

# Indoor Air Pollution By Ultrafine Particles From Wood Stoves

Kåre Press-Kristensen<sup>1)</sup>, Mette Torsbjerg Møller<sup>1)</sup>, Patrick Huth<sup>2)</sup>, Hannah von Blumröder<sup>2)</sup> & Axel Friedrich<sup>3)</sup>

1) Ecological Council, Denmark; 2) Deutsche Umwelthilfe, Germany & 3) International air pollution advisor

## Background

Residential heating with wood (and coal) in private stoves is a well-known source to outdoor air pollution. However, only a few studies have investigated indoor air pollution with health damaging ultrafine particles from stoves. People spend 90-95 percent of their lives indoors and thereby inhale 90-95 percent indoor air, and as stoves are inside, they could emit particles directly to the indoor air. Hence, stoves could cause serious indoor air pollution when people are at home in the winter season where ventilation is limited.

## Purpose

The purpose was to investigate indoor air pollution of ultrafine particles from wood stoves and to see if pollution levels were related to specific stove/chimney conditions.

## Methods

This study investigates indoor air pollution with ultrafine particles emitted directly from typical wood stoves placed in living rooms inside 20 Danish one-family houses.

Both pollution from old wood stoves and new stoves with the Nordic eco-label (Nordic Swan) connected to both new and old chimneys were investigated.

Measurements were carried out in real exposure distance (typically 2-3 m from the stoves). Measurements started 10-15 minutes before turning on the stoves (background) and continued for 1 to 2 hours during normal (by house owners) operation of the stoves. Pollution levels from the operation period were compared to background levels.

House owners were carefully instructed not to smoke, cook, vacuum or use candles before/during the measurements.

Ultrafine particles were measured as particle number using P-Trak's model 8525 (range 20-1,000 nm).

## Results

In 20 percent (4 houses), no significant increase of indoor air pollution by ultrafine particles was measured when operating the wood stoves compared to the background levels measured just before turning on the stoves.

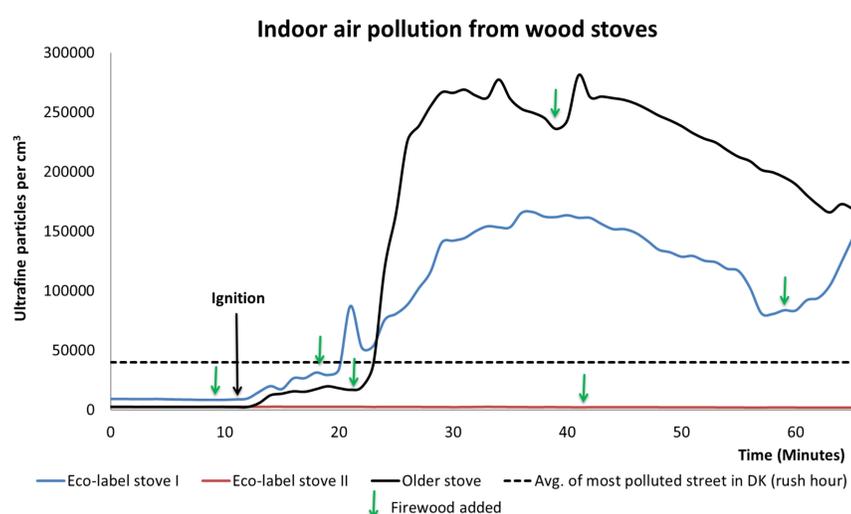
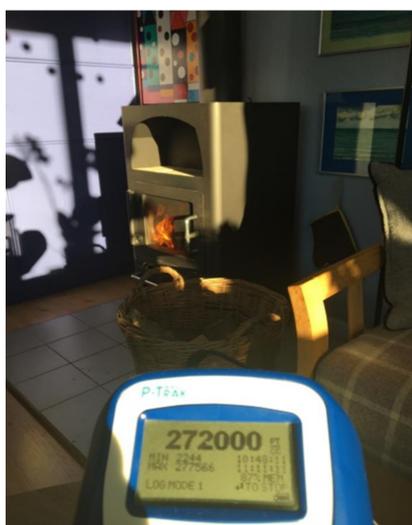
In 80 percent (16 houses), a significant increase of indoor pollution was measured compared to background levels. In 6 houses, pollution levels increased with up to a factor 10 when operating the stoves. In 10 houses, pollution levels increased with more than a factor 10 when operating the stoves. In the worst 20 percent (2 houses) pollution levels increased more than 50 times reaching much higher levels than the most polluted Danish streets in the rush hour.

It was not possible to identify connections between indoor air pollution and the type/age of stoves and chimneys in the measurements. Even some new stoves with the Nordic eco-label connected to new well-insulated chimneys caused high indoor pollution.

From observations during the measurements we believe indoor air pollution from wood stoves is caused by:

- 1) Particles leaking through the stove door when open.
- 2) Leaking seams in (hot) stoves and the smoke pipes.
- 3) Sudden reverse ventilation down through the chimney.
- 4) Dust burning on stove surfaces (characteristic smell).

In two houses, we finalized by measuring in other rooms (e.g. bedrooms). We found that pollution from stoves easily spread to rooms directly connected (open doors or stairways) to living rooms polluted by stoves.



## Discussion

Indoor air pollution levels by ultrafine particles from wood stoves found in this study are in the same levels as found in a screening study by the Danish Building Research Institute.

Four different causes leading to indoor pollution with ultrafine particles were identified in this study. In some cases, it was clearly one cause dominating the observed particle emission whereas it was probably a combination in other cases.

A well-functioning chimney draught is believed to explain why some stoves could be operated without, or almost without, increasing indoor air pollution. Too few measurements and/or fluctuating weather conditions, especially wind speed, might explain why no connections were identified between pollution levels and type/age of stoves and chimneys.

During the project, we realized that measurements should be carried out for at least 2 hours during stove operation since some stoves first start polluting when they become really hot.

## Conclusion

Significant indoor air pollution with health damaging ultrafine particles from wood stoves was measured in 80 percent of the investigated 20 one-family houses in Denmark.

It was not possible to identify connections between indoor air pollution and the type/age of stoves and chimneys. Even new wood stoves carrying the Nordic eco-label connected to well-insulated chimneys can cause significant indoor air pollution.

## Perspectives

More detailed investigations focusing on indoor pollution from stoves in one-family houses should be carried out to identify why stoves cause indoor pollution and how this can be reduced by better stoves and chimneys as well as behavioral changes.

Public information campaigns highlighting the risk of high indoor air pollution caused by stoves should be performed since many stove users are unaware of this risk. These campaigns might be an important supplement to information campaigns on outdoor air pollution from stoves and in the attempt to get stove users to switch to clean heat sources.

## Further info:

Clean Heat website: [www.clean-heat.eu](http://www.clean-heat.eu)

Danish Ecological Council: [www.ecocouncil.dk](http://www.ecocouncil.dk)

Deutsche Umwelthilfe: [www.duh.de](http://www.duh.de)

LIFE program of the EU: [ec.europa.eu/environment/life/](http://ec.europa.eu/environment/life/)



## Main author:

Kaare Press-Kristensen has a master degree and a Ph.D. degree in environmental engineering from the Technical University of Denmark. He has been teaching air pollution for 17 years at the university (recent years as external). His work is focused on wood burning, road traffic, shipping, non-road machinery, aircrafts & indoor pollution sources. He works with emissions, ambient air concentrations and the connected risk to public health as well as work related exposure and public information.

Contact info: [karp@env.dtu.dk](mailto:karp@env.dtu.dk) / (+45) 22 81 10 27



Old stoves connected to old chimneys, still in used in poor parts of Europe, will probably pollute indoor air to even higher levels than measured in this study, which can cause a higher risk of the adverse effects related to indoor air pollution in these areas.

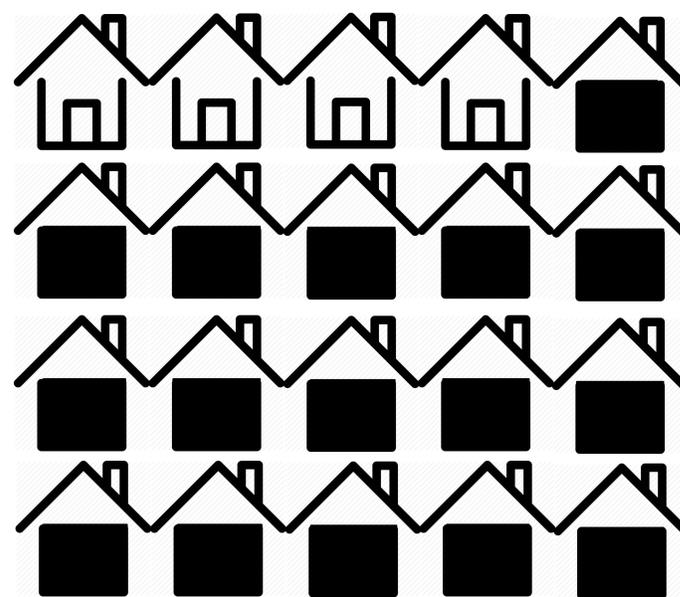
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No significant increase of indoor air pollution



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