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A Data-Driven Approach to Evaluating Energy Savings Per Household: Insights from Ireland's Retrofit Grant Programmes

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EXTENDED ABSTRACT

Home energy upgrade programmes play a critical role in enhancing residential energy efficiency and reducing carbon emissions. Retrofit grants have been instrumental in encouraging homeowners to adopt energy-saving measures. However, there is limited research that integrates individual energy savings estimates into a programme impact reporting process. This study developed a data-driven methodology to measure annual energy savings per household to bridge this gap.

Introduction / background

Home energy efficiency is a cornerstone of sustainable development, contributing to reduced carbon emissions and lower energy costs for households. In Ireland, retrofit grant programmes have been pivotal in promoting energy-saving measures among homeowners[1]. Despite the success of these programmes, there is a lack of comprehensive research that quantifies the individual energy savings achieved through these initiatives. This study aims to fill this gap by developing a robust, data-driven methodology to evaluate energy savings per household.

Methodology

The methodology employed in this study involves several key steps, each designed to ensure a comprehensive evaluation of energy savings and the effectiveness of retrofit measures (Figure *1*).

Figure 1 Methodology for a data-driven approach to evaluating energy savings per household

The first step involved gathering extensive data from Irish Energy Performance Certificates (EPCs) and retrofit grant aid programmes. This data provided detailed information on energy performance and the specific retrofit measures implemented across various households. Once the data was collected, it underwent thorough preprocessing to clean and organise it. This step included removing any inconsistencies or errors and ensuring the data was formatted correctly. Additionally, data from different sources were merged to create a unified dataset.

The next step was conducting a detailed energy analysis. This involved evaluating pre- and post-retrofit energy consumption to determine the impact of the retrofit measures. The analysis focused on comparing energy usage before and after the implementation of retrofit measures, allowing for a clear assessment of the energy

[1] Irish Retrofit grant programmes

savings achieved. Following the energy analysis, the evaluation of savings was performed. This step involved calculating per-home energy and emission savings. By quantifying the energy savings and CO_2 emissions reductions for each household, the study provided valuable insights into the effectiveness of the retrofit programmes. The evaluation considered both delivered energy savings and primary energy savings, accounting for rebound effects based on existing literature [2].

The final step was to compare the data-driven results with existing estimated savings approaches. This analysis demonstrated that the data-driven method provides more reliable results based on actual energy performance, rather than assumed fixed assumptions, and offered recommendations for improving future energy-saving estimations and policies.

Results

The application of this methodology to Irish retrofit programmes revealed significant findings. Specifically, the study focused on. Specifically, the study focused on the National Retrofit Scheme One Stop Shop (OSS). The OSS provides a complete energy solution for homes, managed via a One Stop Shop service provider. It typically supports measures such as home energy assessments, insulation upgrades, heating system improvements, and the installation of renewable energy technologies. Over the years 2022 to 2024, there is a substantial increase in average annual energy savings per household under the under this scheme[3]. Annual delivered energy savings, even accounting for rebound effects, showed a marked improvement, rising from 5,266 kWh in 2022, 6,189 kWh in 2023, and 7,878 kWh in 2024. These results demonstrate the effectiveness of the scheme over time. Furthermore, the existing approach, which assumes a fixed annual delivered energy savings of 6,000 kWh, does not account for variations in household energy use or mixed fuel usage. In contrast, the proposed methodology shows a more dynamic and tailored evaluation of energy savings per household. This represents a percentage change of -12.23% in 2022, 3.15% in 2023, and 31.30% in 2024 compared to the fixed assumption.

CO_2 emissions savings per home also saw a notable increase, from 2,903 $kgCO_2$ in 2022, 3254 $kgCO_2$ in 2023 and 3,995 $kgCO_2$ in 2024, reflecting the environmental benefits of the retrofit programmes. The sample size expanded significantly, from 343 in 2022 to 1465 in 2024, indicating a substantial increase in the number of retrofits carried out. Average primary energy consumption pre-retrofit decreased slightly from 230 kWh/m² to 212 kWh/m², while average post-retrofit consumption saw a significant reduction from 78 kWh/m² to 48 kWh/m². The uplift in primary energy savings increased from 151 kWh/m² to 163 kWh/m², underscoring the improvements in energy efficiency.

Conclusion & discussions

This study offers valuable insights for policymakers, grant administrators, and the broader community. By understanding the effectiveness of various retrofit measures under the National Retrofit Scheme OSS, stakeholders can optimise grant allocation and promote high-impact energy-saving solutions. The significant increase in energy savings and CO_2 emissions reductions per home demonstrates the effectiveness of retrofit programmes in enhancing energy efficiency and reducing carbon footprints. The findings support the development of a more energy-efficient housing stock, contributing to national climate goals and delivering long-term economic and environmental benefits. Future research could explore the integration of additional data sources and the application of this methodology to other retrofit programmes.

[2] Energy efficiency and economy-wide rebound effects: A review of the evidence and its implications

[3] National Retrofit Scheme One Stop Shop