

Case study of personal heaters in a Plus energy building

- Simulations of potential energy savings and results from a field test

Niels Lassen

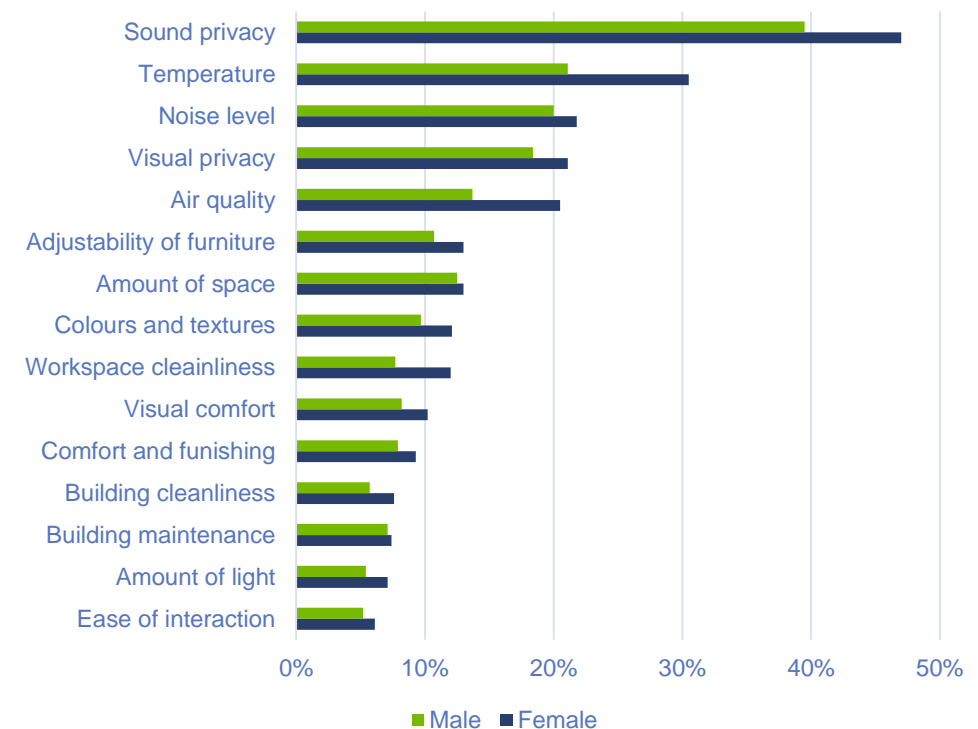
PhD Candidate, Skanska Norway

Introduction – thermal comfort

Most office buildings in Europe and North America are controlled to a tight temperature dead-band, where the mean dead-band is found to be:

- 1-2°C in North America and
- 2°C in Norwegian buildings.

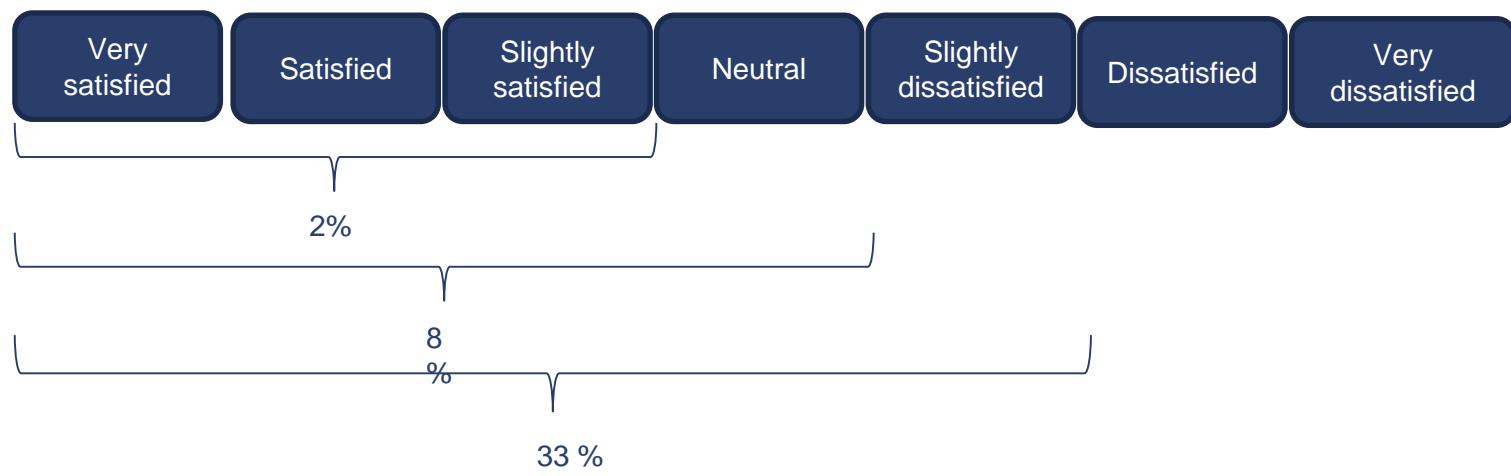
Percentage dissatisfied with IEQ measures



After (Kim et al., 2013).

Introduction – actual satisfaction

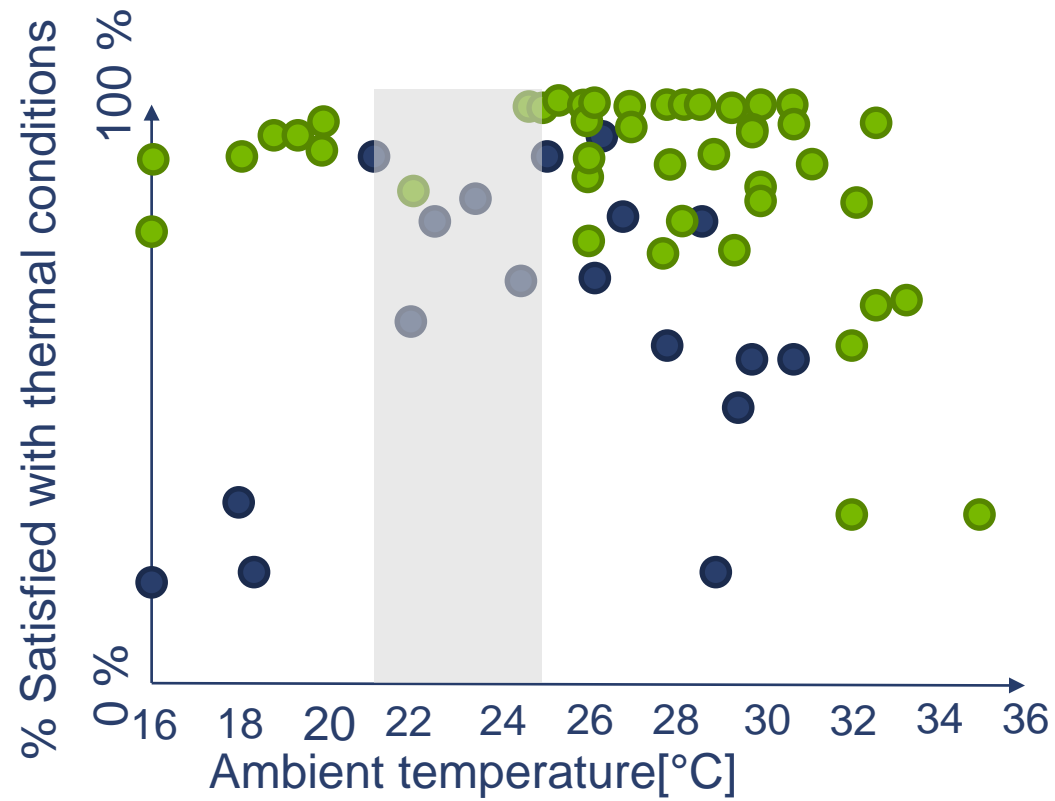
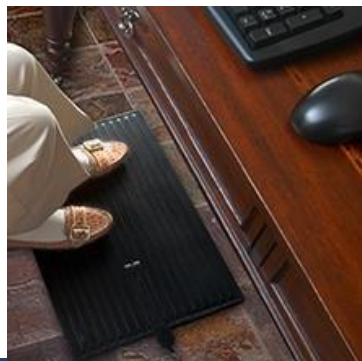
«How satisfied are you with the temperature of your workspace?»



351 buildings, 52.980 votes

After Karmann, Schiavon, Arens (2018)

Introduction - PCS



- Systems without PEC
- Systems with PEC

A review of scientific studies on PCS systems has found that they can provide a corrective power (CP) of

- 1 - 6°C for cooling
- 2 - 10 °C for heating.

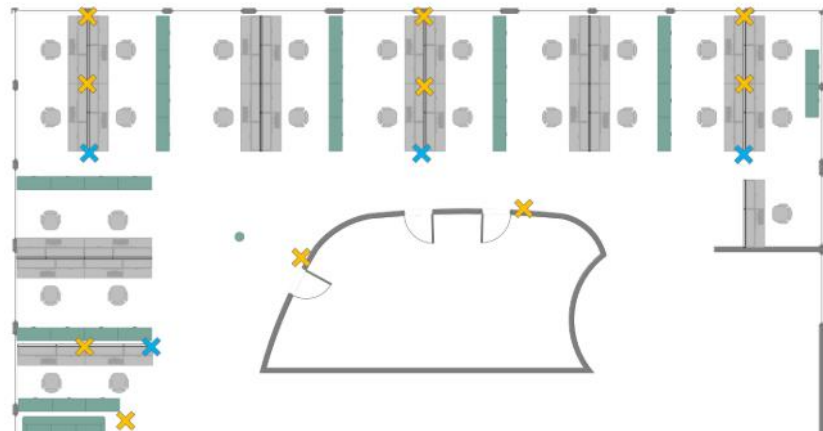
Objectives

1. Test PCS heaters in a modern Norwegian office environment and see how they are appreciated by office workers.
2. Investigate how large energy savings can be anticipated in a ZEB building by the use of PCS heaters.

Case building



- Open plan office
- 26 workers
- Previous complaints about cold temperatures
- 3 months duration



Field study

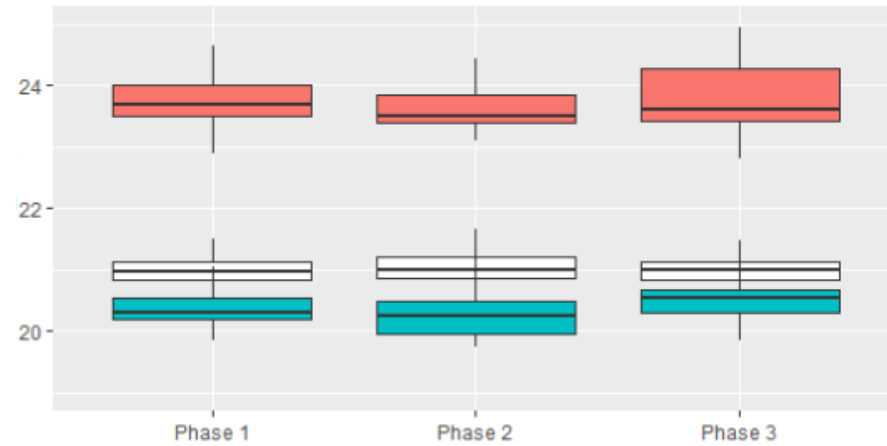
Table 1. Field study sequence and progress	
	Date
Study start	05.11.2018
First survey distributed	16.11. 2018
QR codes installed	19.11. 2018
Second survey distributed	30.11. 2018
Under desk heaters installed	04.12. 2018
Interview of 3 occupants	10.01. 2019
QR code removed and changed to manual control of heaters	
Third survey distributed	23.01. 2019
End of study	02.02. 2019

Survey Questions & energy simulation

	Question
Whole-body thermal sensation vote (according to NS-EN 15251)	“Where on this scale would you place your experience of the temperature?”
General temperature acceptability (according to NS-EN 15251)	“How did you experience the temperature during the period?”
Perceived control	“How much control do you think you have over your indoor climate?”
Portion who used QR code / heater	“Have you used the (QR code / heater) during the period?”

- Calculated using the software SIMIEN ver.6.0.10 and the original design phase energy model.
- The under desk heaters were assumed to have a corrective power of 2.8 °C, according to a study of under desk heaters with similar surface temperatures.
- For the reference case, the year-round heating set-point was set to 22 °C. For the PCS case, the set-point was lowered to 19.2 °C.

Results



	1 st survey	2 nd survey	3 rd survey
Number of respondents	16	10	11
Mean thermal sensation vote	-1.0	-1.2	-1.0
General temperature acceptability (% acceptable)	75 %	80 %	82 %
<i>p-value 1st – 3rd survey</i>			<i>p=0.68</i>
<i>p-value 2nd – 3rd survey</i>			<i>p=0.92</i>
Perceived control [0-3]	0.64	0.60	1.18
<i>p-value 1st – 3rd survey</i>			S1: <i>p=0.07</i>
<i>p-value 2nd – 3rd survey</i>			S2: <i>p=0.10</i>
Portion who used QR code / heater (% Yes)	-	20%	45 %
<i>p-value 2nd – 3rd survey</i>			<i>p=0.23</i>

Results

Energy simulations:

	Heating energy [kWh/m ²]		Total energy [kWh/m ²]	
	Net		Net	Gross
22 °C heating set-point (Reference)	18.1		44.5	26.6
19.2 °C heating set-point	13.7		40.2	25.4

- Net heating energy demand was reduced by 4.4 kWh/m², or 24%.
- Net total energy use was reduced by 4.3 kWh/m², or 9%.
- Gross energy use was reduced by 1.2 kWh/m², or 5%.
- Expected annual energy use of heaters is 0,5 kWh/m² (depending on assumptions)

The focus group interviews produced the following main findings:

- Two of three have used the heater «all the time». The third person's heater did not work, but he is content with the temperature as it is and does not want one.
- Two of them want to keep the heater. One of them claims "I love it".
- "Half an hour is way too short. That's why I have disconnected the heater from the smart plug and use the manual control. I have helped several others do the same."

Conclusions

- No significant increase in occupant thermal acceptability, but increase in perceived control.
- Interview results suggest that PCS heaters are a good solution for improving the satisfaction of the limited number of occupants who have special needs.
- Potential energy savings are dependent on building efficiency. 3% energy savings, even in this efficient building.
- *PCS systems can help relax the demands set to other climate installations in the building. This again can allow the use of more environmentally friendly solutions such as utilization of thermal mass, temperature stratification and natural ventilation.*