Performance-based approaches for ventilation requirements in dwellings

Samuel Caillou
BBRI – Belgian Building Research Institute
Belgium

PREVENT project in Belgium:
Development of new standard for dwelling ventilation

- Hot topics: DCV, natural & hybrid ventilation, ...
- But also: Feasability of performance-based approach

- Objectives of this presentation
  - Comparison of different performance-based approaches
  - Lessons learned from our experience of performance-based approach in the context of EP-calculation
Ventilation is part of a broader IAQ strategy

- But the design of ventilation is always necessary at a given moment

Different aproaches are possible to set ventilation requirements

- Requirements in the form of
  - Flow rates?
  - IAQ criteria?

- 2 extreme examples
  - Flow rates and prescriptive rules: current ventilation standard for dwellings in Belgium (NBN D 50-001)
  - Maximum CO2 concentration during use: new regulation for workplaces in Belgium
Extreme example 1: flow rate requirements and prescriptive rules for dwellings in Belgium (NBN D 50-001)

- **Approach**
  - Minimum flow rates (based on type and surface of the spaces)
  - One flow path is authorized: supply → transfer → exhaust
  - 4 systems: A, B, C, D
  - Prescriptive rules (for natural ventilation systems)
    Ex. Design of natural ventilation openings for $\Delta P = 2$ Pa

Extreme example 1: flow rate requirements and prescriptive rules for dwellings in Belgium (NBN D 50-001)

- **Pros**
  - Easy to design ventilation systems (manufacturers, designers,...)
  - Easy to check conformity

- **Cons**
  - Non equivalency between natural and mechanical systems
    Could be partly solved by improved descriptives rules
  - Block innovation (flow path, DCV, natural systems,...)
    Could be partly solved by others rules, but it is always temporary
  - ...
(Non-)equivelency between systems

Extreme example 2: Maximum CO2 concentration during use (new regulation for workplaces)

- Approach
  - Maximum CO2 concentration of 800 ppm (absolute)
Extreme example 2: Maximum CO2 concentration during use (new regulation for workplaces)

- **Pros**
  - Performance-based approach

- **Cons**
  - Only one pollutant (rather tracer)
    Could be partly solved using other IAQ metrics
  - Difficult to design ventilation systems
    Hypothesis and finally flow rates are needed
  - Dispersed responsibility
    Occupants (use of spaces, overcrowded)
    Building operator (here, the employer)
    Building and ventilation designers and installers/contractors

Intermediate conclusions

- **Prescriptive approach**
  - Block innovation

- **Extreme performance-based approach**
  - Is maybe an illusion?
  - Hypothesis are necessary to design ventilation
    These hypothesis could preferably be part of the requirements
    → equivalency approaches
Between these 2 extreme examples, intermediate equivalency approaches are possible

- Several equivalency approaches exist for EP-calculation
  - France, The Netherlands, Spain, US, Belgium
    → see previous presentation of Gaelle Guyot

- Could also be used for IAQ/ventilation requirements

- General idea: numerical simulations
  - Ex. Multizone models (Contam,...)

What we need for such simulations

- Simulation tool
- Weather data
- Building(s): geometry, airtightness, etc.
- Occupant profile(s)
- IAQ criteria (and IAQ metrics)

- Ventilation system to be tested: components, regulation, etc.

- And what we get from these simulations
  - Flow rates (eventually reduction factors for EP-calculation)
  - Conformity against IAQ criteria
Examples of possible equivalency approaches

- (1) Product approach
  - Reference building(s)
  - Reference profile(s)
  - Ventilation systems to be tested

- (2) Building approach
  - Real building
  - Reference profile(s)
  - Ventilation systems to be tested

- (3) Building + occupants/sources approach
  - Real building
  - Real occupants/sources
  - Ventilation systems to be tested

(1) Product approach

- Approach
  - Equivalent IAQ criteria
  - Simulations carried out on products (ventilation systems)
    On one or more reference building(s)
    With standard/reference conditions

- Can be applied on large scale (products)

- Challenges
  - Not for combination building + ventilation system: see building approach
  - See example of Belgium (next slides)
(2) Building approach

- **Approach**
  - Simulation of the real building + ventilation system
    - Also possible to evaluate natural ventilation (building + system)
  - Reference occupant/sources profile(s)

- **Challenges**
  - More expensive?
    - Simulation per building in place of per product

(3) Building + occupant/source approach

- **Approach**
  - Simulation of the real building + ventilation system
  - Also real occupant profile(s) and sources

- **Challenges**
  - Not only the building (design) but also the occupants and users
    - not building independent
      - Occupant profile and building independent: not recommended
      - Building sources: ok if sources are known + IAQ criteria
Belgian example (Product approach in EPB)
IAQ criteria

- **Problem?**
  - Initially: only CO2 criteria
  - But the required flow rates in the standard are not only for CO2 but also to evacuate odors and humidity from services spaces
  - New IAQ criteria has been developed: odors + mold risk

- **What can be learned?**
  - Coherence needed between:
    - Requirement (e.g. flow rate) ↔ IAQ criteria

Belgian example (Product approach in EPB)
Reference building

- **Problem?**
  - Only 1 reference building
  - But some systems can be largely influenced by the building

- **What can be learned?**
  - If influence of the building (e.g. natural systems):
    - Or several reference buildings
    - Or follow the « building approach »
Belgian example (Product approach in EPB)  
Occupant profiles

- Problem?
  - Several profile(s), 2 to 6 persons
    + probabilistic approach → average
  - Meaning of the average?

- What can be learned?
  - Maybe 1-2 (well chosen) profiles is enough?
    Ventilation requirement: maximum occupancy (most unfavourable)
    EP-calculation: mean occupancy (statistically significant)

Belgian example (Product approach in EPB)  
Input data

- Problem?
  - Differences between data used in the simulations and real data of the components/products
    Ex. accuracy of CO2 sensors

- What can be learned?
  - Robust compliance framework is needed
    Reliable input data
    Who do the simulation? Who check them?
Belgian example (Product approach in EPB)
Simulation tool = black-box

- Problem?
  - Not logically expected result
  - The limits of the model have been reached!
  
  Ex. A system with DCV: lower flow rate $\rightarrow$ largely better IAQ

- What can be learned?
  - Need explanation of the simulation result
  
  Reference systems to be simulated
  The results should be compared to and explained based on these references

Equivalency approaches: challenges, recommendations, conclusions

- Simple approaches based on flow rate remain necessary
  
  To design simple buildings and systems on large scale and low price
  $\rightarrow$ combining both (flow rates + equivalency)

- Could be used for EP-calculation and for ventilation requirements

- Product approach
  
  Check influence of the reference building
  Use building approach if necessary

- Building + occupant/sources approach
  
  Occupant profile: not recommended?
  Building sources: ok if sources are known + IAQ criteria
Equivalency approaches: challenges, recommendations, conclusions (2)

- **Occupant profile(s)**
  Maybe 1-2 (well chosen) profiles is enough?

- **Coherence between**
  IAQ criteria ↔ flow rates requirements

- **Compliance issues**
  Reliable input data for simulations (components, building,...)
  Who do the simulations? Who check them?

- **Black-box: how to avoid wrong result?**
  Simulate reference systems (nominal flow rates, in-/exfiltration,...)
  Explain the results compared to these references

- **Need of IAQ metrics**

---

Thank you for your attention

Samuel Caillou
BBRI – Belgian Building Research Institute
Belgium