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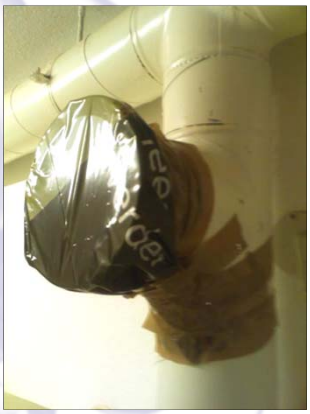
AIVC Residential Ventilation Workshop
Brussels, March 18+19, 2013

OUTCOMES OF A FIELD STUDY IN THE NETHERLANDS



Atze Boerstra (et al., see papers at the end)
BBA Indoor Environmental Consultancy +
Eindhoven University of Technology

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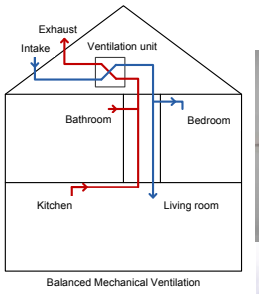
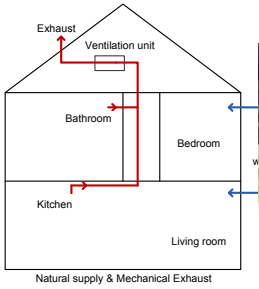
Standard systems

Most common ventilation systems in new NL houses:

- Balanced mechanical ventilation + heat recovery (MVHR, system D)
- Natural supply + mechanical exhaust ventilation (MEV, system C)



Balanced Mechanical Ventilation



Natural supply & Mechanical Exhaust

How it started...

- Occupants of new, energy efficient Dutch houses esp. with MVHR report noise and draught complaints, poor indoor air quality and health symptoms
- A number of national TV programmes and newspapers reported on this subject from 2008
- Several times NL parliament has addressed the issue

Research questions Ministry

1) What are the most common shortcomings of mechanical ventilation systems in recently built single-family houses in the Netherlands?

2) What is the relationship between shortcomings of ventilation systems and subjective (self-reported) health and perceived indoor environmental quality?

3) Is there a difference in self-reported health and perceived indoor environment between occupants of dwellings with MVHR and MEV (system D vs. C)?

Method

- Part 1: Inspections & measurements
  - Visual inspections of building and installation characteristics
  - Measurements
- Part 2: Occupant questionnaire
  - One occupant per home
  - Analysed by the RIVM (National Institute of Public Health and the Environment)

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Method: selection

- Selection of 299 dwellings
  - 150 balanced mechanical ventilation
  - 149 mechanical exhaust

- Selection criteria
  - Single-family houses
  - Completed between June 2006 and January 2008
  - Located all over the Netherlands
  - Selected from a database of a prior study by the government
  - Majority houses owned, not rented

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Part 1: Inspections & Measurements

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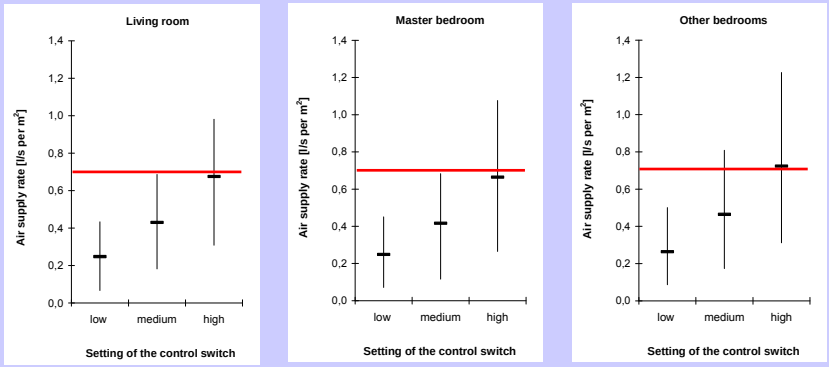
Method: Inspections & measurements

- Performance measurements:
  - Ventilation rates
  - Installation noise levels
  - No direct measurements of CO_2, TVOC etc
- Characteristics / risk factors:
  - Ventilation capacity: such as capacity of the ventilation unit and grills, commissioning
  - Indoor air quality: such as the hygienic condition of the ventilation unit and ducts
  - Thermal comfort: such as the presence of a bypass on the heat recovery
  - Installation noise: such as the presence of (proper mounted) silencers
  - Other: such as options for personal control
- Reference:
  - Requirements Dutch Building code 2003
  - GIW/ISSO guidelines for installations in dwellings

Results: Performance SUPPLY

Air supply rates:

- Total air supply: 48% insufficient (MVHR)
- In one or more rooms: 85% insufficient (MVHR)



Average, P10 & P90; Horizontal line = reference level according to the Dutch Building Code (0,7 l/s/m²)

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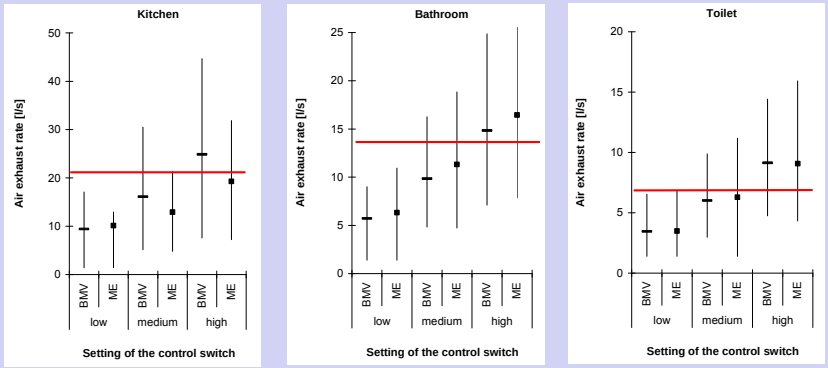
Results: Performance EXHAUST

Air exhaust rates:

- Total air supply: 55% (MVHR) resp. 69% (MEV) insufficient
- In one or more rooms: 85% (MVHR) resp. 76% (MEV) insufficient

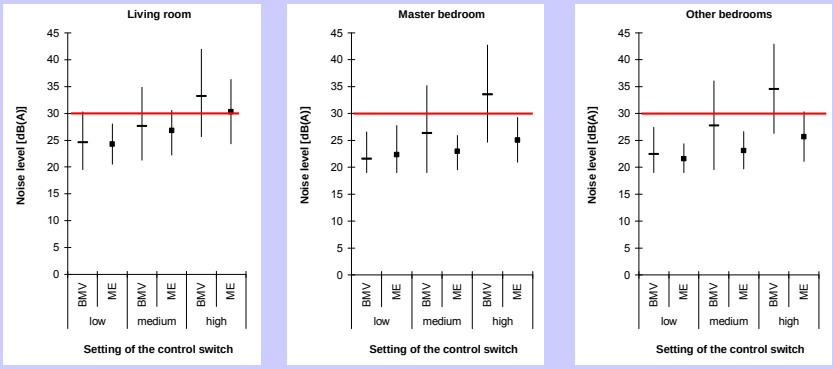


(Average, P10 & P90; Horizontal line = reference levels according to the Dutch Building Code)

Results: Performance NOISE

Installation noise levels:

- Living room: 72% (MVHR) resp. 54% (MEV) too high (> 30 dB(A)
- One or more bedrooms: 86% (MVHR) resp. 21% (MEV) too high



(Average, P10 & P90; Horizontal line = reference level according to GIW/ISSO (30 dB(A))

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Results: Other shortcomings (1)

- Improper design, e.g.
  - no control options (3-step switch) in BOTH bathroom and kitchen (81% MVHR, 70% MEV)
  - air supply valves too close to wall or exhausts (31% MVHR)
  - overcomplicated, non-logic switches (19% MVHR,13% MEV)
- Improper installation, e.g.
  - ductwork not properly installed (excess bending of ducts etc) (48% MVHR, 40% MEV)
- Improper usage, e.g.
  - improper use of control switches (96% MVHR, 96% MEV)

Results: Other shortcomings (2)

- No (warm weather) bypass on heat recovery (49% MVHR)
- Hygiene problems, e.g.
  - excess dust/dirt in supply ducts (77% MVHR)
  - filters too dirty (visual check) (43% MVHR)
- Insufficient maintenance, e.g.
  - no annual inspection (66% MVHR, 82% MEV)
  - filters are changed less then 2x per year (47% MVHR)
- Unintentional recirculation of exhaust air (59% MVHR); caused by leakage inside ventilation unit?
- No operable windows in one or more bedrooms / living room (6% MVHR, 5% MEV))

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Conclusions Part 1

- Performance of mechanical ventilation systems in newly built single-family homes is often poor regarding e.g. ventilation capacity, noise and internal hygiene
- BOTH type of ventilation systems (MVHR and MEV) have serious shortcomings
- Shortcomings originate from problems with design, construction, commissioning, usability and maintenance
- **All-in-all we saw a big gap between actual performance and performance on paper**

Intermezzo: EPBD

Energy Performance of Buildings Directive

- "This Directive lays down requirements […] on the energy performance of buildings."
- ".. requirements shall take account of **general indoor climate conditions**, in order to avoid possible negative effects such as **inadequate ventilation** .."
- " .. measures […] should take into account climatic and local conditions as well as **indoor climate environment** and cost-effectiveness."

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Part 2: Occupant questionnaire

Analyses performed by RIVM

Method

- Composed of mostly standardized questions on:
  - Subjective health;
  - Nonspecific (self reported) health symptoms;
  - Indoor environment related health symptoms;
  - Sleep disturbance;
  - Perceived Indoor Environment;
  - Perceived controllability of the ventilation system.
- Statistical analysis
  - Testing associations with non-parametrical tests (i.e. Spearman, Kruskal-Wallis, Fisher exact and Chi square);
  - Associations with $p<0.10$ were stratified according to potential confounding variables;
  - False discovery rate (FDR) was calculated, only findings with FDR≤1 were considered significant.

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Results (1)

- No significant differences in subjective health and sleep disturbance between both groups
- But… occupants with MVHR perceive the indoor environment as LESS favorable than occupants with MEV:

	MVHR	MEV	p-value
'The indoor air quality is good or very good'	66%	79%	0.01
'I experience dryness of air at least weekly'	20%	7%	0.001
'I rate the noise nuisance from my ventilation system …' (1 = no nuisance at all - 10 = extreme nuisance)	1,9	1,3	0.003
'The ventilation system has insufficient controls to adjust it to my wishes'	32%	18%	0.01

Results (2)

Three technical features were significantly associated with subjective health or perceived indoor environment:

- Less nonspecific health symptoms in houses with well ventilated bedrooms (relative weak association)
- Perceived air quality lower in houses where we measured 'short-circuiting' between supply and exhaust air (only relevant with MVHR systems)
- More noise annoyance in houses with higher measured overall exhaust air flow at night

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Conclusions Part 2

- Subjective health of occupants in dwellings with MVHR and MEV are comparable
- Occupants with MVHR perceive the indoor environment as less favourable than occupants with MEV (perceived Air Quality, controlability, noise and 'dry air' (3x higher))
- Three technical features were associated with subjective health and perceived indoor environment
- **All-in-all some - but limited - proof that MVHR houses have more complaints and health symptoms**

  (Note that the Dutch media interpreted the end-report differently!)

Recommendations

- All parties involved in ventilation system design, installation and use should ‘step-it-up’
- Include maximum noise level requirements in the new building code and make operable windows obligatory
- Some key recommendations for building professionals:
  - Don’t be penny wise and pound foolish (invest in health);
  - Set clear design requirements that go beyond the (legal) minimum requirements (e.g. referring to ISSO/GIW guideline);
  - Check actual performance in the commissioning phase and e.g. only pay the final term (30%) when actual performance (fresh air supply, noise level etc) meets the requirements;
  - Provide clear user instructions (and keep things simple);
  - Make maintenance contracts ‘obligatory’.

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Questions?

For further reading about this study see:
- Article in Architectural Science Review, 55:1, p 4-14
- Indoor Air 2011 conference papers #372, 799, 829 and 838
- Conference proceedings AIVC Tightvent 2012

Atze Boerstra MSc
BBA Binnenmilieu
ab-bba@binnenmilieu.nl