Use of GIS for energy modelling of Trondheim's building stock

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Introduction

Increasing demand of electricity → Measures that help to reduce energy demand and capacity issues

Planification and decision of which and where the measures should be implemented as smart and efficient as possible

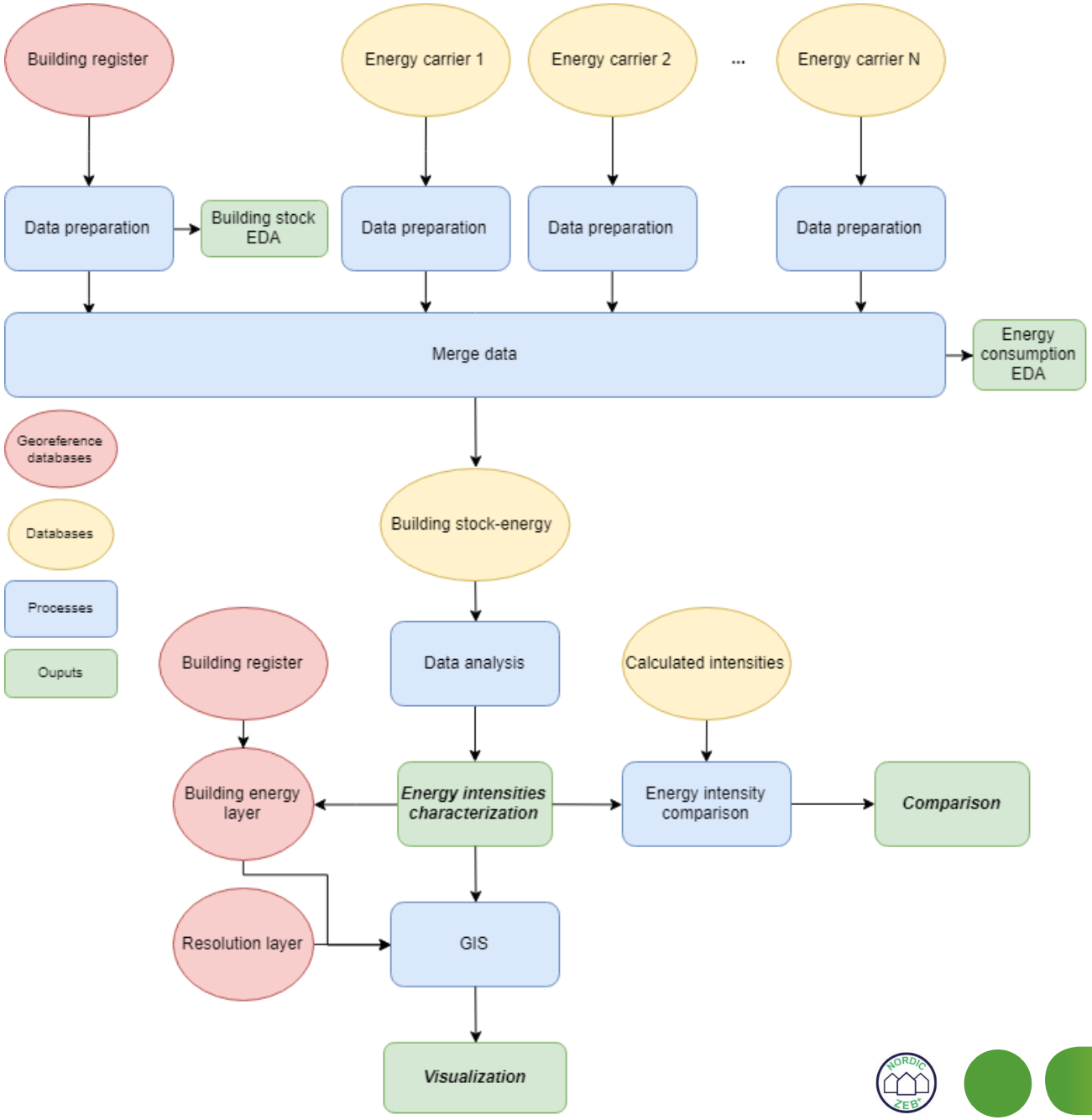
Goal of the study

Combine GIS and real energy data in order to provide a better understanding of the spatial distribution of electricity and heat consumption of non-residential buildings of Trondheim

Research questions

- What characterises the **energy intensities** of different types of non-residential buildings in Trondheim?
- How is the current energy use of Trondheim´s building stock **spatially distributed**, for different types and age cohorts of non-residential buildings?
- What is the **appropriate methodology** in order to calculate and visualize the energy use aspects for non-residential building stocks?
- Why should energy maps become **valuable tools** when analysing energy systems and in decision making?

Methodology: General framework



Methodology: Data analysis and GIS

Database name	Information	Number of records (before and after the cleaning process)	Year(s) / Location	Source
Building stock database	Specific information for each dwelling/unit in Trondheim	Before: 42 099 (for Trondheim) After: 39 224 (for Trondheim)	2018 / Norway	(Geodata, 2018)
Heat consumption database	Measured heat consumption from the building stock covered by the district heating supplier	Before: 2 262 After: 1 090 (628 non-residential)	2018/Norway and Sweden	(Statkraft Varme, 2018b)
Electricity consumption database	Measured electricity consumption	Before: - After: 29 076 (1 370 non-residential)	2013-2018 / Trondheim	(TronderEnergi, 2018)
Calculated energy intensities database	Calculated energy intensities for office, businesses and educational buildings	-	2018 / Oslo	(Sandberg, 2019)

Building stock information

- Age, type and useful floor area ← main properties
- Exclusion of building typologies not significantly energy demanding from electricty and district heating sources
- Classification by types and age cohorts

Methodology: Data analysis and GIS

TEK	Years
<1949	-1949
TEK49	1950-1968
TEK69	1969-1986
TEK87	1969-1996
TEK97	1997-2006
TEK07	2007-2009
TEK10	2010-2016
TEK17	2017-2018

Building type	Area analysed (m^2)	Electricity only records	Heat only records	Electricity and heat records
Business	1 376 227 (88%)	430	107	83
Cultural/Sport	260 966 (67%)	149	58	39
Education	720 283 (69%)	236	113	69
Health	380 081 (77%)	67	31	22
Industry	499 567 (66%)	155	70	51
Office	887 315 (77%)	236	84	64
Service	26 632 (9%)	97	24	19
Total	4 183 018 (73%)	1370	487	347

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Methodology: Data analysis and GIS

Data analysis

- Cleaning and pre-processing of real energy data and building stock information
- EDA (Exploratory Data Analysis)

Visualization

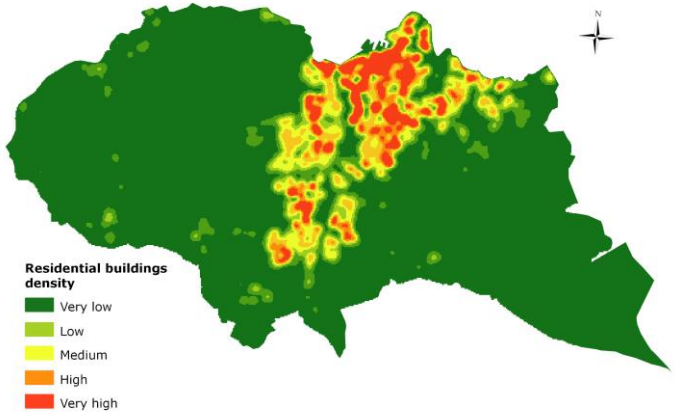
- Regulations must be taken into account
- Developed different spatial resolutions

Basic calculations

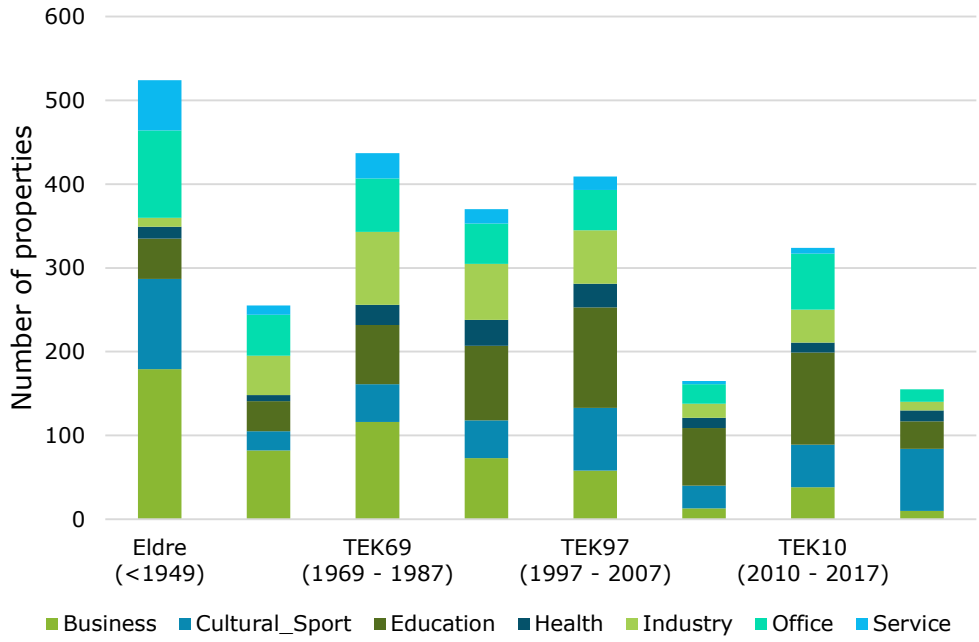
Individual building intensties	Non-skewed energy intensities distributions	Skewed energy intensities distributions
$EI_{b,ec} = \frac{E_{ec,b}}{A_b}$	$EI_{c,t,ec} = \frac{\sum_{b=1}^{n} EI_{b,c,t,ec}}{n} \pm \sigma$	$EI_{c,t,ec} = Q$ where $Q_1 = X_{n+1/4}$, $Q_2 = X_{n+1/2}$ and $Q_1 = X_{3(n+1)/4}$ being X ={$EI_{1,c,t,ec}, EI_{2,c,t,ec}, \dots, EI_{b,c,t,ec}$} an ordered series of data

Results

Building stock

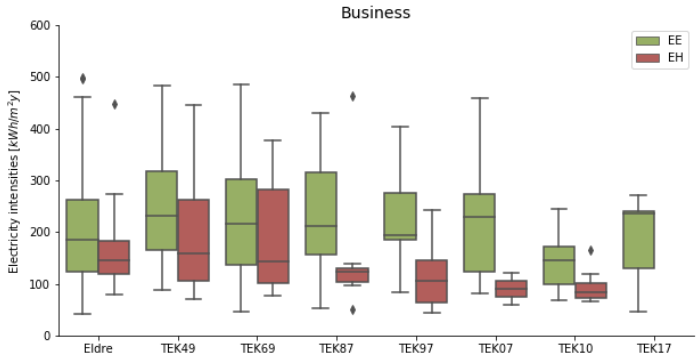


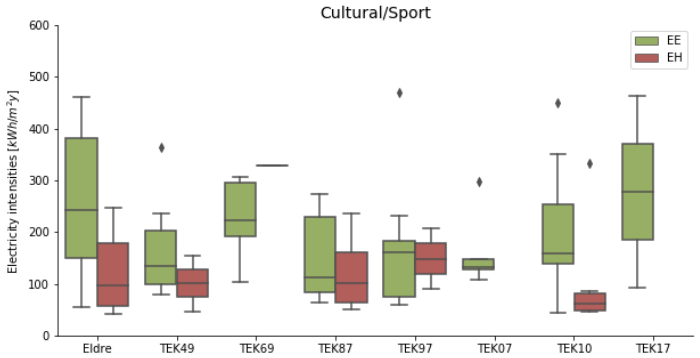
Number of non-residential units in Trondheim by age cohort and typology

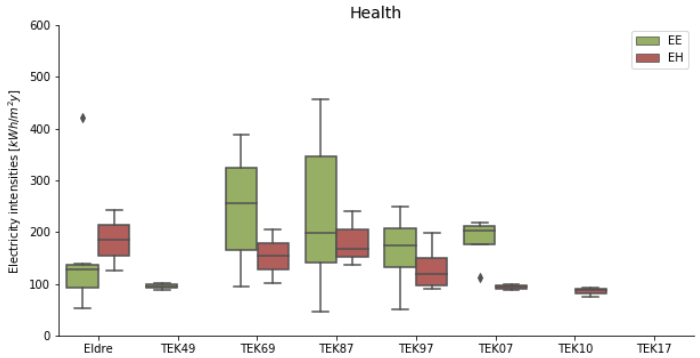


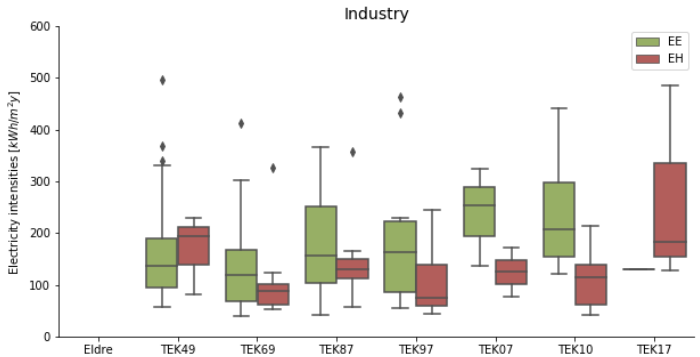
Results

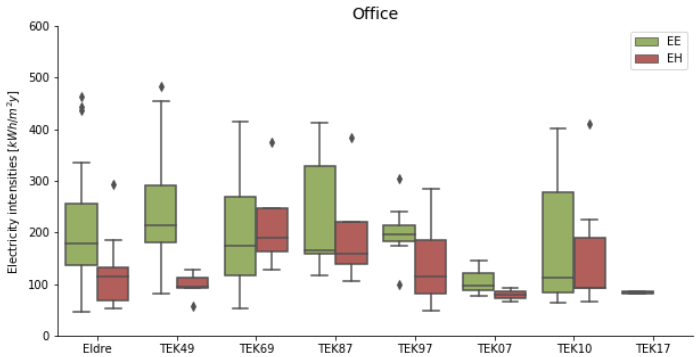
Electricity intensities

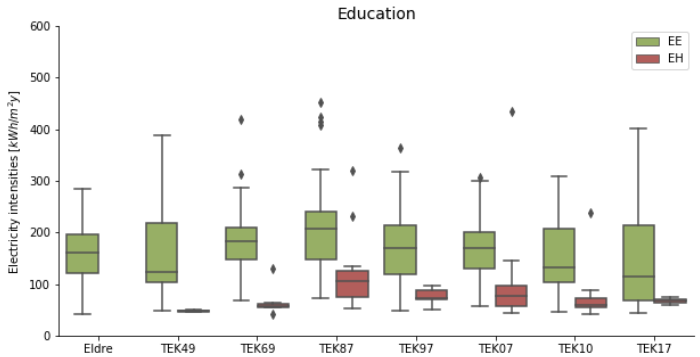






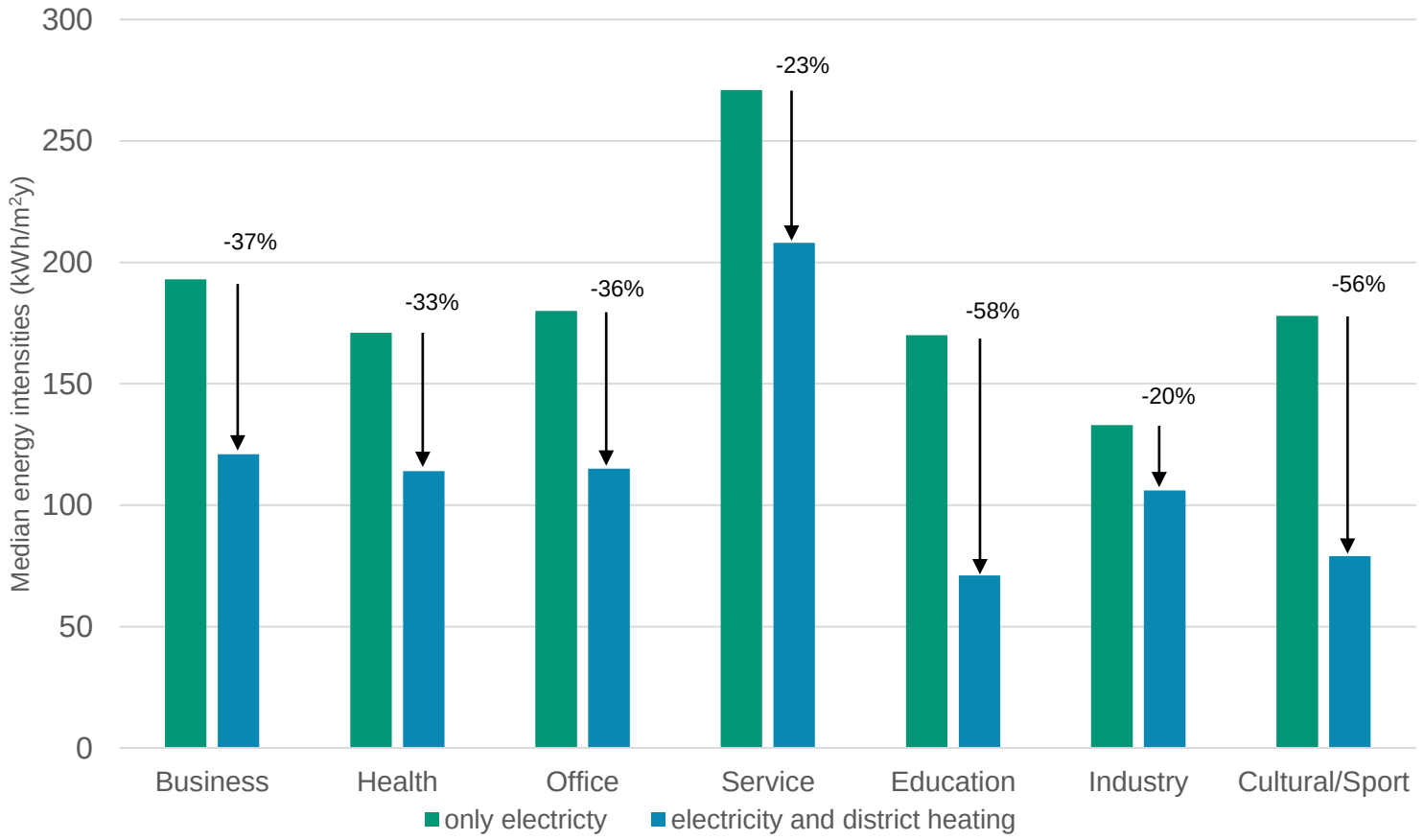






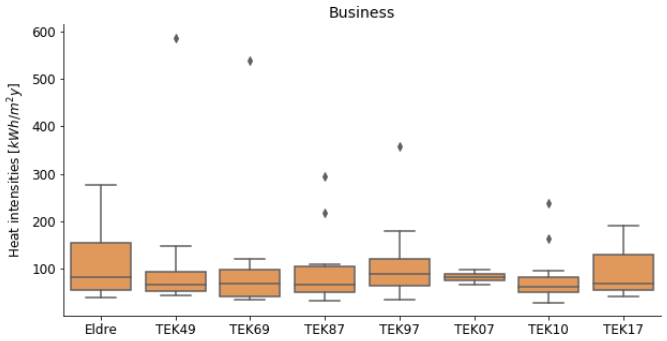
Results

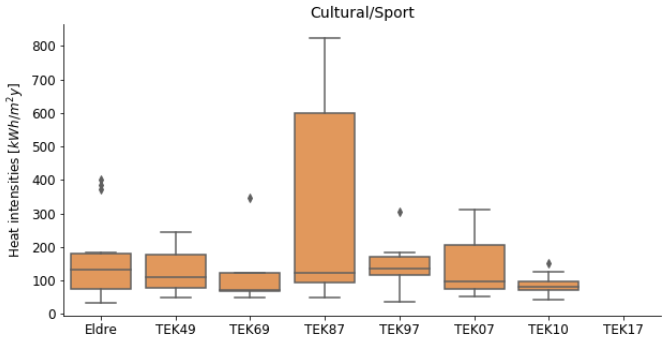
Electricity intensities

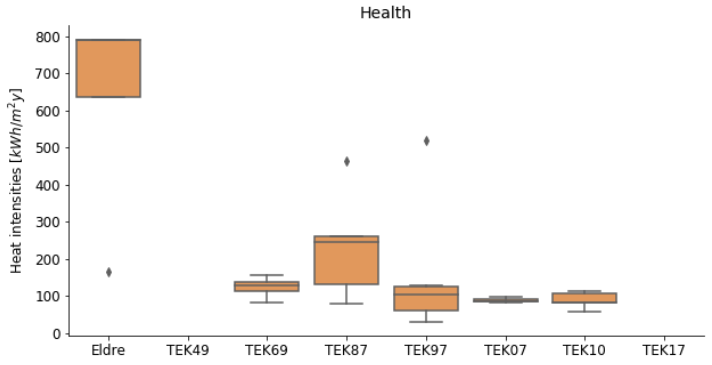


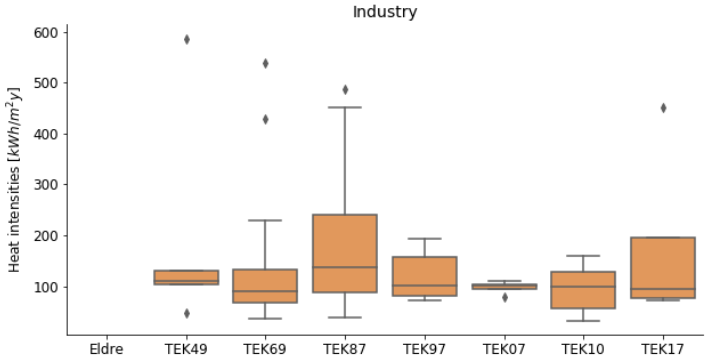
Results

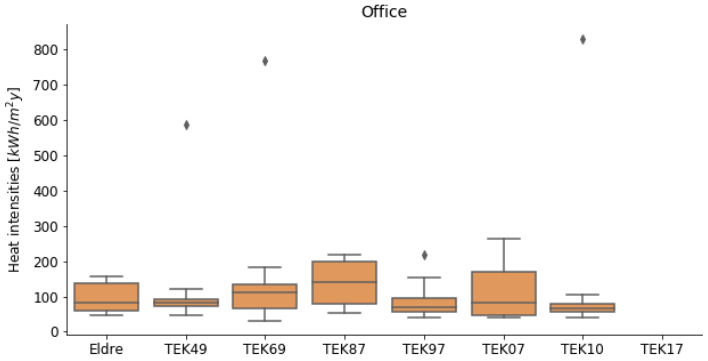
Heat intensities

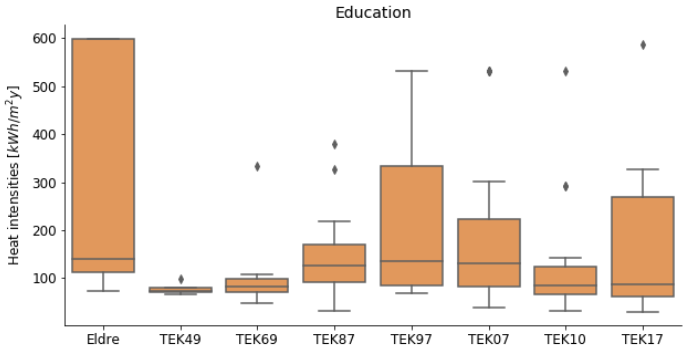






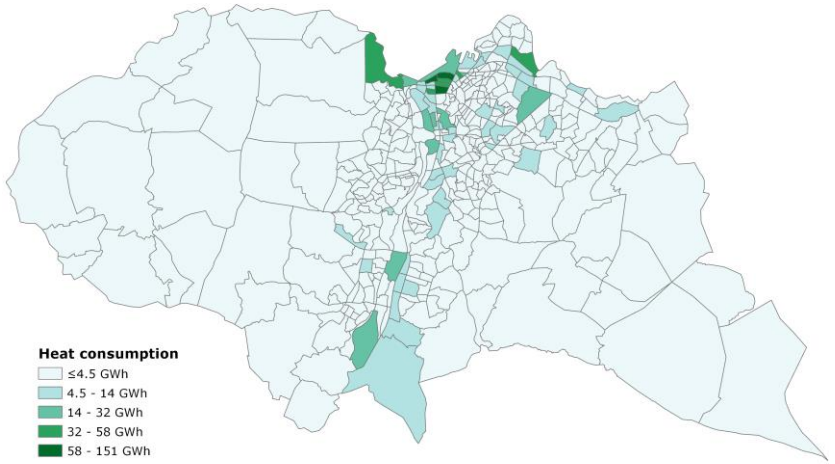


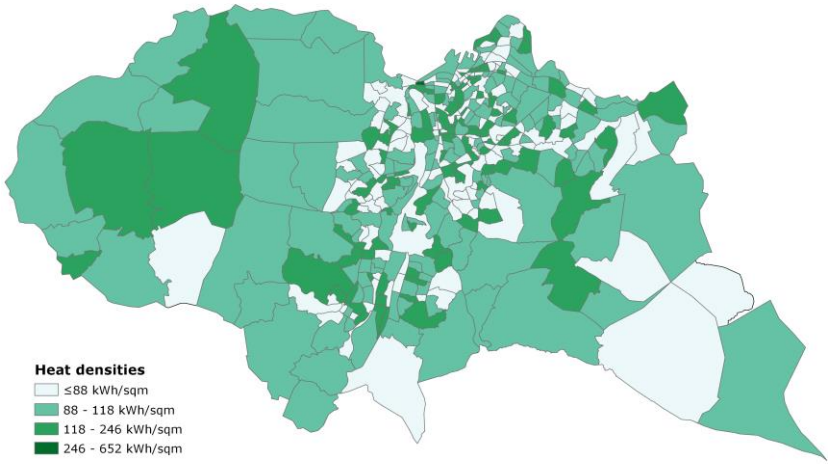


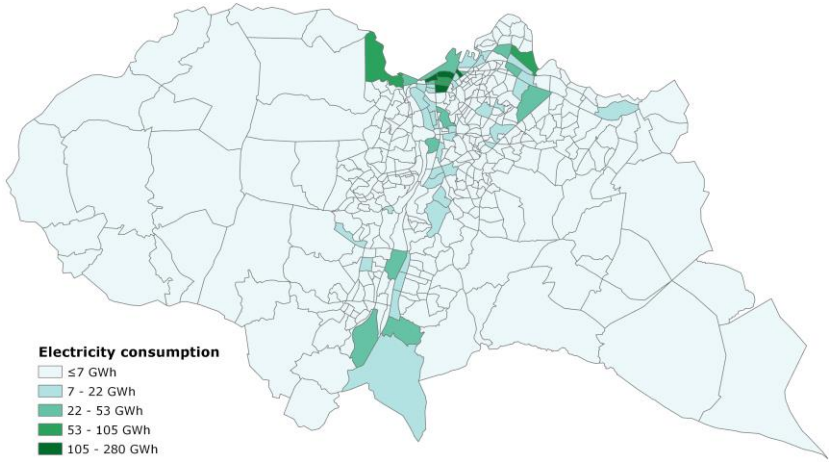


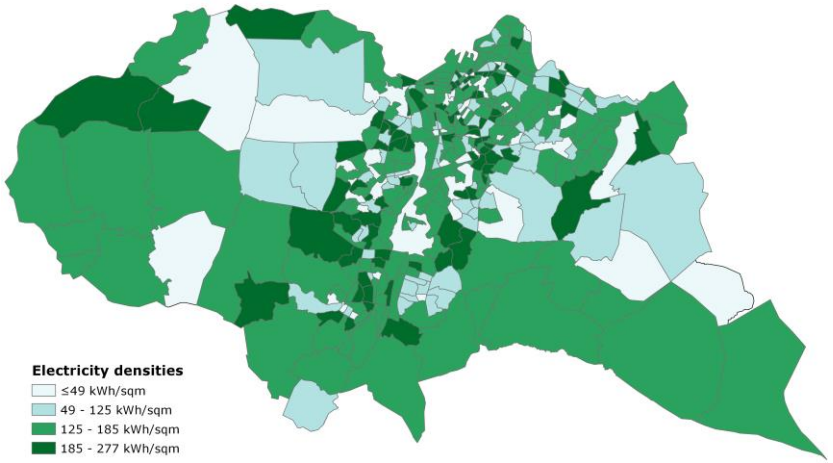
Results

Energy maps



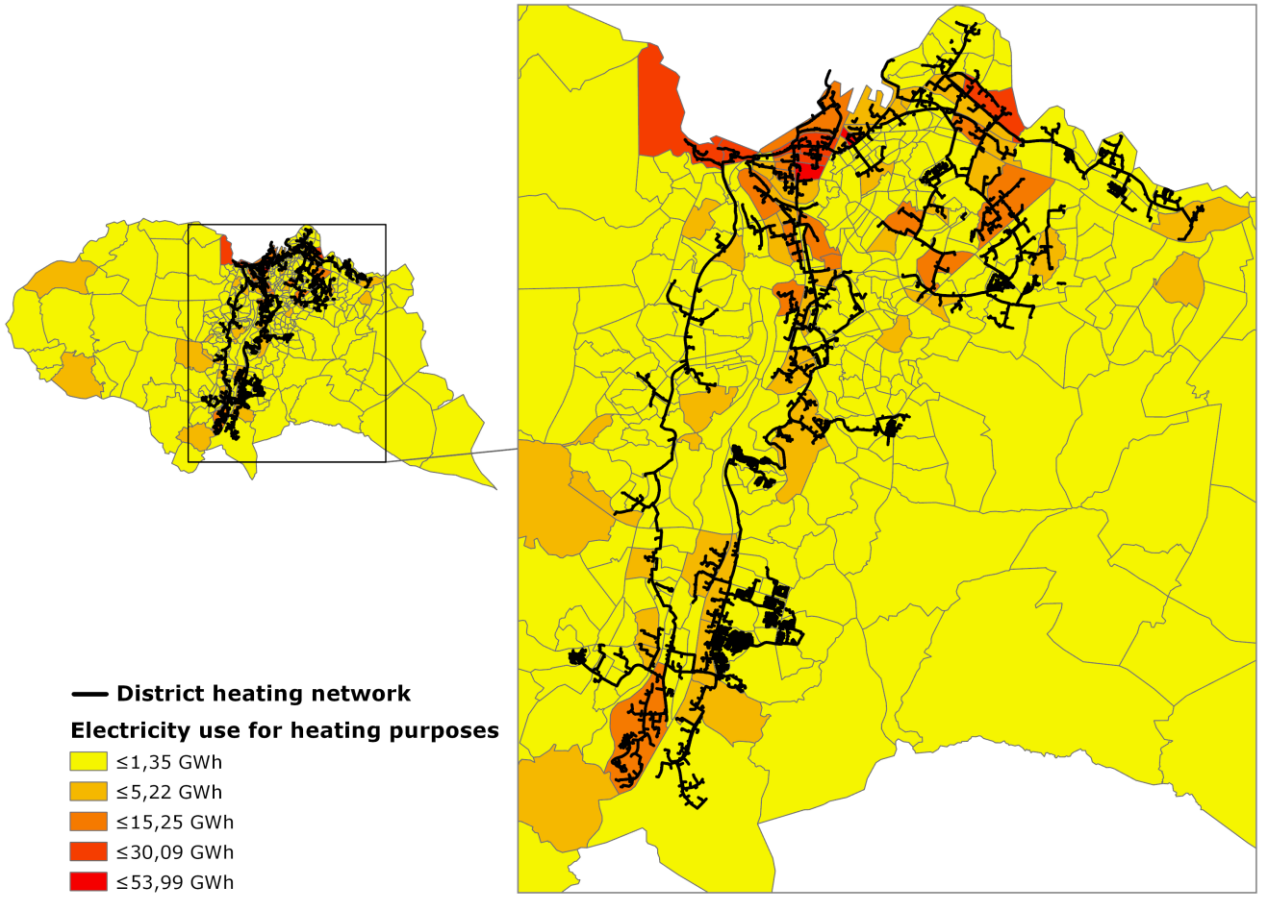






Results

Energy maps



Conclusion and discussion

- Old and new buildings tend to have lower consumptions
- Significant variations inside the same typology, specially in mid-cohorts
- Business and office buildings → highest electricity and heat consumption per area

  Industries → large spaces without energy demand.

  Educational buildings are also main consumers in Trondheim

Understand each typology

- District heating concession area within the most demanding region, but still potential to grow.
- The information and resolution of an energy map depend on the purpose.
- Resolution versus interpretation
- More effort on data gathering → promotion of bottom-up approaches
- Constrains due to data cleaning and available georeference databases

Thank you!