_{50Pa} = 1 \left[\frac{vol}{h}\right]$$

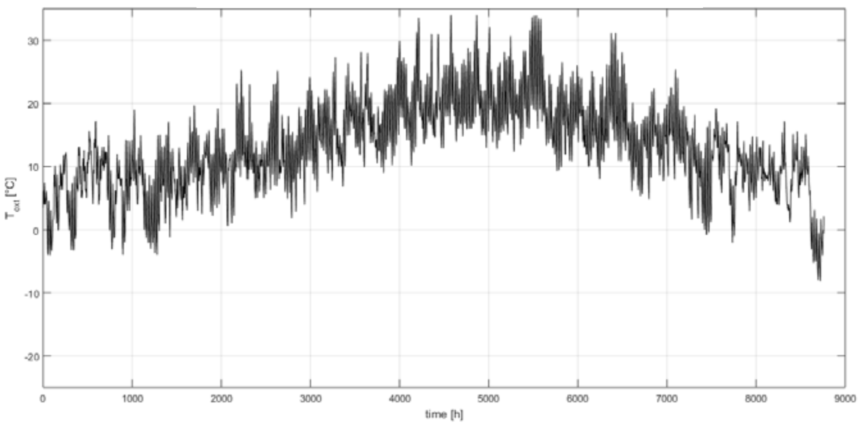
Massive structure
(Brick wall + external insulation)

Annual performances: numerical simulation

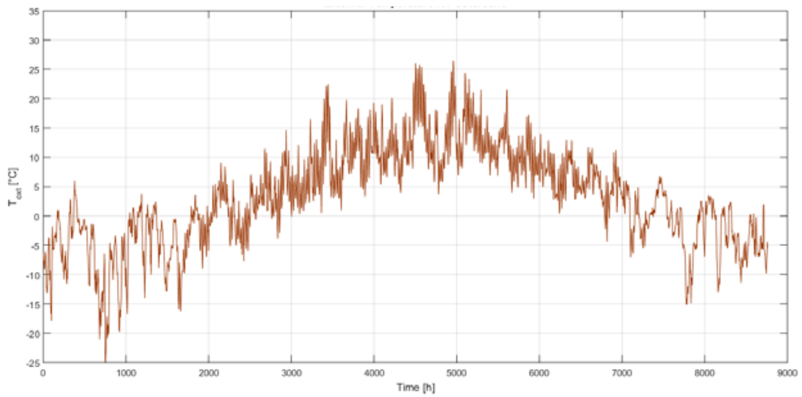
Bruxelles (Belgium)



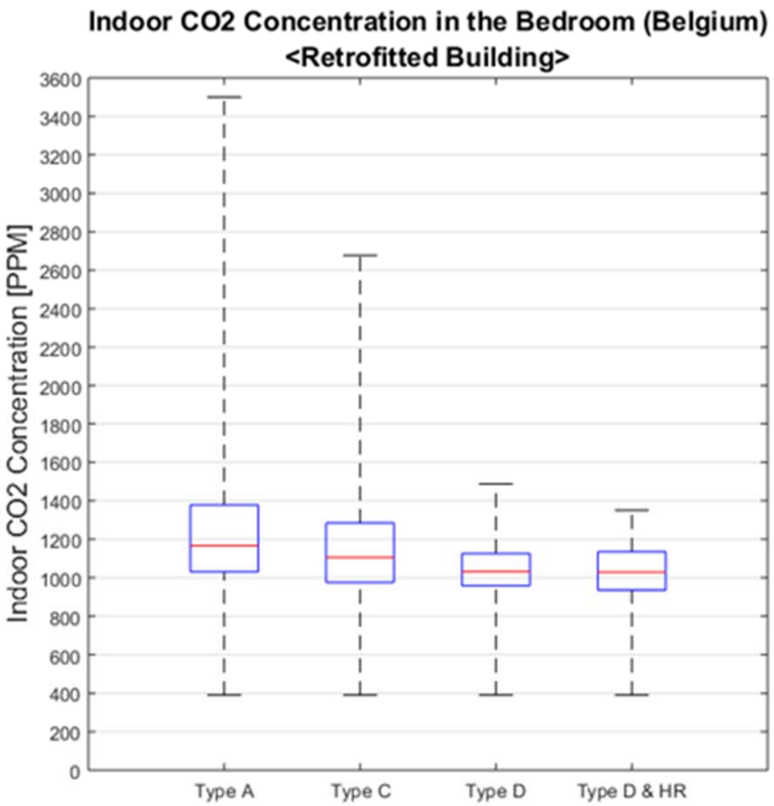
Bordeaux (France)

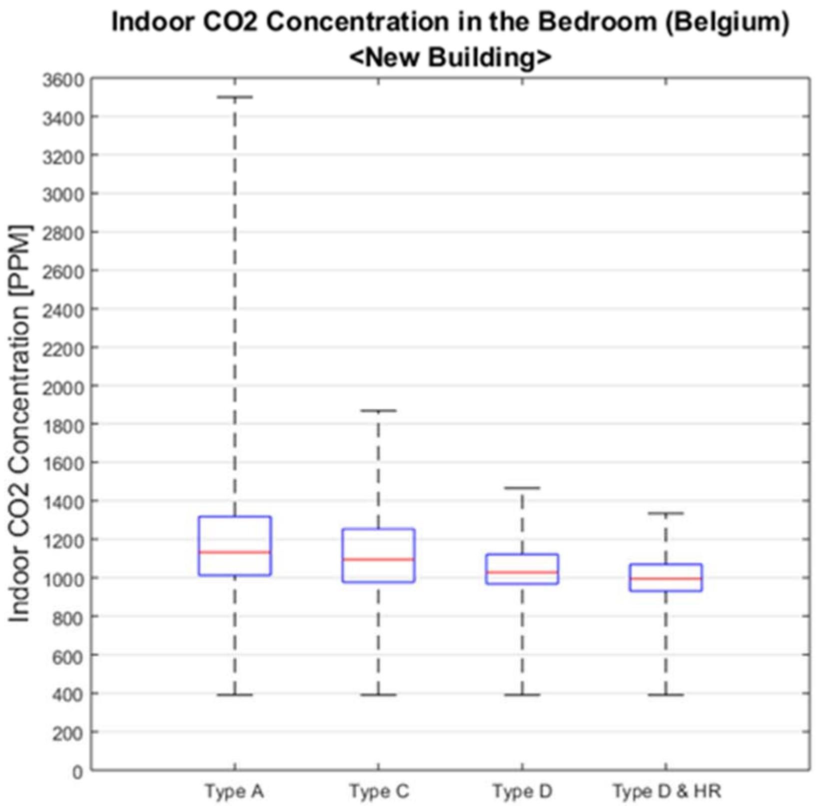


Ostersund (Sweden)



Influence of the ventilation system on the indoor CO_2 concentration





* Same conclusion can be drawn for other climate

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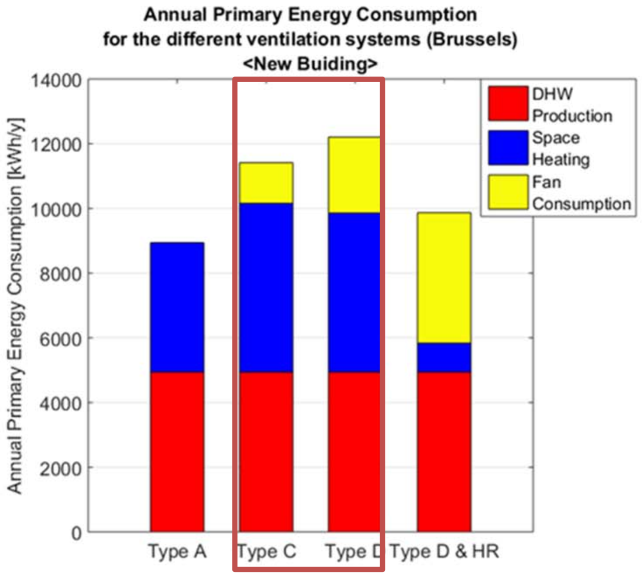
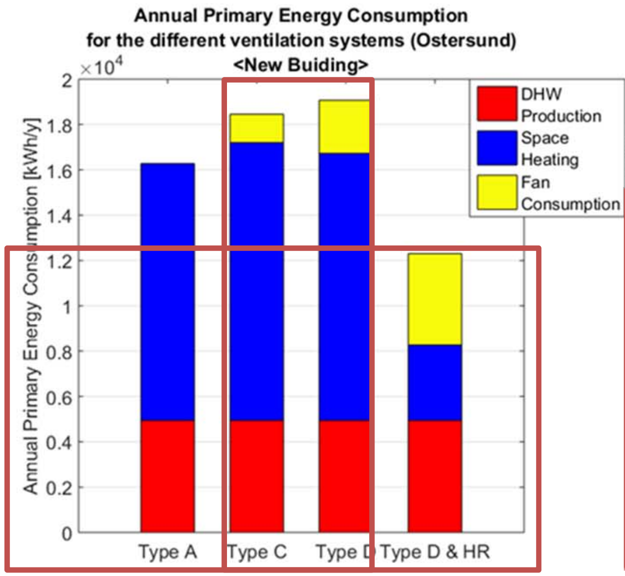
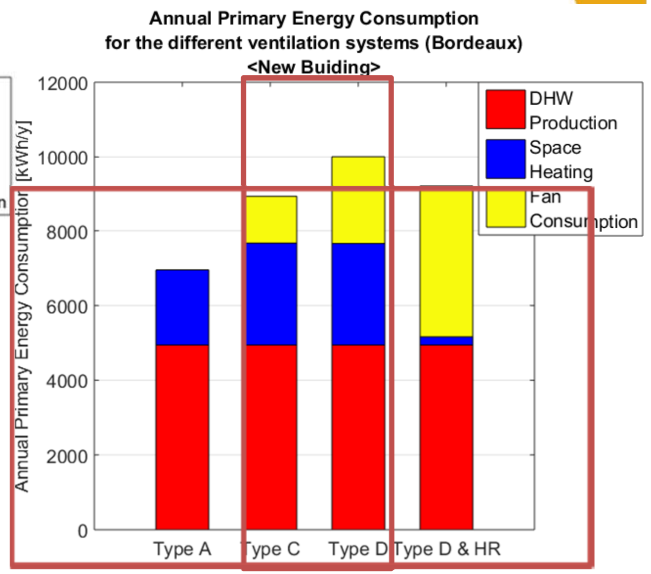
Ventilation system vs climate?

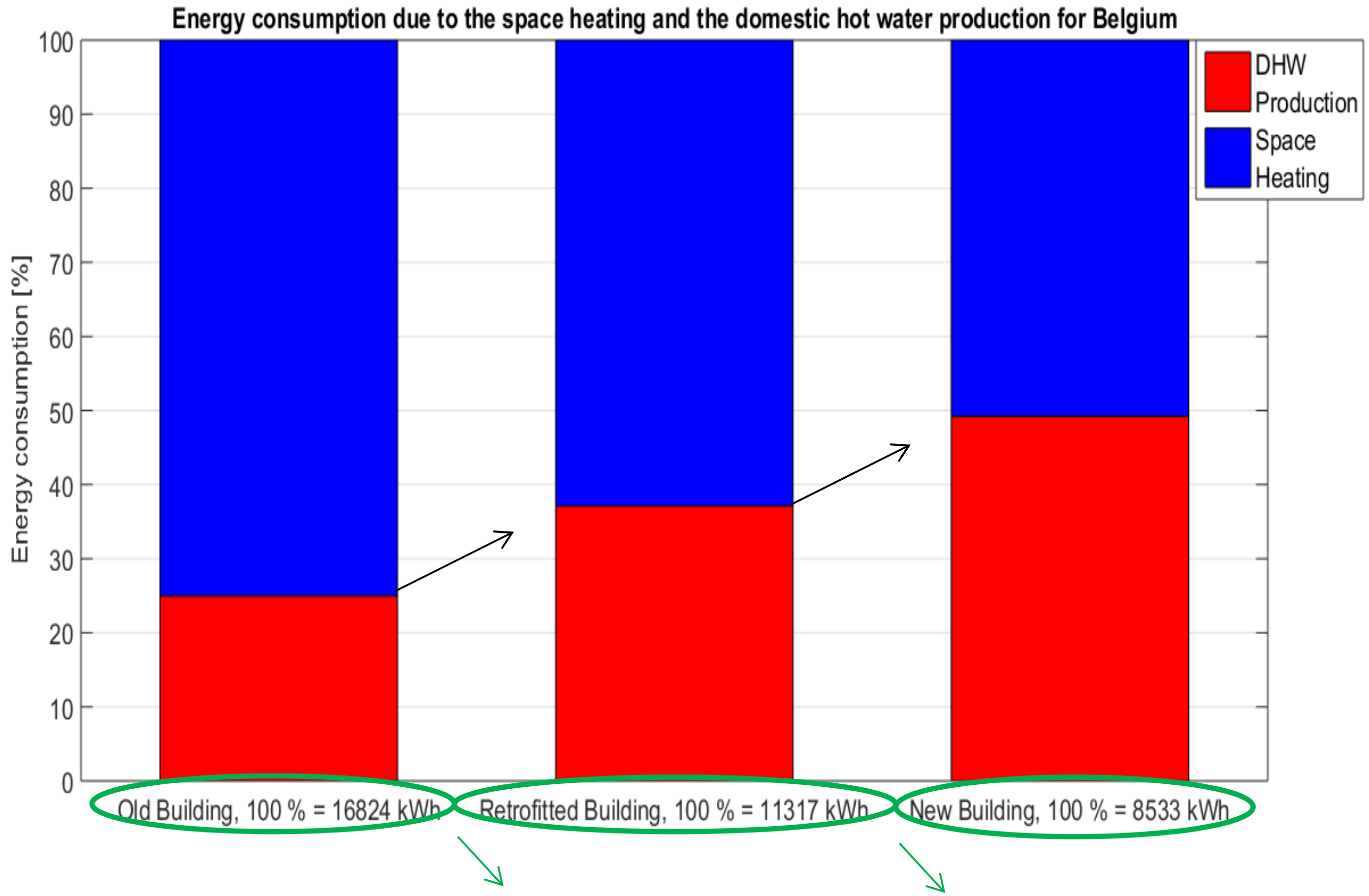






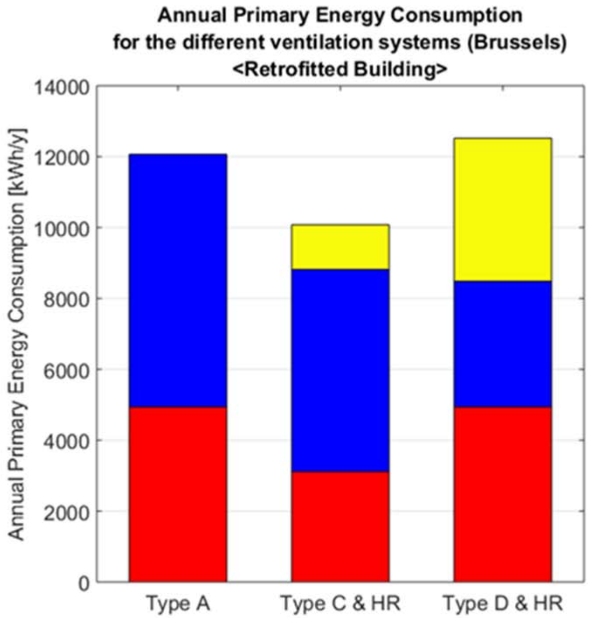
- Systems C and D consume more than system A for each considered climate (price for a better control of flow rate): Fan consumption and no HR
  - System D with HR seems more suitable for cold climate
  Heat recovered over one year > Fan consumption (! ε_{HR}, ΔP, η_{fan} !)
    - No point of using System D with HR in warmer climate
    Heat recovered over one year < Fan consumption (! ε_{HR}, ΔP, η_{fan} !)
      - Fan consumption is not negligible (! ΔP and η_{fan} !)

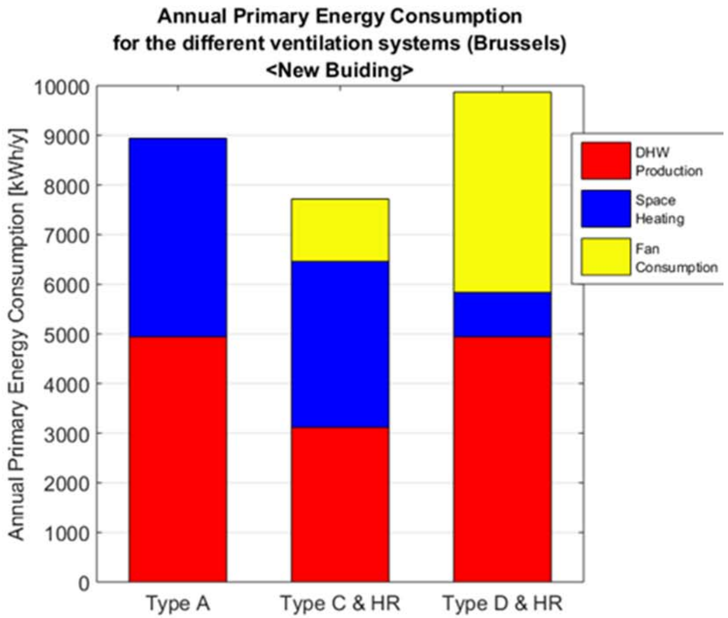
Active heat recovery?

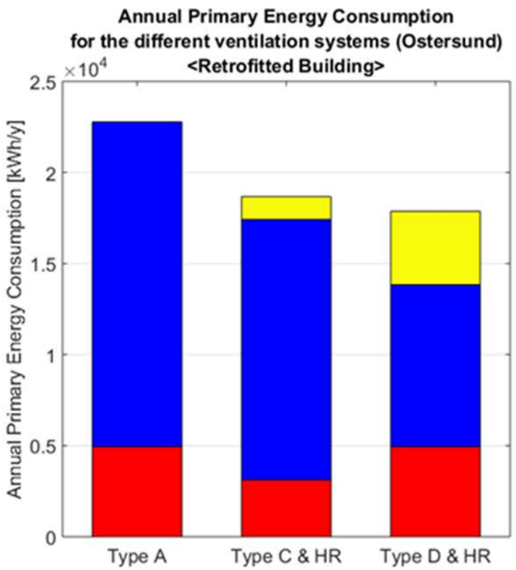


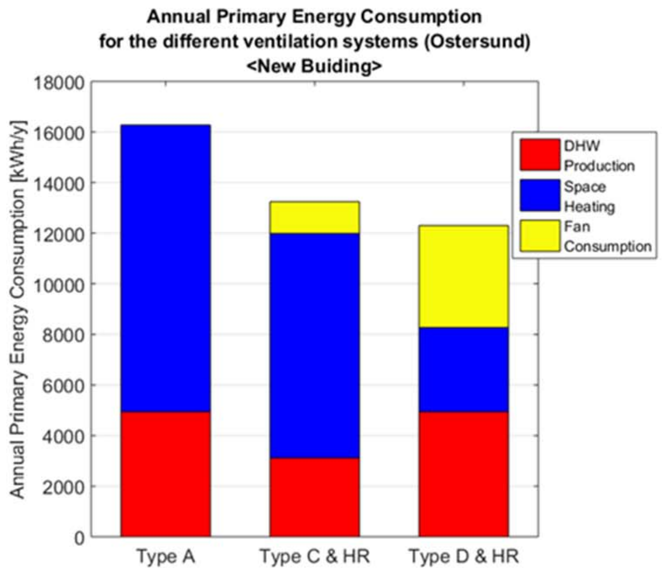
- Decrease of the energy demand due to better airtightness and insulation
  - Rise of the relative part due to the DHW production
    - Same conclusions for other climate

Active heat recovery?









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Conclusions

- Relative part dedicated to **ventilation** and **domestic hot water** consumption **will increase** in the future

- Need for **innovative ventilation** systems

- Large amount of **selection criteria** for ventilation systems comparison

- **Advantages and drawbacks** for each ventilation system (A, B, C, D)

- Quite difficult to draw general conclusions concerning the use of a specific ventilation system: dependent **on several parameters** (airthightness, climate, construction or retroffiting, investment cost, space dedicated to ductings, noise,....)

- Importance of the **fan consumption/performance**

- Ventilation systems should be selected on a case-by-case basis **depending on the parameters and the situation** of the building

Thank you for your attention!

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