EXPERIENCES WITH DANISH LOW-ENERGY HOUSES

HENRIK N. KNUDSEN
Experiences and satisfaction among occupants
Objective

Evaluate experiences and satisfaction with the new generation of low-energy class 2015 detached single-family houses

This presentation

- “The low-energy house”
- Technical installations – focus ventilation system
- Satisfaction with perceived indoor climate – focus perceived IAQ
- What we (maybe) can do…
“The low-energy house”
Kære ejer af et lavenergihus,

Vi er glade for, at du vil hjælpe os ved at udfylde dette spørgeskema. Som del af vores relevante forskningsprojekt ved Statens Byggeforskningsinstitut og Aalborg Universitet vil vi gerne have din mening i forbindelse med en lavenergiudvikling.

For nogle af spørgsmålene kan du være påbevist af personalgrenen. Du er her nu, for at komme videre og du kan komme tilbage til et allerede besvaret spørgsmål. Spørgeskemaet er først færdigudfyldt når du har trykket på "Afslut" til sidst. Du kan også vende tilbage til dine besvarelser på et senere tidspunkt, da svarerne gemmes.

Eventuelle spørgsmål kan rettes til undertegnede.

På forhånd tak for hjælpem

Med venlig hilsen
Henrik

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370 out of 869 responded = Response rate of 43 %
Questions

- The houses/Technical installations
- Overall satisfaction
- Specific satisfaction
  - Perceived indoor climate
  - ..
"The low-energy house"

- Low-energy class 2015 (Building Regulations 2010)
- Average size: 186 m²
- Ventilation systems with heat recovery (76%)
- Heat pump (65%)
- Floor heating (94%)
- PV (71%)
Technical installations

**District heating**

**Gas**

Heat pump, geothermal system (liquid to water-heat pump)

Heat pump, air to water

Heat pump, air to air

**Ventilation system with heat recovery**

**Ventilation systems with heat recovery and hot water heating**

**Ventilation systems with DHW heat pump**

Solar heating for DHW and evt. space heating

Solar cells for electricity generation

Wood stove or the like

Other...
Information - Technical installations

Do you find that you have been given enough information about how the house's various technical installations works?

- Yes: 62% (230)
- No: 38% (143)
Information - Technical installations

Which of the following installations are you lacking information about?

- Heating system: 49%
- Heat pump: 47%
- Ventilation system: 83%
- Solar heating for DHW: 3%
- Solar cells for electricity generation: 31%
- Wood stove or the like: 1%
- Other installations: 9%
Technical installations

• Houses are getting more complicated
  – Ventilation system
  – Heating system / floor heating
  – Geothermal heat / heat pump
  – Photovoltaics
  – Solar heating

"The system is so complex that it's hard to remember what to do for the proper operation of installations"

"The manual is intended for engineering nerds"
Overall satisfaction

Can you recommend others to live in a low-energy house?

Justifications:
Good indoor climate and low energy and operating costs
Perceived indoor climate

- Temperature
- Draught
- Noise
- Air quality
- Daylight
How often have you perceived problems with unpleasant odour?

- Never: 95% (302)
- Monthly: 3% (9)
- Weekly: 2% (5)
- Daily: 1% (2)

Winter 2012-2013
How often have you perceived problems with stuffy air?

- Never: 94% (299 respondents)
- Monthly: 3% (11 respondents)
- Weekly: 2% (5 respondents)
- Daily: 1% (2 respondents)

Winter 2012-2013
How often have you perceived problems with dry air?

- Never: 71% (228)
- Monthly: 11% (36)
- Weekly: 11% (34)
- Daily: 7% (23)

Winter 2012-2013
How did you find the **air quality** in your house?

**Winter 2012-2013**
- Very unsatisfactory: 3%
- Unsatisfactory: 1%
- Neither nor: 8%
- Satisfactory: 24%
- Very satisfactory: 64%

**Summer 2013**
- Very unsatisfactory: 3%
- Unsatisfactory: 1%
- Neither nor: 5%
- Satisfactory: 29%
- Very satisfactory: 61%
How do you find the **air quality** in your new house compared with your previous dwelling?

- Better: 84% (311)
- Unchanged: 14% (51)
- Worse: 2% (8)

- Better: 67% (248)
- Unchanged: 26% (96)
- Worse: 8% (28)

- Better: 77% (285)
- Unchanged: 21% (78)
- Worse: 2% (8)
How often have you perceived problems with noise from the ventilation system?

- Never: 74% (237)
- Monthly: 11% (35)
- Weekly: 6% (19)
- Daily: 9% (29)

Winter 2012-2013
Taking everything into consideration…

How would you rate the **indoor climate** in your house?

<table>
<thead>
<tr>
<th>Rating</th>
<th>Winter 2012-2013</th>
<th>Summer 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very unsatisfactory</td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>Unsatisfactory</td>
<td>0%</td>
<td>2%</td>
</tr>
<tr>
<td>Neither nor</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>Satisfactory</td>
<td>25%</td>
<td>33%</td>
</tr>
<tr>
<td>Very satisfactory</td>
<td>69%</td>
<td>60%</td>
</tr>
</tbody>
</table>
Conclusions

- Overall satisfaction with low-energy houses
- The indoor climate is perceived positively
Remember (to satisfy occupants)

- Pollution sources…
- Ventilation – how much?, when?, where? …
- Avoid high temperatures in summer
- Avoid noise from technical installations
- Handover procedure – make things work from day one
- Robust and user-friendly technical installations
- Bedroom/children’s rooms may need special attention during the design of ventilation solution/system
- Align expectations
  - Comfort and energy
Strategy for good IAQ

- Source control
- Ventilation
  - Constant
  - Demand-controlled?
- Air cleaning
6.3 Air quality

6.3.1 Ventilation

Buildings must be ventilated. Ventilation systems must be designed, built, operated and maintained so as to achieve **satisfactory air quality and humidity** conditions while they are in use.

6.3.1.2 Domestic buildings

- **Fresh air supply:** 0.3 l/s per m²
  - In each habitable room
  - In the dwelling as a whole
  - Similar to **0.5 times air change rate (h⁻¹)**
Devils advocate…

What we (maybe) can (in an unoccupied dwelling)
• Provide the prerequisites for good IAQ

What we (definitely) can’t (in an occupied dwelling)
• Control occupant behaviour
  • Non building materials
  • Consumer Products
  • Humidity

It will be very hard to convince authorities to lower/change the requirements for ventilation rate in dwellings…
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