

# EXPERIENCES WITH DANISH LOW-ENERGY HOUSES



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**DANISH BUILDING RESEARCH INSTITUTE**  
AALBORG UNIVERSITY COPENHAGEN

# Experiences and satisfaction among occupants



STATENS BYGGEFORSKNINGSINSTITUT  
ÅLBORG UNIVERSITET KØBENHAVN

## ENERGIRENOVERING

INCITAMENTER OG BARRIERER BLANDT HUSEJERE  
I FURESØ KOMMUNE

SBI 2013:22



DANISH BUILDING RESEARCH INSTITUTE  
ÅRBORG UNIVERSITY COPENHAGEN

## TENANTS' EXPERIENCES AND SATISFACTION WITH RENOVATED AND ENERGY RETROFITTED SOCIAL HOUSING

SBI 2015:28



STATENS BYGGEFORSKNINGSINSTITUT  
ÅLBORG UNIVERSITET KØBENHAVN

## EVALUERING AF ENERGIKLASSERNE 2015 OG 2020 I BR10

OPLEVELSER BLANDT EJERE AF NYE LAVENERGI-ENFAMILIEHUSE  
OG ERFARINGER BLANDT AKTØRER I BYGGEBRANCHEN

SBI 2014:07





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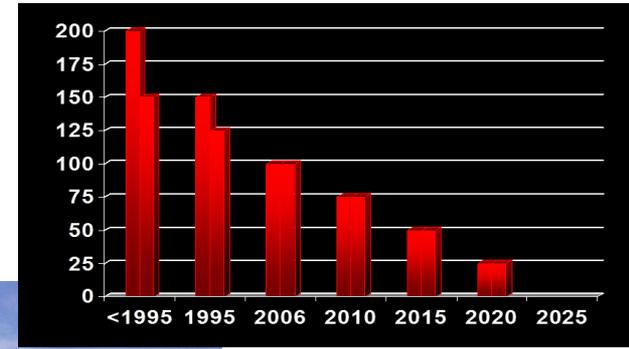
# Objective

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”



# Questionnaire survey



SurveyXact - Windows Internet Explorer  
https://www.survey-xact.dk/servlet/com.pls.morpheus.web.pages.CoreRespondentCollectLinkAnonymous?singlequestionnaireid=784581 Ramboll Management Consulting A/S [DK]



STATENS BYGGEFORSKNINGSINSTITUT  
AALBORG UNIVERSITET

Kære ejer af et lavenergihus,

Vi er glade for, at du vil hjælpe os ved at udfylde

For nogle af spørgsmålene er der brug for svar fra sommeren 2015 og Sommeren 2013. Hvis du er flyttet ind i huset i løbet af disse perioder, vil vi gerne have dit svar. Hvis du kun har boet i huset i sommeren 2015, springer du blot disse spørgsmål over. Vi vil gerne høre om dine erfaringer med at bo i et lavenergihus.

For at komme videre og du kan komme tilbage til et allerede besvaret spørgsmål, tryk på "Tilbage". Spørgeskemaet er først færdigudfyldt når du har trykket på "Afslut" til sidst. Du kan gemme dit svar midlertidigt og vende tilbage til dine besvarelser på et senere tidspunkt, da svarene gemmes automatisk.

Eventuelle spørgsmål kan rettes til undertegnede.

**På forhånd tak for hjælpen**

Med venlig hilsen  
Henrik

Henrik N. Knudsen, seniorforsker  
Statens Byggeforskningsinstitut (SBI)/Aalborg Universitet København  
mb. 2662 2128, e-mail: hnk@sbi.aau.dk

Forrige 3% Næste

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 m<sup>2</sup>
- 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**

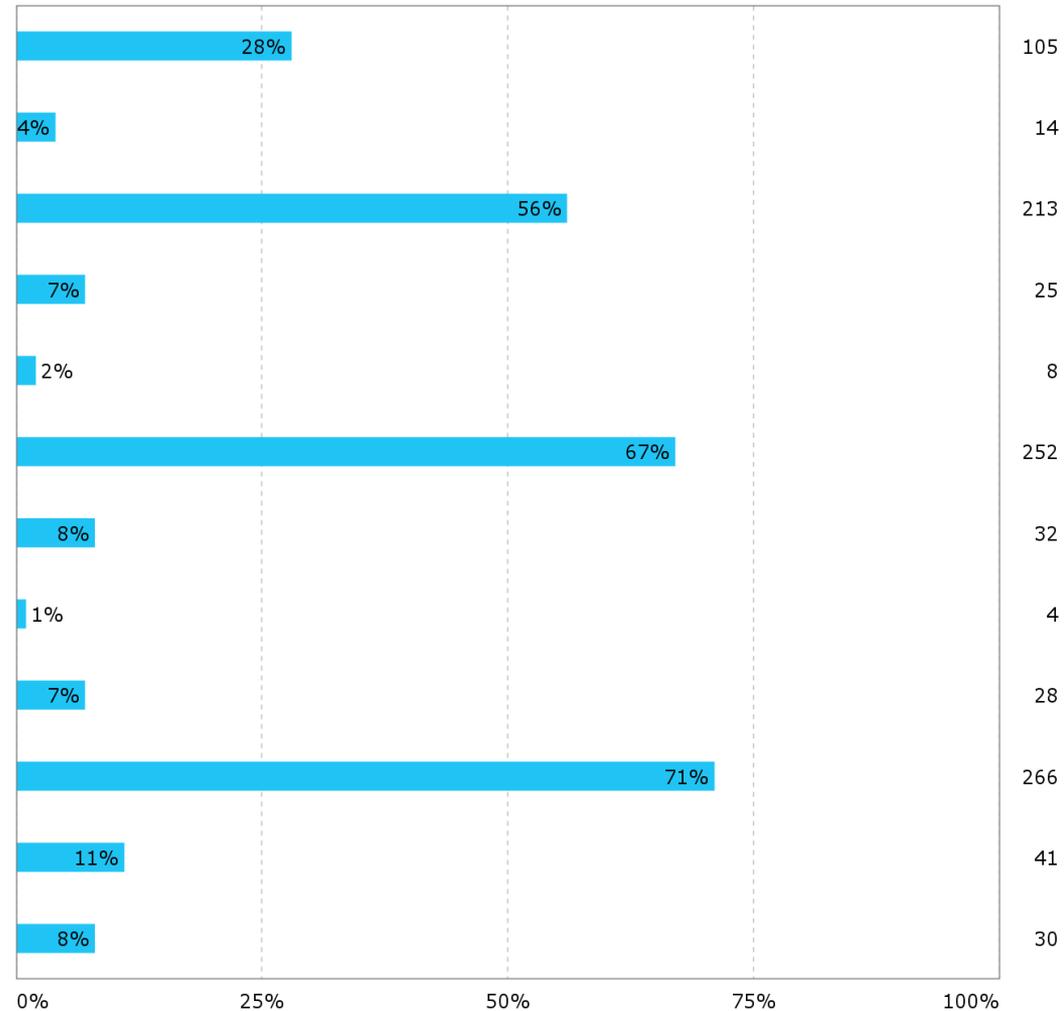
**Ventilation systems with DHW heat pump**

**Solar heating for DHW and evt. space heating**

**Solar cells for electricity generation**

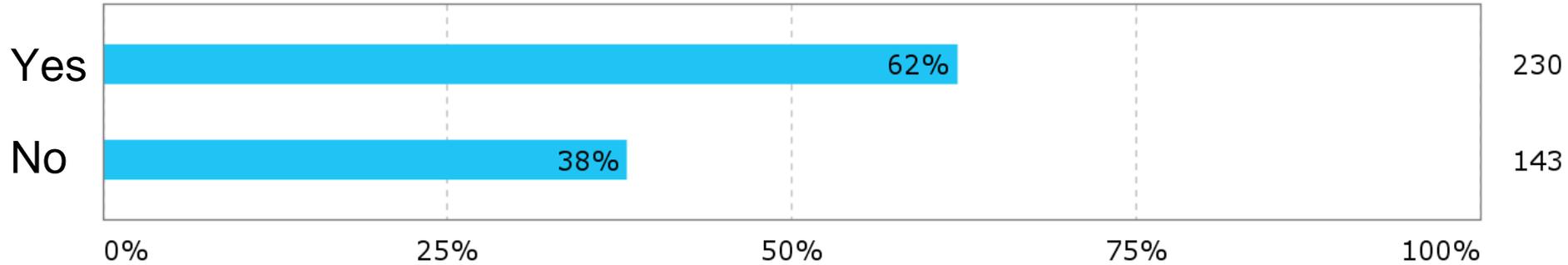
**Wood stove or the like**

**Other...**



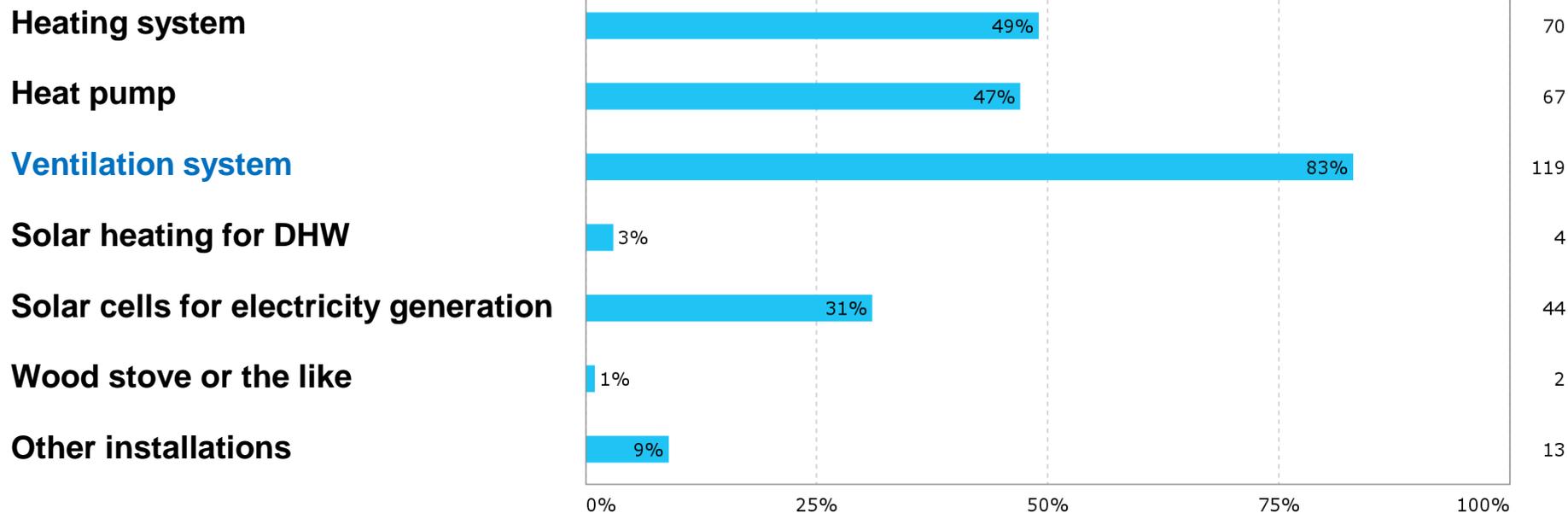
# Information - Technical installations

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



# Information - Technical installations

Which of the following installations are you lacking information about?



# Technical installations

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

**Ease of use,  
please!!**

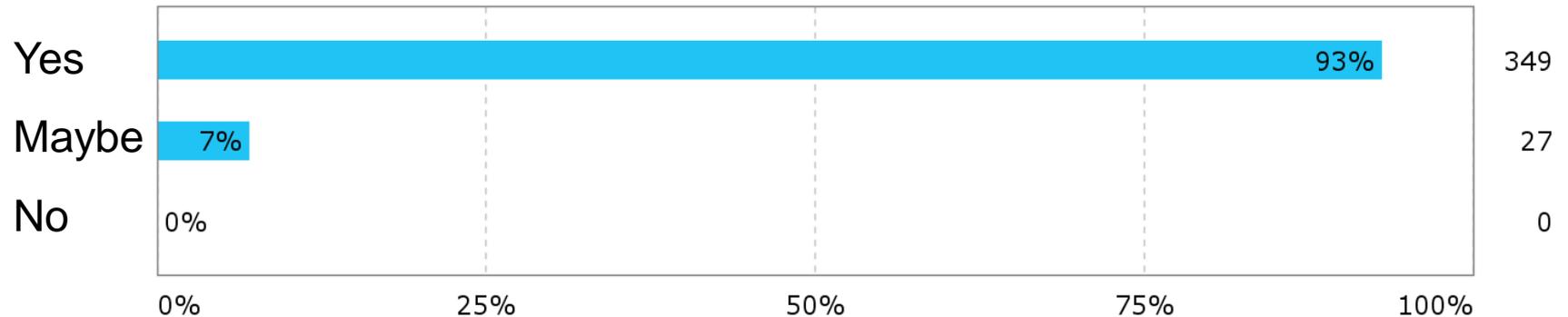
”The system is so **complex** that it's hard to remember what to do for the proper operation of installations”

”The manual is intended for engineering **nerds**”



# Overall satisfaction

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

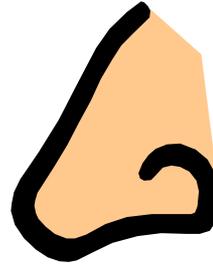


Justifications:

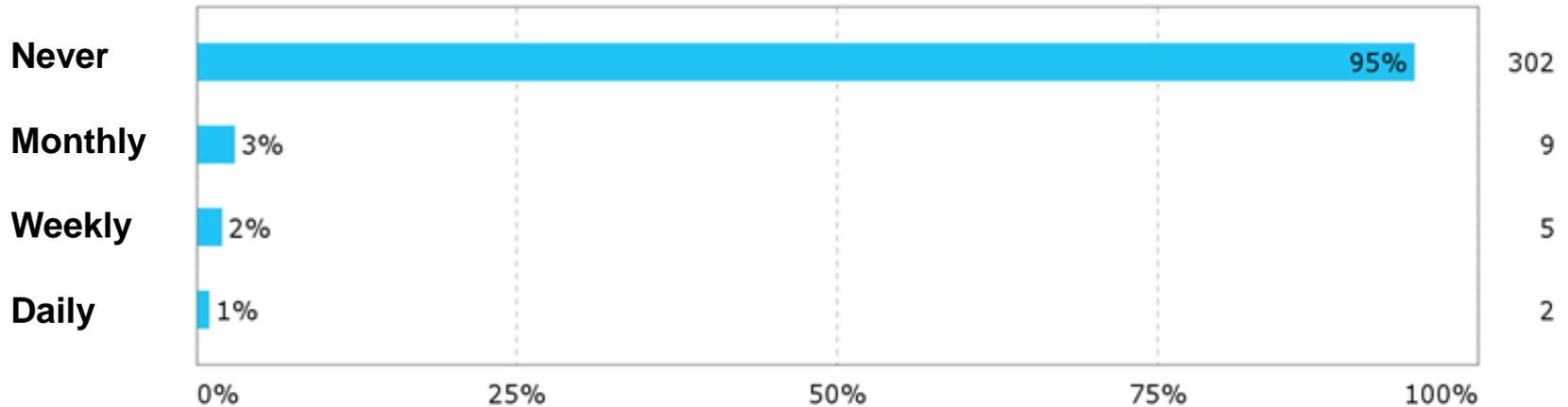
Good indoor climate and low energy and operating costs

# Perceived indoor climate

- Temperature
- Draught
- Noise
- **Air quality**
- Daylight

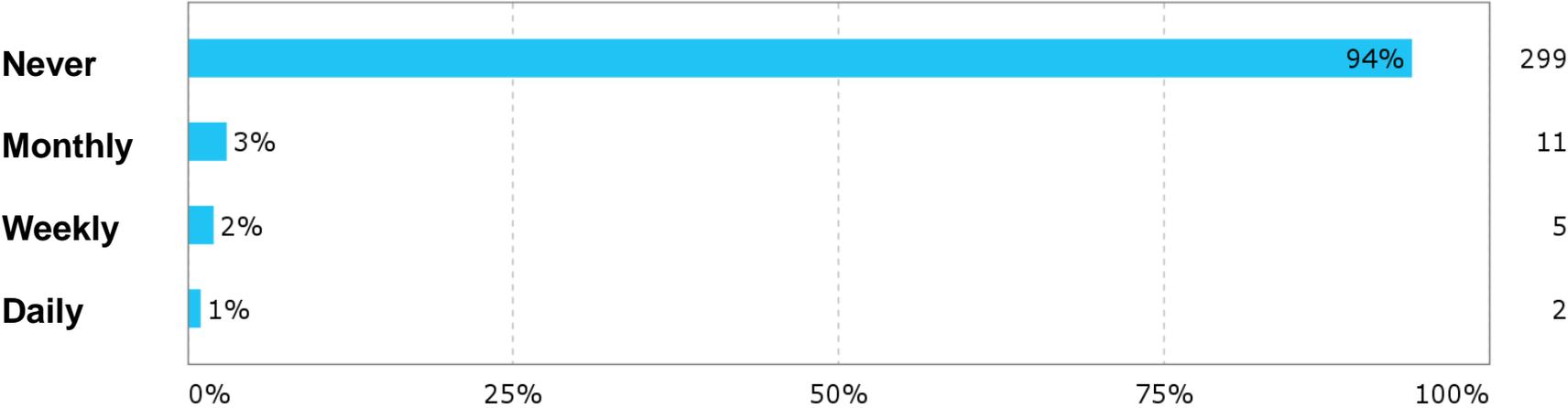


# How often have you perceived problems with unpleasant odour?



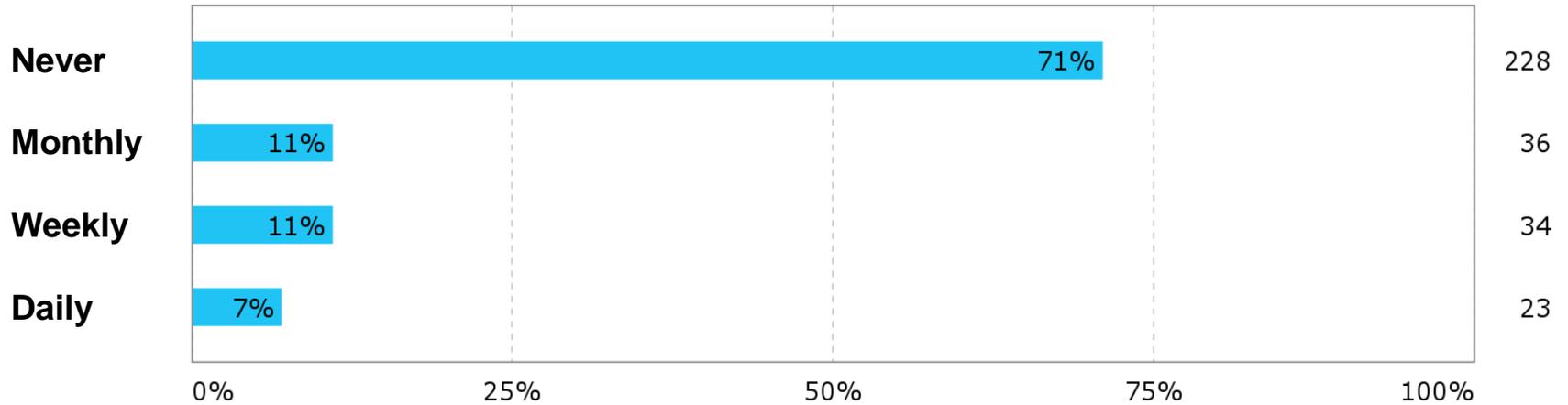
Winter 2012-2013

# How often have you perceived problems with stuffy air?



Winter 2012-2013

# How often have you perceived problems with dry air?



**Winter 2012-2013**

# How did you find the **air quality** in your house?

Very unsatisfactory

3%

Unsatisfactory

1%

Neither nor

8%

Satisfactory

24%

Very satisfactory

64%

**Winter 2012-2013**

9

3

26

79

208

0%

25%

50%

75%

100%

Very unsatisfactory

3%

Unsatisfactory

1%

Neither nor

5%

Satisfactory

29%

Very satisfactory

61%

**Summer 2013**

12

5

18

107

225

0%

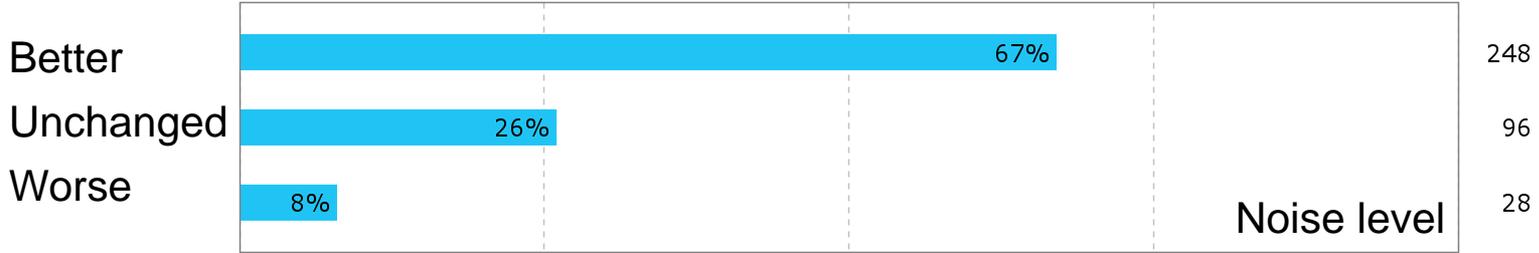
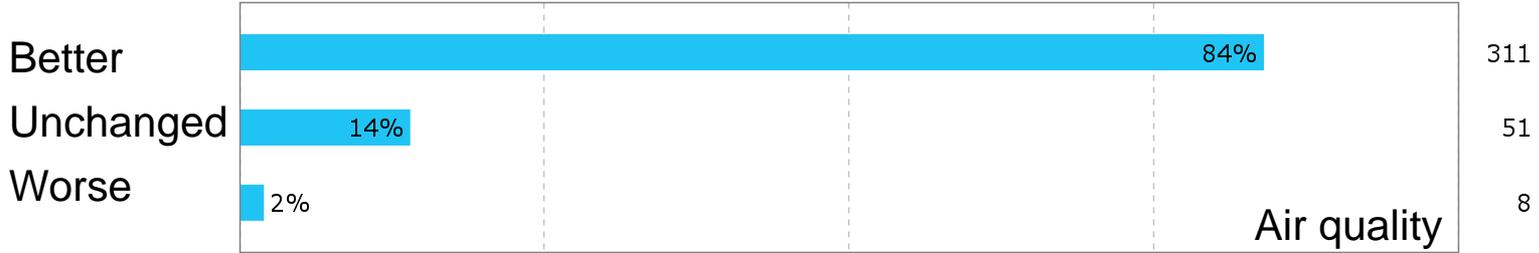
25%

50%

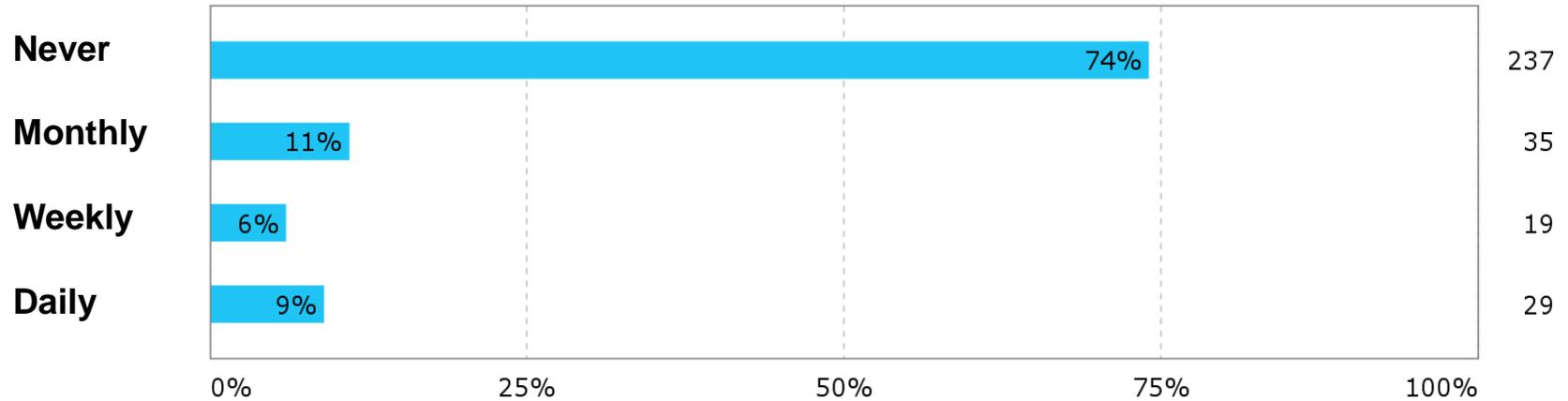
75%

100%

# How do you find the **air quality** in your new house compared with your previous dwelling?



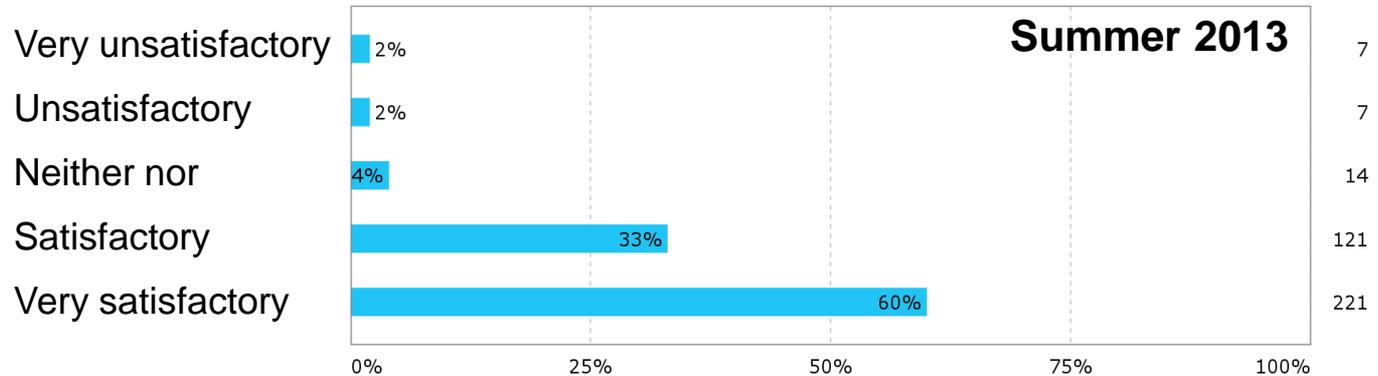
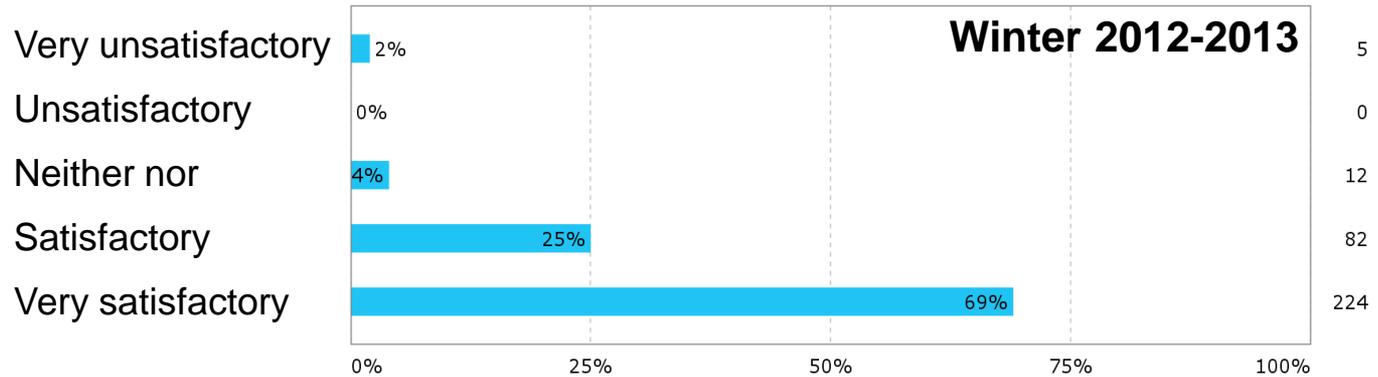
# How often have you perceived problems with noise from the ventilation system?



**Winter 2012-2013**

# Taking everything into consideration...

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



# 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



EUROPEAN COLLABORATIVE ACTION  
URBAN AIR, INDOOR ENVIRONMENT AND HUMAN EXPOSURE

Environment and Quality of Life

Report No 24

**Harmonisation of indoor material  
emissions labelling systems in the EU**

Inventory of existing schemes



EUROPEAN COMMISSION  
DIRECTORATE JOINT RESEARCH CENTRE  
Institute for Health and Consumer Protection  
Physical and Chemical Exposure Unit

2005

EUR 21891 EN

# Danish Building Regulations 2015 (BR15)

## 6.3 Air quality

### 6.3.1 Ventilation

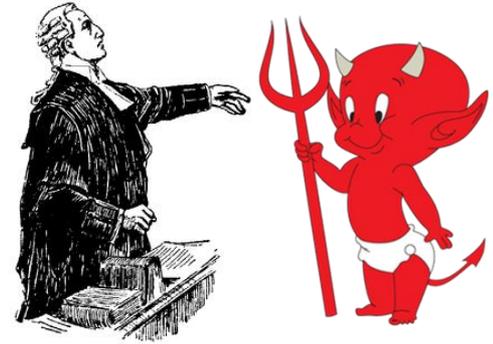
Buildings must be ventilated. Ventilation systems must be designed, built, operated and maintained so as to achieve **satisfactory air quality and humidity** conditions while they are in use.

#### 6.3.1.2 Domestic buildings

- **Fresh air supply: 0.3 l/s per m<sup>2</sup>**
  - In each habitable room
  - In the dwelling as a whole
  - Similar to **0.5 times air change rate (h<sup>-1</sup>)**



# Devils advocat...



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...

Henrik N. Knudsen, Senior Researcher, Ph.D.

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