

Pollution inside houses with wood stoves

Previous versions of this brief were composed for Green Transition Denmark, while this updated version has been composed by Healthy Indoor Environment: www.healthyindoorenvironment.org

It is well recognised that wood smoke is a significant source of outdoor air pollution. Wood smoke contains same health hazardous and carcinogenic compounds as tobacco smoke. According to the Danish authorities, wood smoke in the ambient air contributes significantly to morbidity and premature mortality.

However, focus on indoor air pollution from wood stoves is very limited despite that wood stoves are placed inside houses, e.g., in the living room, and thereby can emit pollution directly to the indoor air where it can disperse to the entire house (e.g., bedrooms and children's rooms). Furthermore, wood stoves are mainly used during seasons where ventilation is limited and while families are at home; people are therefore potentially exposed to high levels of air pollution for hours in their home if their wood stove leaks pollution.

The pollution can leak from the wood stove when logs are put in (open stove door), because the chimney pipe and/or the wood stove are leaking, or because dust is burned on the hot surfaces of the wood stove.

Previous investigations from 2012 made by the Danish Building Research Institute showed that even new eco-labelled wood stoves can cause high levels of indoor pollution. These investigations were confirmed by Green Transition Denmark who performed measurements in 20 houses in 2017-18. In the fall 2021, students at the Technical University of Denmark confirmed once more that even new eco-labelled wood stoves can cause high indoor pollution levels.

Despite these investigations, there are still no requirements on indoor pollution levels from wood stoves; not even for new eco-labelled stoves. Healthy Indoor Environment has now (2023) made new measurements to clarify if residents themselves can smell the pollution in their houses and use this (smell of wood smoke) as an indicator of exposure to health hazardous compounds and an urgent need for ventilation.

Pollution screening

Healthy Indoor Environment has performed a screening of the particle pollution in three houses with installations of newer wood stoves and compared them with previous measurements from 2022. The results are summarized on the following pages. The purpose was to clarify if the residents can smell smoke from their wood stove in their house with high levels of indoor air pollution. The measurements were financed by European Climate Foundation and Birdlife Europe.

Conclusion

The screening confirms that significant indoor air pollution with ultrafine particles can occur even in houses where the wood stoves are eco-labelled. Pollution levels can be sky high and exceed both the levels measured at the most polluted streets during rush hour and the level of 20,000 ultrafine particles per cm³ (measured as an hourly average), which is the level that the World Health Organisation (WHO) considers as a high level that should be avoided. More important, the residents could not smell smoke and are therefore not aware of the health hazardous air pollution they inhale.

Recommendations

- 1) Authorities should thoroughly inform about the risk of toxic indoor air pollution from wood stoves.
- 2) The eco-label should require that eco-labelled wood stoves cannot cause indoor air pollution.
- 3) People should change to electric fireplaces to sustain a cozy atmosphere and avoid indoor air pollution.

Further information

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Results

The table shows the results of the measurements. Background measurements were performed outside the house and indoor in the living room before kindling the wood stove. Both the average and highest (hourly average) pollution levels of particle pollution are stated and compared with both the pollution level that WHO considers as high and should be avoided, and the average pollution level measured along the most polluted street in Copenhagen during rush hour.

Table 1: Measurements of indoor pollution from wood stoves (all values are in particles per cm³, rounded off values)

	In the house at sitting distance from the wood stove			Rush hour at the most polluted street in Denmark (hourly average)	WHO's limit for high air pollution (hourly average)
	Before kindling	After kindling			
		Average	Max. (hourly av.)		
House 1	1,850	7,350	15,250	15,000	20,000
House 2	2,150	35,700	59,350		
House 3	700 ¹⁾	58,450	109,350		
House 4	6,700 ²⁾	12,100	15,000		
House 5	4,150	115,500	181,200		
House A	700 ³⁾	5,900	10,950		
House B	2,000	44,950	82,200		
House C	5,150 ⁴⁾	10,200	20,550		

1) It was not possible to explain the low background concentration. Repeated measurements with other equipment resulted in the same levels.

2) The relatively high pollution in the living room before kindling may have been caused by late night use of the wood stove the day before.

3) The low concentration prior kindling is caused by unusual meteorological conditions (very strong wind = very clean air).

4) The high pollution level prior kindling is most likely caused by an intense tailback during rush hour right outside the house.

The table shows a significant increase in indoor air pollution in all eight houses while using wood stoves.

The lowest (but still significant) pollution is seen in House A where the pollution level stays below the level seen during rush hour on a highly polluted street in the central Copenhagen.

In two of the eight houses (Houses 1 and 4), pollution levels reach the same level as a highly trafficked street during rush hour but 25% below the level that WHO considers as a high pollution level.

In the last five houses, the particle pollution levels exceed the levels that are found at one of the most polluted streets in Denmark during rush hour and exceed the level that WHO considers as a high pollution level that should be avoided. At House 5, the pollution reaches levels 12 times the pollution level at one of the most polluted streets in Denmark and 9 times above the pollution level that WHO considers as air pollution levels that should be avoided.

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Measurements made around the houses after the measurements in the room of the stoves show that the particle pollution from the wood stove is dispersed to all connecting rooms with open doors. In Houses A-C, the cooker hood was switched on the last 20 minutes of the measurements to see if that had any effect on the air pollution. No significant effect of having the cooker hood on was seen in any of the three houses.

The graphs of each of the eight measurements are displayed on the following pages. The graphs show that there is not always a correlation between when logs are put on the fire and an increase in the pollution in the living room. This indicates that the pollution detected in the living rooms may enter through leakages in the chimney pipe, the wood stove itself, and/or because dust is burned on the hot surfaces of the wood stove.

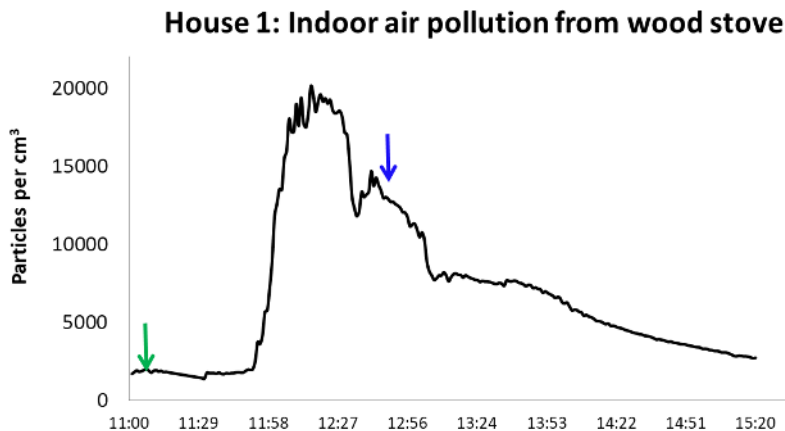
According to the residents, none of them can smell smoke when the stove is in use. One resident is nevertheless in doubt, and some only when kindling. Nonetheless, the graphs show that the peaks of air pollution often occur an hour or more after kindling, which implies that when the pollution is the highest the residents cannot smell smoke. There can be several reasons for this. Firstly, the particles are odourless contrary to the volatile organic compounds, which are dominant while kindling. Secondly, the residents may possibly get used to the smell of smoke in the house (as one gets used to other odours inside a house). Hence, the smell of smoke cannot be used as an indicator for high levels of air pollution with toxic particles from wood stoves inside houses.

Pollution measurements

Ultrafine particles were measured with calibrated P-Traks (Model 8525 Ultrafine Particle Counter) from TSI. During measurements, the P-Traks were placed where the residents would typically stay while using the stove, e.g., on the coffee table or dining table.

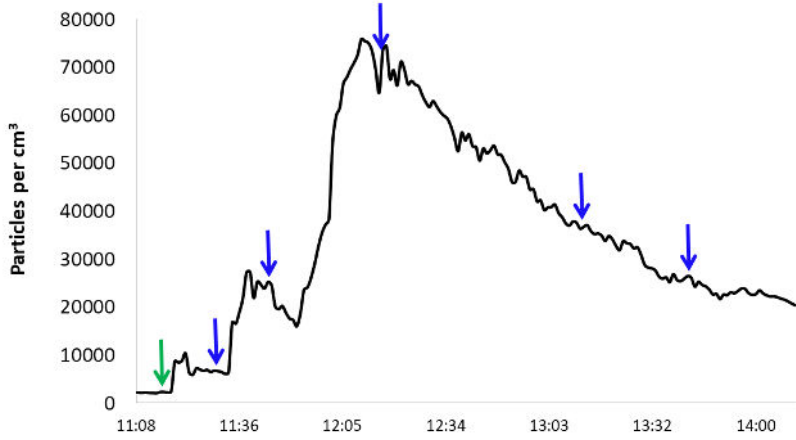
At each house, there was a three-hour duration of measurements, which corresponds to more than 10,000 measurement points per house (one measurement per second). 8-10 minutes before kindling, background measurements were made. The residents were then asked to kindle and put logs on as usual, taking notes of when they put on a new log. (At House C, the resident was not able to stay and keep the fire going, therefore we stayed to do that). Candles, tobacco smoking, cooking, or other air pollution generating activities were avoided during measurements. Hence, measurements reflect pollution generated by the wood stove.

Green arrows indicate kindling, blue arrows indicate when logs are put on the fire, and orange arrows at Houses A-C indicate when the cooker hood is switched on and off, respectively.

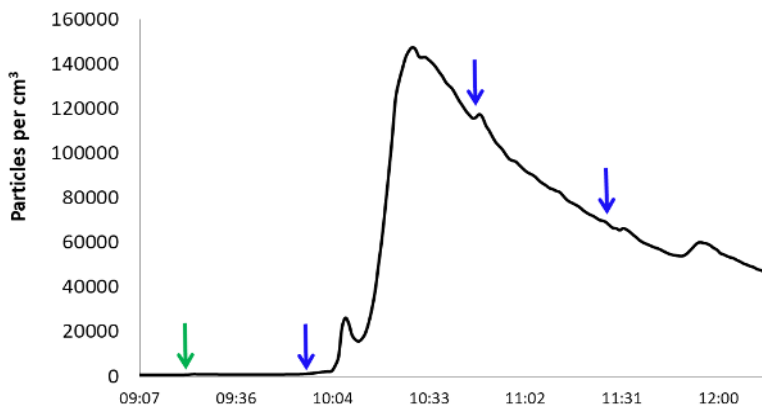


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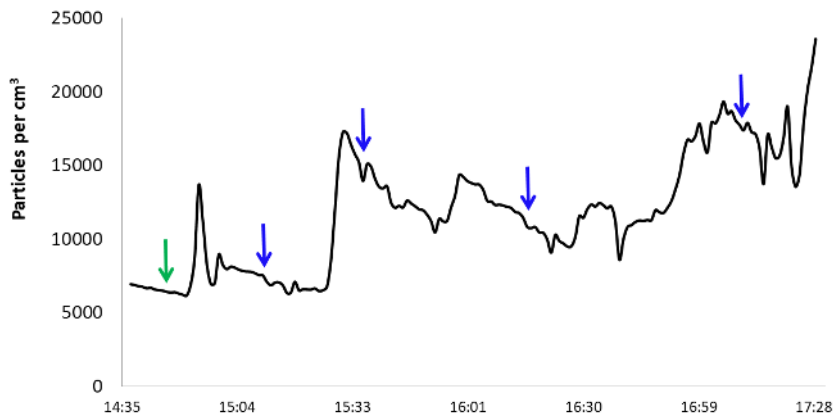
House 2: Indoor air pollution from wood stove



House 3: Indoor air pollution from wood stove

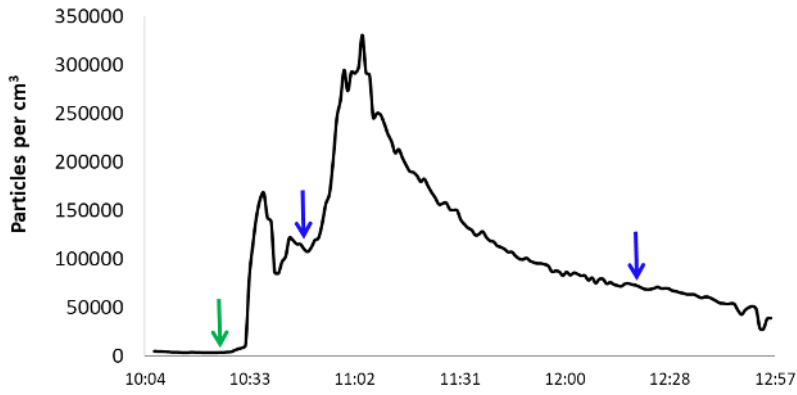


House 4: Indoor air pollution from wood stove

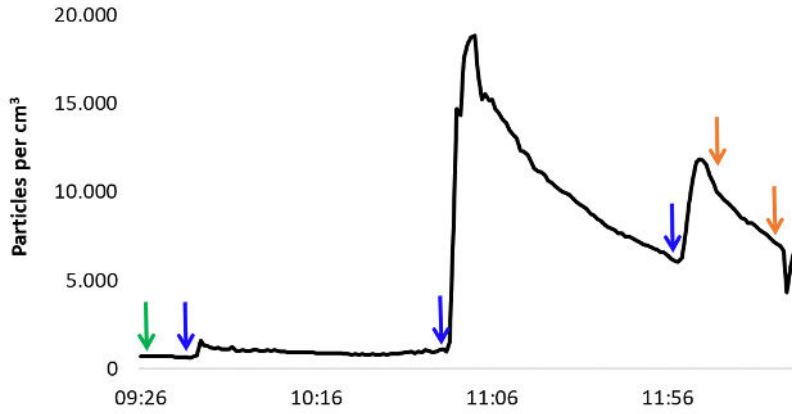


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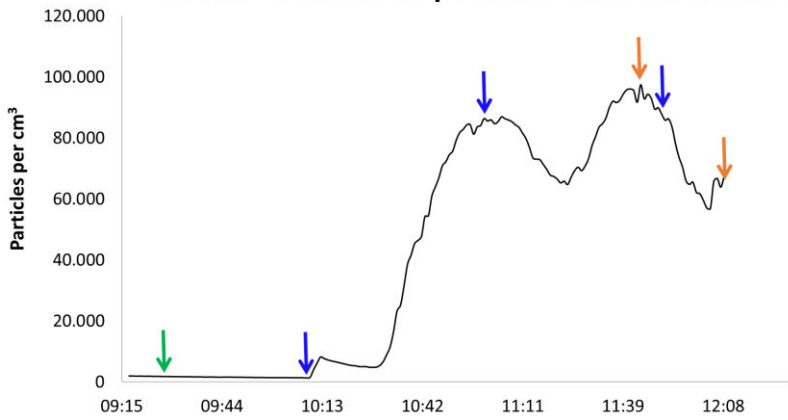
House 5: Indoor air pollution from wood stove



House A: Indoor air pollution from wood stove



House B: Indoor air pollution from wood stove



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