Nearly Zero Energy Buildings and Indoor Exposures to Ambient PM

O. Hänninen, R. Sorjamaa, A. Asikainen

National Institute for Health and Welfare (THL), Department of Health Protection, P.O. Box 95, 70701 Kuopio, Finland

Keywords: Energy efficiency, ventilation, particulate matter, infiltration, lung deposition, uptake

Presenting author email: otto.hanninen@thl.fi

Nearly zero-energy buildings have very high energy performance. The low amount of energy that these buildings require comes mostly from renewable sources. The Energy Performance of Buildings Directive requires all new buildings to be nearly zero-energy by the end of 2020. All new public buildings must be nearly zero-energy by 2018 (EC 2016). It is estimated that buildings have the potential to reach a 90 % reduction in their greenhouse gas emissions by 2050 (JRC 2016, EC 2014). To reach this high level reduction in Northern European countries, the insulation thickness and air tightness of the building envelope has to increase substantially and heat exchanging techniques are needed for heat recovery. In practice in Nordic countries these imply use of mechanical ventilation systems.

$PM_{2.5}$ is the most significant environmental exposure threatening human health in developed countries (Hänninen et al., 2014). Harmful suspended particulate matter consists of aerosol particles ranging from nanometers to micrometers in diameter, leading to particle size dependency of both filtration efficiency as well as deposition rate in indoor air.

The objective of this paper is to estimate the indoor-outdoor relationship of ambient particulate matter in nearly zero energy buildings (NZEB) using minimal demand controlled ventilation. As an option we account also for a possibility of using various levels of air exchange.

Methods. Using international and EU Directive definitions of NZEB buildings and health based ventilation guidelines developed in the HEALTHVENT project (Hänninen & Asikainen 2013, ECA 2016) we investigate the potential infiltration of particulate matter as function of particle size and ventilation using previously developed and evaluated model (Hänninen et al., 2013). For the building leakage we use values proposed in the energy efficiency of buildings proposals for Nordic countries and for ventilation system FP7 level filter efficiencies.

Further we consider the impact on respiratory trac uptake of particles using ICRP (1994) model evaluated recently elsewhere (Hofmann 2011).

Results. Increasing building tightness reduces substantially air infiltration through the building envelope. Assuming that a mechanical ventilation system is equipped with FP7 class filters, properly sealed and maintained, and that the ventilation rates are adjusted using health based demand control, the indoor exposures are expected to be substantially reduced. The reduction especially affects ultrafine and coarse (super micron) particles, leaving mostly accumulation mode particles suspended in the fresh air supply.

The relative impact on respiratory tract uptakes is less dramatic due to the dominating role of accumulation mode particles. Nevertheless, it is likely that the exposures of population living in NZEB will be less than 50% of the average current building stock values. This will potentially contribute to the reduction of health impacts of ambient air pollution in Nordic countries. Concerns have been expressed related to moisture and humidity behavior and mold and dampness related problems. Thus further investigations of environmental health risks in the future building stocks are necessary.

This work has been supported by Academy of Finland Contract 285672 (BATMAN); Nordic Programme on Health and Welfare project #75007 (Nordic WelfAir); Finnish Ministries of Environment and Health (ISTE) and intramural funding by THL.

References

EC 2016. https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings/nearly-zero-energy-buildings

EC 2014. The European construction sector. A global partner (2014). European Commission.

ECA 2016. Report No 30. Framework for health-based ventilation guidelines in Europe. JRC.

Hänninen, O, Knol, A, et al. (2014), EHP **122**(5):439-446.

Hänninen, O., Sorjamaa, R.,et al. (2013) *J Aer Sci:* **66**:111-122.

Hofmann, W. (2011) *J Aer Sci:**42**:693-742.*

Hänninen & Asikainen 2013. Efficient reduction of indoor exposures. THL Report 2/2013.

ICRP (1994) *Annals of ICRP* **24**(1–3).

JRC 2016. Promoting healthy and energy efficient buildings in the European Union. National implementation of related requirements of the Energy Performance Buildings Directive (2010/31/EU). Report EUR 27665 EN.