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Interplay between the ventilation system (their design and functionality) and occupants behaviour (how occupants understand it and use it)

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# Some short facts about me

- PhD 2002 with a thesis called " *Ventilation and Window Opening in Schools. Experiment and Analysis*"
- **Main focus ventilation, indoor climate, energy use in buildings, sustainability**
- Have mainly studied schools, homes, have worked for some years as a consultant, investigating indoor environmental deficiencies
- Senior lecturer at Building Services, Department of Building and Environmental Technology, Faculty of Engineering, Lund University
- Do research and teach civil engineer and architectural students
- Currently "studierektor" at our department
- Member of CHIE Centre for Healthy Indoor Environments – chair
- **My overall goal and interest has always been to create a healthy indoor environment**

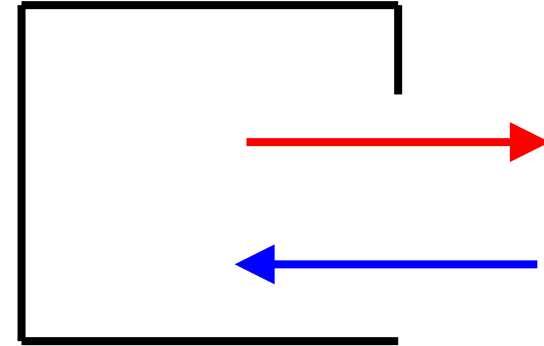
[Birgitta Nordquist - Lund University](#)

# Window opening flows

BBR minimum req. outdoor air supply 0,35 l/m<sup>2</sup> floor area

50 m<sup>2</sup> apt. 18 l/s, **100 m<sup>2</sup> apt. 35 l/s**

Toilet 15 l/s      PAX-fan 26 l/s



	Temperature indoor (°C)	Temperature outdoor (°C)	Air flow in both directions
Door opening 2*1 m	23	21	100 l/s
	23	22	70 l/s
Window 1*1 m	20	0	<b>136 l/s</b>
fully open			ca 4 * BBR for 100 m <sup>2</sup> apt.
Window 1*1 m, 15°	20	10	<b>35 l/s</b>
			= BBR for 100 m <sup>2</sup> lgh

Can be remarkable large air flows through windows and door openings

May affect pollutant spread and dilution between two rooms

# Interactions between humans and technical systems

- Humans do affect amount of air flow both via the ventilation system and via other openings
- Give some examples

Flagg-  
husen



One example  
Modern low-energy buildings

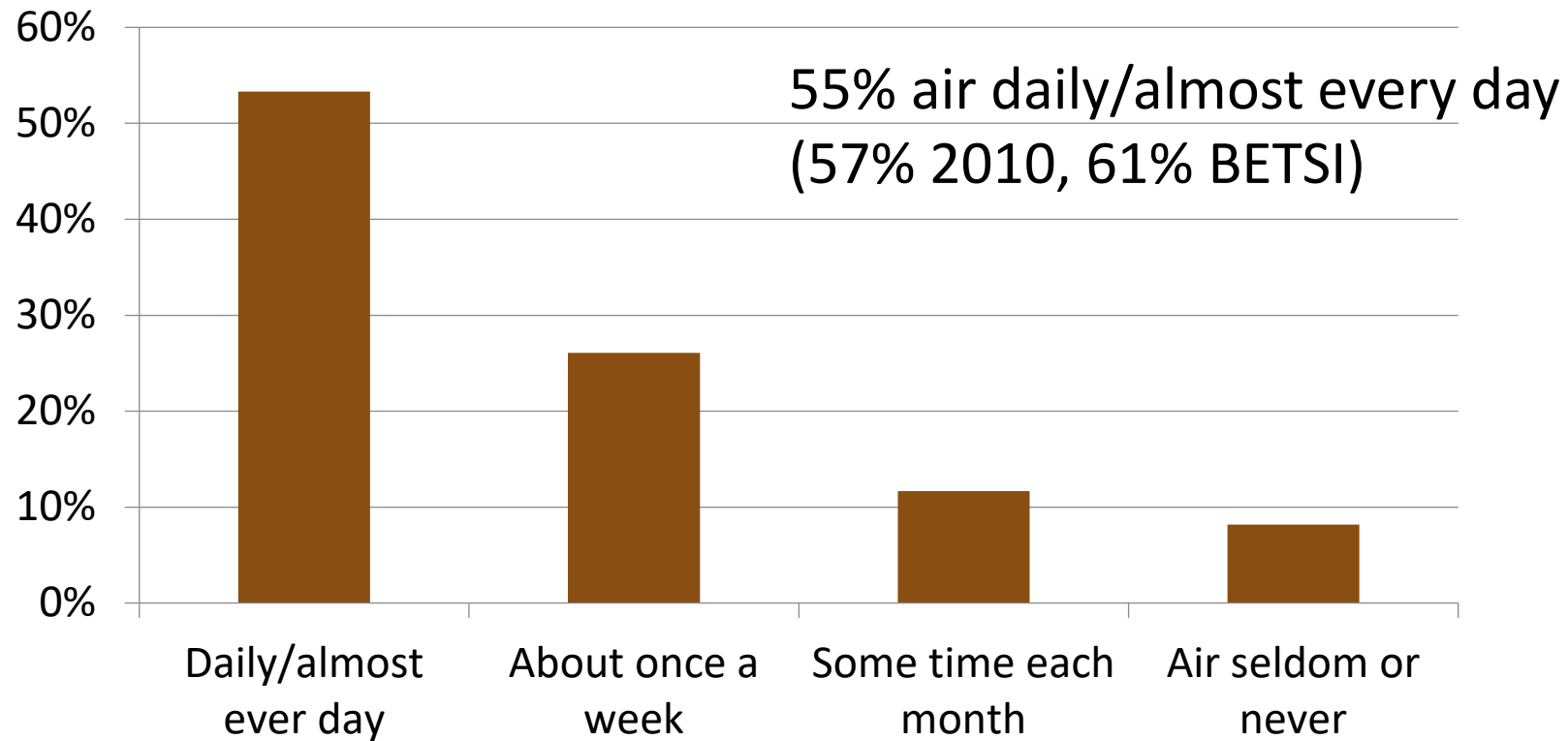
FTX

Mechanical supply and exhaust  
ventilation system

Fan located inside apartment or  
central in the attic

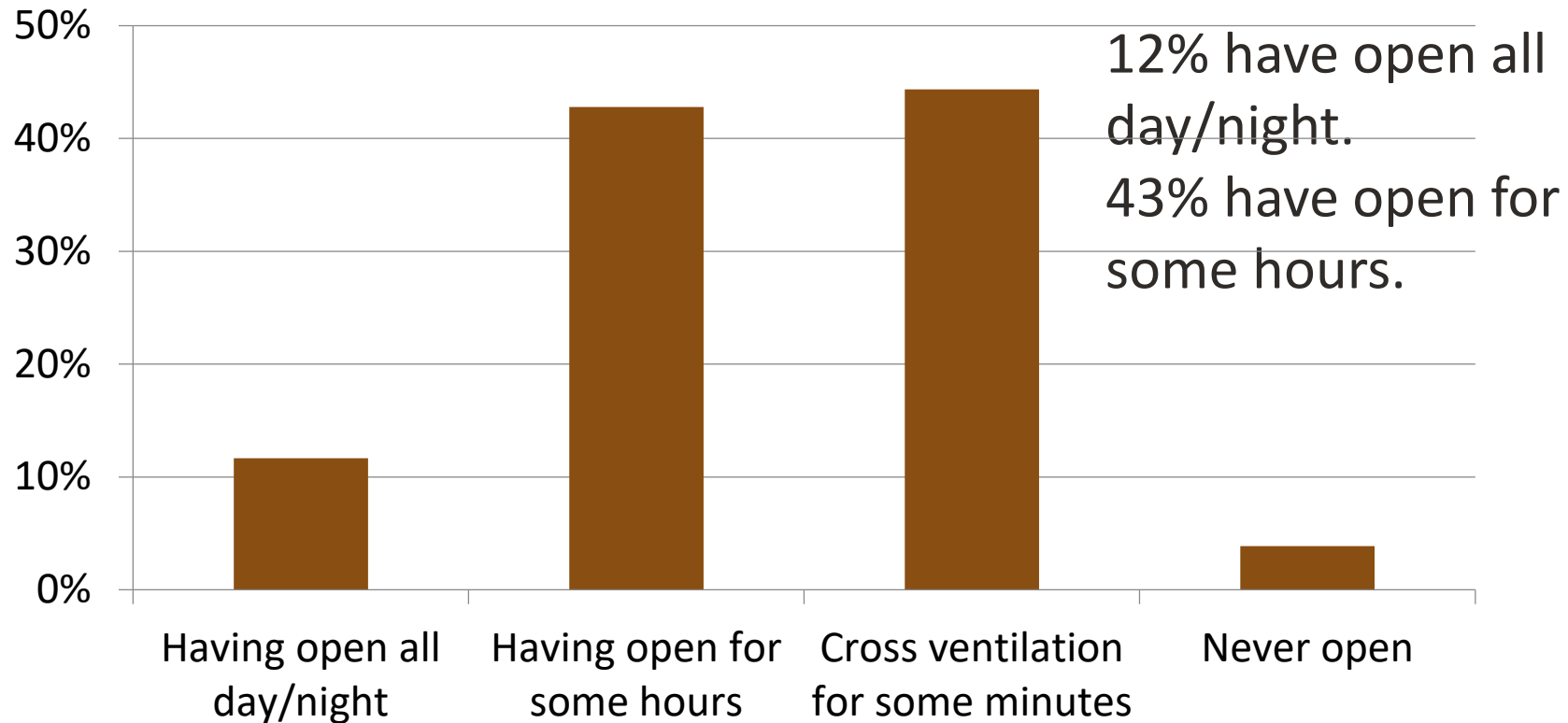
Plate heat exchanger or rotary heat  
exchanger

## Question 15. How often do you air usually during the heating season?



Conclusion: A majority of the respondents air frequently in these new buildings with modern mechanical ventilation systems.

## Question 16. When you air, do you then usually air by .....



Conclusion: A majority (55%) of the respondents have open for a relative long time.

Why do a majority open for a relative long time in this modern FTX- ventilated homes?

# Measured total supply air flow to the apartments

Apartment	Supply air flow	Air flow demand BBR	Supply air flow/ m <sup>2</sup> floor (0,35 l/s m <sup>2</sup> )
1	18,0 l/s	21,3 l/s	0,3 l/s m <sup>2</sup>
3:1	19,3 l/s	19,6 l/s	0,34 l/s m <sup>2</sup>
3:2	Room1:12,5l/s Room2:8,0 l/s Not meas. in one room due to shelf	23,8 l/s	>0,30 l/s m <sup>2</sup>
3:3	27,6 l/s	26,3 l/s	0,37 l/s m <sup>2</sup>
4:1	28,4 l/s	28,4 l/s	0,35 l/s m <sup>2</sup>
4:2	14,4 l/s	34,7 l/s	0,15 l/s m <sup>2</sup>
5:1	25,3 l/s	38,5 l/s	0,23 l/s m <sup>2</sup>
5:2	23,8 l/s	35,7 l/s	0,23 l/s m <sup>2</sup>
Average air flow			0,28 l/s m <sup>2</sup>

Concl. The measured supply air flow is below the demand in 5 of 8 apartments.



Designed with an away-mode for non-occupancy to save energy



## Measured total supply air flow to the apartments

Apartment	Supply air flow	Air flow demand BBR	Supply air flow/ m <sup>2</sup> floor (0,35 l/s m <sup>2</sup> )	Flow-mode for units located in apartment
1	18,0 l/s	21,3 l/s	0,3 l/s m <sup>2</sup>	Centrally located
3:1	19,3 l/s	19,6 l/s	0,34 l/s m <sup>2</sup>	Away-mode
3:2	Room1:12,5l/s Room2:8,0 l/s Not meas. in one room due to shelf	23,8 l/s	>0,30 l/s m <sup>2</sup>	Normal
3:3	27,6 l/s	26,3 l/s	0,37 l/s m <sup>2</sup>	Normal
4:1	28,4 l/s	28,4 l/s	0,35 l/s m <sup>2</sup>	Normal
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5:1	25,3 l/s	38,5 l/s	0,23 l/s m <sup>2</sup>	Away-mode
5:2	23,8 l/s	35,7 l/s	0,23 l/s m <sup>2</sup>	Away-mode
Average air flow			0,28 l/s m <sup>2</sup>	

Concl. The measured supply air flow is below the demand in 5 of 8 apartments.

The away-mode is used for various reasons:

**reduce the air flow deliberately** due to noise experience

some report **no knowledge or interest**

”oh I don’t know anything about the ventilation system, I never change the setting or mode”



Complex interaction between the unit, it's performance (noise), understanding of how controlling it, the interest, knowledge and the experience of the residents => the interaction will create the final indoor climate

All factors must be observed

# Another example – effect of the users interaction with the ventilation system

Exhaust ventilation in existing homes

Outdoor air should be supplied via the tall airing openings

Users are expected to regulate the opening

We have measured CO<sub>2</sub> levels and used an ADS-system: Magnetic sensors registrering open/closed



The PEIRE-project was financed by Energimyndigheten (43092-1) and Formas (2016-0079) and is approved by the Ethical board in Lund.

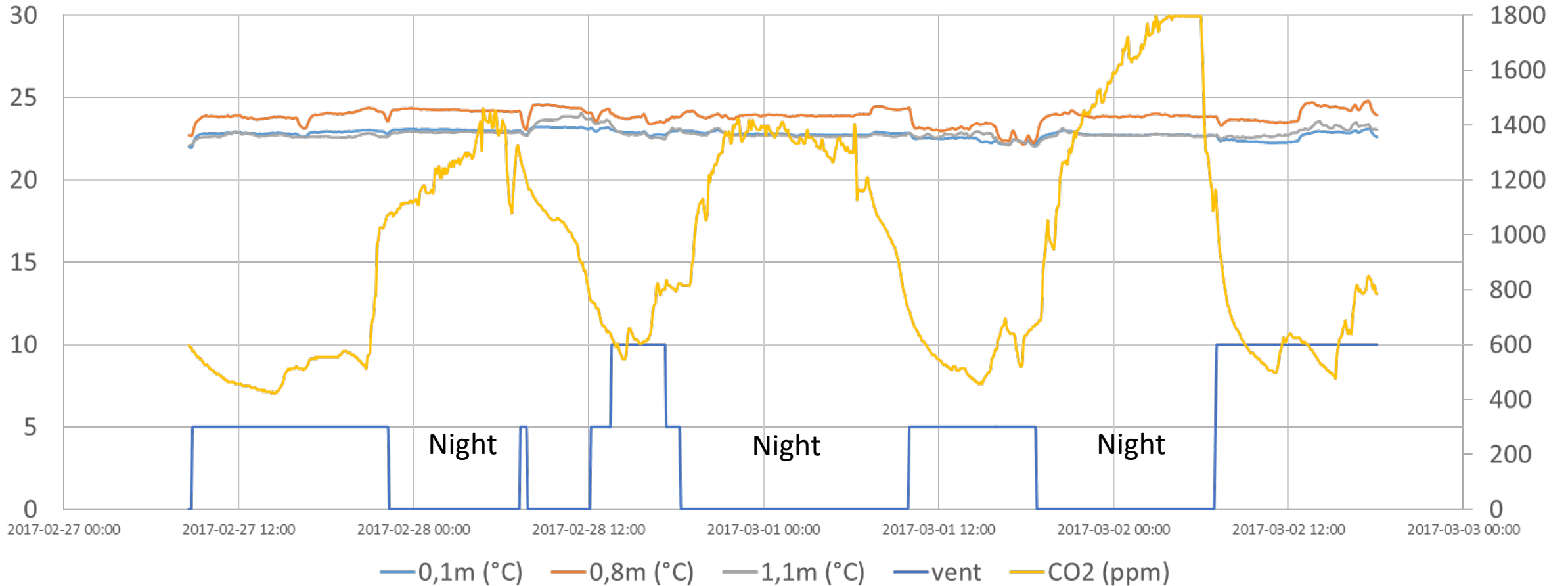
# What CO<sub>2</sub> levels will occur in the bedrooms during the night?

Example closed during the night due to thermal discomfort, open during the day

Temperature °C

Bed room apt 6

CO<sub>2</sub> ppm



Blue line 1 vent opening open=5, 2 openings open=10

IF the openings are shut, CO<sub>2</sub> levels above 1000 ppm will occur.

# Interaction between human and technical systems

- **Humans do affect both amount of air flow and direction of air flows both via ventilation system and other openings**
- Type of ventilation system influences, have seen in other studies (have to calculate for specific case):
- Mechanical supply and exhaust
  - Opening a window in one classroom will increase the air change in this room
  - Other classrooms are not significantly affected
- Exhaust ventilation in apartments
  - Opening the bath room window results in short-circuiting in bedrooms reducing the supply in bedrooms
- Natural/fan-assisted in schools
  - Opening the wrong exhaust opening results in reverse flow in the supply system, resulting in re-circulated air

## One reflection

**As engineers we tend to think that the air only moves through the ventilation system and in the correct direction. We need to also include the human, their perception and their interaction with the system**