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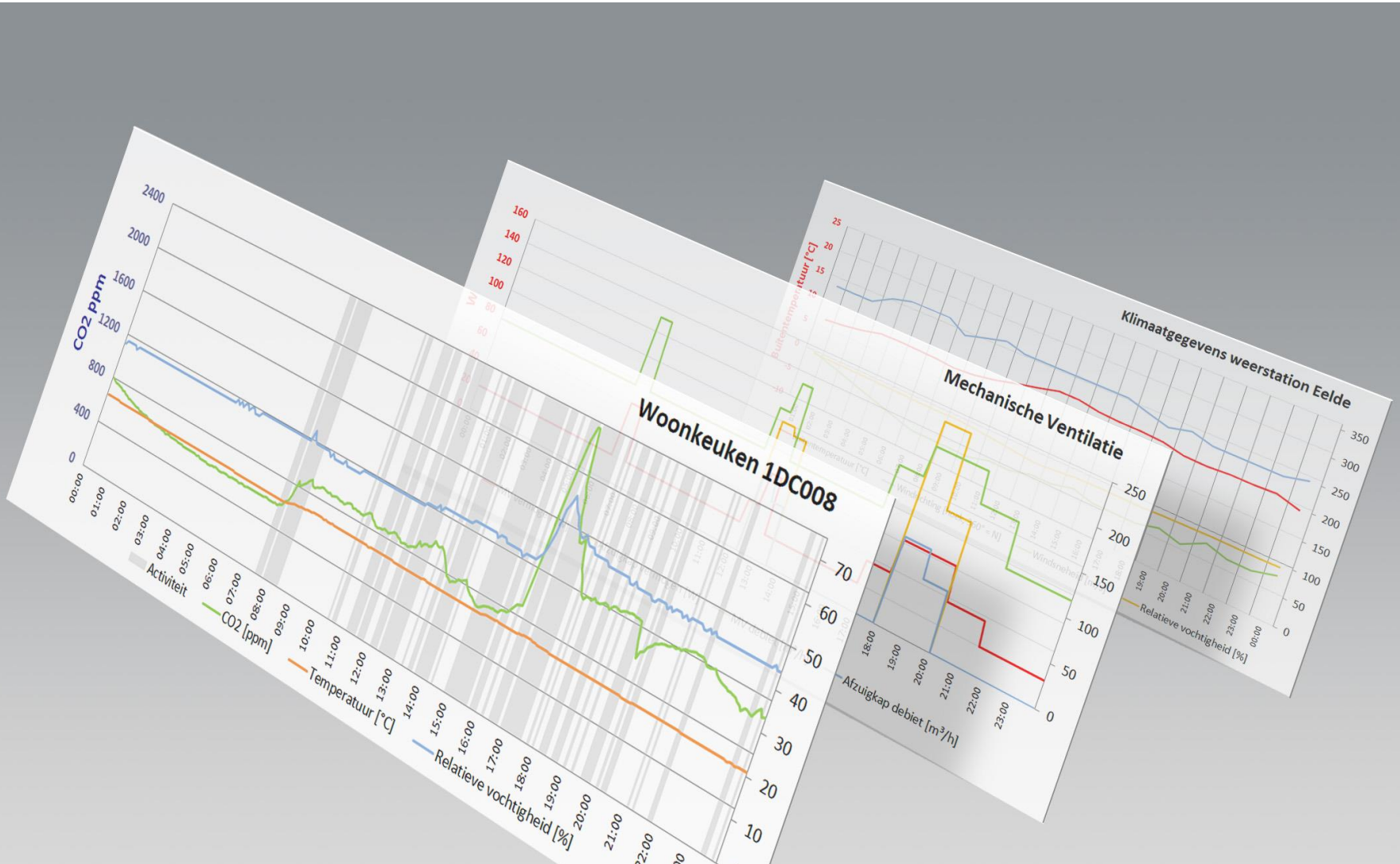
Large differences in real life IAQ- and Energy Performance of Code Compliant Residential Ventilation Systems



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MONICAIR:

MONItoring & Control of Air quality in Individual Rooms

MONICAIR is a pre-competitive field research project into the real-life IAQ- and Energy Performance of ventilation systems in Dutch residential dwellings.

Final goal:
Further improvement of residential ventilation systems, building codes and energy assessment methods

By:
Rob van Holsteijn, managing director VHK
Projectleader MONICAIR

MONICAIR CONSORTIUM

Participating parties:

Manufacturers:

BRINK Climate Systems

ClimaRad INDOOR AIR QUALITY

itho daalderop

zehnder

Honeywell CUSTOMIZED COMFORT PRODUCTS

Consulting agencies :

Nieman

VIK

Research institutions :

TU Delft Delft University of Technology

TNO innovation for life

MONICAIR PROJECT FUNDING

Total project costs	**:** 1,57 million euro
Contribution Dutch Ministry of Economic Affairs*	: 0,86 million euro
Contribution Consortium Members	: 0,63 million euro
Contribution Housing Corporations	: 0,08 million euro

** Within the framework of TKI (Top Consortia for Knowledge & Innovation)*

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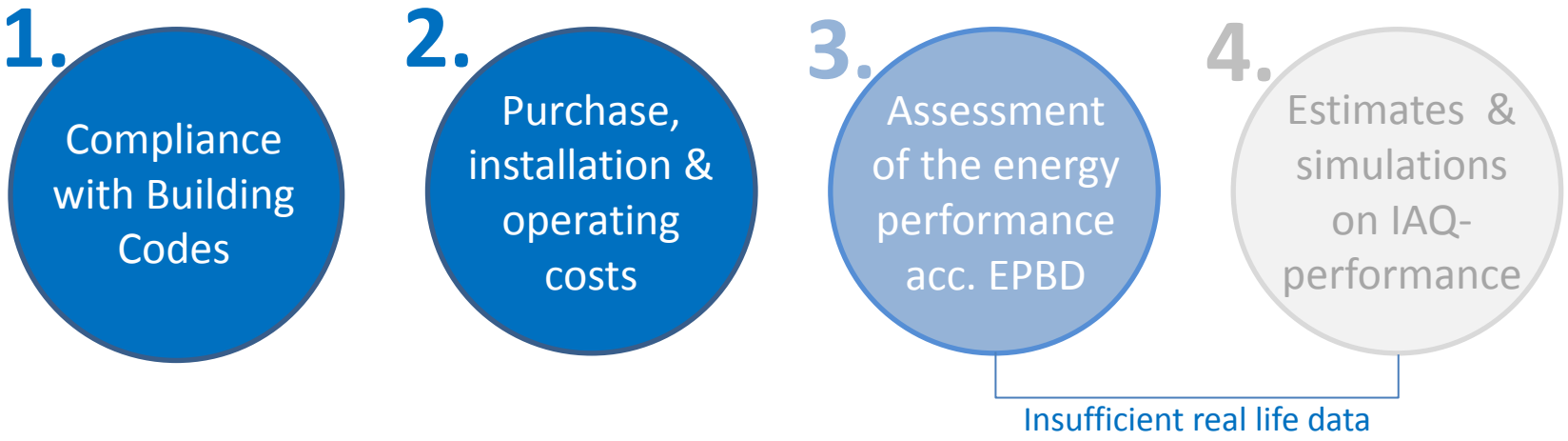
PROJECT RATIONAL

Lack of data on the real-life IAQ- and Energy Performance of residential ventilation systems

Ventilation systems are selected, based on:



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PROJECT RATIONAL

Energy-performance of ventilation systems is ***estimated*** (based on EPBD-calculation methods)

IAQ- performance is ***assumed***, and estimated equal for all code compliant ventilation systems

MONICAIR collects **real-life data** on the IAQ- & Energy Performance of code compliant ventilation systems, in order to gain knowledge and improve systems & assessment methods

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DETAILS MONITORING PROJECT

- 62 terraced / semi detached houses
- 10 ventilation systems, tuned to building codes
- Monitoring of CO_2, RH, Temperature and Presence in all rooms
- Monitoring of power consumption of all mech. ventilation units
- Sampling frequency: 5 minutes
- Meteorological data imported from most nearby weather stations
- Period: 2 heating seasons, one summer season

Resulting in a MONICAR database of over 100 million data-points

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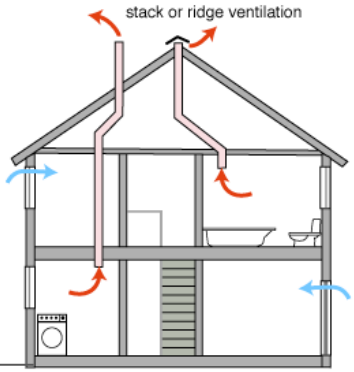
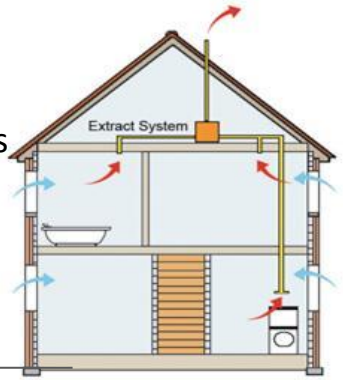
TYPE OF VENTILATION SYSTEMS

Type A:
Natural supply in all rooms
Natural exhaust wet rooms



Type C:
Natural supply hab. rooms
Mech. exhaust wet rooms



System type		Section of house that is served	Air exchange provisions			Controls	
			Exhaust	Supply	Heat Rec.	Exhaust	Supply
A.		Whole house	Nat. extraction in wet-rooms	Stnrd nat.supply vents in all rooms	No	No Control	Manual
Type C Systems	C.1	Whole house	Mech. extraction in wet-rooms	Stnrd nat.supply vents in hab.rooms	No	Manual 3-pos. switch	Manual
	C.2c	Whole house	Mech. extraction in wet-rooms	Wind contrl. nat. supply in hab.rooms	No	Manual 3-pos. switch	Manual
	C.4a	Whole house	Mech. extraction in wet-rooms	Wind contrl. nat. supply in hab.rooms	No	CO_2-sensor in living room	Manual
	C.4c	Whole house	Mech. extraction in all rooms	Wind contrl. nat. supply in hab.rooms	No	CO_2/ RH cntrl in all hab.rooms	Manual

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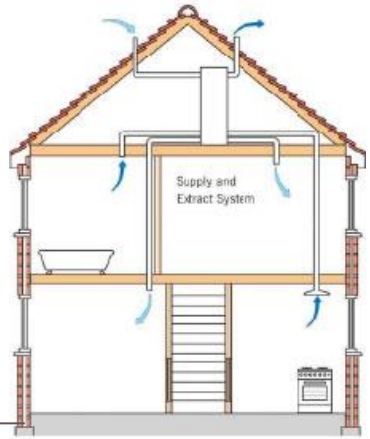
TYPE OF VENTILATION SYSTEMS

Type D:
Mechanical supply
Mechanical exhaust
Heat Recovery



System type		Section of house that is served	Air exchange provisions			Controls	
			Exhaust	Supply	Heat Rec.	Exhaust	Supply
Type D Systems	D.2	Whole house	Mech. extraction in wet-rooms	Mech. supply in hab.rooms	Yes	Manual 3-pos. switch	
	D.5a	Whole house	Mech. extraction in wet-rooms	Mech. supply in hab.rooms	Yes	Manual 3-pos. switch with CO_2-contrl in 2 zones	
	D.5b	Whole house	Mech. extraction in all rooms	Mech. supply in hab.rooms	Yes	CO_2 and RH -controlled ventilation in all rooms	
	D.x	Whole house	Mech. extraction in all rooms	Mech. supply in con.spaces	Yes	CO_2- & RH control in all hab.rooms	

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TYPE OF VENTILATION SYSTEMS

Type X1/C and X1/A

A combination of systems:

Living section : Mechanical supply & exhaust per room with HR

Sleeping section : System C of system A

System type		Section of house that is served	Air exchange provisions			Controls	
			Exhaust	Supply	Heat Rec.	Exhaust	Supply
Comb. of systems	X1/C	Living section: D	Mech. extraction in hab.rooms	Mech. supply in hab.rooms	Yes	CO_2 and RH -controlled ventilation in living room	
		Sleeping section:C.2c	Mech. extraction in wet-rooms	Wind contrl. nat. supply in bedrooms	No	Manual 2-pos. switch	Manual
	X1/A	Living section: D	Mech. extraction in hab.rooms	Mech. supply in hab.rooms	Yes	CO_2 and RH -controlled ventilation in living room	
		Sleeping section: A	Nat. extraction in wet-rooms	Wind contrl. nat. supply in bedrooms	No	No control	Manual

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INDICATOR IAQ-PERFORMANCE

Purpose of ventilation systems: to exchange polluted indoor air by cleaner outdoor air in all rooms of a dwelling, thus diluting the concentrations of all possible indoor contaminants.

The IAQ-performance of ventilation systems is based on their ability to – under all kinds of real life circumstances – achieve the requested air exchange rates in each individual room.

For habitable rooms: CO_2-concentration

The CO_2-concentration is generally accepted as indicator, not only for hygienic thresholds, but also for the actually occurring air-exchange-rates in a room during presence

For wet rooms: RH

Since dwell time in wet rooms is limited, RH is used as indicator for the IAQ-performance in wet rooms

INDICATOR IAQ-PERFORMANCE

Indicator for the IAQ-performance of ventilation systems in habitable rooms

Over a whole heating season:

duration CO_2-conc. > 1200 ppm multiplied by degree of excess

In formula

$$\text{IAQ-performance} = \sum_{\text{day 1}}^{\text{day 212}} \left(t_{>1200} * (C_{CO2} > 1200 - 1200) \right) / 1000 \text{ in kppmh/hs}$$

Indicator for the IAQ-performance of ventilation systems in wet rooms

Over a whole heating season: average nr. of hours per day with RH> 70%

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INDICATOR ENERGY-PERFORMANCE

1. Determine hourly mech. ventilation volume flow (air exchange)
2. Calculate hourly difference in thermal energy content of exchanged air (based on hourly averages on $\Delta T_{in\text{-}out}$, $\Delta RH_{in\text{-}out}$, and air pressure) : $Q_{th;h}$
3. Correct $Q_{th;h}$ for average heating system efficiency (85%) : $Q_{th;h} / 85\%$
4. Determine hourly power cons. vent. units (converted to primary) : $Q_{elec;h} / 40\%$
5. Totalize all hourly data of heating season, resulting in : $Q_{vent;prim;\ ht.ssn}$
6. Divide $Q_{vent;prim;\ ht.ssn}$ by heated surface of the dwelling : A_h

In formula

$$\text{Energy-performance} = \sum \left(Q_{th;h} / 85\% + Q_{elec;h} / 40\% \right) / A_h \quad \text{in MJ/m}^2\text{/ht.ssn}$$

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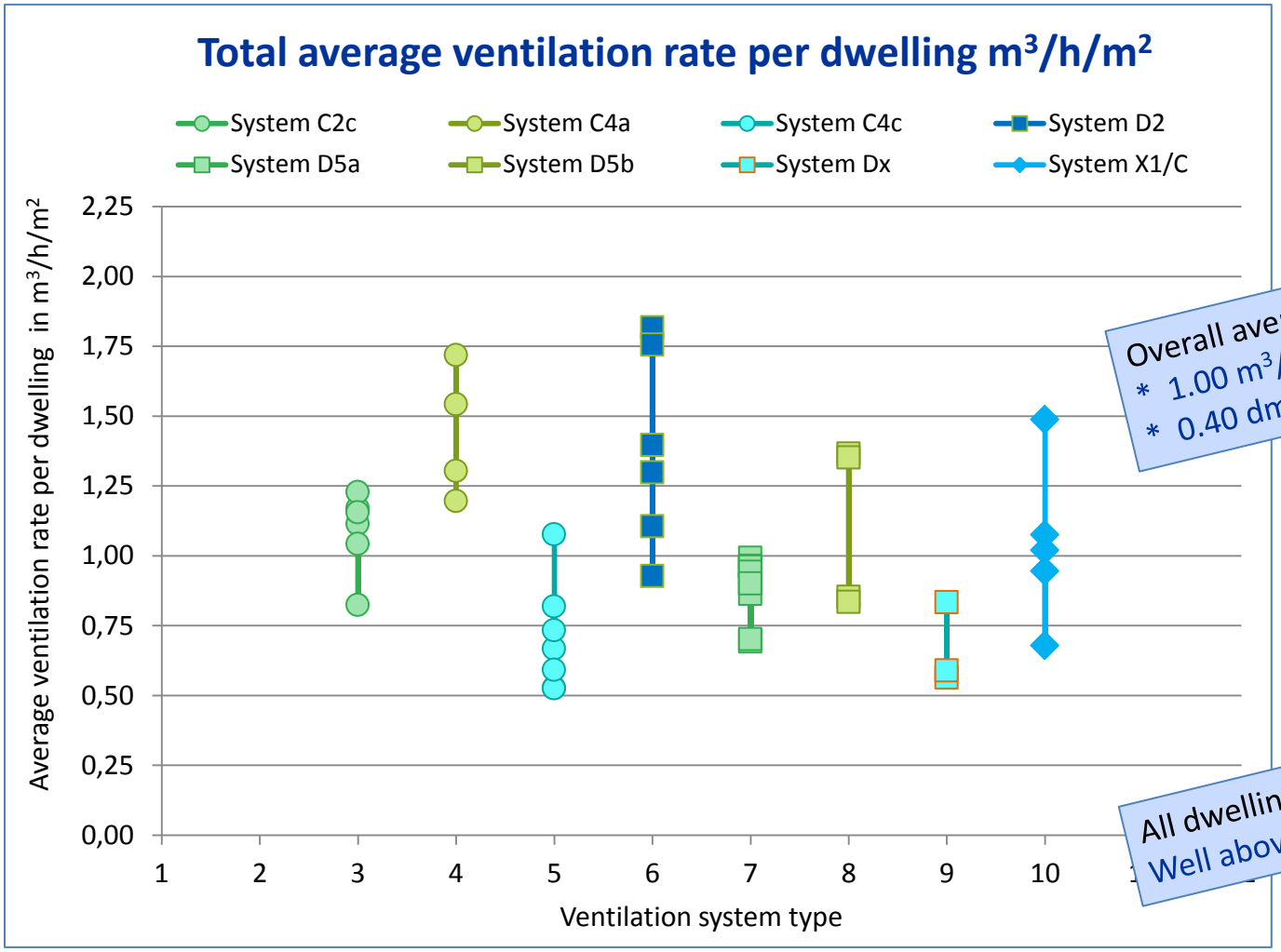
RESULTS

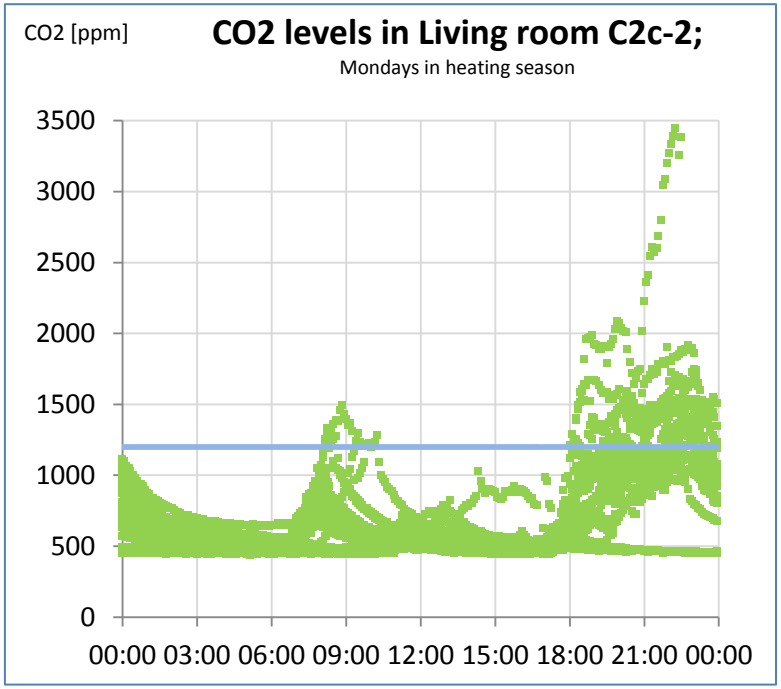


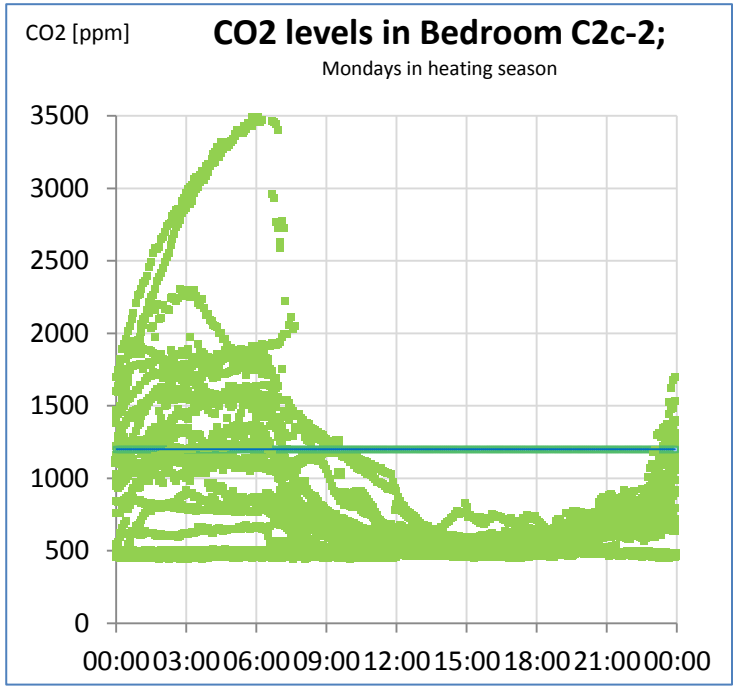
Overall averages:
* 1.00 $m^3/h/m^2$ A_{heated}
* 0.40 $dm^3/s/m^2$ $A_{habitable}$

All dwellings/systems:
Well above 35 m^3/pp/h

RESULTS

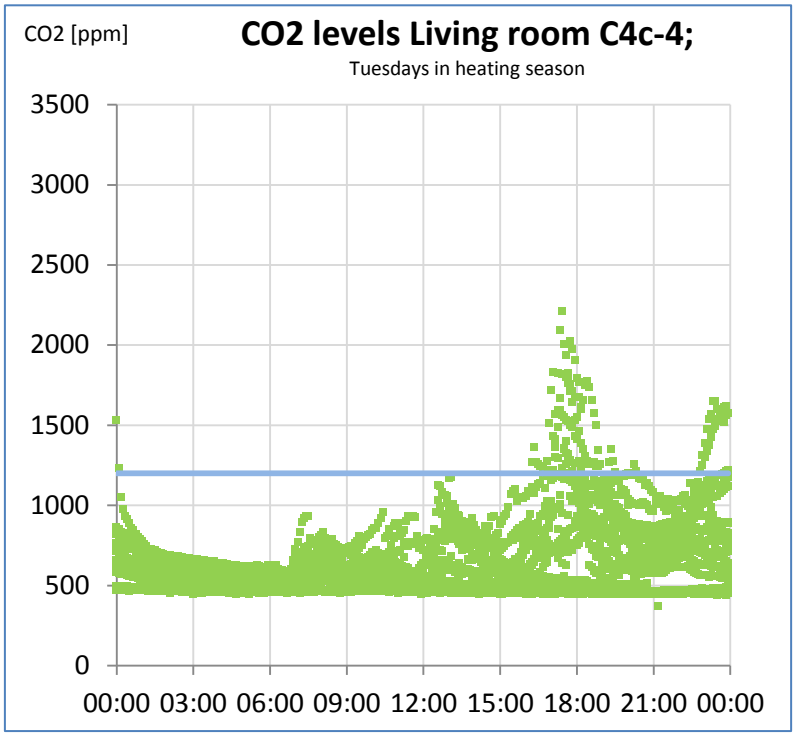
Some examples CO_2-levels system C2c (nat.supply & exhaust in hab.rooms)

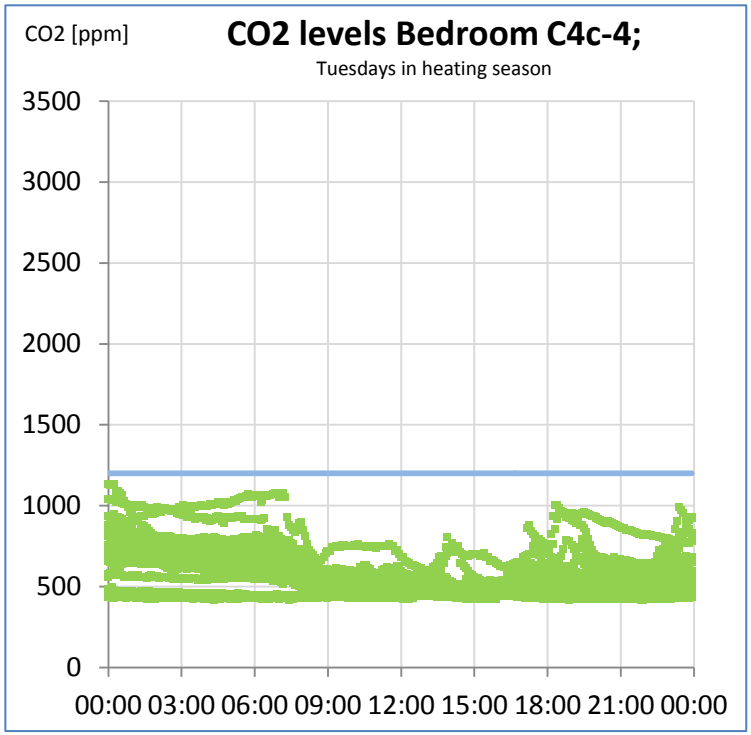




RESULTS

Some examples CO_2-levels system C4c (nat.supply & mech.exhaust in hab.rooms)





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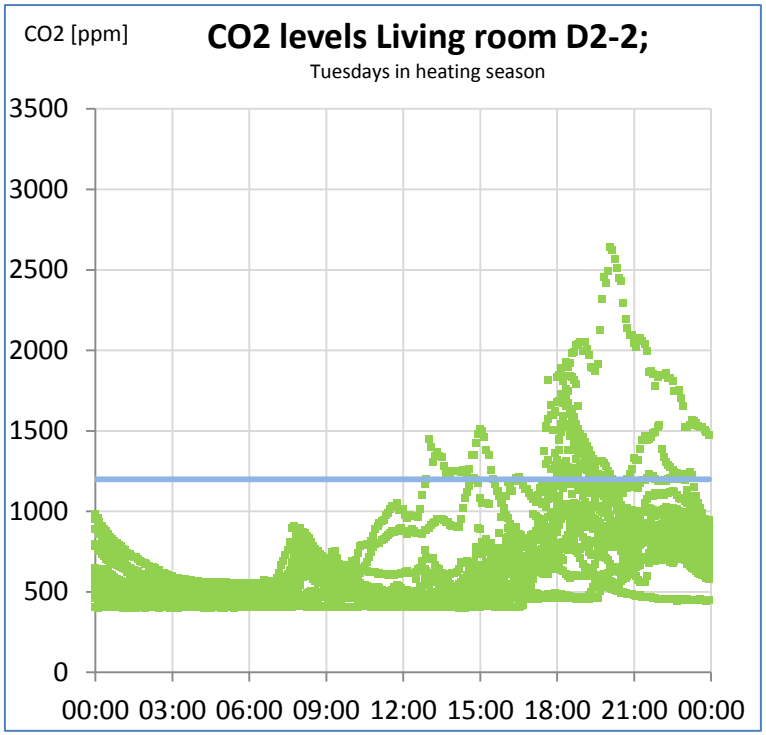
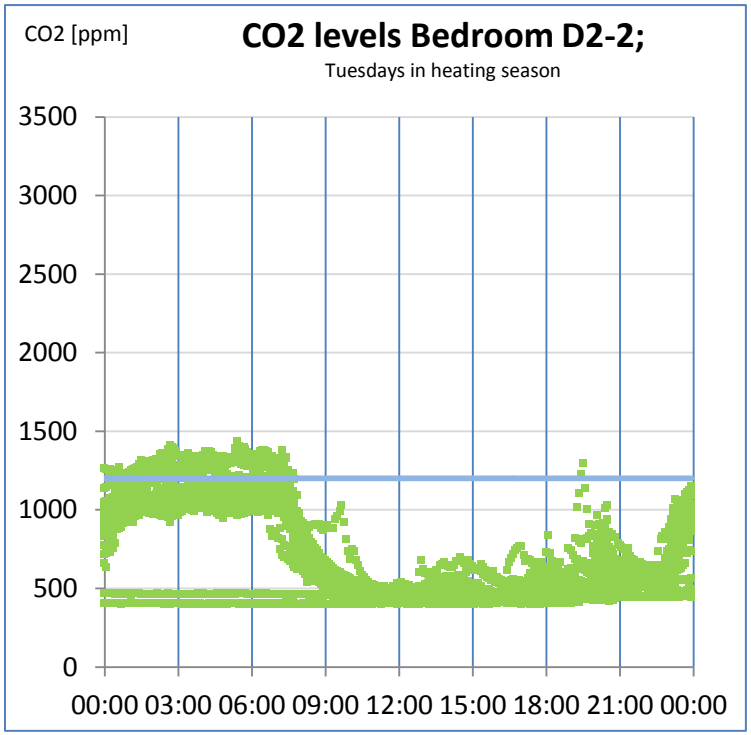
RESULTS

Some examples CO_2-levels system D2 (mech.supply & nat.exhaust in hab.rooms)





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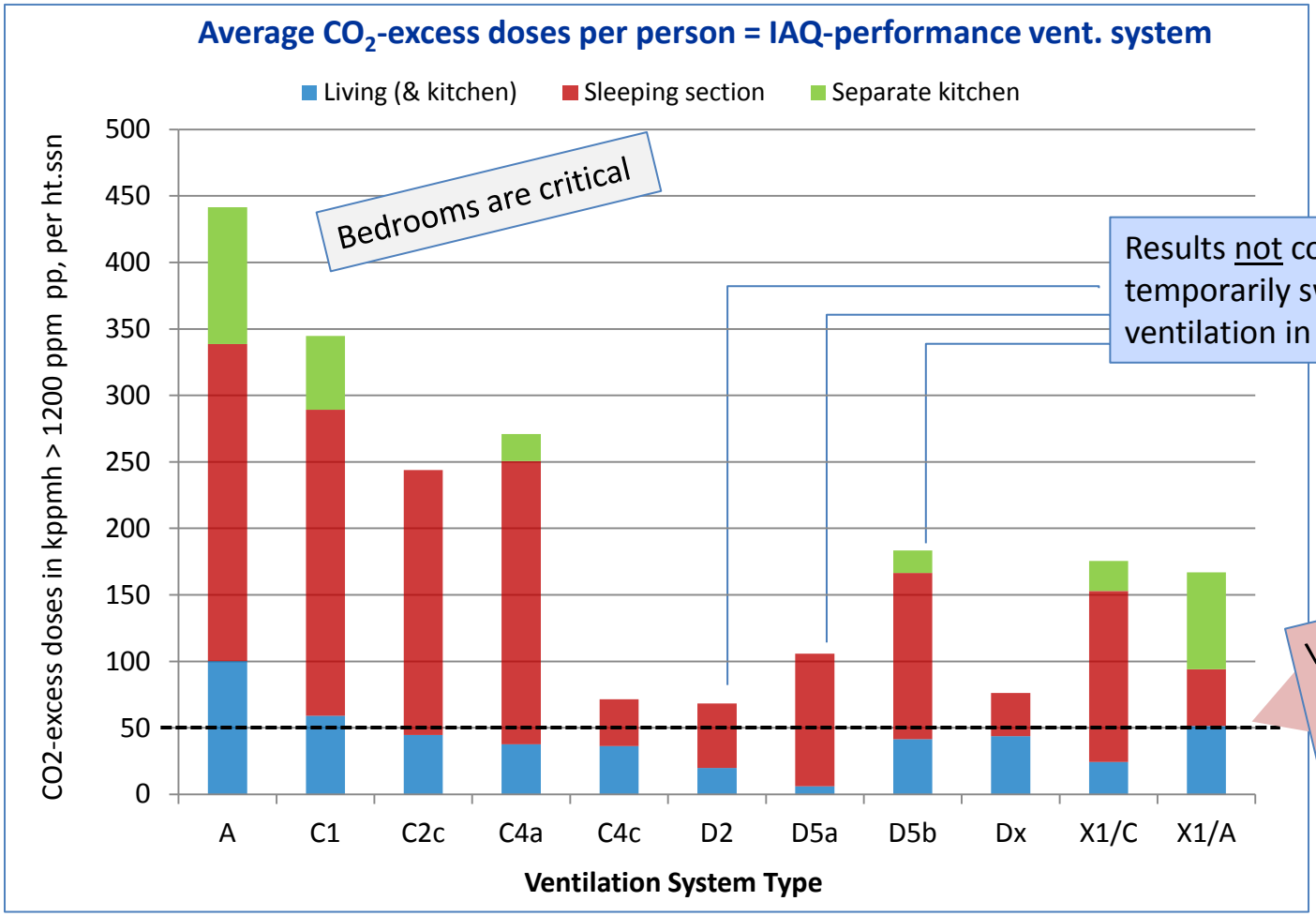
RESULTS



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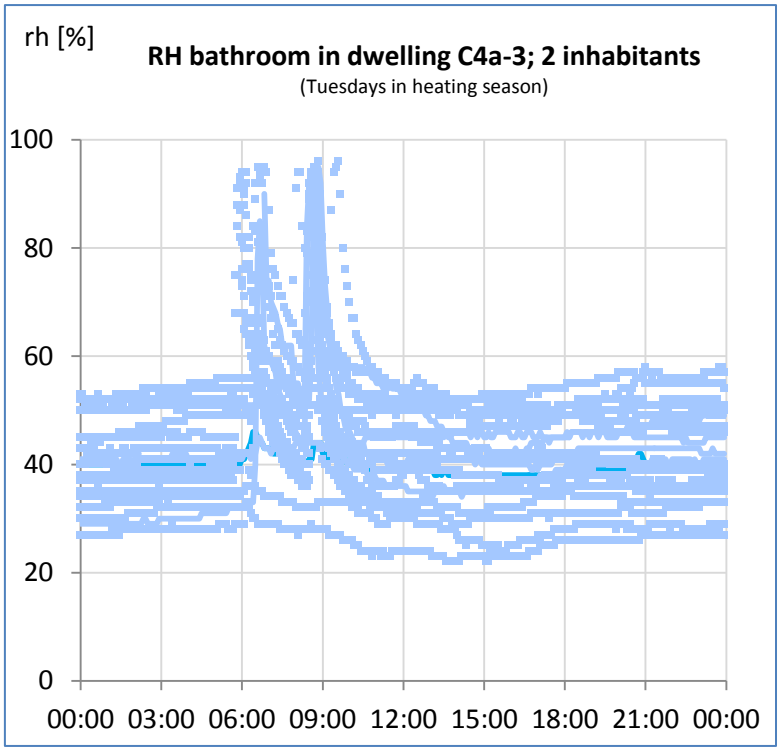
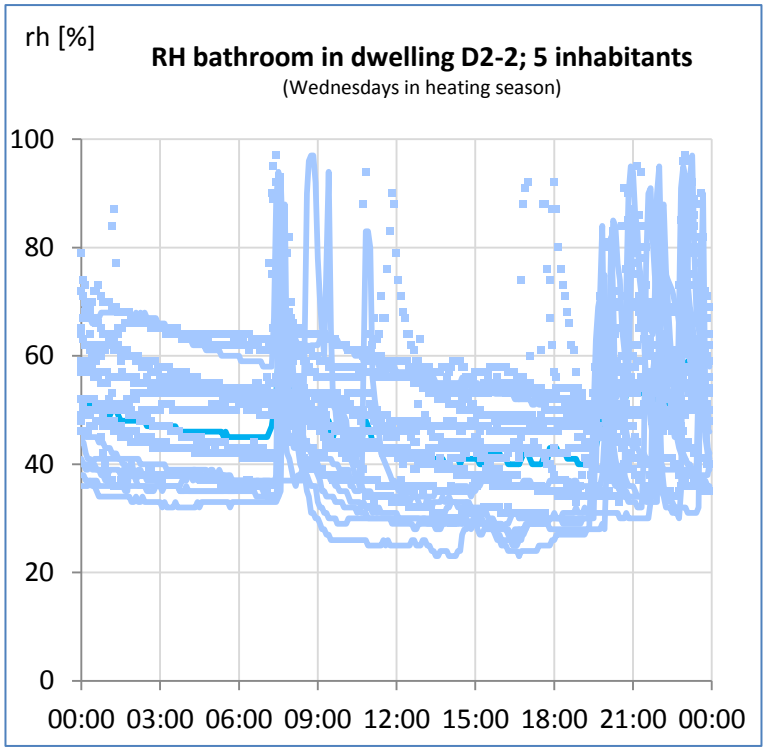
RESULTS

Some examples RH-levels





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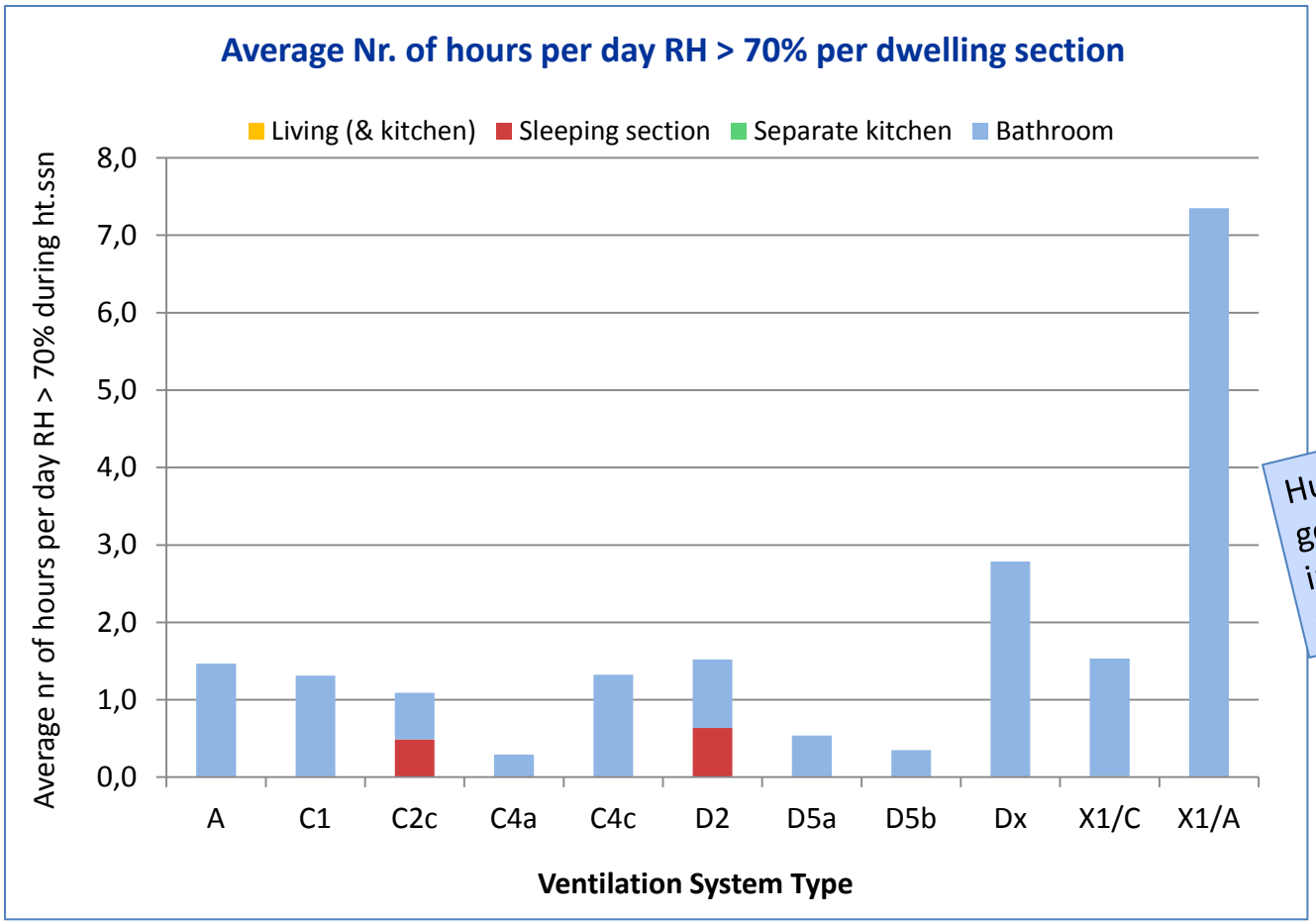
RESULTS



Humidity wet rooms generally okay, except in some bathrooms with natural exhaust

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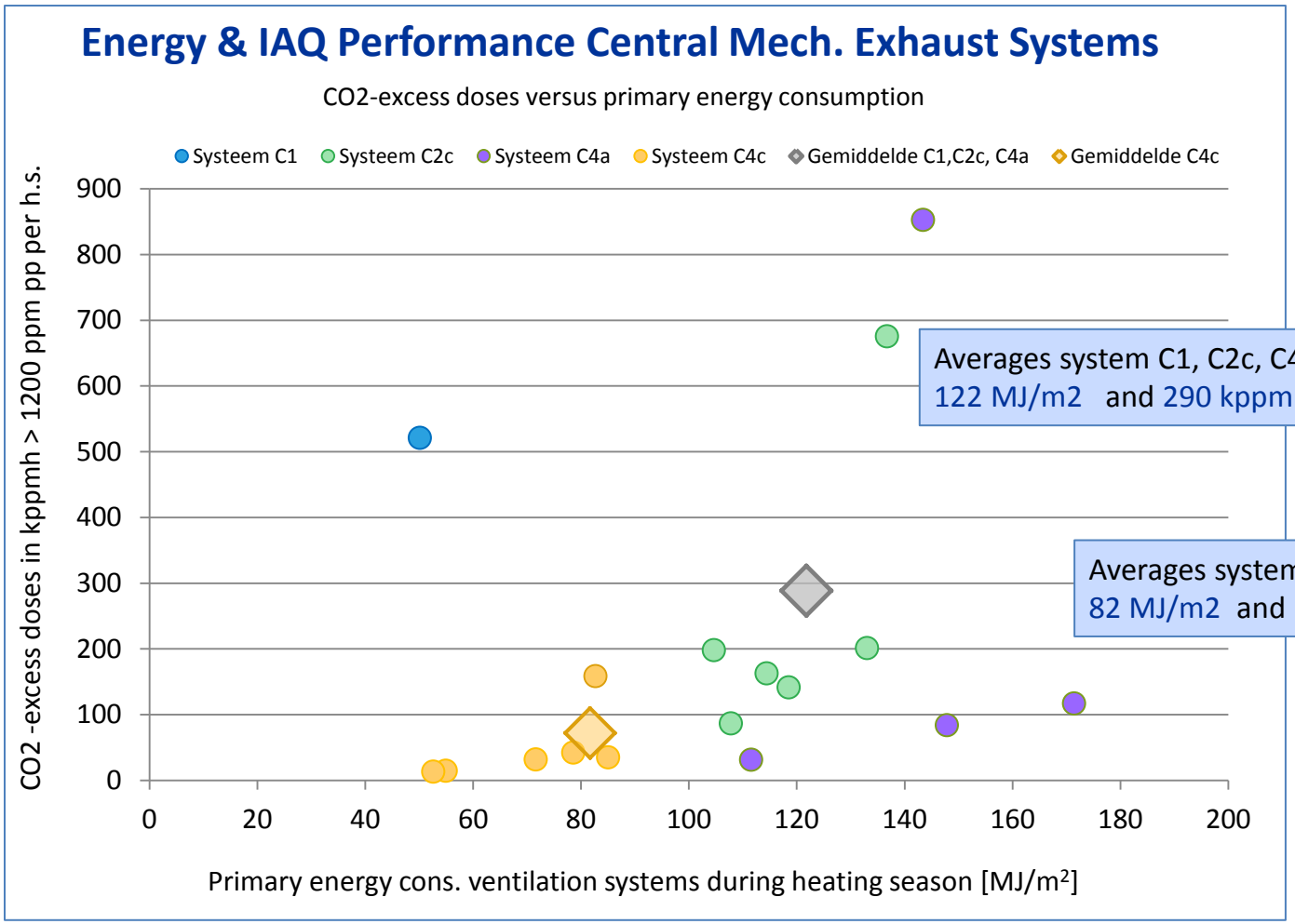
RESULTS



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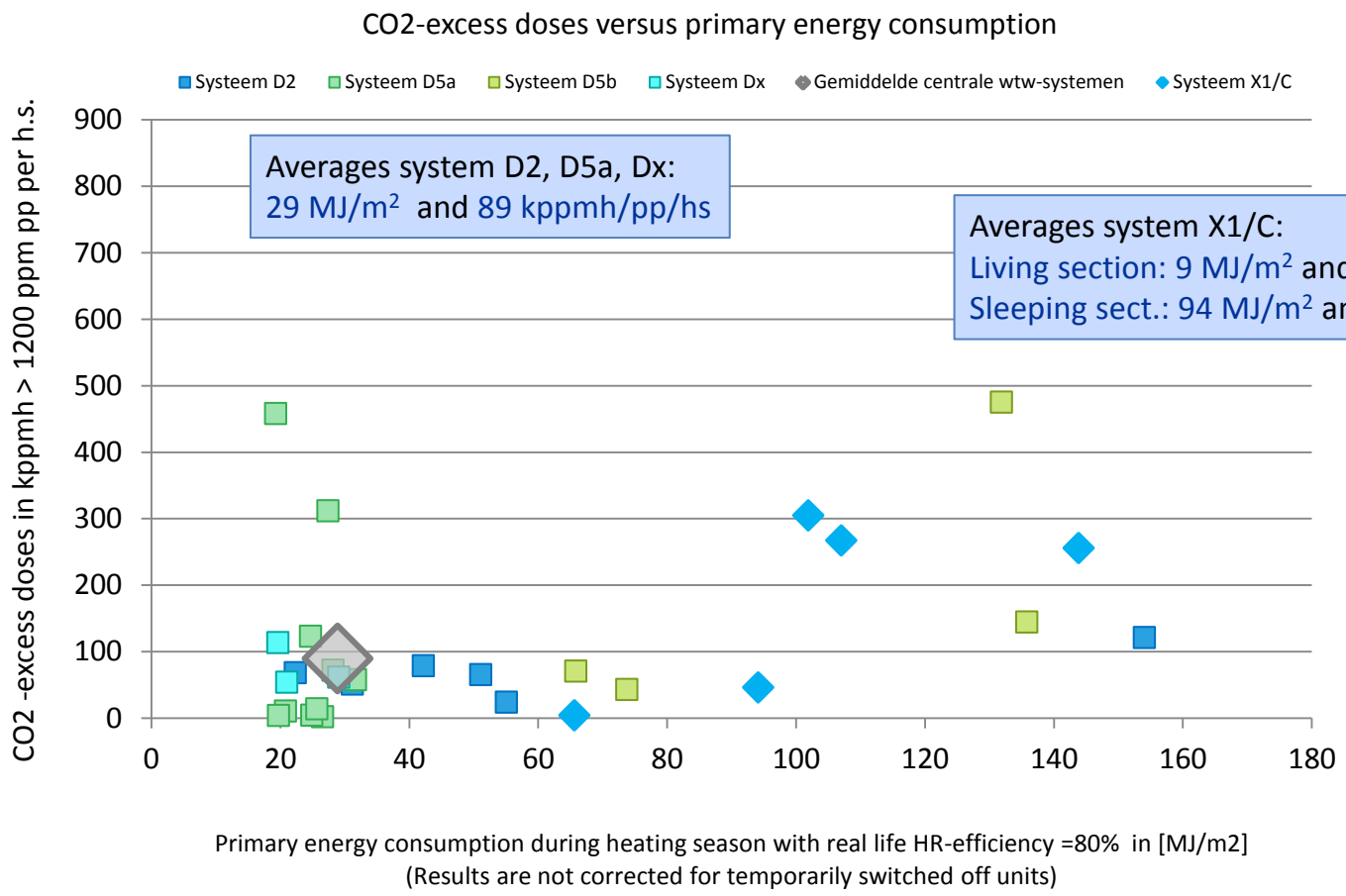
RESULTS

Energy & IAQ Performance Central and Local mech. systems with HR



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RESULTS

Ventilation systemsSS	$Q_{vent;prim}/m^2$ η HR = 80%	CO_2 excess dose kppmh/pp/hs	Stnrd Dev. kppmh/pp/hs
System A	No data	442	438
System C1	No data	349	276
System C2c	119	244	216
System C4a	144	271	389
System C4c	82	72	78
System D2	40	68	32
System D5a	25	105	156
System D5b	103	183	32
System Dx	23	76	199
System X/C (*living* / sleeping section)	*9* / 94	*30* / 145	*33* / 103

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RESULTS

Main findings of MONICAIR:

1. Average flow rates of ventilation systems are very close to flows corresponding with setting 1 of ventilation switch
2. For all dwellings/systems average flows are well above 35 m3/h/pp
3. Large differences in IAQ-performance of code compliant ventilation systems (0 – 853 kppmh/pp/ht.ssn)
4. Large differences in standard deviation of IAQ-performance (32 – 438 kppmh)
5. Bedrooms are critical
6. Differences in real-life energy performance and EPBD assessment methods
7. Inhabitants do not react on high CO2-levels (> 3000 ppm CO2)
8. Noise and draught are reasons to temporarily switch off mech. vent. units
9. Leaks in dwellings façade or roof do not improve the IAQ
10. For dwellings with only natural air- supply and extract provisions in habitable rooms, an increase in flow rate does not improve the IAQ
11. Correlation between IAQ and flow rate is strongest for systems with mechanical air exchange provisions and IAQ-sensors in habitable rooms

CONCLUSIONS

1. Compliance with Buildings Codes does not guarantee the IAQ-performance of the ventilation system

2. Code compliant ventilation systems largely differ in their IAQ-performance

3. An assessment of the Energy Performance of ventilation systems is meaningless without an assessment of its key-function *"the ability to exchange air in all rooms under all circumstances"*

4. Building codes, assessment methods and standards can be further improved to overcome this omission

5. Ventilation systems can be further improved to guarantee a proper IAQ-performance

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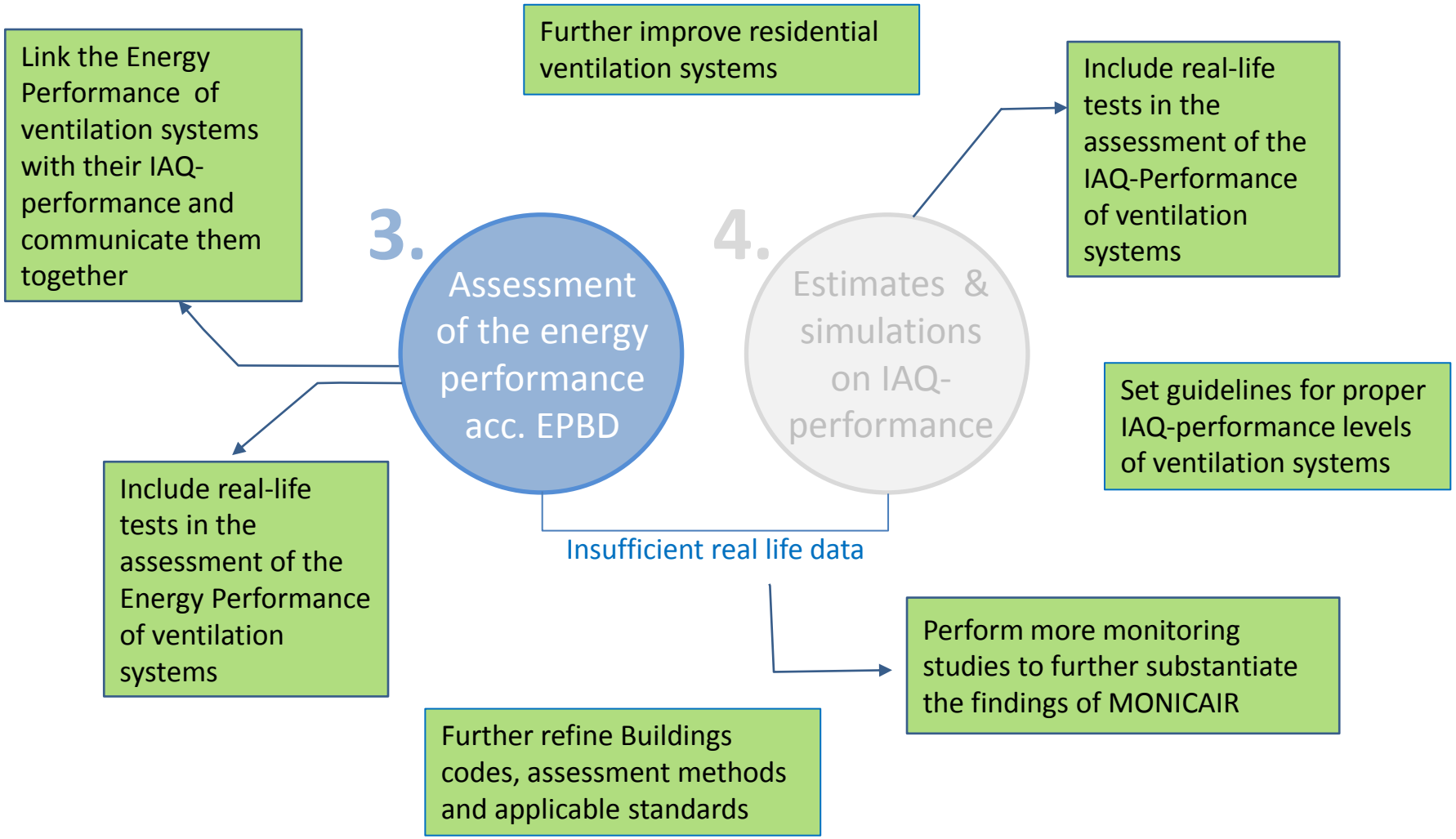
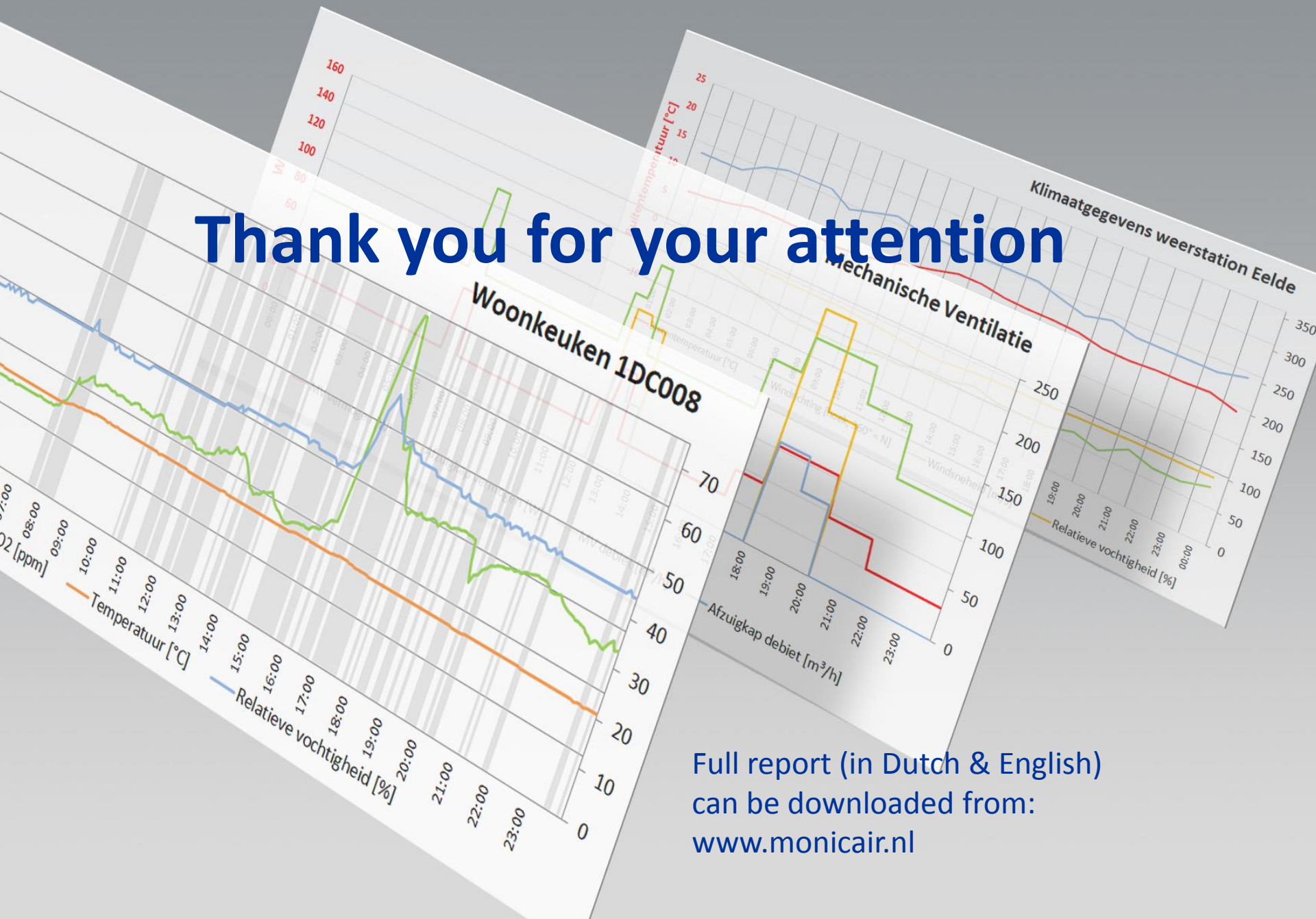
RECOMMENDATIONS



Thank you for your attention



Full report (in Dutch & English)
can be downloaded from:
www.monicair.nl