Travail de fin d'études et stage[BR]- Travail de fin d'études : Analysis of the flexibility potential of low temperature heat pumps for the space heating of residential buildings by underfloor heating[BR]- Stage d'insertion professionnelle

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Analysis of the flexibility potential of low temperature heat pumps for the space heating of residential buildings by underfloor heating

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In 2018, the residential space heating sector represented 16.64% of the European final energy consumption, and 13.8% of the Belgian green house gases emissions in 2019. A way to reduce the consumption and optimise the generation resources is to use heat pumps -that are expected to replace by 2050 in Belgium most of the fossil fuel based heating technologies-, to implement demand side management (DSM) strategies and to decouple the heat and electricity needs using the thermal energy storage (TES) of the building. This work attempts to evaluate the flexibility potential of residential buildings heated by low temperature heat pumps and equipped with floor heating. The aim is to understand the relevance, the advantages and drawbacks of the strategy on different configurations. In order to achieve this goal, a single zone dynamic building model with a heat pump model is developed, and three cases are investigated: the time period of storage/discharge of heat in the building, the possibility to increase self-consumption of a photovoltaic installation and the economic interest thereof in Belgium, and the potential heat load that can be shifted from peak to off-peak hours in a dynamic pricing context. The building investigated is a representative Belgian detached house, within two refurbishing states: a K30 insulation level and yearly heating needs of 89 kWh/(m^2*y), and an advanced refurbishment state with yearly heating needs of 43 kWh/(m^2*y) and a K25 insulation level. The results show that the flexibility period can vary from 2h up to more than a day, depending on the outside temperature, the setpoint temperatures and the building insulation. The increase of self-consumption in the configuration of the rule based control defined in this work seems not economically interesting, with a total cost increased by 1% for the lower insulation level, and a cost reduction of 1.8% for the low energy state. However, other control strategies could lead to better results. Finally, a complete shift of the heating demand can be achieved for periods from 2h for lower insulation houses and up to 4 hours for low energy buildings, with an average rebound period of 4 hours for both. An important conclusion of the work is that the flexibility potential is larger for very well insulted buildings, and the insulation level is more important than the building's thermal capacity.

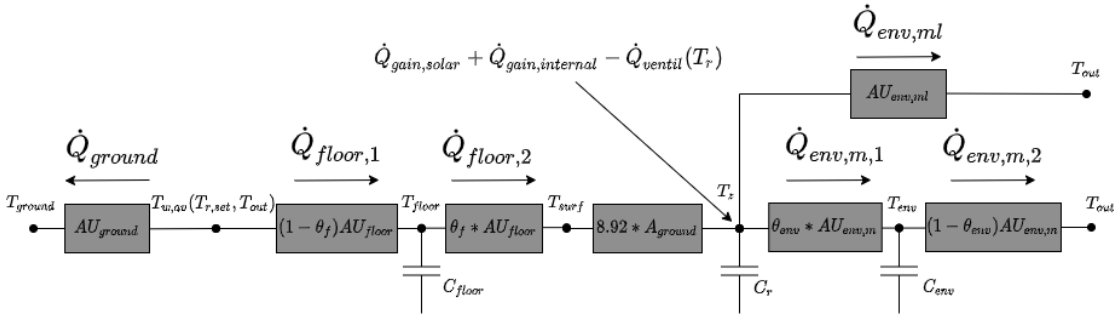

Figure 1: Equivalent RC circuit of the dynamic building model developed in this work.

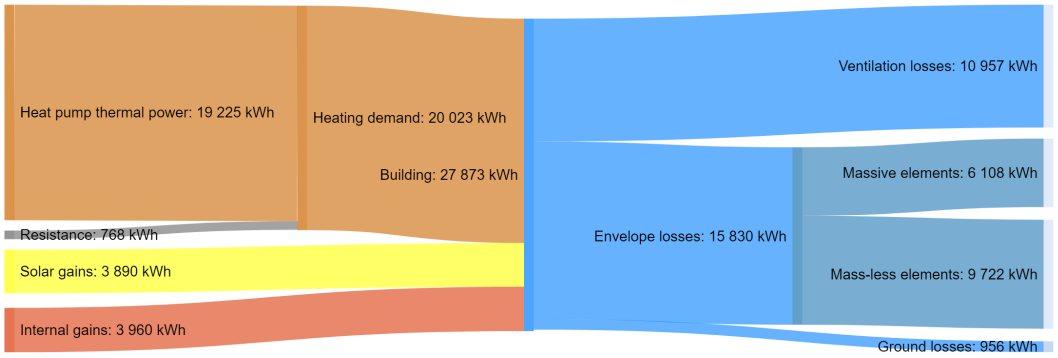

Figure 2: Sankey diagram representing the gains and the losses of the building's zone over the heating season for the low insulated house level with a minimum use of the backup resistance.

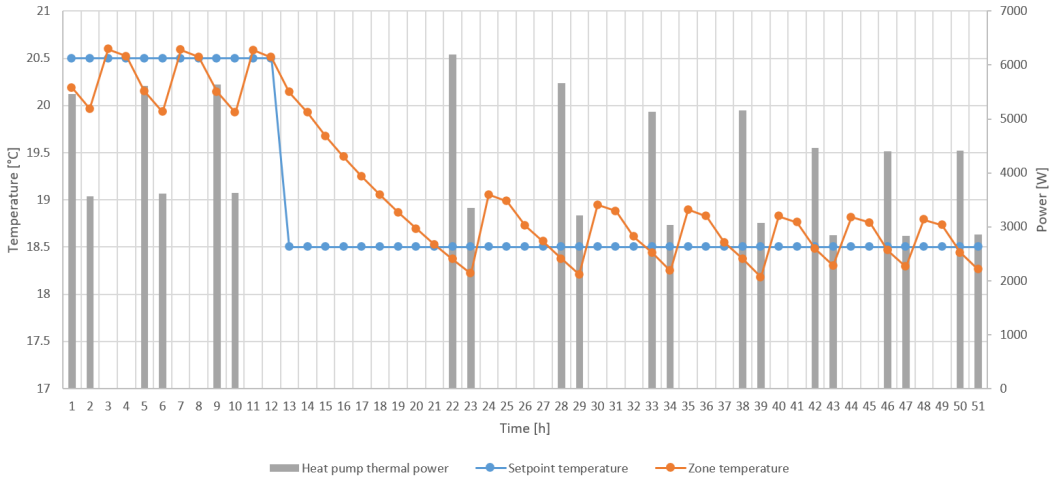

Figure 3: Zone's temperature evolution of the low energy building to understand the time of non heating when the zone setpoint temperature is changed from 20.5°C to 18.5°C and the outside temperature is 5°C. Nine hours without heating the zone can be reached.

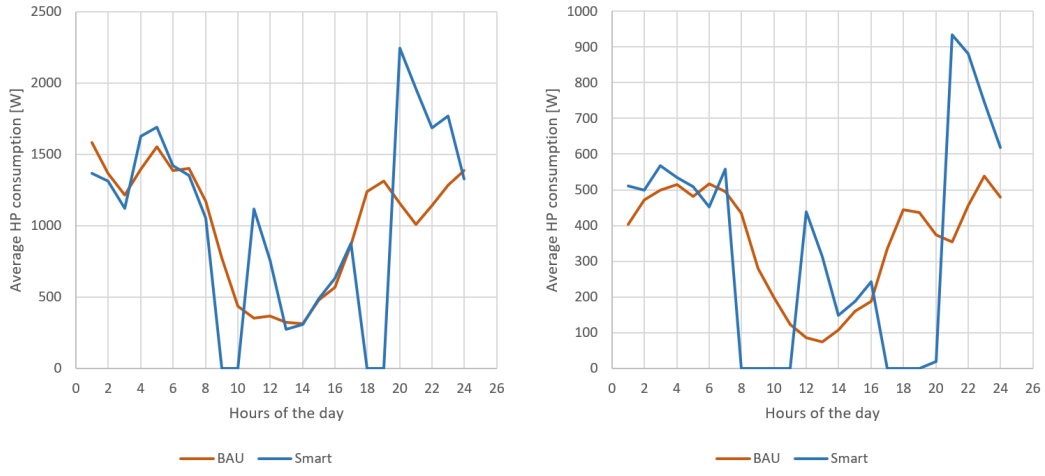

Figure 4: Average heat pump consumption within the day over the heating season, without load shifting strategy (BAU) and with load shifting strategy (smart) for the low insulation level (left) and the high insulation level (right). The consumption is shifted to the noon and the end of the evening with different rebound periods.