USE OF DCV FOR HEATING AND THE INFLUENCE ON IAQ IN PASSIVE HOUSE BUILDINGS

Vegard Aslaksen[1]

1 Norconsult AS
Vestfjordgaten 4
1338 Sandvika,Norway

ABSTRACT

Measurements were performed in a test room at SINTEF building and infrastructure, Oslo. The test room is 16 m^2 and built according to NS-EN 442-2. Measurements of various air flow rates (9 l/s, 18 l/s, 34 l/s and 50 l/s) and different supply air temperatures (2, 4, 6 and 10 degrees over room temperature) were performed. Tracer gas (SF_6) measurements were performed to evaluate ventilation effectiveness and age of air in occupied zone.
These tests were performed with 2 different exhaust positions (down by the floor and up under the ceiling) to check if the position of the exhaust influence the ventilation efficiency and age of air in the occupied zone.
The test room used an Active supply air diffuser from Lindinvent, (http://www.lindinvent.com/products/air-diffusers/ttc/) designed to keep a constant air velocity with various air flow rate.

The results show variable local air change index in the breathing zone based on air flow rate and the difference between room temperature and supply air temperature. The heating demand that's needed can be delivered without influencing the IAQ in passive house buildings. Results show the different local air change index in the breathing zone for the different exhaust positions.

There are preformed measurements with heat sources, and they appear to increase mixing, and measurements done without heat sources are a worst case scenario.

KEYWORDS

Air heating, indoor climate, Tracer gas, passive housing, cold climate

1 INTRODUCTION

The Norwegian government are implementing new and stricter regulations for new buildings. The new regulations in TEK15 mean that new buildings after 2015 will have to meet passive house requirements. New requirements for isolation and airtightness will reduce the heating demand. And due to energy regulations, new buildings often use ventilations systems with variable air volume (VAV) as opposed to constant air volume (CAV).
This project is part of the research project “For Klima”. “For Klima” is a research project which is researching the possibility to simplify the solutions for heating, while maintaining a good indoor climate.

This project has been focused on the possibility of using the ventilation system to supply heating. If the ventilation system can be used, this will reduce both investment- and operating costs.
The heating demand in passive house buildings has been calculated, and the data has been used to estimate how frequent heating is used. There is also been built a test room to measure the local air change index with different heating demands covered by using heated supply air and with varying air flows.

2 METHOD

2.1 Heating demand and occurrence

The testing plan for the tracer gas measurements are based on the calculated heating demand. The calculated heat deamand is based on heat loss and internal loads from “Prosjektrapport 42” (Mads Mysen 2009) from SINTEF building and infrastructure.

Table 1: Test plan for tracer gas measurements. It will be done with two different placements of the exhaust.

Test plan					
Air Flow: 50 l/s					
ΔT	2	4	6	10	Isothermal
Air Flow: 34 l/s					
ΔT	2	4	6	10	Isothermal
Air Flow: 18 l/s					
ΔT	2	4	6	10	Isothermal
Air Flow: 9 l/s					
ΔT	2	4	6	10	Isothermal

The test plan consists of four different airflows, where 18 l/s is air flow equivalent to requirements set by TEK10(DIBK). The test plan is carried out twice, with exhaust located both in the ceiling and by the floor. This is done to examine how exhaust location affect local air change index.

Heating demand is used in combination with metrological data to estimate the occurrence of outdoor temperatures that leads to a heating demand in passive house buildings.

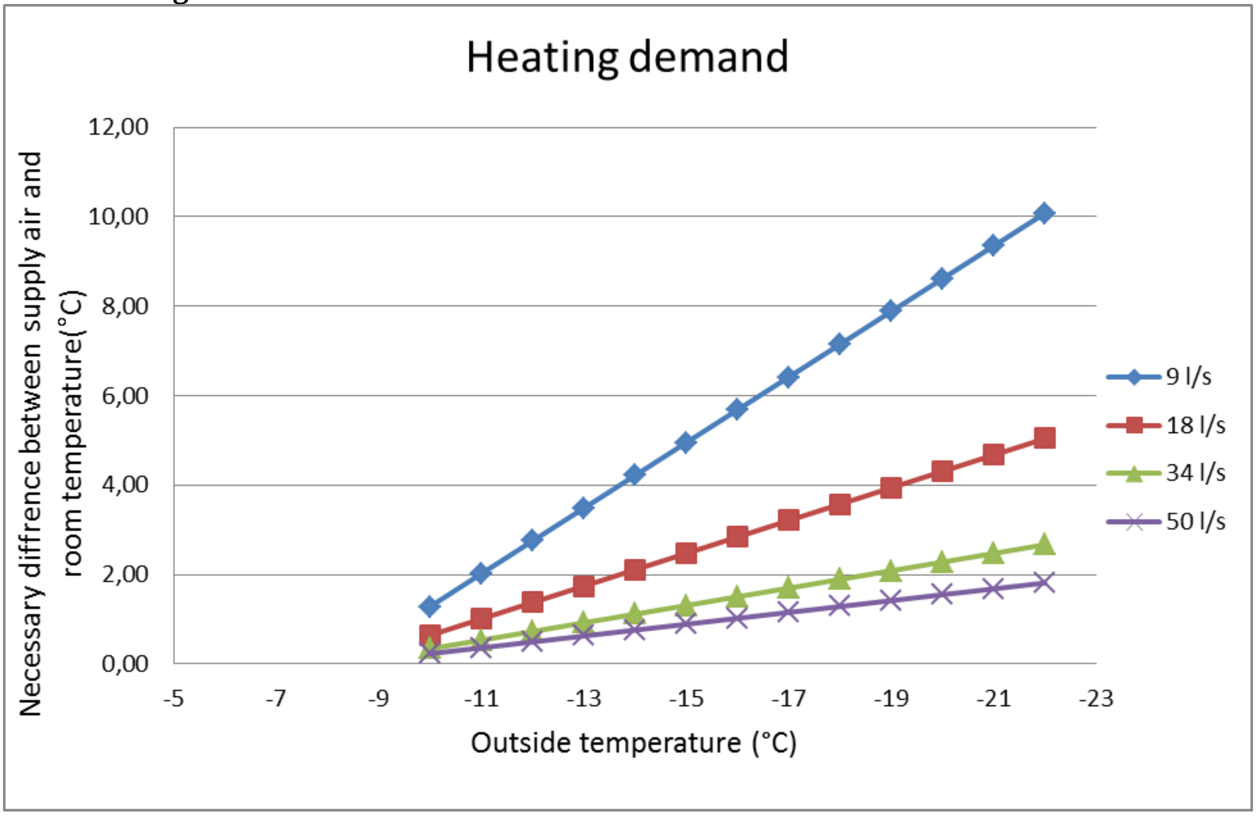
2.2 Tracer gas measurements

The test room used in tracer gas measurements is 16 m^2 room built according to NS-EN 442-2(Norge 1996) and is used to simulate an office. To simulate a heating demand in the room, it's possible to regulate the temperatures of the walls. This is done by pumping water trough pipes in the walls. Only one wall was cooled down during testing, this was done to simulate an office with one outer wall. The test room is built with a separate air supply connected to a active supply air diffuser from Lindinvent (http://www.lindinvent.com/products/air-diffusers/ttc/) for easy regulation of the air flow. Heating of the supply air is done with a heat coil. Temperature measurements during testing includes: Surface temperatures in the room, supply air temperature and room temperatures. These measurements are used to make sure there are stable conditions during the tracer gas measurements.

The tracer gas measurements are analysed using both a step up and step down analysis to determine local air change efficiency in the breathing zone. The analysis is done by using a analysis-tool developed by Peter Schild, SINTEF Building and infrastructure / HiOA.

3 RESULTS

3.1 Heating demand



Figur 1: The temperature difference between supply air and room temperature necessary to cover the heating demand at different outside temperatures with different air flows.

Figure 1 shows the increasing difference between the supply air temperature and the room temperature necessary to cover the heating demand at different outside temperatures. The result shows that passive house buildings don't have a heating demand until the outside

temperatures reach as low as -8 °C, and that the air flow has a significant impact on the necessary difference between supply and room temperatures.
The necessary difference between air supply and room temperature at an outside temperature of -22 °C varies between 2 °C and 10 °C based on the size of the air flow.
Air flow according to TEK10 (18 l/s) gives a necessary difference between supply air and room temperature at 5 °C at an outside temperature at -22 °C.

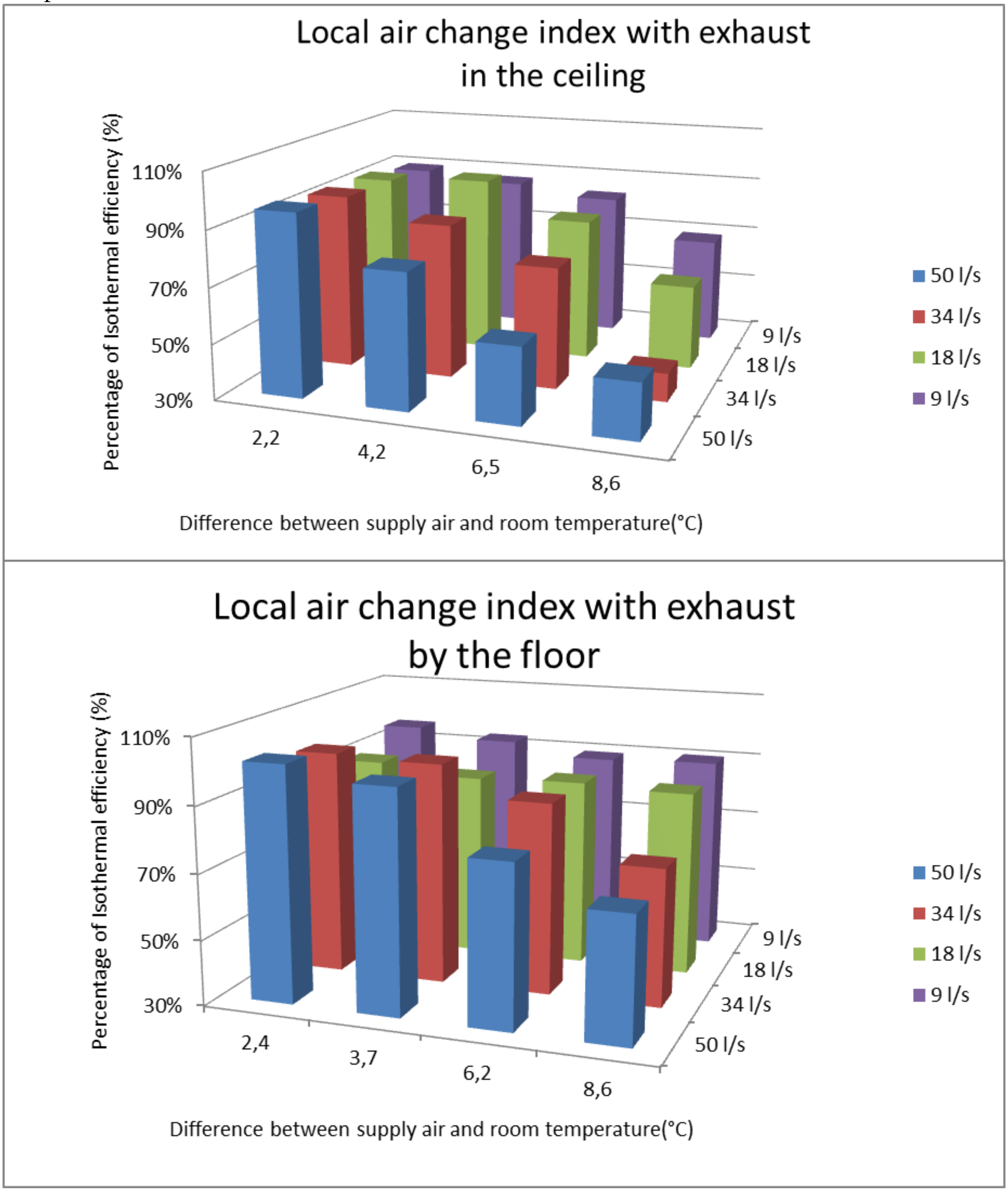
Table 2: The occurrence of days with temperatures below a set point. Data from the last 10 years collected at Blindern, Oslo. From eklima, Metrologiske institutt.

Measuring station Oslo-Blindern							
Results from 2004-2013 (10 years)							
	Jan	Feb	Mar	Nov	Des	Tot	Snitt pr. år
Days with -8 °C	85	78	45	8	74	290	29
Days with -14 °C	18	16	6	0	17	57	5,7
Days with -20 °C	2	0	0	0	0	2	0,2

Table 2 shows the number of days with occurrence of temperatures below -8, -14 and -20 ° C. -8 ° C is the highest outside temperature resulting in a heating demand in passive house buildings. While -14 ° C is the outdoor temperature that will require a difference between the supply and room temperature of 2 ° C when using air flow based on the requirements in TEK10. These figures will vary depending on your location and altitude, these figures represent the situation in Oslo, Norway.
The figures indicate the occurrence of the given temperature or below during a 24 hour period, so the occurrence during working hours is lower than the number given, since the coldest periods of the day often occurs outside working hours.
The incidence of days that requires heating is low and very rarely is there a need that exceeds 2 ° C difference between the air supply and room temperature, when using air flow based on requirements in TEK10.

3.2 Tracer gas measurements

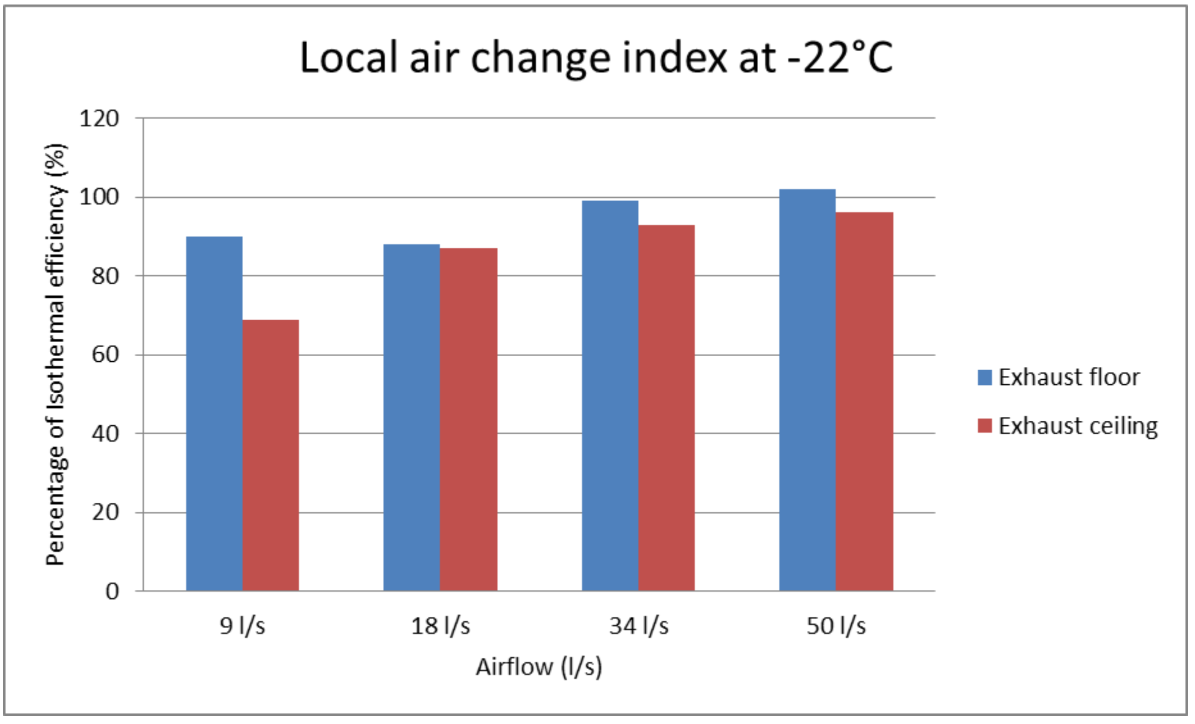
Tracer gas measurements to find the local air change index in the breathing zone were conducted at isothermal conditions. Measurements were then performed according to the test plan, with the corresponding variations in air flow, temperature difference between supply air and room temperature and exhaust position. The results are then presented by comparing local air change index in the breathing zone with the corresponding result from the measurements done under isothermal conditions. The results therefore shows how the temperature difference between supply air and room temperature affects local air change index in the breathing zone compared to isothermal conditions.



Figur 2: Development of local air change index for different air flows with increasing temperature difference between supply air and room temperature. Graphs for both exhaust positions.

Figure 2 shows the development of local air change index in the breathing zone with increasing temperature difference between the supply air and the room temperature with exhaust placed both in the ceiling and down by the floor and with different air flows.

Local air change index in the breathing zone is affected by both the exhaust location and the difference between the supply air and room temperature. The results shows that placing the exhaust down by the floor, provides a consistently higher local air exchange index in the breathing zone than the exhaust positioned at the ceiling. Local air change index will also decrease with increasing difference between supply air and room temperature. While placing the exhaust down by the floor, gives the same trend, the local air change index decreases slower and at lower air flow rates (9 l / s and 18 l / s) the curve is flat, and you keep a constant local air change index in the breathing zone.



Figur 3Local air change index with a temperature difference between supply air and room temperature that covers the heating demand at an outside temperature at -22 °C. Compares different air flows and exhaust position

Figure 3 shows the local air change index in the breathing zone for different airflows with a difference in supply air and room temperature that corresponds to a heating demand with an outside temperature at -22 °C. It also shows how the location of the exhaust affects the results under these circumstances.

The figure shows that the exhaust location is less important at the above temperatures, when you use a airflow corresponding to the requirements in Norway or higher (18 l/s or higher). Exhaust placement is of greater importance when the difference between supply air and room temperature are higher, which corresponds to greater heating demands than passive house buildings, or a lower airflow.

3.3 Heat sources

Trace gas measurements conducted and presented in the results are done without heat sources in the room. A room without heat sources is thought to be a worst case scenario, and introducing heat sources in the room will increase mixing and increase the local air change index in the breathing zone. To test this assumption, two tests were conducted with heat sources in the room and compared to the same test done without heat sources. The heat sources that were introduced were a dummy to simulate a human working by the desk and a lamp placed at the desk.

Table 3: The effect of heats sources in the room.

Effect of heat sources				
Air flow: 34 l/s				
	Exhaust by the floor		Exhaust in the ceiling	
	Temperature difference (ΔT)	Local air change index(%)	Temperature difference (ΔT)	Local air change index(%)
Without heat sources	9,9	72	4,1	86
With heat sources	10,2	90	5,1	97

Table 3 shows the results of the tests. In both cases, the temperature difference is slightly higher with the introduction of heat sources than without. Introduction of heat sources increased local air change index by 18% with exhaust located by the floor, and 11% with the exhaust located in the ceiling. This is a good indication that the assumption was correct, and heat sources increases the mixing and therefore the local air change index in the breathing zone.

4 CONCLUSION

The results for the calculation of heating demands and use of meteorological data shows that buildings on passive house level, rarely needs a temperature difference between supply air and room temperature that exceeds 2 °C when using air flows according to TEK10. At this temperature difference the exhaust position has a negligible effect and the results for local air change index in the breathing zone shows that it’s possible to maintain a good IAQ.

The results show that even on the coldest days of winter (-22 °C) it’s possible to maintain a high local air change index and the position of exhaust is negligible when using air flow according to TEK10. This means that you can maintain a good IAQ even on the coldest days of winter.

This means that the use of the ventilation system for heating buildings at passive house level can be performed while maintaining good air quality in the breathing zone on even the coldest days of the year.

5 REFERENCES

DIBK. "TEK10." from http://www.dibk.no/no/BYGGEREGLER/TEK10-Forskrift-om-tekniske-krav-til-byggverk-med-veiledning/.

Mads Mysen, M. K., Matthias Haase, Tor Helge Dokka (2009). "Kriterier for passivhus- og lavenergibygg- Yrkesbygg, Prosjektrapport 42."

Norge, S. (1996). NS-EN 442-2 Radiatorer og konvektorer. Standard.no, Standard Norge.