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# IMPACT OF INTEGRATION OF ELECTRIC AND GAS HEAT PUMPS ON THE FINAL ENERGY CONSUMPTION OF BELGIAN RESIDENTIAL BUILDING STOCK

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## 1. ABSTRACT

The paper investigates the evolution of electricity-driven and gas-driven heat pumps technologies used for heating in the residential building stock. A base and predictive scenarios are considered. The base scenario includes the current share of the existing heat pumps in the Belgian market while the predictive scenario considers the increased share of the studied heating systems based on the evolution of the buildings envelope over the period 2020-2050. Two different types of heat pumps are considered, one driven by electricity which performance indicators are based on the literature, while experimental data is used for natural gas-driven heat pumps.

## 2. METHODOLOGY

- The methodology used in this paper is based on the modeling of the heating energy end-use consumptions.
- This paper also used an updated model of the tree structure model representing the Belgian residential building stock developed by Gendebien et. al [1].
- This paper presents the entire housing stock in Belgium which is divided in **752 cases** representing **4.6 million** buildings in **2012**.
- This study uses MAR regional atmospheric model [2], data sets of the Typical Meteorological Years (TMY) are used for future scenarios (SSP5.85) and historical scenarios.

## 3. BUILDING STOCK TREE STRUCTURE

- The Belgian building stock tree structure is based on a hybrid approach.
- The final tree structure of the base scenario is based on different parameters:
  - Building type
  - Year of construction
  - Insulation level for the building
  - Space heating "SH" energy vectors
  - Heating production system
  - Domestic Hot Water "DHW" energy vectors
- There are 2 main scenarios representing the building stock:
  - **Base scenario- up to 2012**
  - **Business-as-usual (BAU) scenario- up to 2050** (this scenario is the first step to update the building stock for the new dwellings, insulation characteristics and the energy sources used for SH and DHW for the period **2013-2050**).
- Average annual construction and demolition rates are set respectively to **0.8% and 0.075%**.
- In addition to that, a total of **1.3%** renovation rate per year is counted.

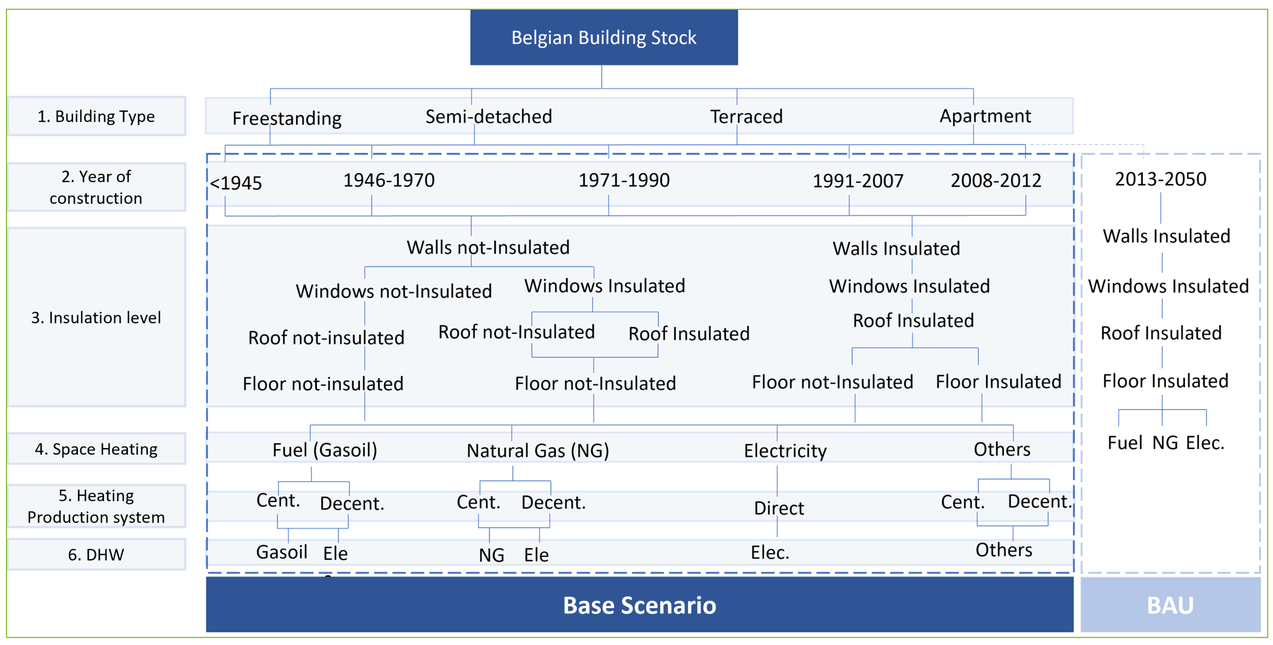


**Fig. 1 -** Belgian building stock tree structure

## 4. BUILDING STOCK ANALYSIS

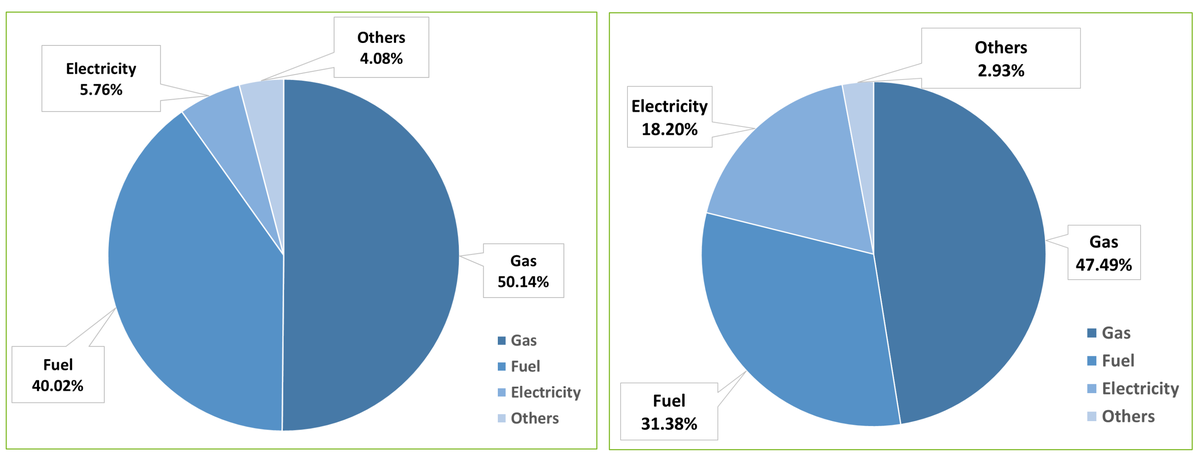


**Fig. 2 -** Distribution of energy sources used for SH (a) Base Scenario (b) BAU Scenario

## 4. HEAT PUMPS SCENARIOS

- There are 2 heat pumps analyzed in this study (electricity-driven and gas-driven).
- The **electricity-driven heat pump scenario** is characterized by the maximum penetration rate of air-source heat pumps used for SH and DHW production.
- Three different types of electricity-driven heat pumps were considered for the sizing depending on the overall U-value of the building.
- The **gas-driven heat pump** system is based on the Water-Ammonia absorption cycle using outdoor air as the low-temperature heat source and NG combustion as high-temperature heat source.
- The same criteria has been used to determine the maximum penetration rate of both heat pumps in the building stock and their impact on the overall building stock energy use.
- The criteria is based on a stationary balance that considers the building SH and DHW loads, by considering a maximum rating power of **8.6 kW for electricity-driven heat pump and 16.9 kW for gas-driven heat pump** at **-10°C**, and **80%** of the loads at these conditions.

## RESULTS AND KEY FINDINGS

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- Fig. 3 shows that, climate change has a significant impact on the energy use of buildings, by 2100 the SH and DHW energy consumption for the whole building stock decreased by **23.8%**.
- The maximum penetration rate of the electricity-driven heat pumps. Based on the criteria mentioned before, **67.6%** is the maximum possible penetration rate in 2050.
- The maximum penetration rate of gas-driven heat pumps is **42.7%** by 2050, compared to the distribution of buildings driven by NG source in BAU scenario in 2050 which is **47.49%** as shown in Fig.2 (b).
- Fig. 4 compares between the average consumption per dwelling in the different scenarios. There is a significant decrease in BAU, electricity-driven and gas driven heat pumps scenarios due to the renovation strategies.

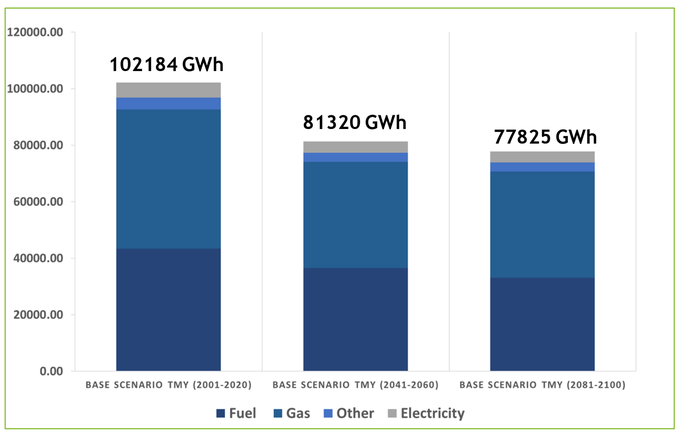


**Fig. 3 -** Comparison between the SH and DHW energy consumption in the Base Scenario in different year

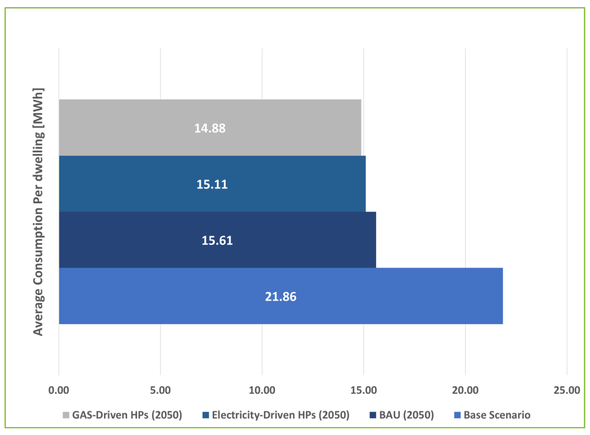


**Fig. 4 -** Comparison between the average SH and DHW consumption per dwelling in the different scenarios

## 7. REFERENCES

- [1] Gendebien S, Georges E, Bertagnolio S, Lemort V. Methodology to characterize a residential building stock using a bottom-up approach: a case study applied to Belgium. International Journal of Sustainable Energy Planning and Management 2015:71-88 Pages. https://doi.org/10.5278/IJSEPM.2014.4.7.
- [2] Doutreloup, Sébastien, Fettweis, Xavier. Typical & Extreme Meteorological Year and Heatwaves for Dynamic Building Simulations in Belgium based on MAR model Simulations 2021. https://doi.org/10.5281/ZENODO.5606983

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