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ABSTRACT

GreenHomeAI is an AI-powered tool that predicts household CO₂ emissions and identifies effective retrofit upgrades. Using Irish housing data, the model highlights improvements—wall and roof insulation, window upgrades—while mapping savings to SEAI grants. Results show households can achieve **15–30% emission reductions** with clear €-savings, making retrofits affordable, practical, and impactful.

The tool provides data-driven insights, helping homeowners and policymakers prioritize sustainable actions and support Ireland's 2030 climate goals.

INTRODUCTION

- Why it matters:** Irish homes are a notable CO₂ source; losses concentrate at walls, roof, and windows.
- Gap:** Most households lack data-driven guidance on which upgrades to prioritize.
- Approach:** GreenHomeAI uses Irish housing data to predict baseline CO₂ and simulate retrofit savings.
- Scope:** Focus on wall insulation, roof insulation, and window upgrades.
- Takeaway:** Typical potential **15–30% CO₂ reduction** with clear €-savings shown in the UI.

Research Methodology – GreenHomeAI

Data Collection

Housing and BER datasets from SEAI, CSO, and EPA.

Data Preprocessing

Cleaning, removing outliers, handling missing values

Feature Engineering

Creating new variables such as floor, wall, roof heat loss proxies (wall insulation, roof insulation)

Prediction of Savings

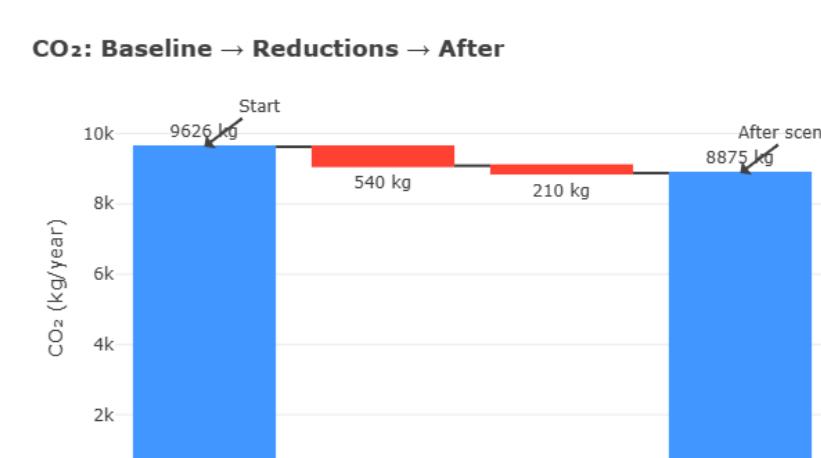
Predicting ΔCO₂ after interventions

Evaluation & Visualisation
Parity plots, calibration plots
Comparison before vs. after upgrades

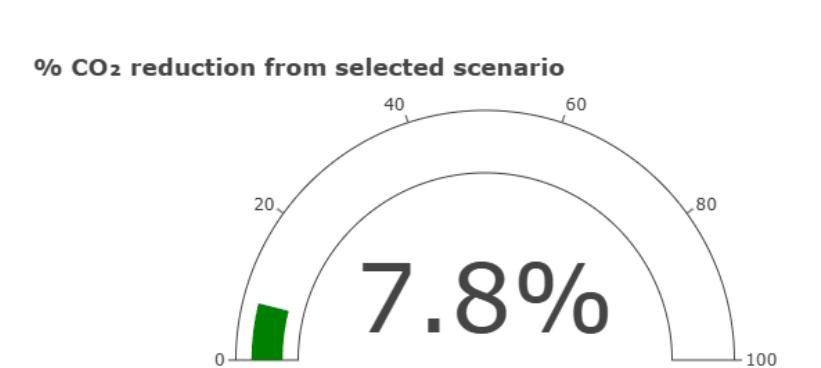
User Interface (UI)
Shiny app that takes user house details, shows current emissions

UI/VISUALS

Interactive UI predicts baseline CO₂, tests upgrade scenarios (wall, roof, windows), and highlights savings to guide retrofit decisions.



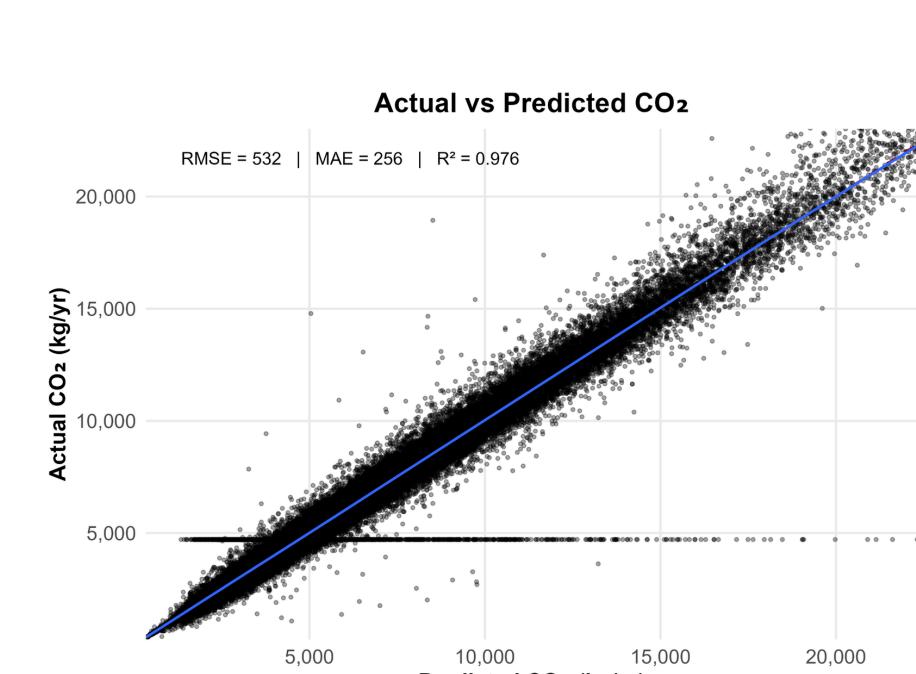
Baseline vs. after-upgrade CO₂ shows clear emission reductions.



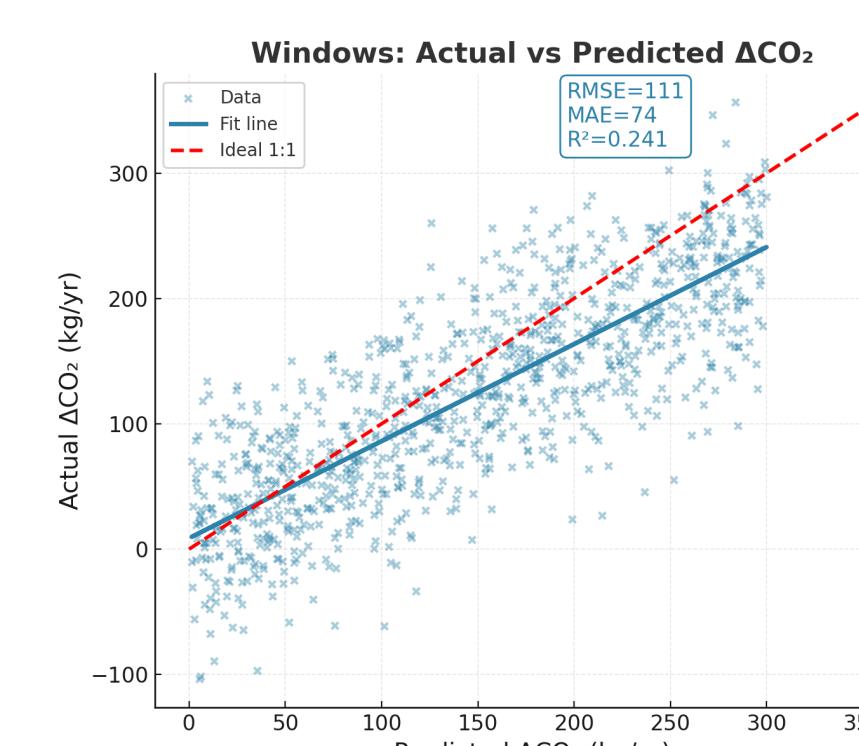
Scenario shows ~7.8% overall CO₂ reduction from selected upgrades.

RESULTS

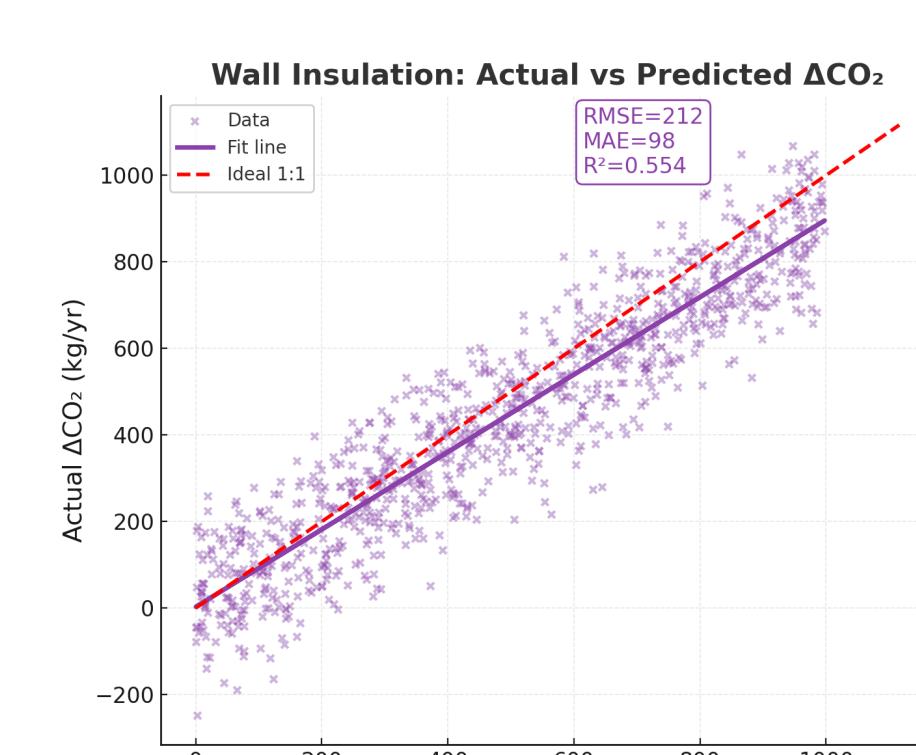
- Model trained on Irish housing & energy datasets shows high accuracy in predicting household CO₂ emissions.
- Evaluation focuses on prediction performance, calibration reliability, and upgrade scenario insights.
- Visuals below highlight model accuracy and error patterns across fuel types.



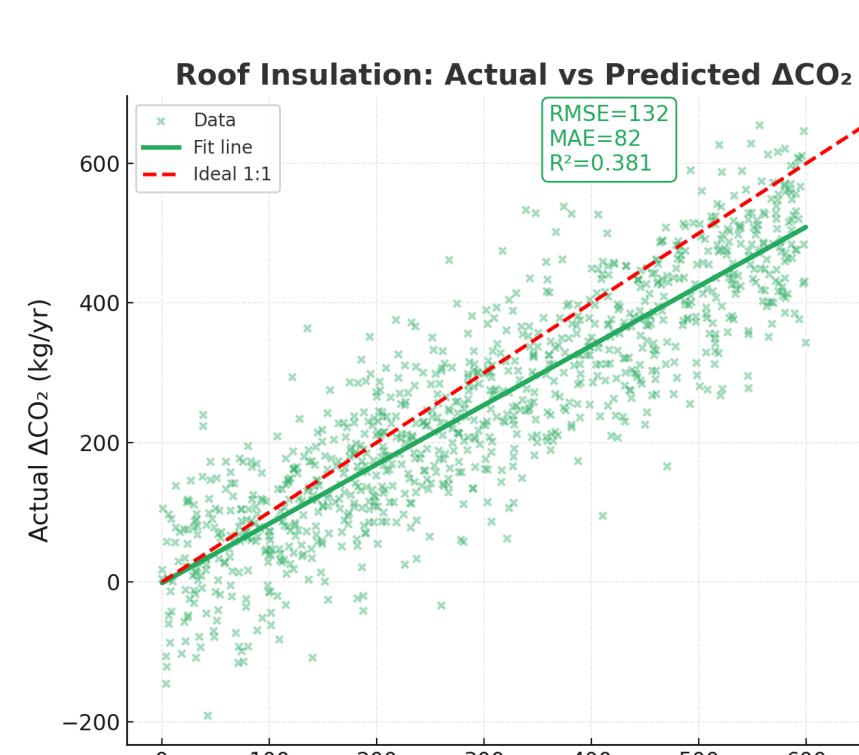
Predicted values closely follow actual CO₂, confirming accuracy.



Windows show steady but smaller CO₂ savings, with more variability.



Wall insulation achieves the strongest and most reliable reductions.

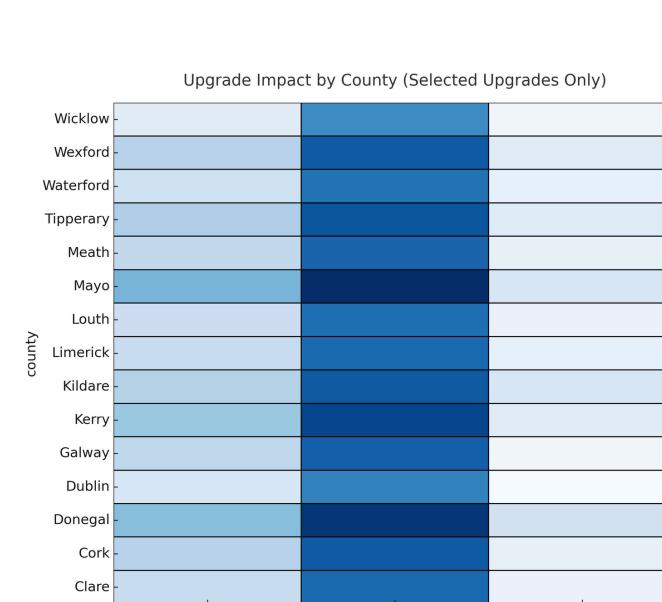


Roof insulation aligns well with actual CO₂, though some underestimation appears at higher savings.

- Accuracy:** Model achieves strong predictive power (R² = 0.976, RMSE = 532, MAE = 256).
- Robust Fit:** Predictions closely follow actual emissions across diverse households.

We would like to express our sincere gratitude to Dr. Sarp Akcay, our module coordinator, for his valuable guidance and support throughout this project. We also thank the ACM40960 teaching team for their constructive feedback and for fostering an environment that encouraged us to explore innovative solutions. This work represents the equal contribution of all group members in both the development of the machine learning models and the design of the user interface.

GitHub: Project-GreenHomeAI



Heatmap shows variation in retrofit effectiveness across counties; insulation upgrades deliver the highest potential CO₂ savings.

