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Impact of Building Renovation on Indoor Particulate Matter Levels in Finnish and Lithuanian Dwellings

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HUMAN SIDE OF TECHNOLOGY

Overview

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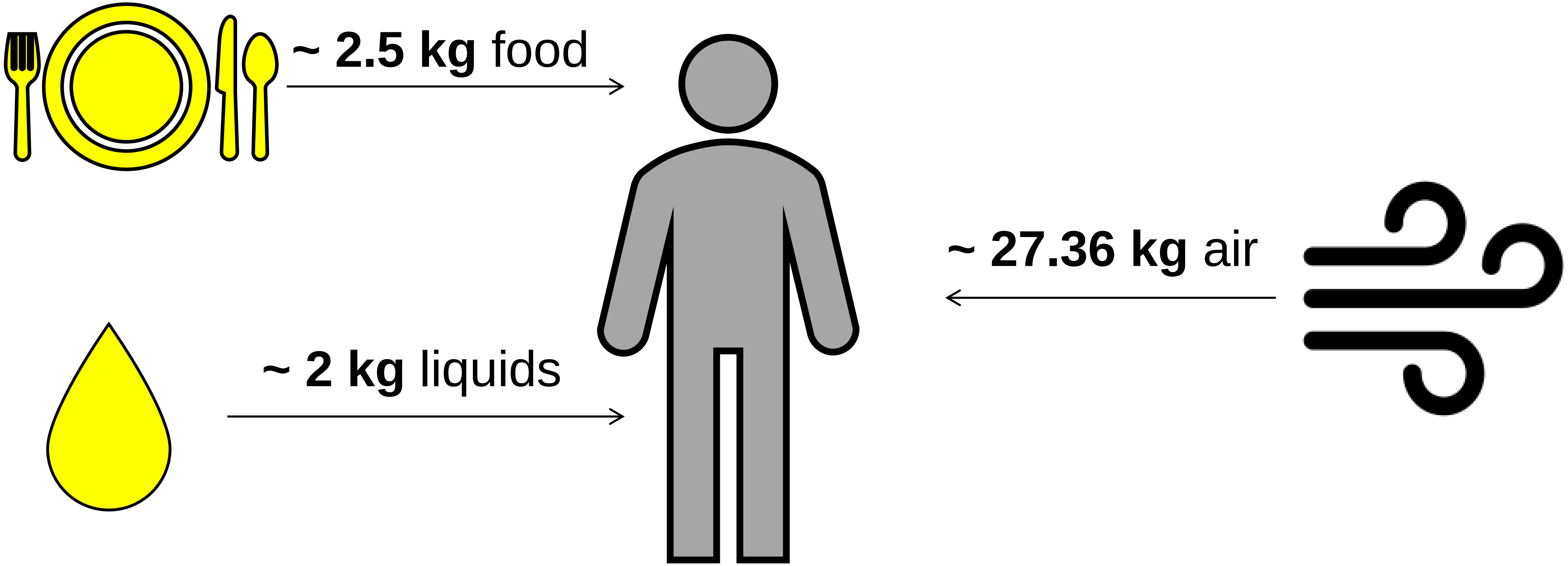
- Motivation
- Background
- Campaign
- Experimental set-up
- Results
- Outlook
- Acknowledgement
- Q&A

Motivation



According to the U.S. EPA’s Exposure Factors Handbook (EPA 2011), an adult male of normal weight with moderate activity for 16 hours and rest for 8 hours consumes ~22.8 m^3 of air per day.

~22.8 $m^3 \cdot 1.2$ kg. m^3 = ~27.36 kg

Ref: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8672270/

Motivation

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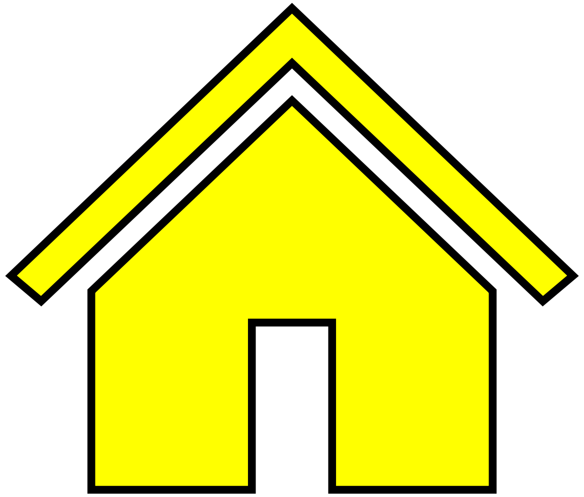
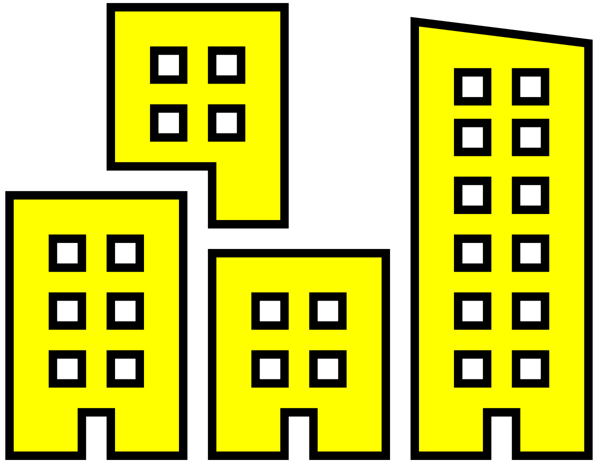
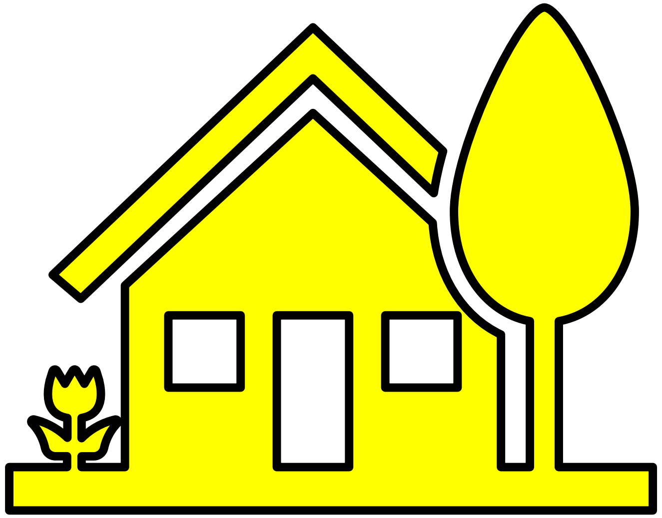
90%

OF TIME IS SPENT INDOORS







Background

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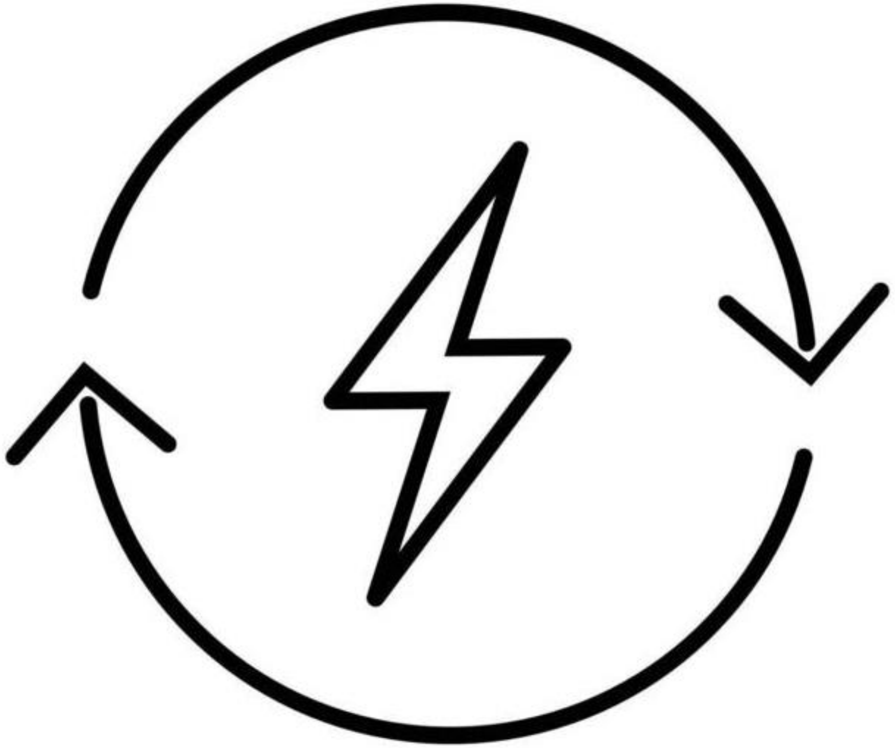


- **ENERGY EFFICIENCY**
  in building sector
- **Energy Performance of Buildings**
  Directive 2010/31/EU
- by 2021, all new buildings have to be zero-energy buildings

BUILDING RENOVATION

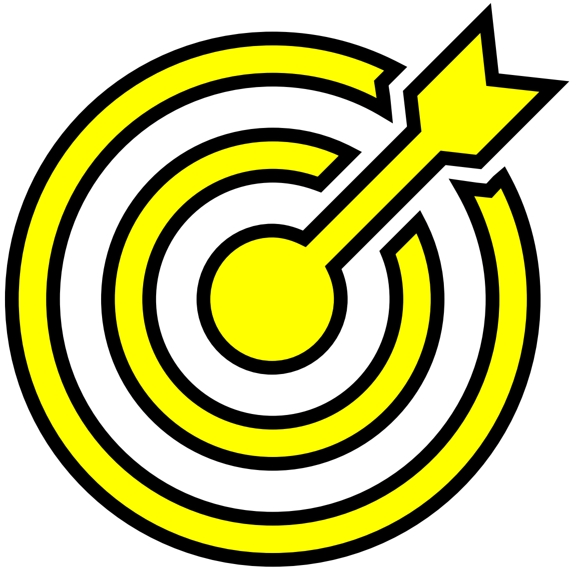
Energy Efficiency

Air Pollutants → Health Effects

A limited number of studies worldwide have assessed the potential effects of improved energy efficiency on health.

Goal

The study aimed to evaluate the effects of improving the energy efficiency of buildings (retrofit activities) on temporal and spatial variations of PM concentrations in multifamily apartment buildings in Lithuania and Finland.



Finland & Lithuania

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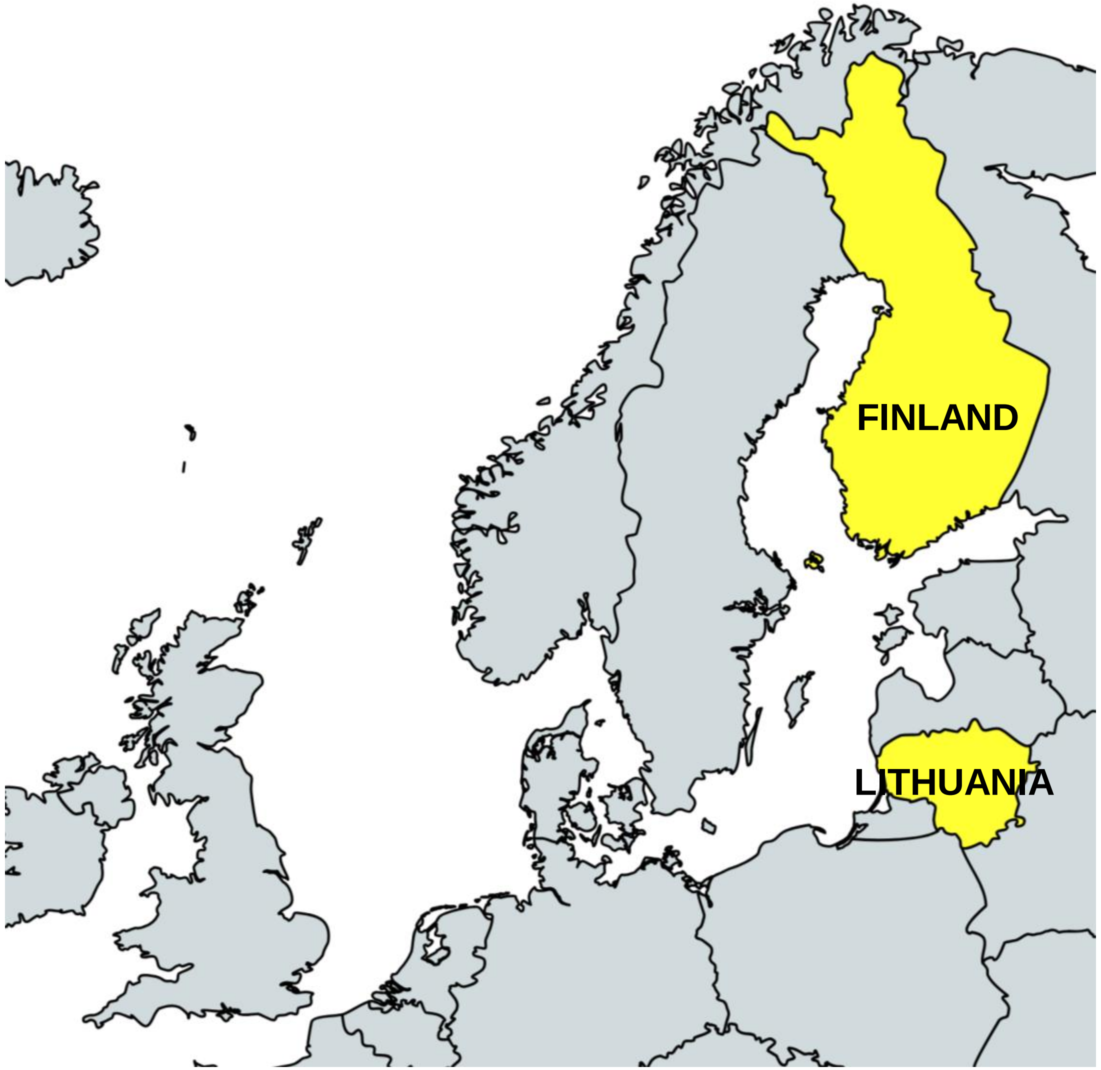

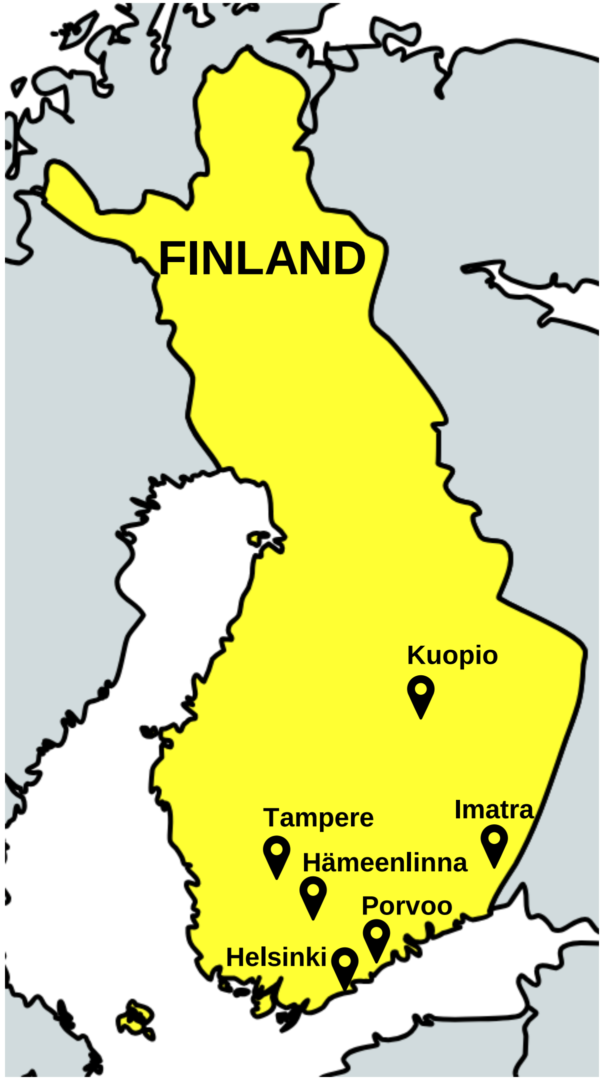

Measurement setup

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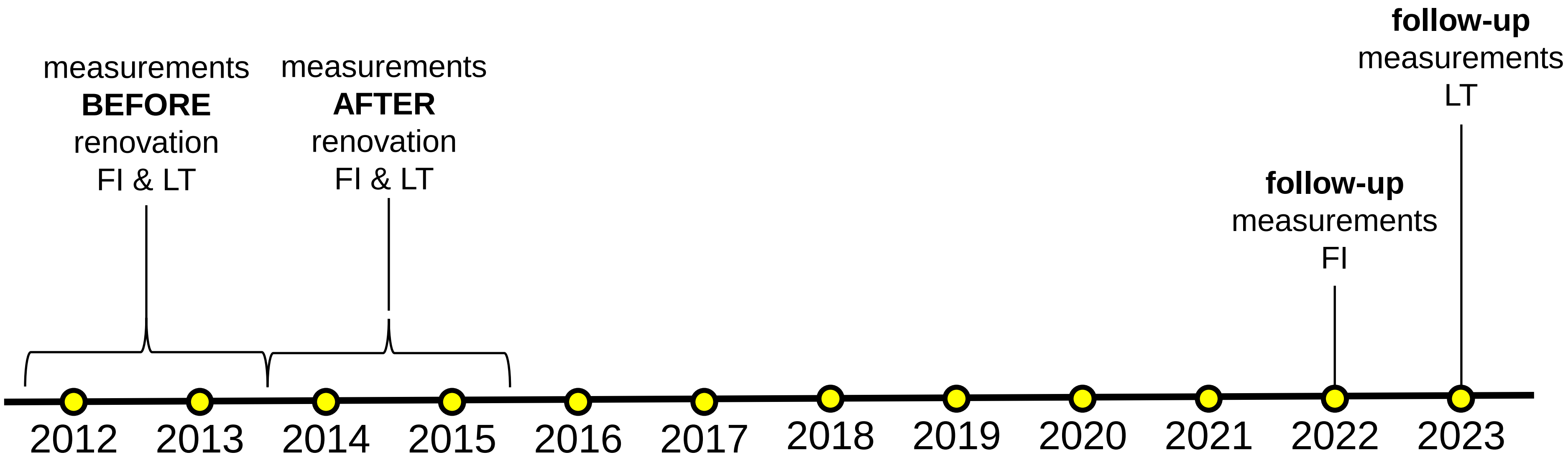
Measurements – during heating season

- heating seasons of 2012-2015 and 2022-2023
- pre-retrofitting assessments were conducted one year before the building renovation
- during heating seasons to minimize outdoor impact on the results
- follow-up visits (after retrofits) were done during the corresponding season, as the first visits



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Measurement setup

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FINLAND

6 cities

46 buildings
241 apartments

CONTROL

8 buildings
30 apartments

CASE

38 buildings
211 apartments

LITHUANIA

1 city

20 buildings
96 apartments

CONTROL

5 buildings
22 apartments

CASE

15 buildings
74 apartments

CONTROL building – not retrofitted; **CASE** building – retrofitted

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Equipment & Monitoring

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Optical particle counter
OPC, Handheld 3016 IAQ, Lighthouse Inc., USA

- monitoring was conducted over 24 hours in each apartment
- data-logging intervals of every 1 minute
- measurement equipment was consistently positioned in apartments before and after retrofits

StatSoft®
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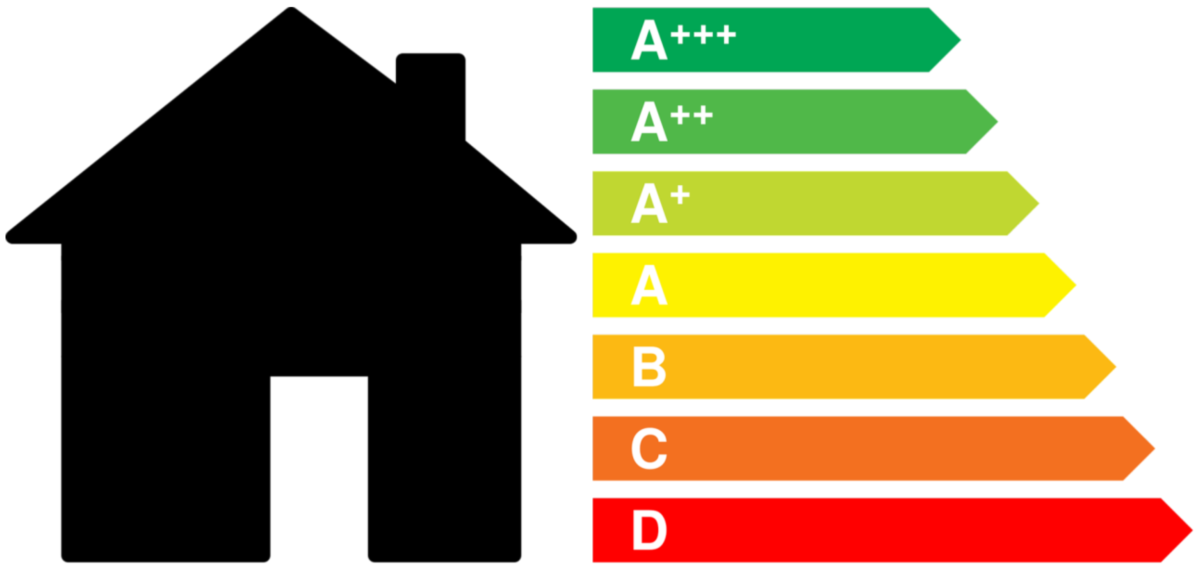
Retrofits



Retrofits included facade insulation and ventilation upgrades and were categorized as either focused energy retrofits or deep energy retrofits.

Results

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- $PM_{2.5}$ and PM_{10} levels
- $PM_{2.5}$ concentration decay rates
- $PM_{2.5}$ / PM_{10} ratio
- $PM_{2.5}$ night-time concentration levels
- $PM_{2.5}$ day-time concentration levels

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Results | $PM_{2.5}$ and PM_{10} levels

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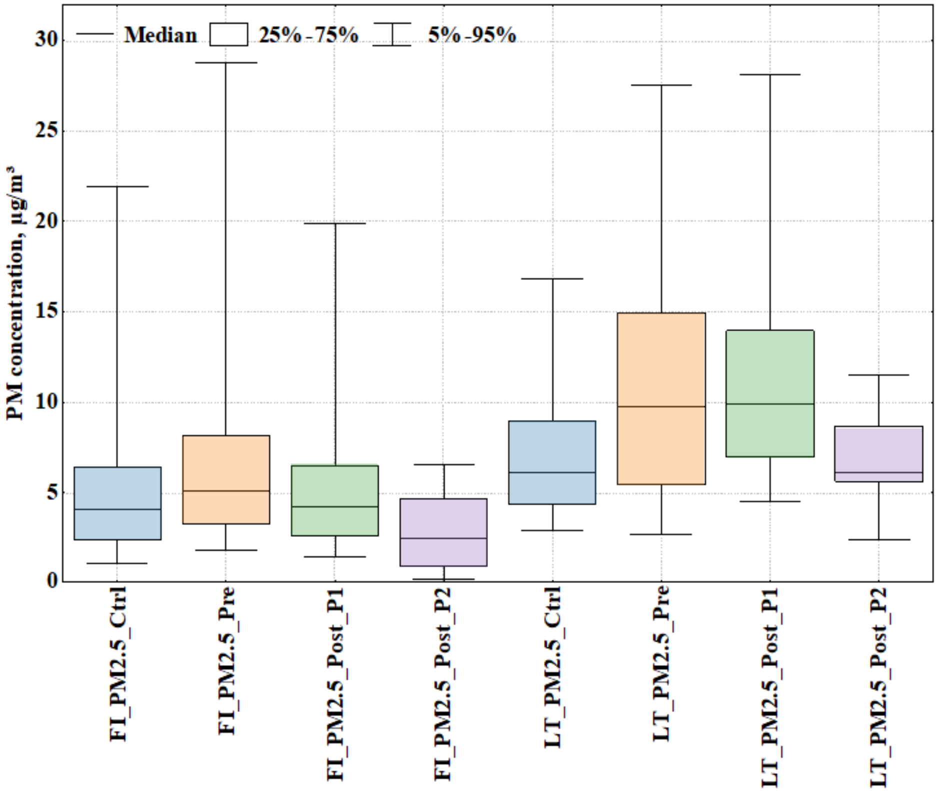
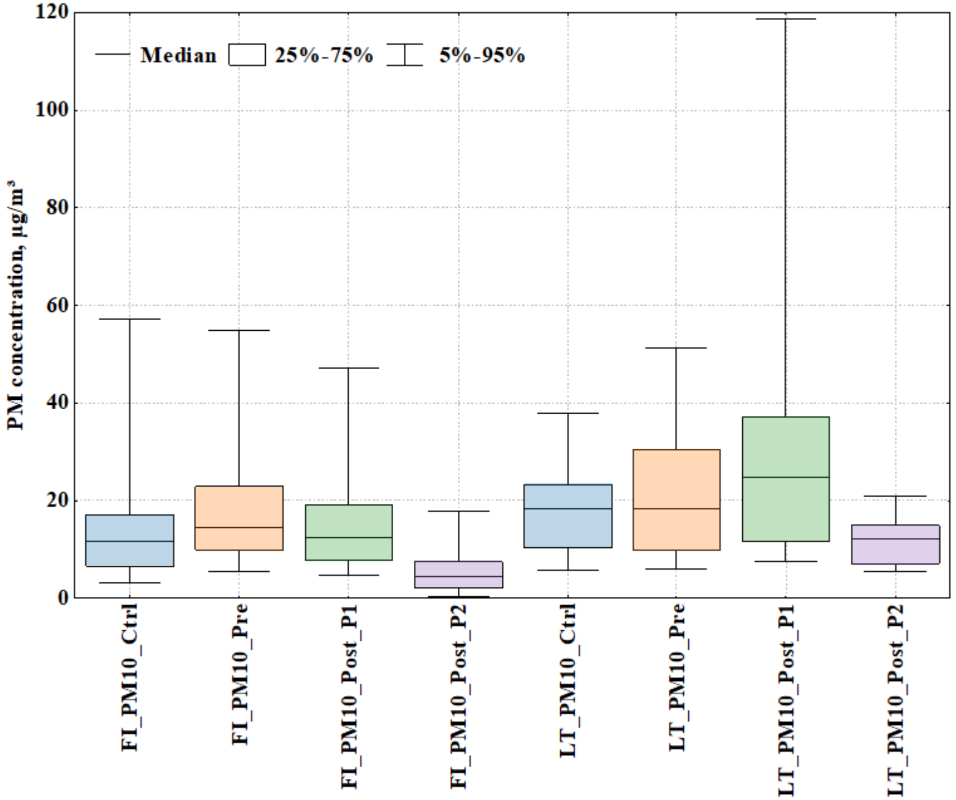


a)



b)

Figure 1. a) $PM_{2.5}$ and b) PM_{10} levels in control and case buildings in Finland (FI) and Lithuania (LT) before (Pre) and after (Post) the retrofits during 2012-2015 (P1) and 2022-2023 (P2) measurements.

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Results | $PM_{2.5}$ concentration decay rates

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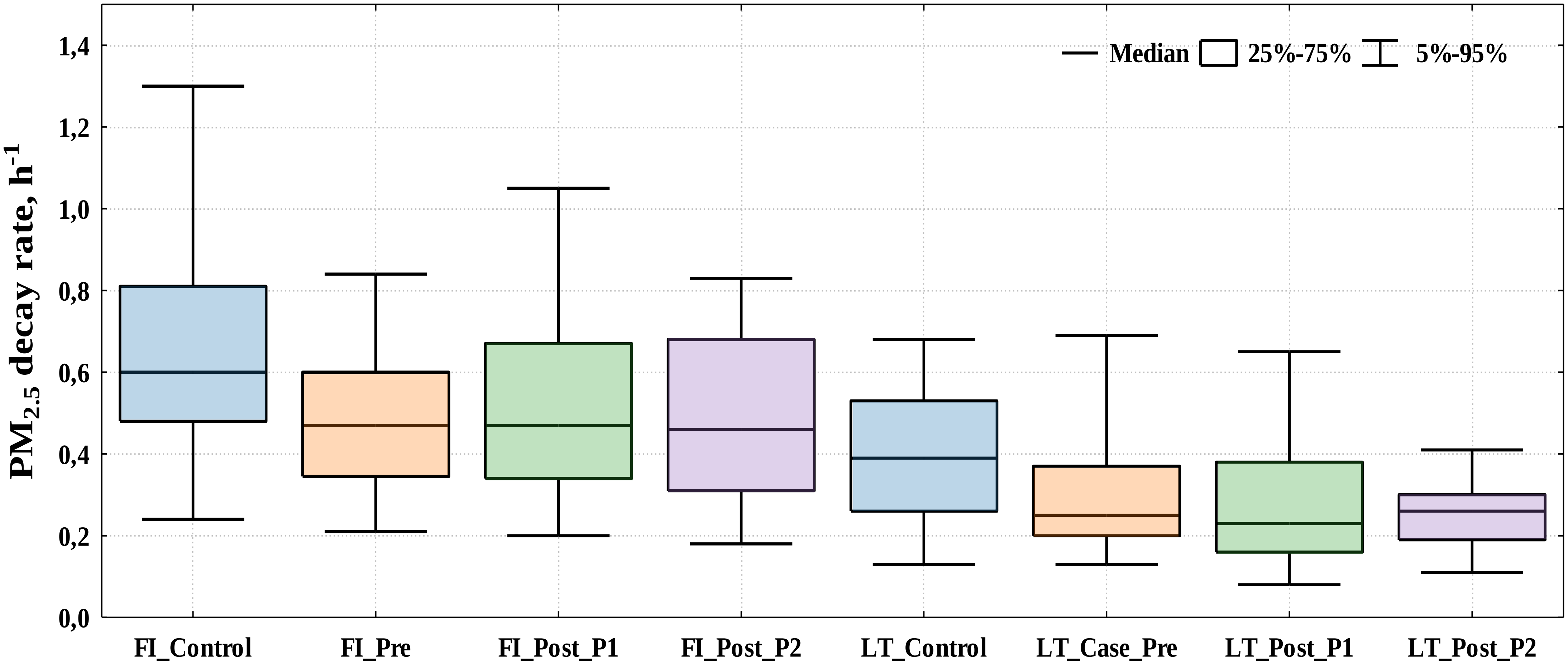

Figure 2. $PM_{2.5}$ concentration decay rates in case and control buildings in Finland (FI) and Lithuania (LT) before (Pre) and after (Post) the retrofits during 2012-2015 (P1) and 2022-2023 (P2) measurements.

Results | $PM_{2.5}$ / PM_{10} ratio

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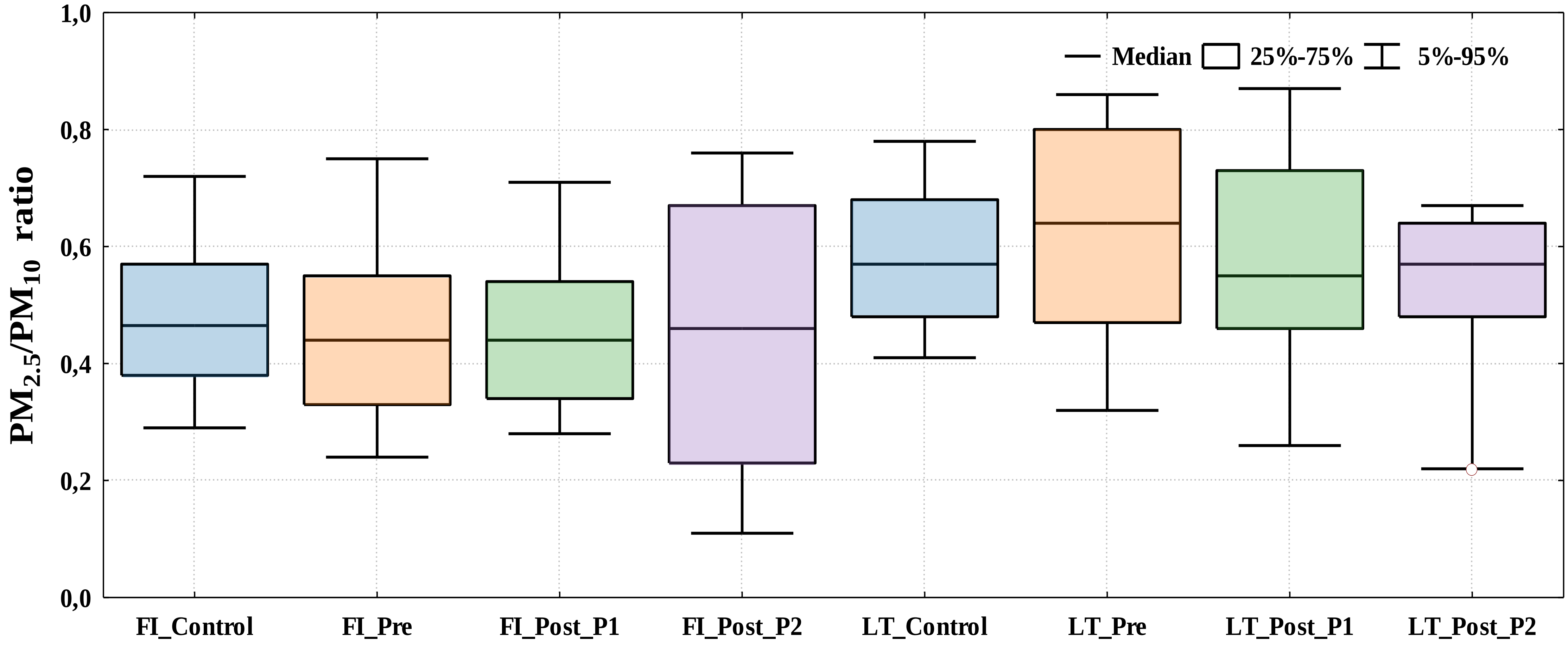

Figure 3. PM2.5/PM10 ratio in case and control buildings in Finland (FI) and Lithuania (LT) before (Pre) and after (Post) the retrofits during 2012-2015 (P1) and 2022-2023 (P2) measurements.

Results | $PM_{2.5}$ night-time concentration levels

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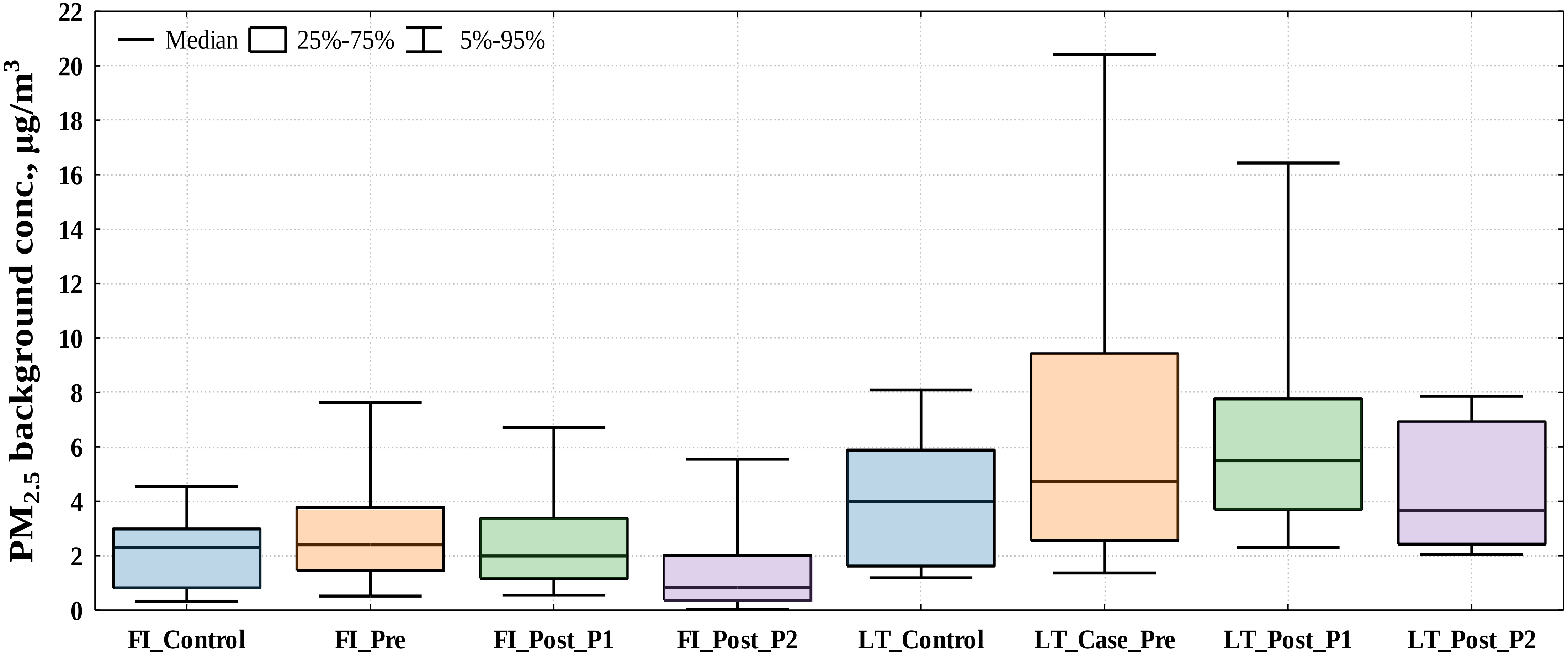

Figure 4. PM2.5 night-time concentration levels in case and control buildings in Finland (FI) and Lithuania (LT) before (Pre) and after (Post) the retrofits during 2012-2015 (P1) and 2022-2023 (P2) measurements.

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Results | $PM_{2.5}$ day-time concentration levels

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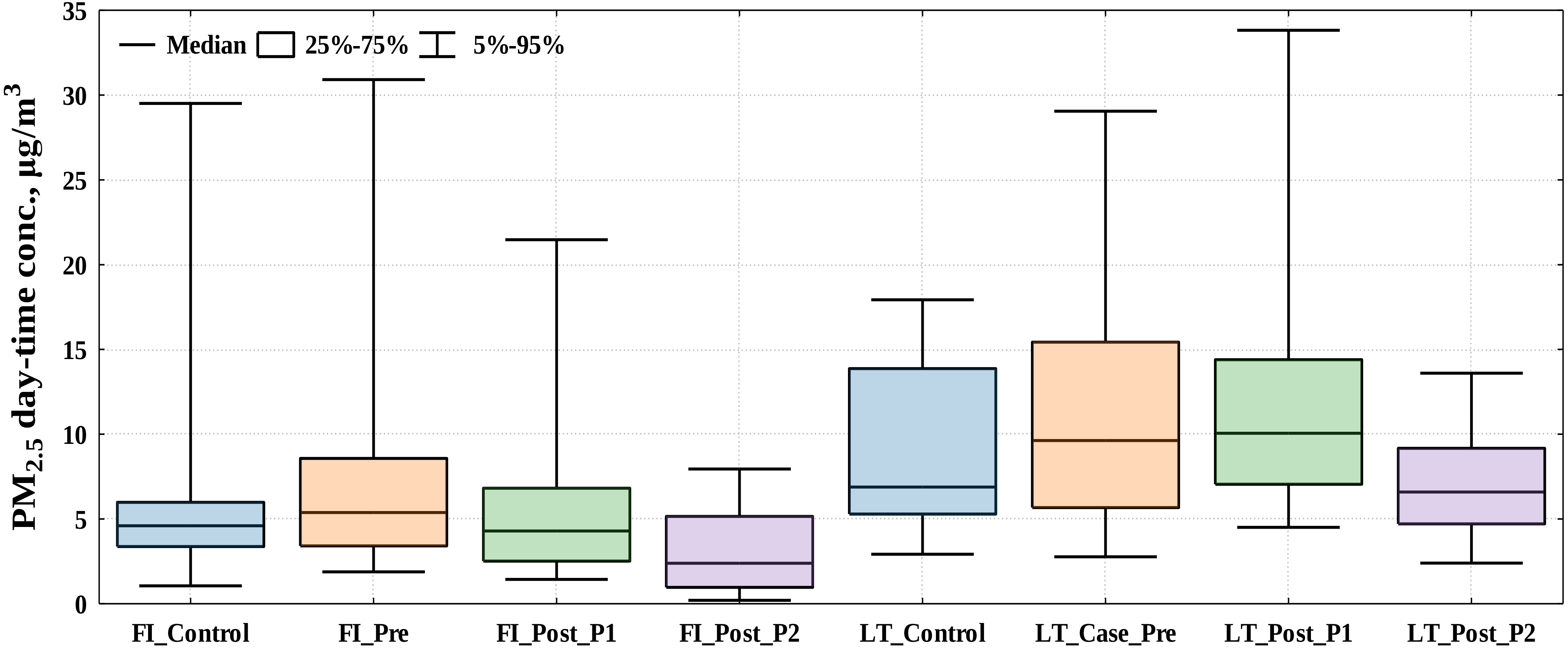

Figure 5. PM2.5 day-time concentration levels in case and control buildings in Finland (FI) and Lithuania (LT) before (Pre) and after (Post) the retrofits during 2012-2015 (P1) and 2022-2023 (P2) measurements.

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Summary & Conclusons

- The study findings suggest that energy retrofits can reduce indoor PM concentrations, rein-forcing the role of such implementations in improving IAQ.
- The observed variability over time also highlights the complexity of the relationship between building retrofits and long-term air quality improvement.
- Some factors, such as outdoor PM levels and exist-ing indoor pollutant sources, were not controlled because the study was conducted in a residential environment. These factors may influence the outcomes and should be considered when interpreting the results.

Acknowledgement

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  was funded by Academy of Finland - Academy Project

Comments & Questions

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