Quality of ventilation systems in Norwegian residential buildings

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Quality in the building process

- Suppliers:
  - Generally reliable documentation
  - Provide other services such as filter subscription, training, etc.

- Designers
  - Small houses: "design service" provided by supplier of ventilation unit, with MagiCAD etc.: Engineering Bachelor or similar
  - Apartment buildings: Consultant engineer with engineering degree
  - Good design guidelines exist

- Installers & commissioning:
  - HVAC contractors with members of "ventilation & tinners guild". Commissioning often minimalistic. Instruments are calibrated
  - "Hands-on" commissioning courses held 2-4 times a year.

- Inspections:
  - Only airtightness of facade

National certification of companies (designers, contractors & controllers)
What do we mean by "quality"?

- A sufficient air flow rate does not guarantee quality. We also need:
  - Energy efficiency
  - Low noise
  - Clean supply air
  - Good ventilation efficiency (pollutant removal)
  - Good thermal comfort
  - User friendliness (easy to control & service)
  - Reliable technology
  - Cost effectiveness
Common problems in existing systems

Mold in a naturally ventilated dwelling with poor ventilation

Rot in roof construction due to poor design and inadequate ventilation

Only proper energy & ventilation retrofits will solve these problems
Common problems in existing systems

Trickle vents are often closed or blocked to prevent cold drafts and to reduce heating costs.

Air transfer is often undersized or non-existent. It is not part of the HVAC contract.

Mechanical exhaust ventilation

Does not eliminate exfiltration at roof level

Cold draft
No air filtration

Radon ingress
Mechanical extract ventilation: What happens when someone opens a window?

- Reference case, $n_{50} = 4 \text{ ach and extract flow rate 1 ach}$
- Improved trickle vents
- Slightly worse transfer grilles between rooms
- 2 bedrooms have window open by 10°
- Both window and bedroom door fully open in first floor bedroom

Exponential growth in balanced ventilation

- Trend: $\times 10$ el. hver år siden 1977 (25% økning per år)
Today's building regulations

- Indoor environment design, generally EN 15251 Class II
  - Average flow in whole dwelling $\geq 1.2 \text{ (m}^3\text{/h)/m}^2 = 0.5 \text{ ach}$
  - Bedroom ventilation $\geq 7 \text{ l/s per person}$
  - Minimum exhaust rate from wet rooms & kitchen hoods
  - Minimum boost requirements for showers and kitchen hoods
  - Openable window in all occupied rooms
  - Thermal comfort, & Draft Rating (DR)
  - Radon $\leq 200 \text{ Bq}$
  - Noise: 30 dB(A) and Room Criterion RC-23

- Energy
  - Heat exchanger annual efficiency $\geq 70\%$ (also taking into account loss due to defrosting)
  - Specific fan power $\leq 2.5 \text{ kW/(m}^3\text{/s)} = 2.5 \text{ kPa} = 2.5 \text{ W/(l/s)}$
Installation faults

"Mistakes made by installer – Damaged ducts, incorrect positioning of supply terminals, missing silencer, missing condensate drain, flap-damper on air intake!!! – The contractor is to blame!"

Overall satisfaction with HRV

<table>
<thead>
<tr>
<th></th>
<th>2003 study on HRV</th>
<th>1995 study on HRV and MEV</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Satisfied</td>
<td>Very satisfied</td>
</tr>
<tr>
<td></td>
<td>44 %</td>
<td>45 %</td>
</tr>
<tr>
<td></td>
<td>Not satisfied</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7 %</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very dissatisfied</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 %</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ingen mening</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 %</td>
<td></td>
</tr>
</tbody>
</table>

Hvis dere kunne velge fritt, ville dere ha valgt samme anlegg i dag?

<table>
<thead>
<tr>
<th></th>
<th>Ja</th>
<th>Vel ikke</th>
<th>Nei</th>
</tr>
</thead>
<tbody>
<tr>
<td>Balansert ventilasjon med varmeveksler (N=171)</td>
<td>36.5%</td>
<td>42.7%</td>
<td>20.8%</td>
</tr>
<tr>
<td>Mekanisk avtrekksanlegg (N=175)</td>
<td>18.3%</td>
<td>42.3%</td>
<td>39.4%</td>
</tr>
</tbody>
</table>
PAQ depends on duct quality

- Flexible ducts:
  - Meget fornøyd: 69
  - Fornøyd: 64
  - Ingen mening: 2
  - Ikke fornøyd: 3
  - Meget misfornøyd: 1

- Rigid round ducts (spiro):
  - Meget fornøyd: 63
  - Fornøyd: 22
  - Ingen mening: 2
  - Ikke fornøyd: 3
  - Meget misfornøyd: 1

Kind of air filter

- Bag filters (EU7): 48%
- Flat filters: 20%
- Coarse: 16%
- Ja, men vet ikke type: 11%
- Vet ikke: 3%
- Elektrofilter: 2%
Noise problems

- No: 70%
- Litt: 28%
- Det er svært ubehagelig: 2%

Duct system and noise problems

- Fleksible kanaler:
  - Nei: 96
  - Litt: 43
  - Det er svært sjenerende: 5

- Stålkanaler:
  - Nei: 71
  - Litt: 20
  - Det er svært sjenerende: 9
Problems with dry air

- Fuktgjenvinning
  - Nei: 13
  - Bare litt: 4
  - Ja: 2

- Ingen fuktgjenvinning
  - Nei: 23
  - Bare litt: 14
  - Ja: 9

Antall svar:
- 0%: 0
- 10%: 1
- 20%: 1
- 30%: 1
- 40%: 1
- 50%: 1
- 60%: 1
- 70%: 1
- 80%: 1
- 90%: 1
- 100%: 1

Easy of maintenance

- Ganske lett: 50%
- Meget lettvint: 30%
- Litt tungvint: 14%
- Ingen mening: 2%
- Meget tungvint: 4%
Quality of the user guide

- Tilsfredsstilende: 60%
- Meget bra: 27%
- Ingen mening: 2%
- Noe uforståelig: 5.3%
- Veldig dårlig forklart: 1%
- Bli levert uten bruksanvisning: 5%

Filter change frequency

- Årlig: 42%
- Hvert 2. år: 11%
- Sjeldnere enn hvert 2. år: 2%
- Ikke gjort ennå: 12%
- 2 ganger årlig eller oftere: 33%
The main remaining technical problems with residential HRV

- Noise
  - Fan and duct system noise
  - Cross-talk between apartments

- Odour
  - People who move from 'leaky' old buildings into modern airtight buildings can be disappointed
  - Modern dwellings have a higher pollutant load than earlier (phthalates and SVOC from new materials ozone & UFP from IT equipment, Black Magic Dust)

- Poor Kitchen hood performance
  - Poor catchment (either due to poor design, insufficient air supply)
  - High noise

Reducing pollutants at the source:

(1) Outdoor emissions: National measures to reduce vehicle emissions, and more use of public transport. The country will be mapped for air quality. Housing etc. can not be built on 'red' zones

(2) Indoor emissions: The building regulations now require low-emitting materials: Below is draft national appendix to NS-EN 15251:

<table>
<thead>
<tr>
<th>Class</th>
<th>Airflow per person l/(s·person)</th>
<th>Very low polluting building</th>
<th>Low polluting building (M1 materials)</th>
<th>Not documented materials</th>
<th>Additional requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>10</td>
<td>0.5</td>
<td>1</td>
<td>2</td>
<td>*</td>
</tr>
<tr>
<td>II</td>
<td>7</td>
<td>0.35</td>
<td>0.7</td>
<td>1.4</td>
<td>*</td>
</tr>
<tr>
<td>III</td>
<td>7</td>
<td>0.35</td>
<td>0.7</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>4</td>
<td>0.2</td>
<td>0.4</td>
<td>0.8</td>
<td></td>
</tr>
</tbody>
</table>

Note
GREEN cells shall be used for design of new dwellings
(* Additional requirements: F7 or better supply air filtration)
Kitchen hoods

Noise
Recirculating hoods have problems too

Effective design
(≥85% at 108 m³/h)

Ineffective design
(even if flow rate is over 250 m³/h)
## Summary: Remaining challenges

<table>
<thead>
<tr>
<th>Issue</th>
<th>Problems</th>
<th>Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Product</strong></td>
<td>● Documentation</td>
<td>● National norm for documentation;</td>
</tr>
<tr>
<td></td>
<td>● Kitchen hood performance</td>
<td>● Eurovent certification;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Ecodesign requirements</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● National minimum requirements for kitchen hood performance (IEC 61591)</td>
</tr>
<tr>
<td><strong>Design</strong></td>
<td>● Ventilation noise (no acoustic calculations.</td>
<td>● Better 'best practice' design guides</td>
</tr>
<tr>
<td></td>
<td>● Odour, Black Magic Dust</td>
<td>● Building regulations: SFP requirement has reduced noise.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>● Considering to increase ventilation requirement to 0.6 ach</td>
</tr>
<tr>
<td>**Installation,</td>
<td>● No third-party checking of flow rates and noise</td>
<td>● Training courses on duct system commissioning.</td>
</tr>
<tr>
<td>Commissioning**</td>
<td></td>
<td>● Discussing possibility of third party spot checks</td>
</tr>
<tr>
<td><strong>Maintenance</strong></td>
<td>● Air filter not replaced, due to owner ignorance.</td>
<td>● Filter subscription</td>
</tr>
<tr>
<td></td>
<td>● System not cleaned</td>
<td>● Service contract (e.g. paid by rent to housing cooperative)</td>
</tr>
<tr>
<td><strong>Inspection</strong></td>
<td>● No inspection</td>
<td>● Obligatory inspections in connection with energy audit for investment support.</td>
</tr>
</tbody>
</table>