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refrigeration appliances over
time and associated impacts:
Dynamic modelling of operational
features and life-cycle**

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**Efficiency loss of household refrigeration appliances over time and associated impacts:
Dynamic modelling of operational features and life-cycle**

Nowadays, household refrigeration appliances belong to the standard equipment of most homes. Since refrigerators, freezers and refrigerator-freezer combinations generally operate continuously throughout their service life, they range among the largest energy users in the residential sector. As a consequence, policies were established and revised over time to improve refrigeration appliance's efficiency and decrease their environmental impacts. However, certain characteristics, such as the efficiency loss over time, were largely disregarded by previous research and, consequently, their impact on appliance's energy consumption is yet unknown. Although operational features, i.e. daily consumer interactions with refrigeration appliances, were monitored in the past their influence on appliance's degrading efficiency was similarly neglected. Two main objectives were addressed in order to close these research gaps.

At first, the age-related efficiency loss over time was investigated. A range of new appliances was acquired and divided in two test groups. One test group was exposed to fluctuating temperatures over the course of two years, whereas the other group was placed under constant ambient conditions. A non-destructive testing method () was developed to investigate the degrading insulation performance and applied in parallel to energy consumption measurements to all sample appliances. This way, both changes in insulation properties and consumption patterns were evaluated. Second, a static energy model was extended to a dynamic approach by including changes in efficiency over time. The consumer behaviour was surveyed by a national online-questionnaire and served as input for the dynamic model to evaluate the impact of behaviour on appliance's energy consumption. A list of advice () on the correct handling of refrigeration appliances was compiled and applied to the dynamic model. The comparison between the real-life consumer behaviour and the determined the share of behaviour in appliance's energy consumption. At last, the investigated efficiency loss was implemented to a life-cycle assessment to estimate environmental impacts and monetary losses resulting from the degrading efficiency throughout the life-cycles of refrigeration appliances.