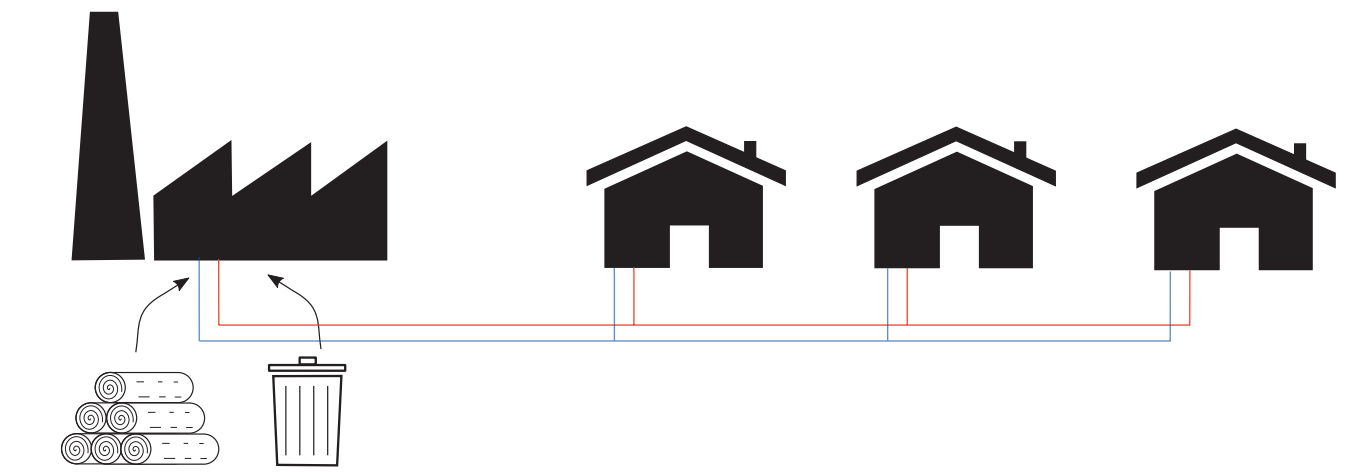# A machine-learning model for the prediction of aggregated building heating demand from pan-European land-use maps

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[1]Idiap Research Institute, Martigny, Switzerland
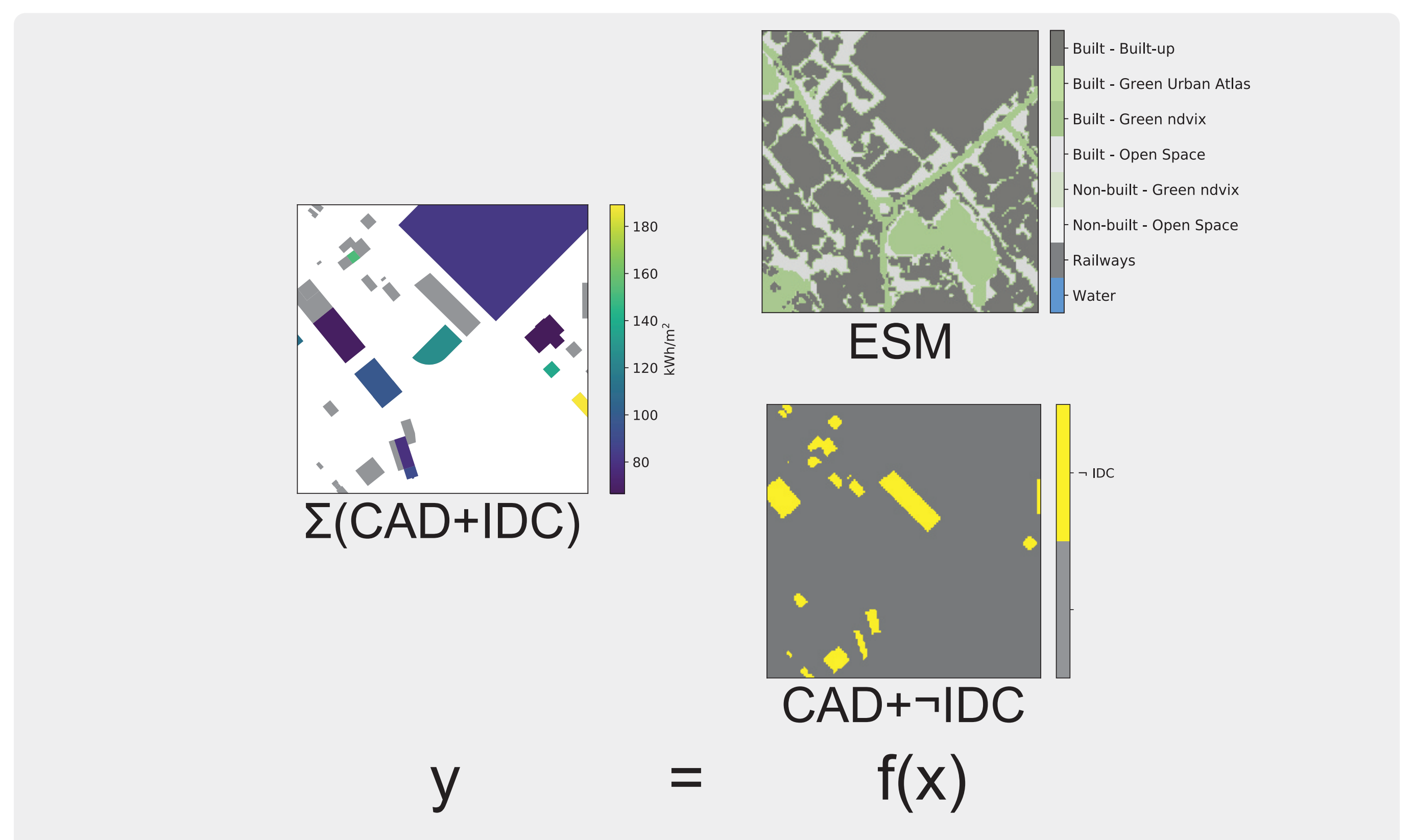[2]EPFL, Lausanne, Switzerland

## OBJECTIVES

- Energy **heating density** predicted on up to 100-m-wide tiles
- A machine-learning model based on **land-use maps only**
- Training and European-wide deployability based on **open data**
- Possible applications for **district heating network** (DHN) potential analysis
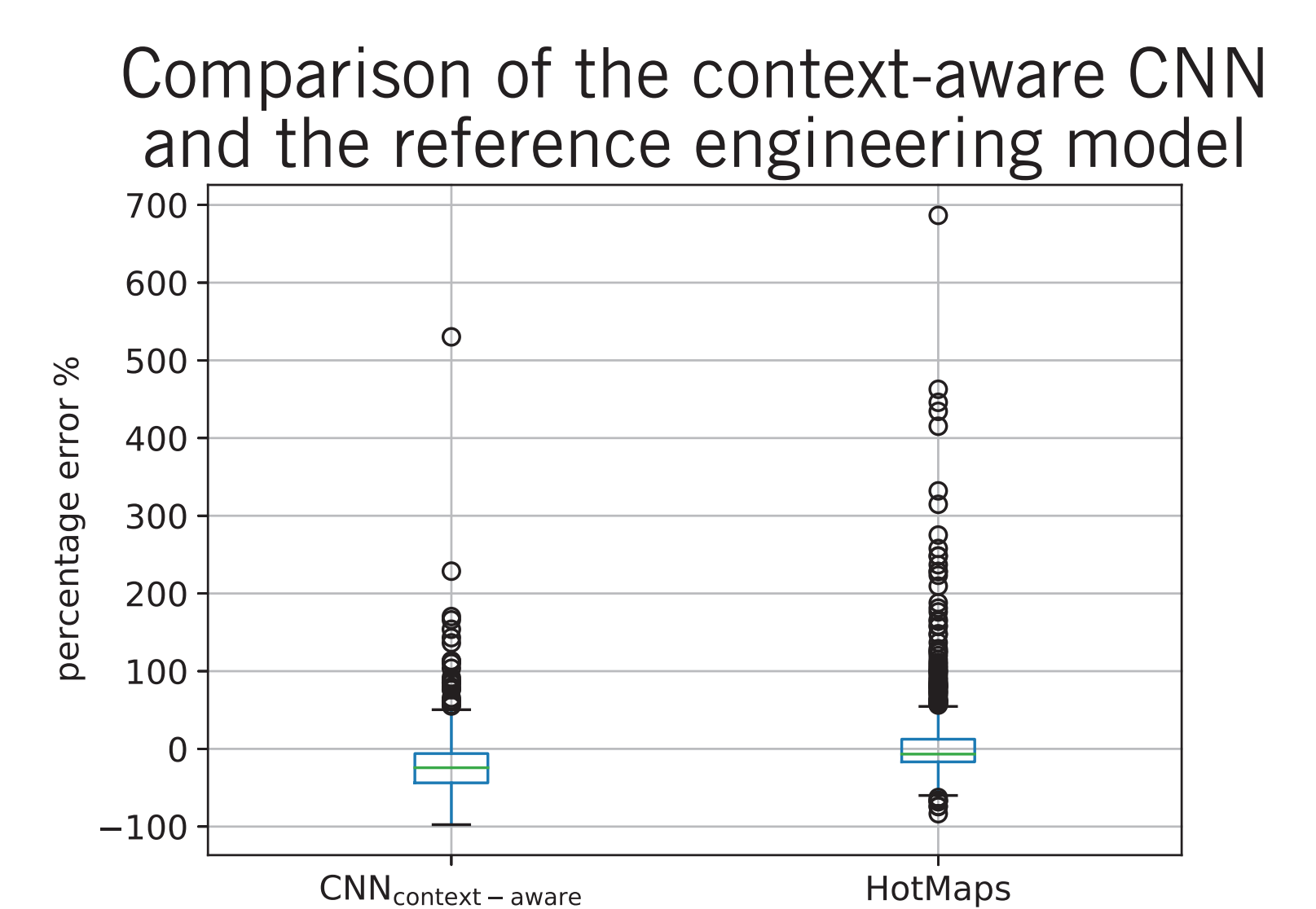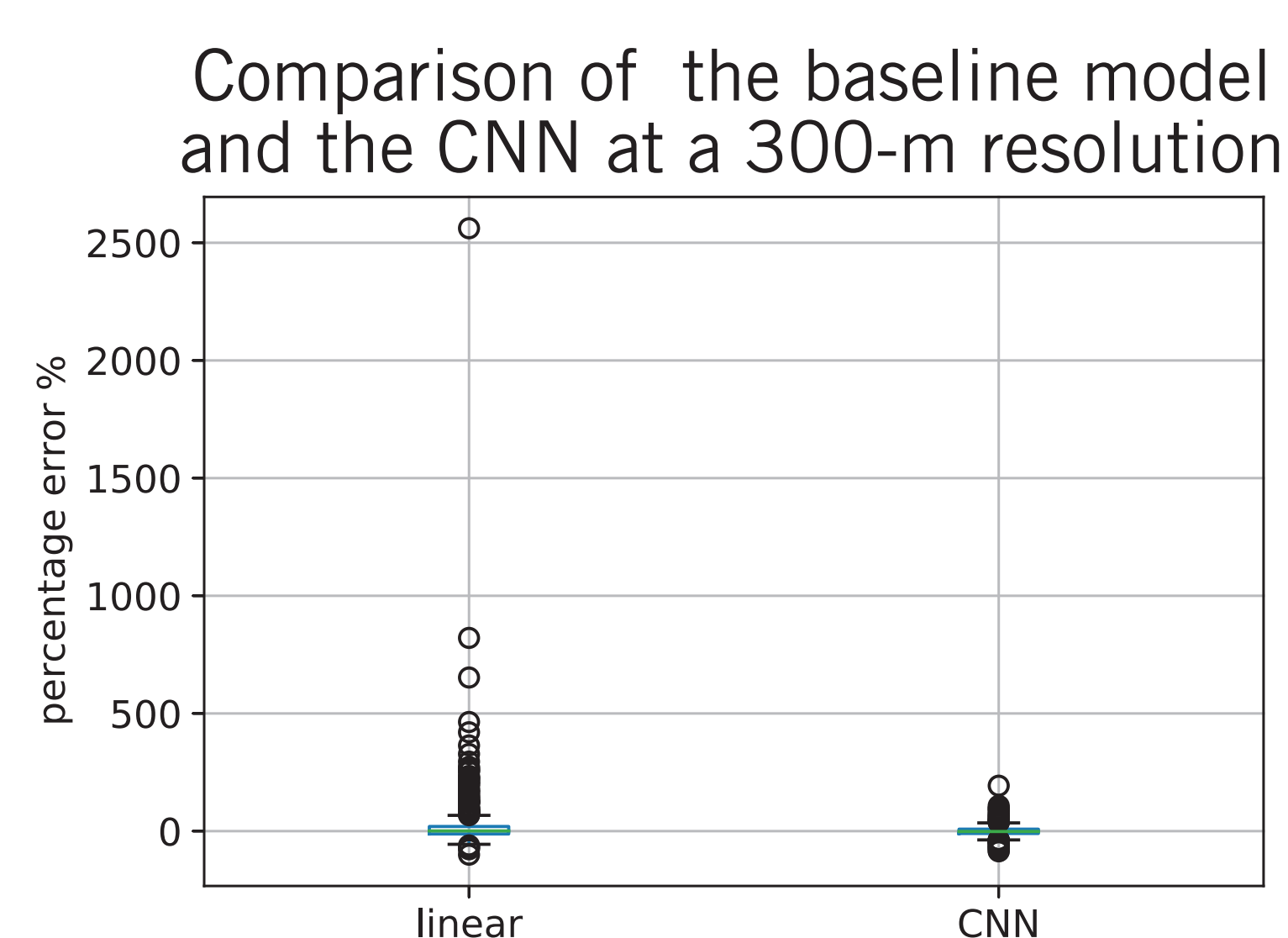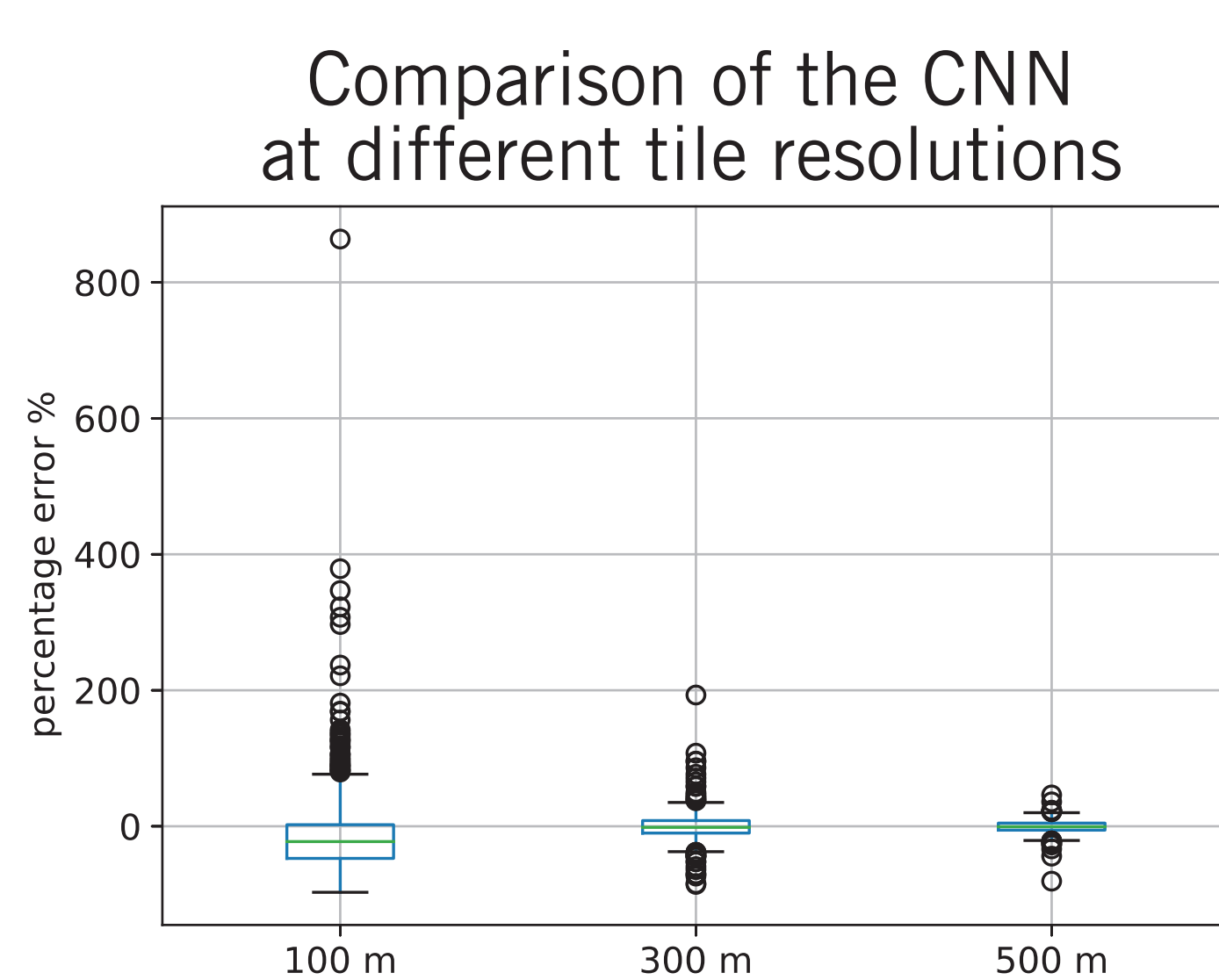
## METHODOLOGY

- A **convolutional neural network** (CNN) trained and tested on building heating demand (IDC) and cadaster (CAD) datasets for over 16,000 buildings in Geneva area (60-20-20% split) using the European settlement map (ESM) as input
- Comparison with a **reference engineering model** (Hotmaps) and a **baseline linear model**
- Spatial aggregation on a fishnet grid (**100, 300, 500-m wide tiles**) including a 100-m buffer for the context-aware model
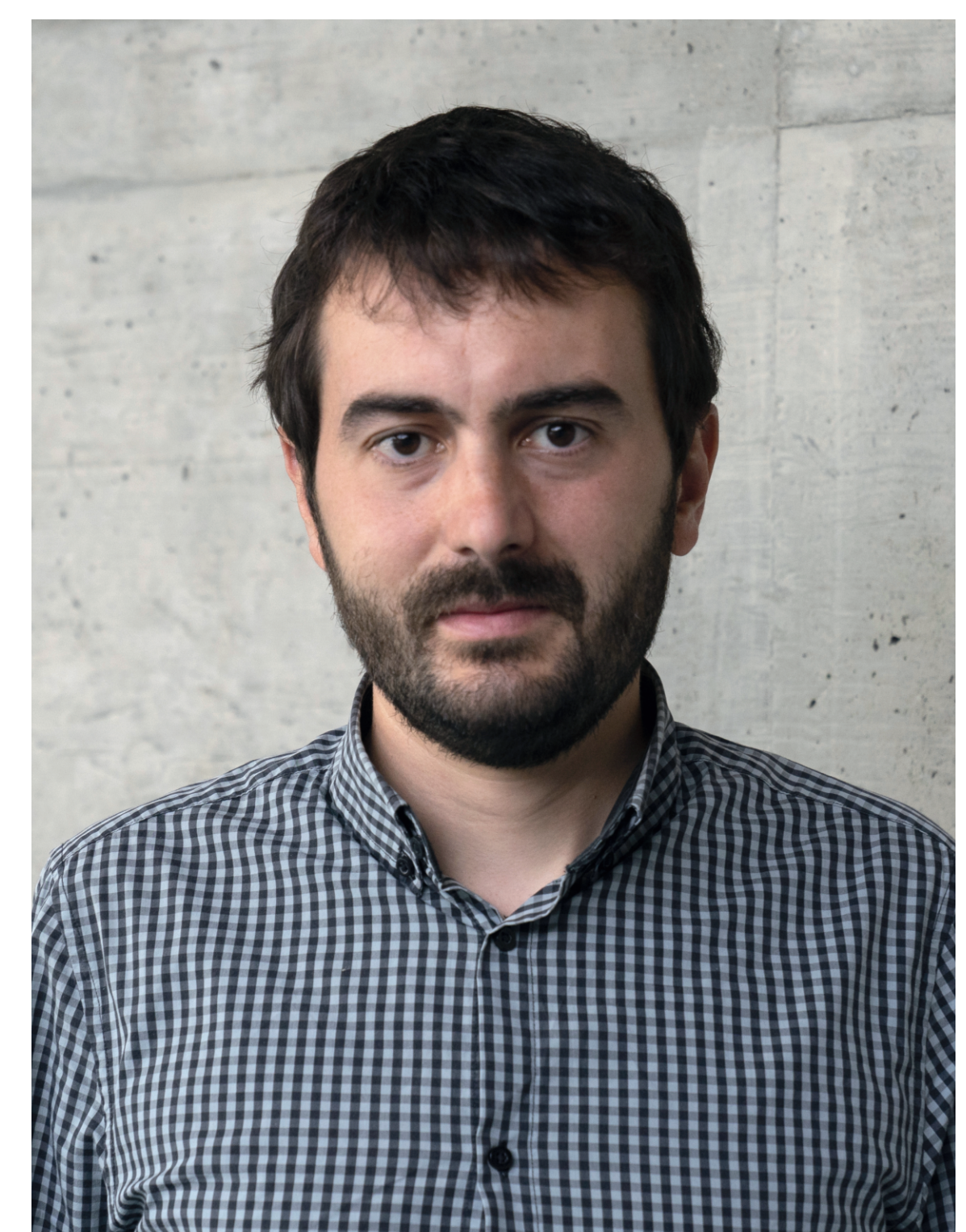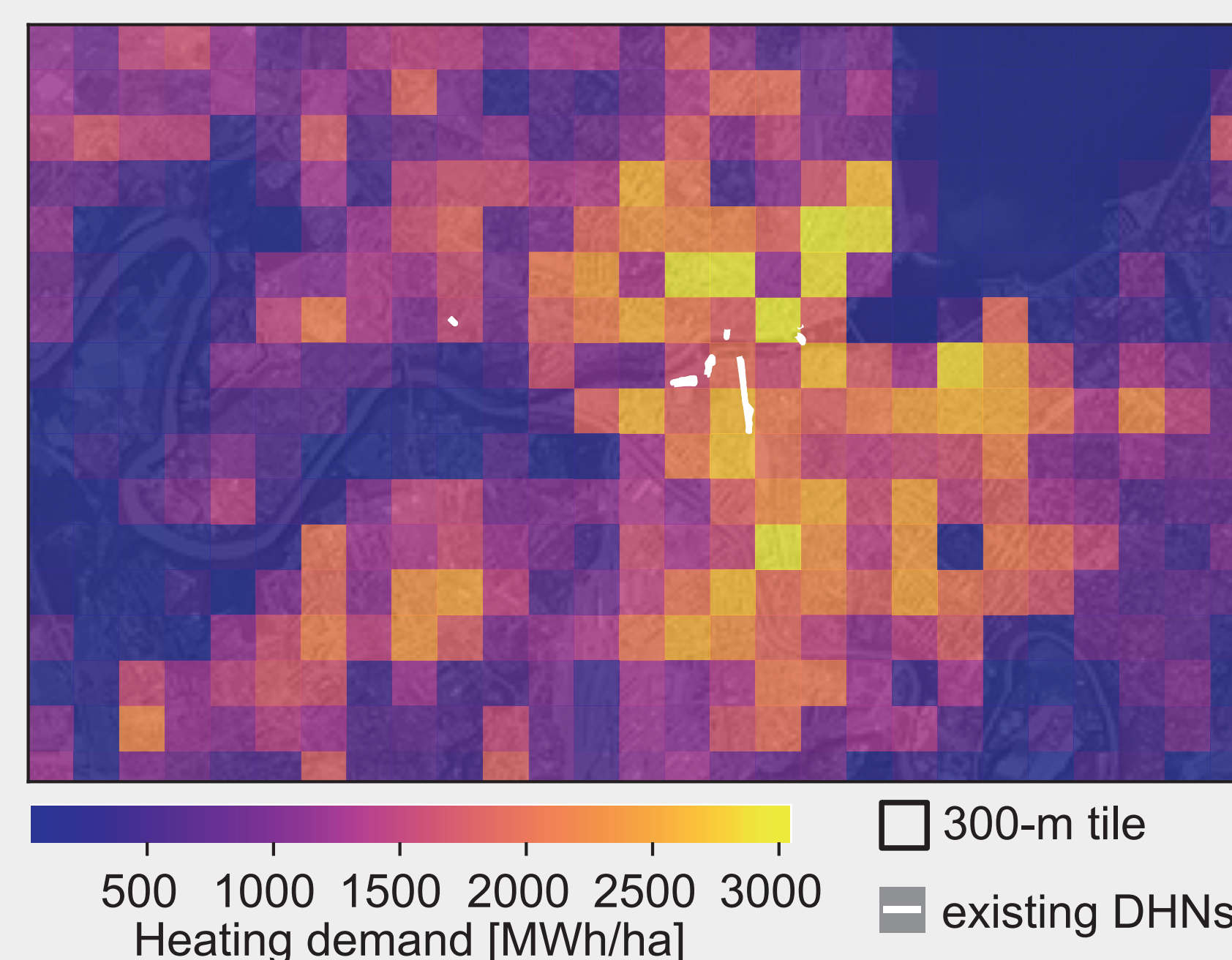


$$y = f(x)$$

## RESULTS

- **Outperformance** over baseline (37 to 13% error)
- Greater accuracy with increasing tile resolution, up to **6.6% error for a 500-m resolution**
- For a 100-m resolution, improvement of about 9 % points (mean error**)** using a **context-aware CNN**

| | | Absolute percentage error | | |
| --- | --- | --- | --- | --- |
| | Resolution | Median | Mean | STD |
| CNN | 500 m | 5.2% | 6.6% | 6.6% |
| CNN | 300 m | 9.4% | 13.4% | 16.1% |
| Linear model | 300 m | 14.3% | 37.2% | 122.4% |
| CNN | 100 m | 34.7% | 42.4% | 49.3% |
| CNN$_{context-aware}$ | 100 m | 28.1% | 33.7% | 30.5% |
| Hotmaps | 100 m | 15.8% | 28.4% | 50.9% |



Comparison of the CNN at different tile resolutions



Comparison of the baseline model and the CNN at a 300-m resolution



Comparison of the context-aware CNN and the reference engineering model

## CONCLUSIONS AND OUTLOOK

- The model reaches similar accuracy as Hotmaps engineering model, but with **fewer, more widely available and open-access input data**
- **DHN-suitable areas** shown by the model predictions are intuitively located in inner urban areas
- The model is ready to be deployed as an **on-the-fly calculation module** in the EnerMaps web platform



500 1000 1500 2000 2500 3000
Heating demand [MWh/ha]
□ 300-m tile
▦ existing DHNs



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