FACULTY OF ENGINEERING AND ARCHITECTURE

DEPARTMENT ARCHITECTURE AND URBAN PLANNING
RESEARCH GROUP BUILDING PHYSICS, CONSTRUCTION AND SERVICES

AIVC WORKSHOP WELLINGTON
TOWARDS HIGHER-PERFORMING BUILDINGS:
THE ROLE OF AIRTIGHTNESS AND VENTILATION

DEMAND CONTROLLED VENTILATION: DESIGN GUIDELINES AND PERFORMANCE CHARACTERISATION IN BELGIUM

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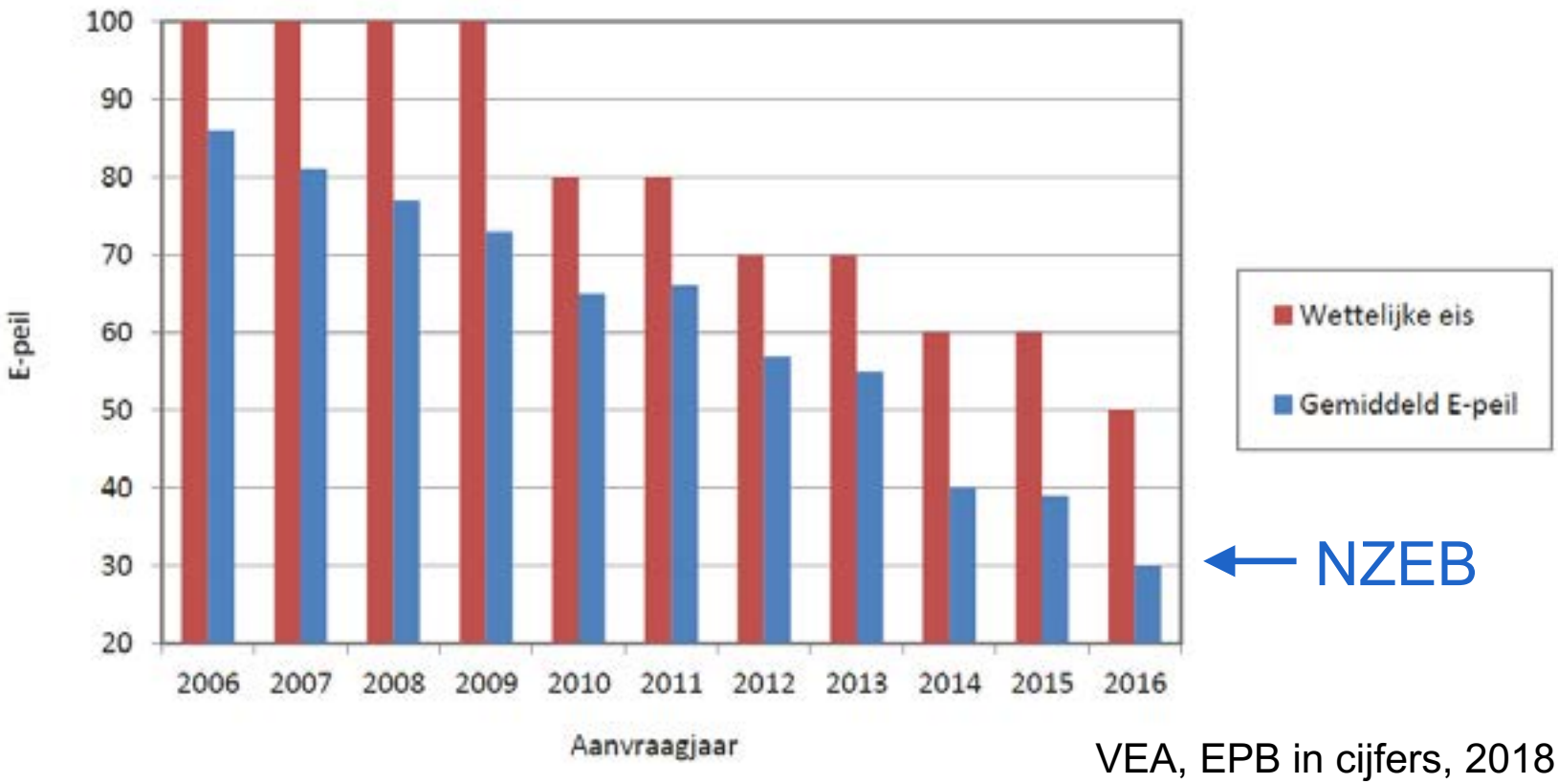
THE SUCCESS OF 10 YEARS EPB FOR NEW DWELLINGS

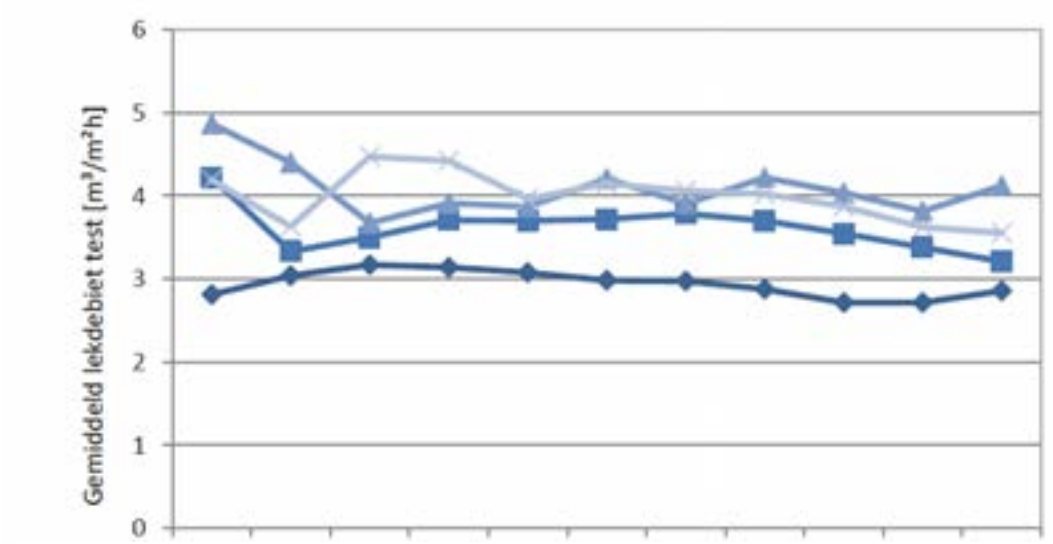
- Building energy assessment is a key driver in the transition towards a carbon neutral housing stock
  - Evolution E-level: new single family houses (300.000 reports)



VEA, EPB in cijfers, 2018

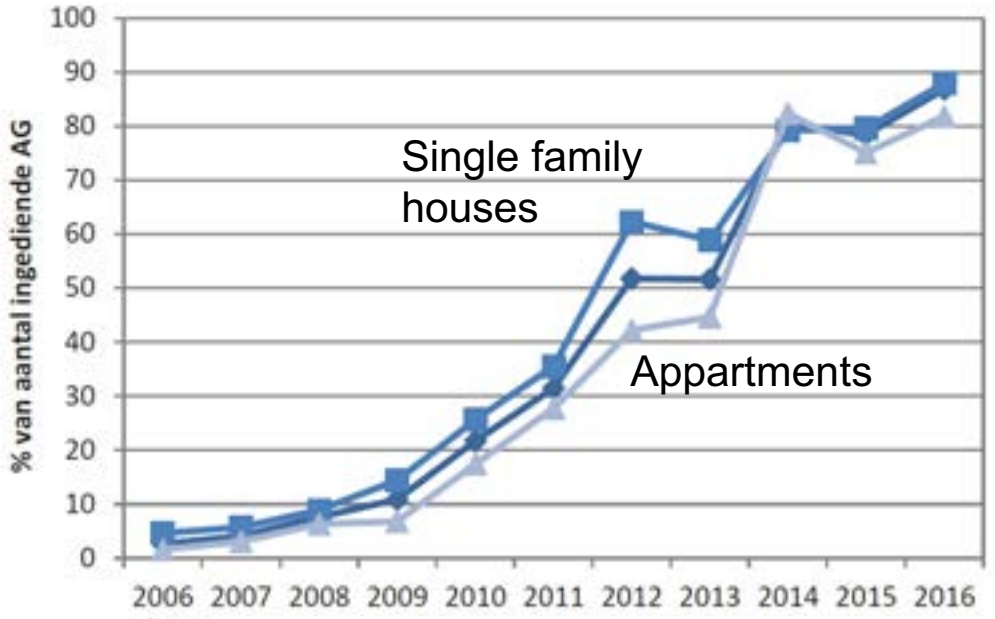
AIR TIGHTNESS OF NEW DWELLINGS

Mean air permeability ($m^3/h/m^2$)



terraced
appartment
semi-detached
detached

Share of dwellings with reported blower door test (%)



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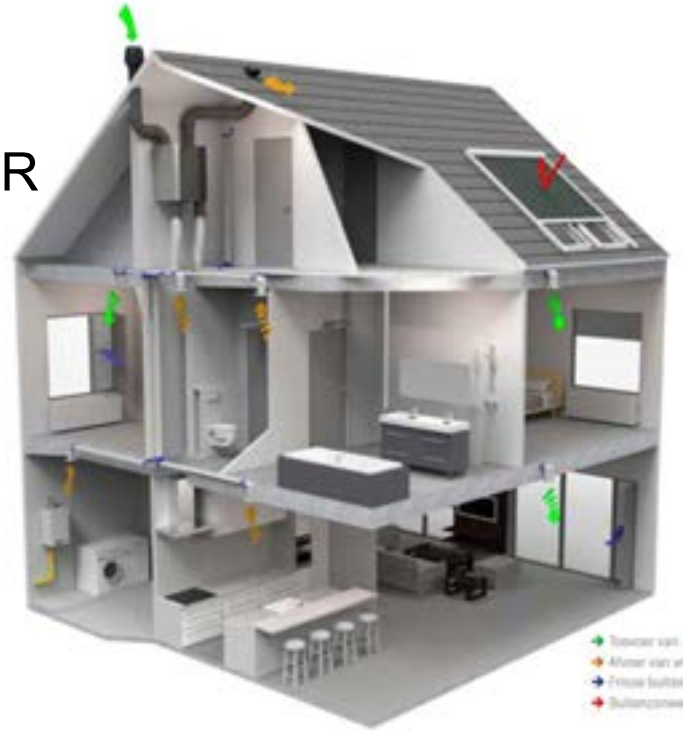
RESIDENTIAL VENTILATION SYSTEMS

- Prescriptive design rules in standard NBN D50-001:1991
  - Fresh air supply to habitable ‘dry’ rooms, extraction from ‘wet’ rooms
  - Compulsory as part of EPB-regulation
- Fresh air supply flow rates based on floor area
  - Generally 3.6 m³/h/m² (=1 l/s/m²)
- 4 simplified systems allowed, permanent operation
  - 2 systems dominate the market

MEV

MVHR



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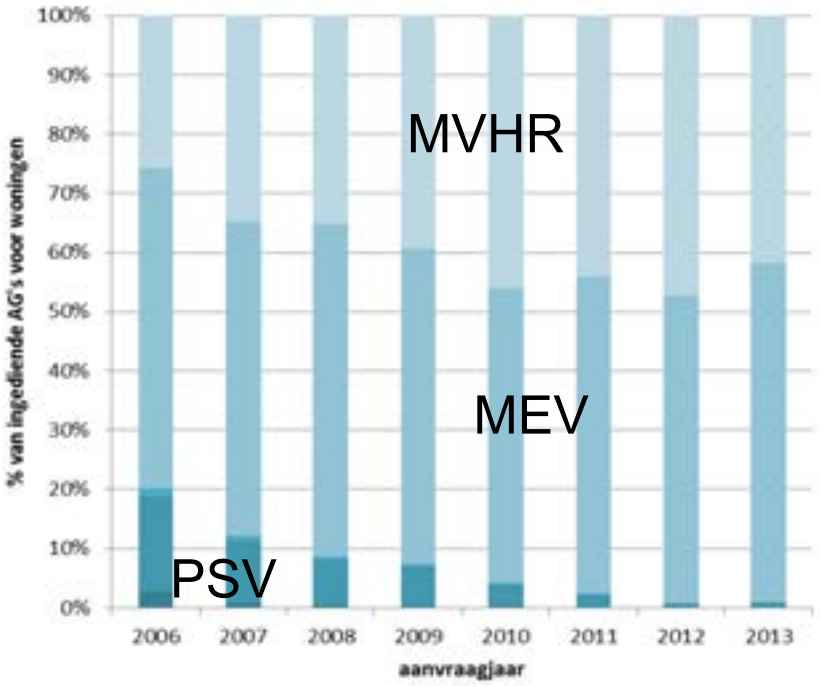
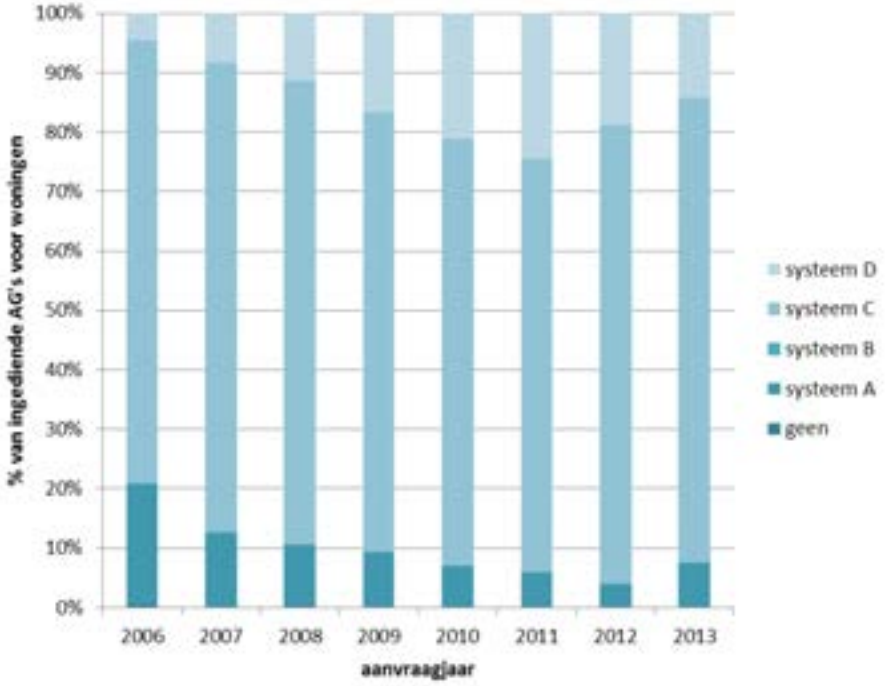
SHARE OF VENTILATION SYSTEMS IN NEW DWELLINGS (VEA 2015)

Single family houses



Multy family buildings



- Mechanical extraction ventilation (MEV) dominates the market
- Increased share of mechanical ventilation with heat recovery (MVHR)

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PRINCIPLE OF EQUIVALENCE

- Goal:
  - Allow for innovation of systems for which energy performance assessment is not included in regulatory calculation method
  - Introduce flexibility and provide temporary alternative solutions within a rigid regulatory framework
- Demand controlled ventilation for residential applications
  - Alternative assessment methods have been developed since 2007-2014 under principle of equivalence
  - Methodology has evolved over time
    - Assessment of mean ventilation heat loss reduction compared to standard systems
    - On condition of equivalent IAQ as provided by standard systems
    - Monte Carlo analysis based on dynamic multizone simulations with stochastic inputs for reference dwelling
  - Integrated in regulatory calculation since 2014

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Laverge, J., N. Van den Bossche, N. Heijmans, A. Janssens. 2011. Energy saving potential and repercussions on indoor air quality of demand controlled residential ventilation strategies. *Building and Environment* 46 (2011), 1497-1503.

INTEGRATION OF DCV IN REGULATORY EPB-CALCULATION

$$H_{V,hyg,heat,fct\ f} = 0,34 \cdot f_{reduc,vent,heat,fct\ f} \cdot r_{preh,heat,fct\ f} \cdot f_{vent,heat,fct\ f} \cdot \dot{V}_{hyg,fct\ f}$$

- Heat loss reduction factor for DCV f_{reduc} taking a representative occupation into account
- Offices-schools: MD 2012
  - Default values f_{reduc} related to control categories EN13779
- Residential: MD 2014
  - By 2014: 35 DCV-systems rated under principle of equivalence, mainly MEV (90%)
  - Development of DCV-classification method and default values f_{reduc} in regulatory calculations

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DEMAND CONTROLLED VENTILATION

- Definition in regulations:

  Ventilation system with automatic control comprising at least following elements:
  - *Detection of ventilation needs*
  - *Control of ventilation flow rates as a function of the needs*
- Definition applies to both residential and non-residential
- Performance depends on:
  - Type and locations of detection
  - Type and locations of flow rate controls

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TYPE OF DETECTION CONSIDERED (RESIDENTIAL)

- In the ‘dry’ habitable rooms (occupancy, acceptability)
  - CO_2
  - Presence detection
- In the ‘wet’ rooms (humidity, odours)
  - RH: kitchen, bathroom, laundry,…
    - alternative: CO_2 in stead of RH, only in kitchen
  - Presence detection: rooms with WC
    - alternative: light switch or VOC in stead of presence detection
- Locations:
  - Local: detection in every room, or in extraction duct serving individual rooms
  - Semi-local: detection in some rooms (eg night vs day zone)
  - Central: detection in main extraction duct

TYPE OF FLOW RATE CONTROLS CONSIDERED

- Which flow is controlled?
  - Supply only
  - Extraction only
  - Supply and extraction
- Where?
  - Local: every room independent of others (eg room specific valves or fans)
  - Semi-local: at least day and night zone
  - Central (eg frequency controlled fan)

PERFORMANCE CHARACTERISATION

❖ General approach

Detection in **wet rooms** and control of **extraction flow rates**

Detection in **dry rooms** and control of **supply flow rates**

	Local detection and control	Local detection and non-local control	**No or other** detection
Local detection and control	$f_{reduc} = ?$		
…			
Central detection and control			
No or other detection			

60 variations defined

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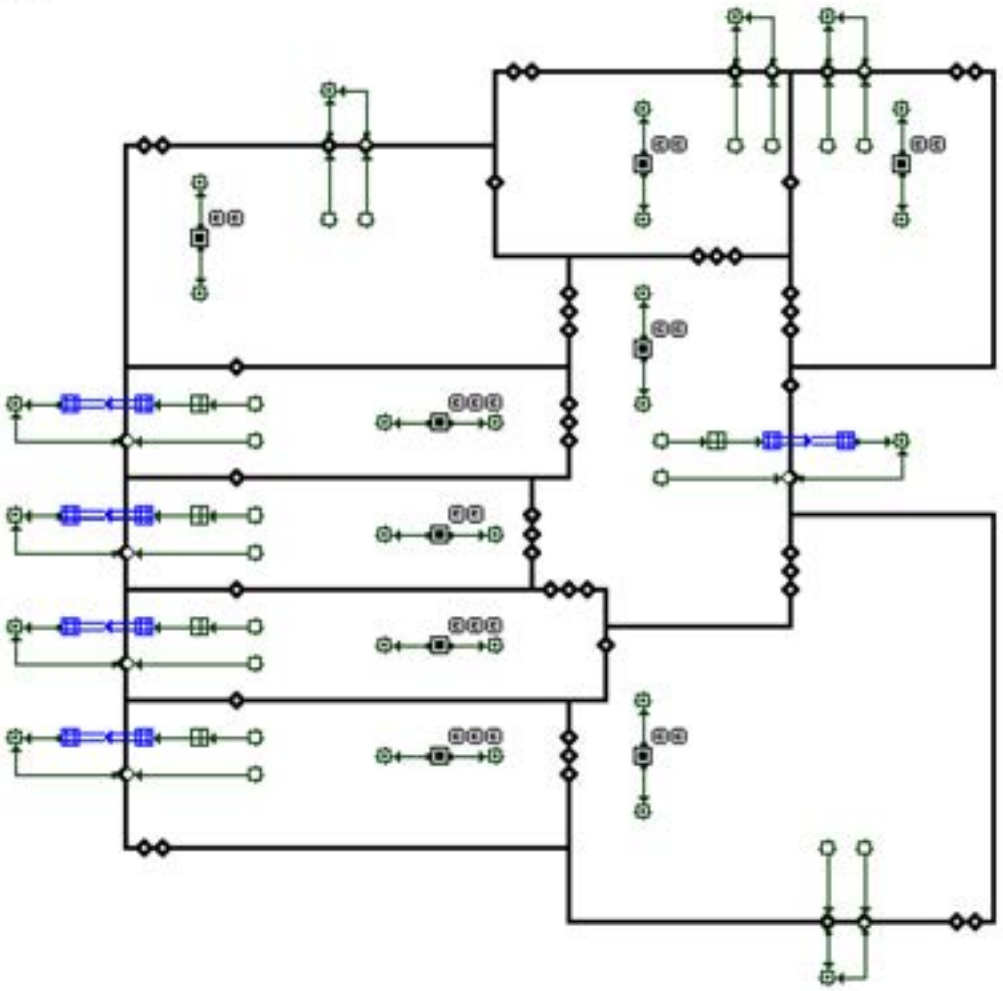
MULTI-ZONE SIMULATIONS CONTAM

- Reference geometry: single floor appartement
- Simulate exposure to:
  - CO_2 (occupants)
  - RH (occupants-activities
  - VOC (materials)
  - Odour (tracer WC)



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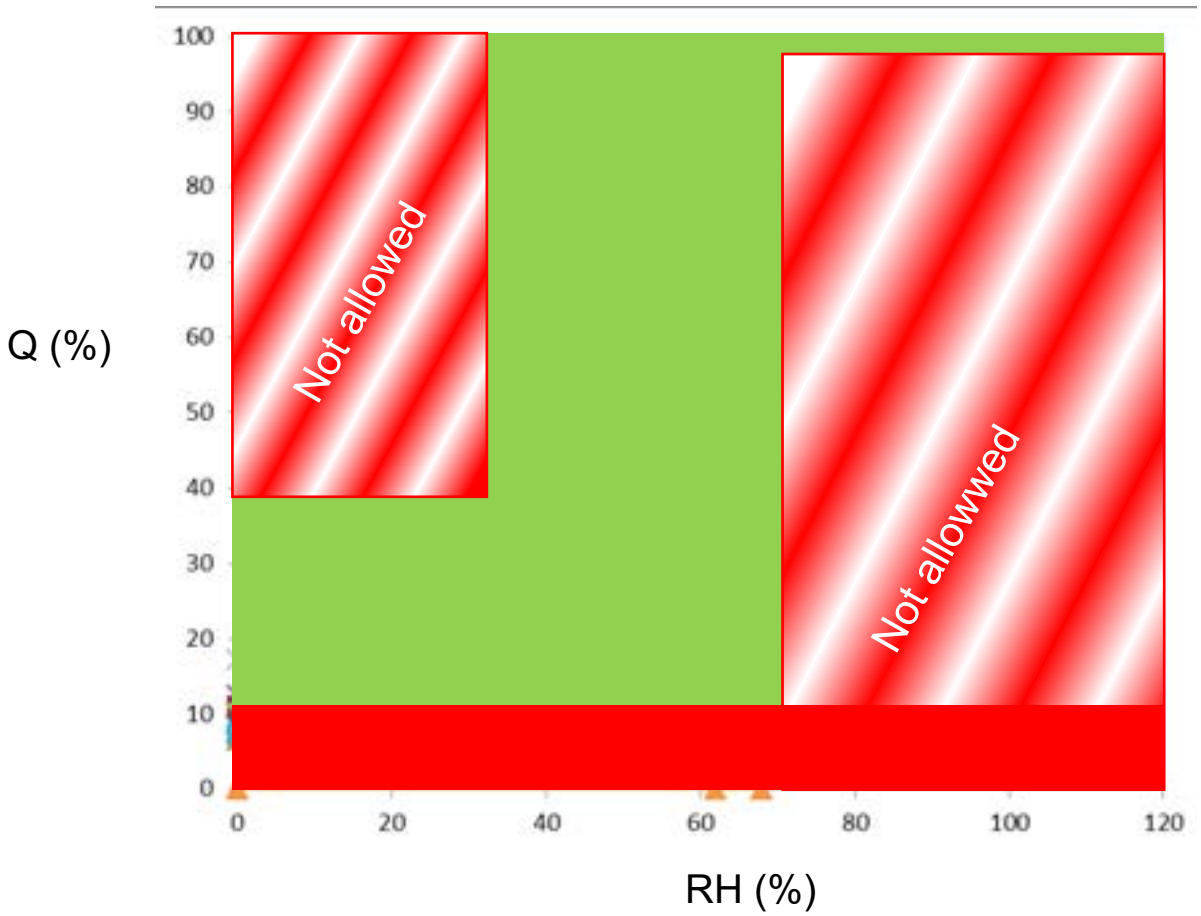
PRESCRIBED CONTROL SET-POINTS

– Eg extraction flow control as a function of relative humidity



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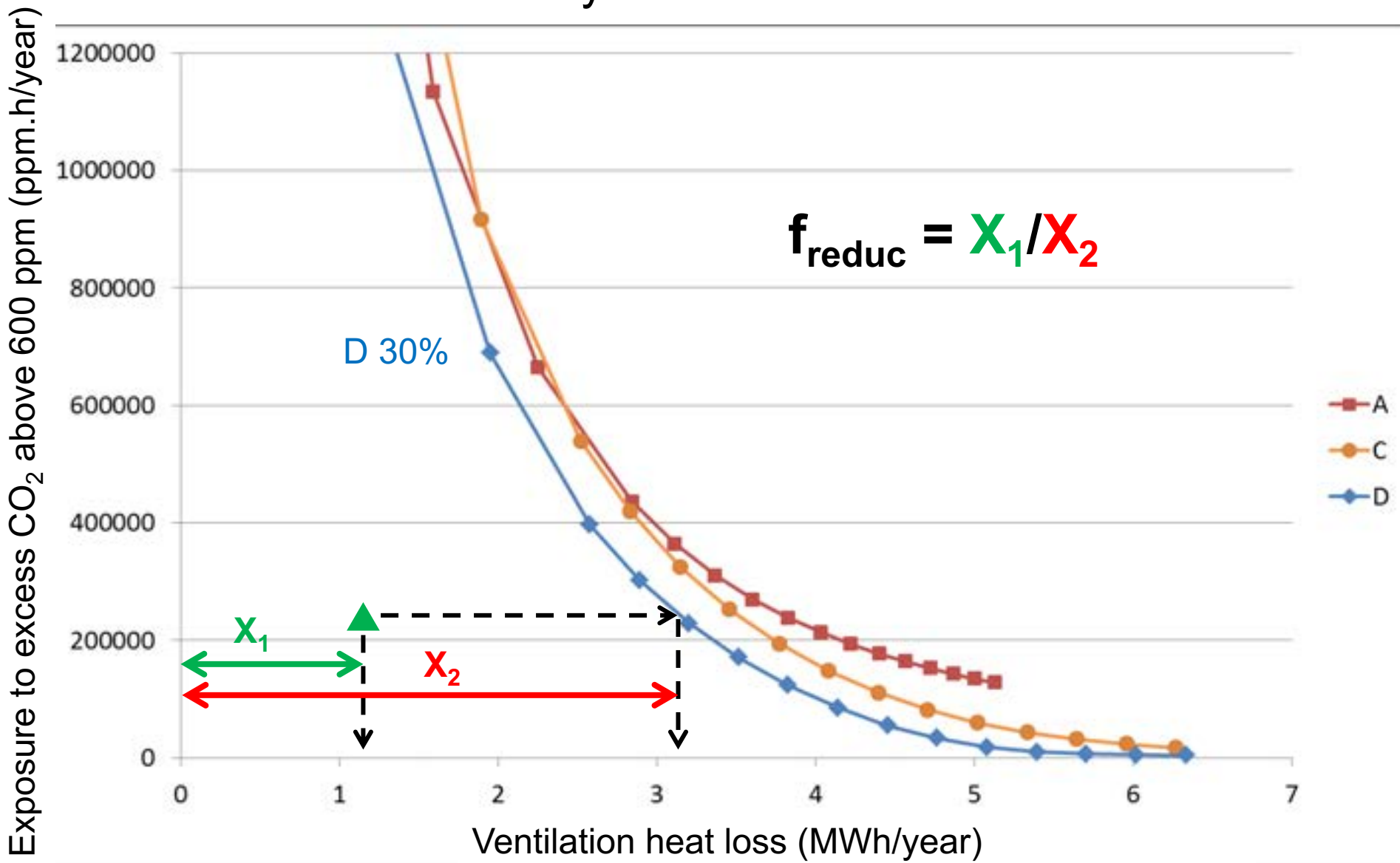
DEFINITION OF F_{REDUC} FOR DCV RESIDENTIAL

– Reference: standard systems with manual control



PERFORMANCE CHARACTERISATION

❖ General approach

Detection in **wet rooms** and control of **extraction flow rates**

Detection in **dry rooms** and control of **supply flow rates**

f_{reduc} =	**Local** detection and control	Local detection and non-local control	**No or other** detection
Local detection and control	0.35	0.38	0.42
…	…	…	…
Central detection and control	0.81	0.87	0.93
No or other detection	0.90	0.95	1,00

60 variations defined

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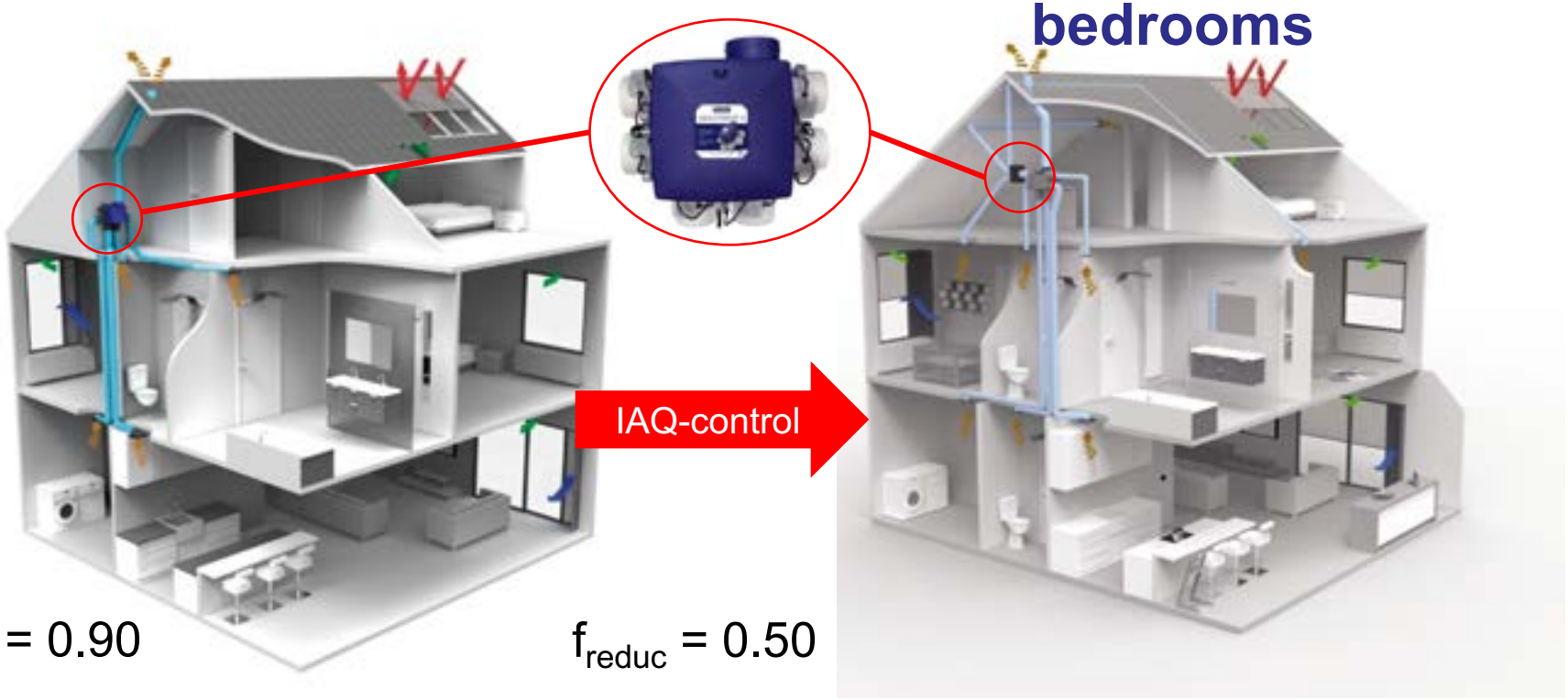
TYPICAL DCV-SYSTEMS ON MARKET



Mechanical extract ventilation (MEV)

- Natural supply (window ventilators) habitable rooms, no control
- Central mechanical extraction (fan) wet rooms, individual RH- and presence detection control

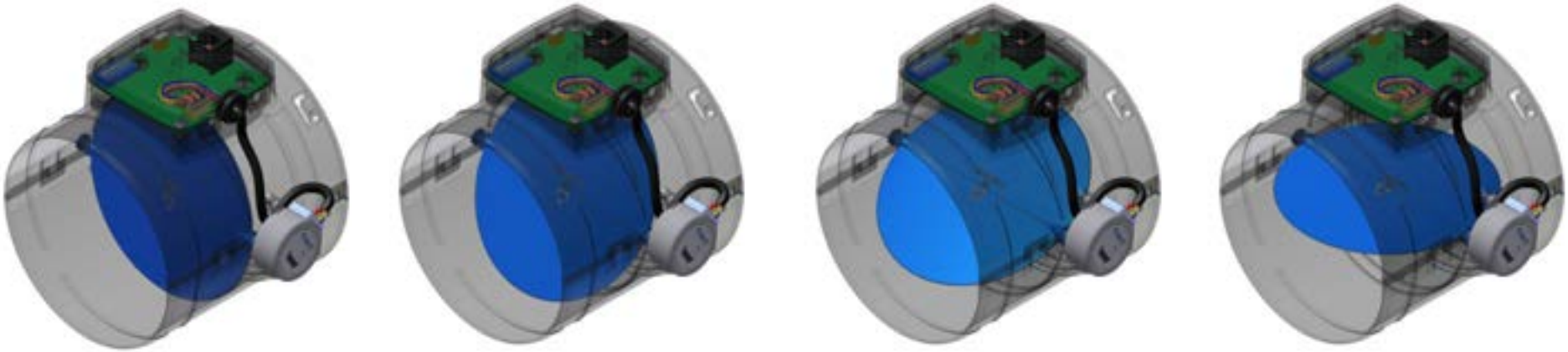
Mechanical extract ventilation (MEV)

- Natural supply (window ventilators) habitable rooms, no control
- Central mechanical extraction (fan) wet rooms **and bedrooms, with individual CO_2-control**

DETECTION AND CONTROLS IN EXTRACTION DUCT CONNECTORS: SYSTEM EXAMPLES

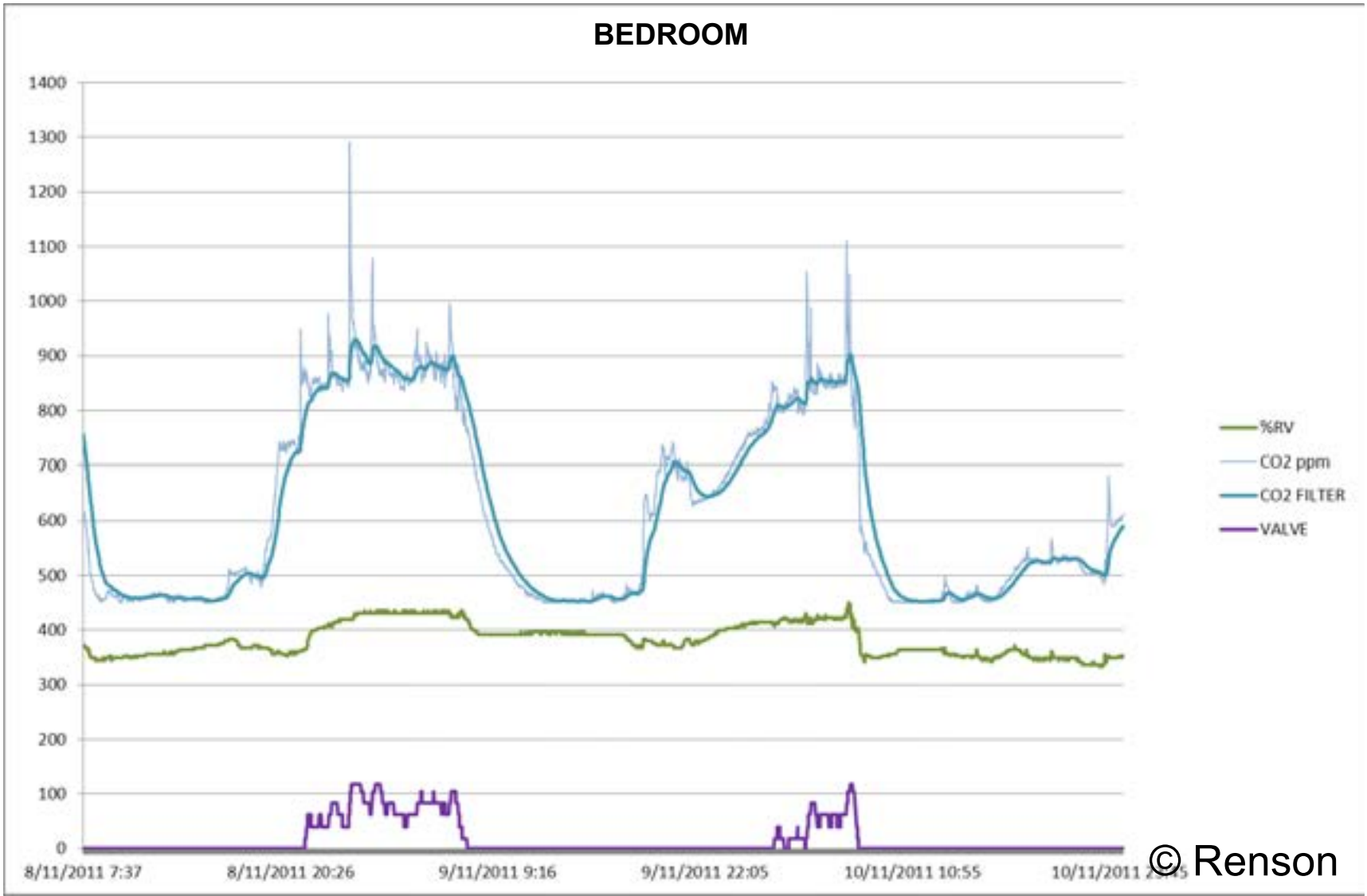
- Automatic operation: extraction rate adapted according to measured values and algorithm

- Control valve with integrated sensors (RH, VOC, CO_2)
  Sensor type selected for most important pollutant in room



Kit slaapkamer - 30 m³/h
CO_2 : 900ppm

Kit slaapkamers - 105 m³/h
CO_2 : 800ppm



CONCLUSIONS

- The Belgian ventilation market is driven by energy performance regulations.
- Regulations allow for the application of demand controlled ventilation to improve indoor air quality and energy efficiency
  - Principle of equivalence
  - Generic DCV-classification method and default values f_{reduc} in regulatory calculations

Thank you for your attention!

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