AALBORG UNIVERSITY

Investigation on Moisture and Indoor Environment in Eight Danish Houses

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Introduction

Focus on reducing the energy demand in buildings often leads to tightening of the building envelope when for instance installing new windows.

Measurements were made in eight houses that all had recurrent problems with dew formation on new windows.

Introduction

House #	Year of construction	Year of renovation	Area [m^2]	Number of floors	Number of occupants	Ventilation type	Period of measurement
1	1944	1998-2009	300.0	2 + basement	5	Natural	23/2-3/3
2	2006		139.5	1	3	Mechanical	26/1-5/2
3	1967	2007	106.4	1	3	Natural	25/2-5/3
4	2005		16.2	1	2	Natural	22/1-19/2
5	1967	2005 (8m^2 extension)	144.6	1	5	Natural	26/1-5/2
6	2005		129.2	1	6	Natural	19/2-25/2
7	1972		236.2	2 + basement	4	Natural	17/2-23/2
8	1972	1984 and 2005	172.1	1 + partial basement	3	Natural	23/11-8/12

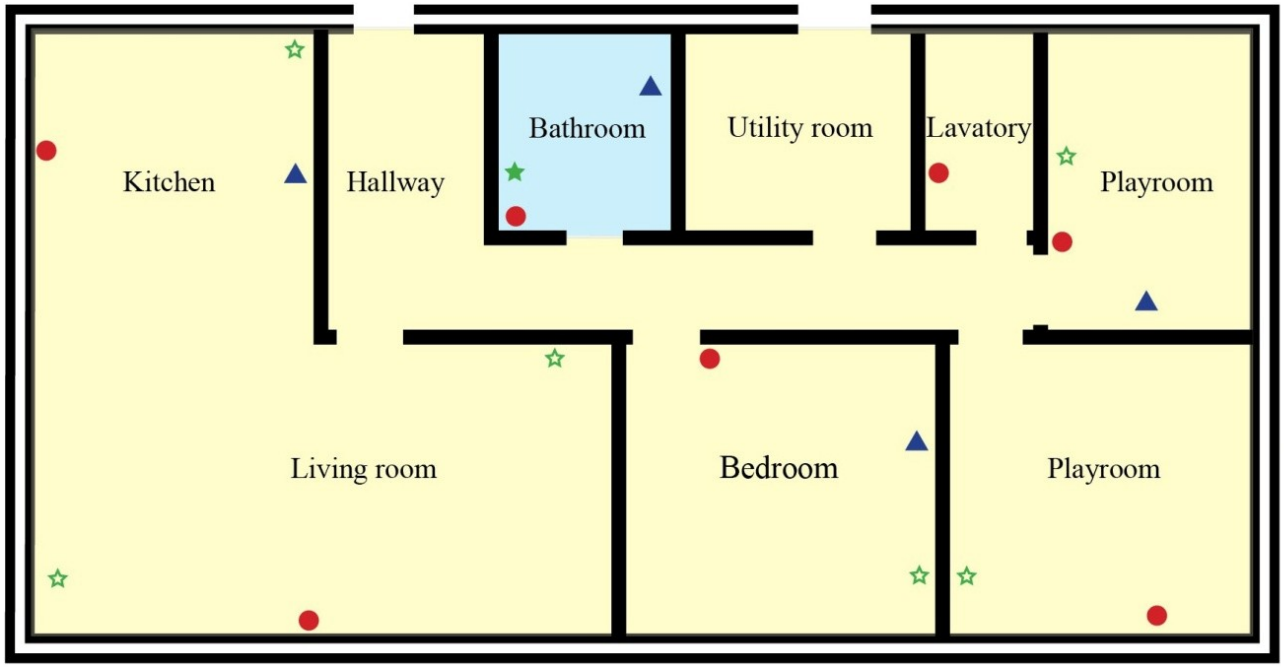
Methods

From our measurements we wanted to determine the:

- outdoor air supply by perfluorocarbon tracer (PFT) technique.
- indoor air quality based on CO_2 concentration.
- use of the house based on relative humidity (RH).
- moisture production as a *rough* estimate.

Therefore, in each house we measured average air change rate, room air temperature, CO_2 concentration, and relative humidity.

Methods



Plan view of house #3 with positions of measurement equipment marked.

Temperature and RH were also measured outside.

Outdoor Air Supply

House #	Air change rate [h^{-1}]	Outdoor air supply [m^3/h]	Outdoor air supply per person [m^3/h/person]	Outdoor air supply [$l/s/m^2$]	Difference from building regulations [$l/s/m^2$]
1	0.3	205	41	0.19	- 46%
2	0.3	139	46	0.28	- 20%
3	0.3	72	24	0.19	- 46%
4	1.5	60	30	1.03	194%
5	0.7	231	46	0.44	26%
6	0.4	109	18	0.23	- 34%
7	0.7	369	92	0.43	23%
8	0.8	307	102	0.50	43%

The requirement for outdoor air supply was added to the Danish building regulations in 1982.
The Danish building regulations from 2010 requires an outdoor air supply of 0.30 $l/s/m_2$ gross area (≈0.35 $l/s/m_2$ net area).

Moisture Production

House #	Moisture production [kg/day]	Moisture production per person [kg/day/person]	Expected moisture production from Koch et al. (1987) [kg/day]
1	18.3	3.7	10.2
2	14.6	4.9	6.8
3	5.9	2.0	6.8
4	4.5	2.2	5.1
5	19.8	4.0	10.2
6	11.8	2.0	12.0
7	22.2	5.6	8.5
8*	20.2	6.7	6.8

* The measurements in house #8 were not conducted after a longer period with low outdoor humidity. Hence, the moisture production may be significantly overestimated in this case.

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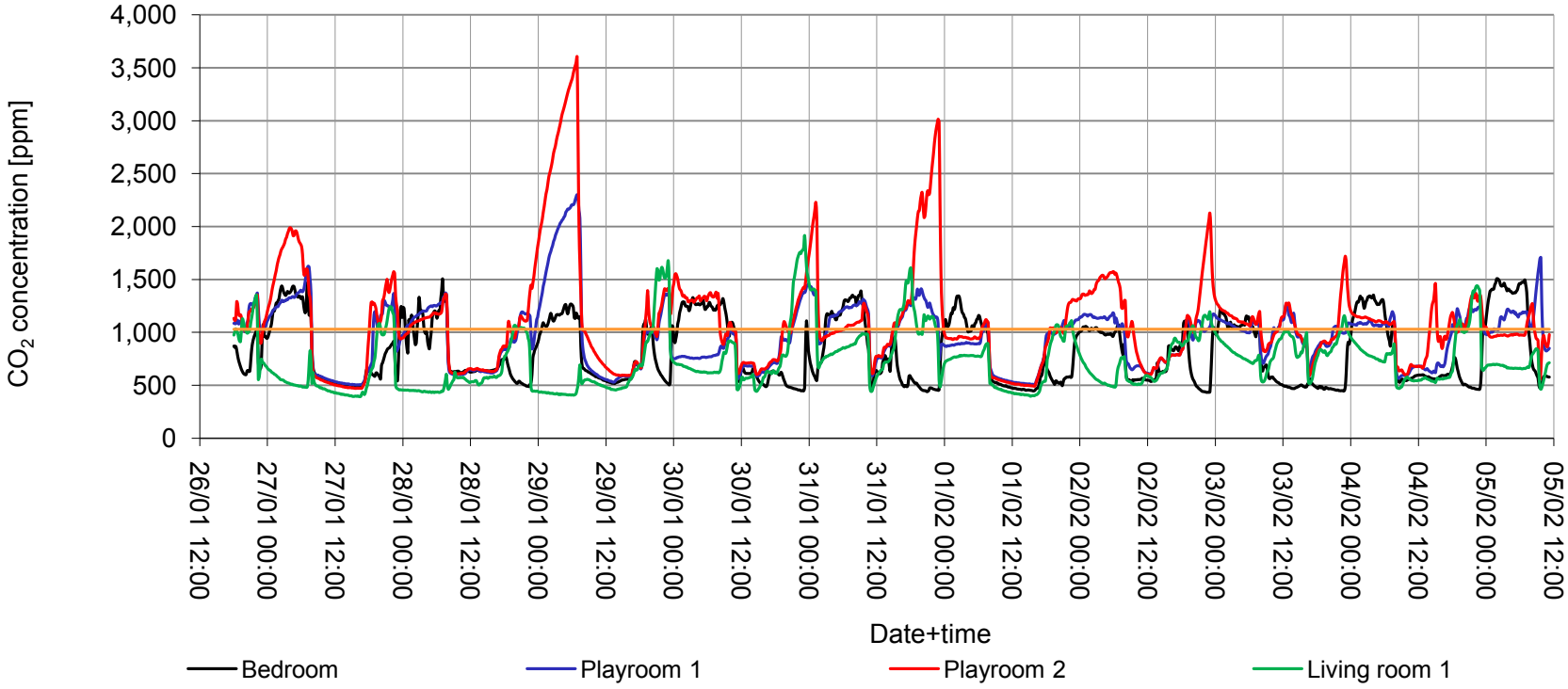
Need for Demand Controlled Ventilation?

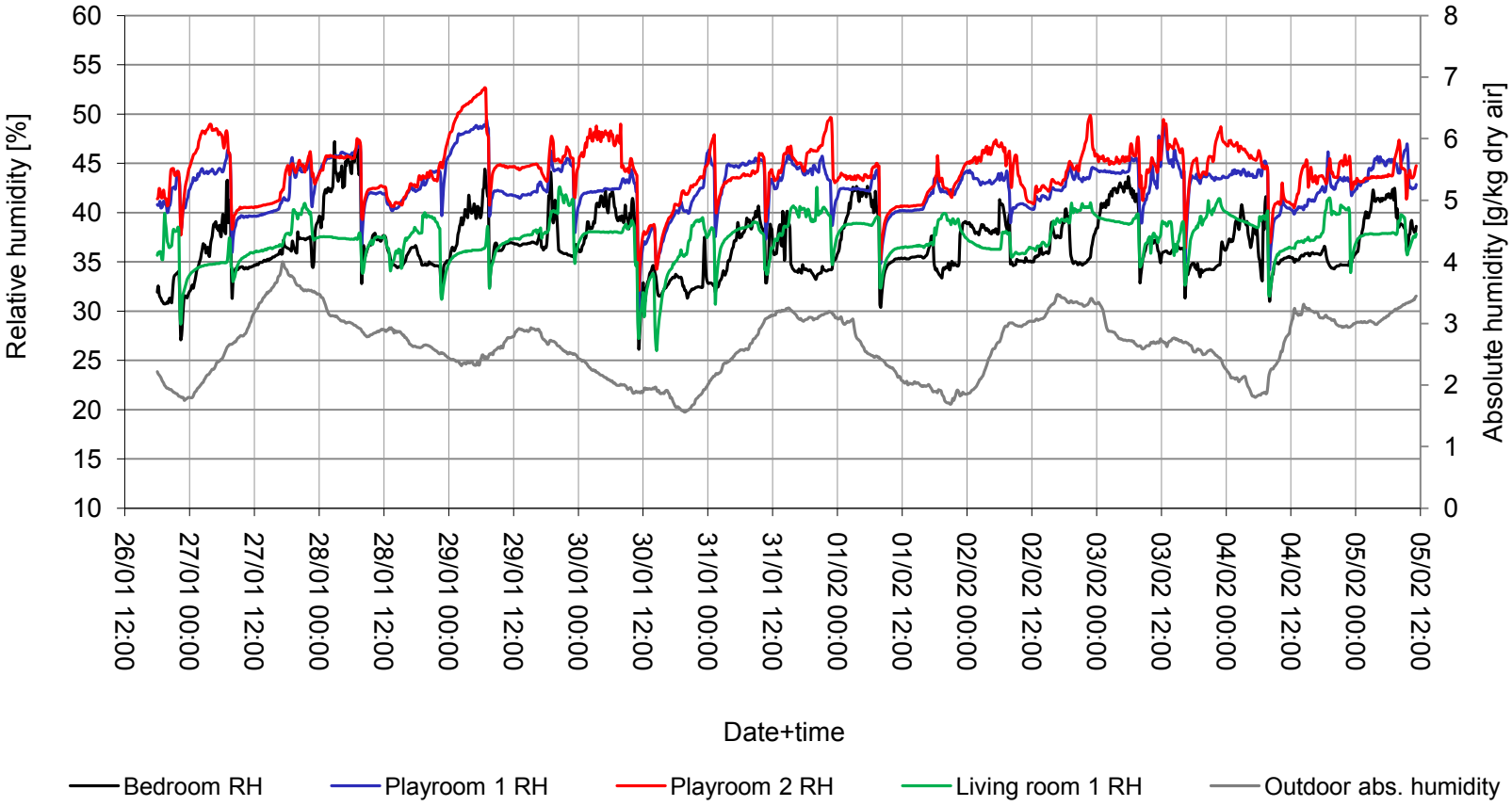
Indoor air quality in house #5



According to CEN report CR 1752 20% are dissatisfied at CO_2 concentrations above 1030 ppm (yellow line).

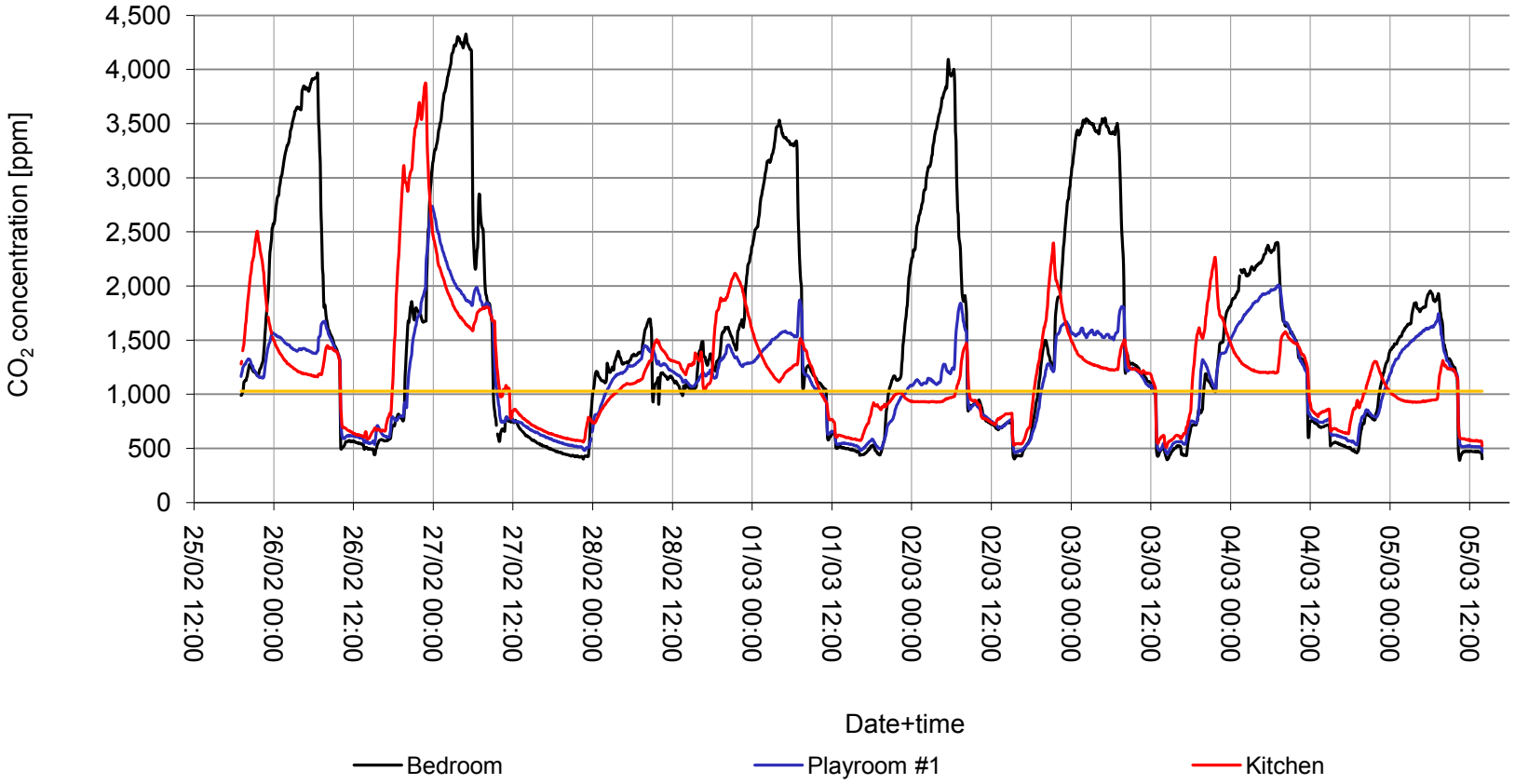
Need for Demand Controlled Ventilation?

Humidity in house #5



Air Tight Building Envelope

Indoor Air Quality in House #3



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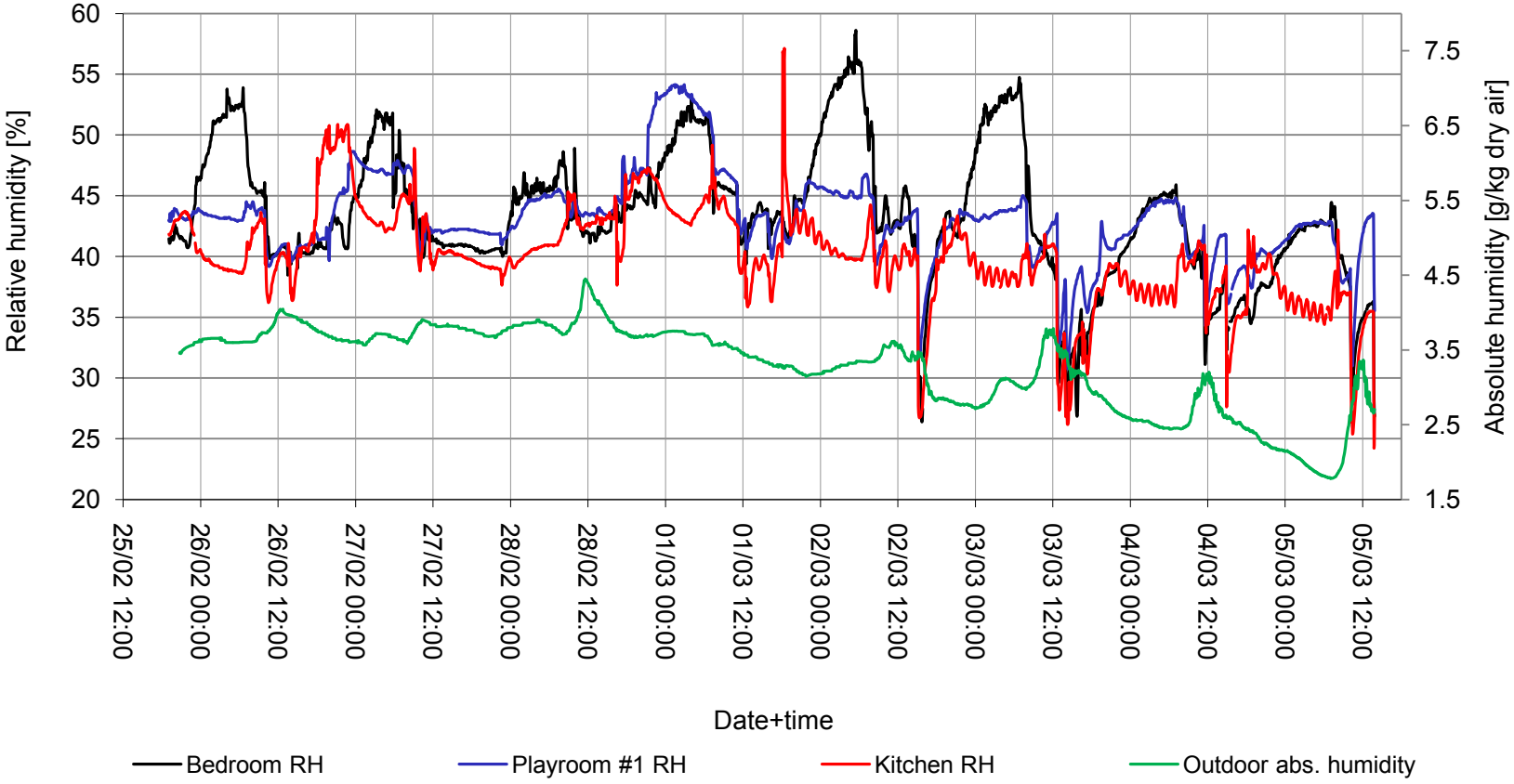
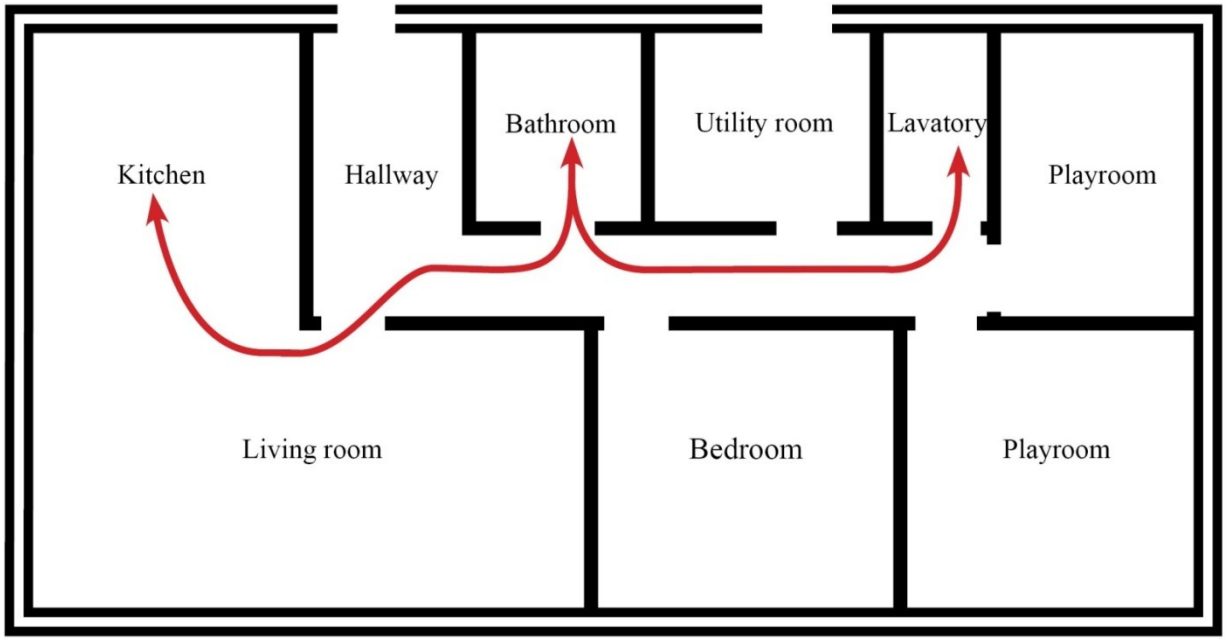


Air Tight Building Envelope

Air flow in house #3



The building envelope was tightened in 2007 where new windows with fresh air inlets were installed.

The occupants closes the fresh air inlets due to draft, which leads to the unfavourable air flow illustrated on the figure.

Conclusion

The requirement of a constant air change rate in the Danish building regulations is not always sufficient to maintain good indoor air quality. Demand controlled ventilation may be a solution.

The indoor air quality was found to be more bad in night zones (bedroom and playrooms) than in day zones (kitchen and living room etc.) .

With the tightening of the building envelope of dwellings the occupants need to be aware of how the dwelling is ventilated.

Tightening of the building envelope may lead to increased demands for comfort from the occupants. In this respect the required level of comfort may not be reached with natural ventilation in wintertime.

Thank you for your attention.