Graduation Project BPS (7S45M0)

Optimization of district-level retrofit strategy

A Dutch Case study

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Background

To reach the European climate goal of achieving energy/CO2 neutrality by 2050, the first task according to the Trias Energetica is reducing the demand for energy. A major share of the demand for energy comes from the building sector. Within this sector, the demand for space heating and domestic hot water are the dominating parts, accounting for 64.7% and 13.9% of the building energy use respectively [1]. This shows a large potential in energy savings, by focusing on optimization of the heating demand of residential buildings.

In order to optimize the heating demand in the building sector, the challenge lies within the retrofit of already existing buildings. To renovate all 7.8 million dwellings in the Netherlands over the next 30 years, there is a substantial required retrofit rate of 260,000 [dwelling/year].

To be able to realize this significant rate, one way is to group buildings in an area (could be a neighborhood, district or even a city) and then regionally plan the renovation of buildings, as opposed to the previous approach of building by building optimization or individual building types.

Aim of this research

1. **Gain insight into the potential of retrofit packages on district-level in terms of: robustness, CO2 saving, Investment cost**
2. **Provide a decision support tool for Dutch municipalities/policy makers**
   - To subsidize specific measure(s) for a certain district / housing type
   - To spatially plan the renovation of their city/districts helping with meet their regional goals
3. **Taking advantage of economies of scale and less CO2-footprint**

Dutch building stock

Table 1: Number of the Dutch reference buildings considered [2]

Construction Period	≤ 1945	1946 - 64	1965 - 74	1975 - 91	1992-2005
Detached housing	441,000		119,000	221,000	178,000
Semi-detached housing	285,000		142,000	224,000	173,000
Terraced housing	523,000	478,000	606,000	879,000	353,000

Research Question/sub~

Research Question

- How to develop a future-proof retrofit strategy for a Dutch neighborhood in order to optimize CO2-emissions and investment cost?

Sub-research questions

- What are the offered retrofit packages?
- What are the considered future scenarios?
- What are the effect of each package on each building type (in terms of CO2-emission reduction and Investment Cost)?
- How are the offered packages ranked in terms of robustness across building types in the chosen neighborhood?
- What combination of packages and building types is the most robust in the chosen neighborhood?

Methodology

Base-case simulations (Table 1)

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Accuracy check with UMGO library [3]

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Defining packages/future scenarios

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Simulating the effect of packages across building types & future scenarios (performance matrix)

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Robustness assessment of packages across building types [4]

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Objective based optimization on neighborhood level: Robustness, CO2 saving, Investment cost

References

[1] Eurostat. (2015). Energy consumption in households. Retrieved from: http://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_consumption_in_households

[2] Agentschap NL. (2011). Voorbeeldwoningen 2011: Bestaande bouw. Chapter (Vol. 6)

[3] Uniforme maatlat Gebouwde Omgeving (UMGO). Retrieved from RVO.nl: https://www.rvo.nl/onderwerpen/duurzaam-ondernemen/duurzame-energie-opwekken/nationaal-expertisecentrum-warmte/instrumenten/uniforme-maatlat-gebouwde-omgeving

[4] Kotireddy, R., Hoes, P.-J., & Hensen, J. L. M. (2018). A methodology for performance robustness assessment of low-energy buildings using scenario analysis. Applied Energy, 212, 428–442.