Research Summary: Evaluation of Deep Retrofitted Housing Using Metered Gas Data

Paul Beagon, Fiona Boland, James O'Donnell
University College Dublin, Royal College of Surgeons in Ireland

In 2014, the Irish housing sector consumed 23.4% of secondary energy, according to Sustainable Energy Authority of Ireland (SEAI). EPA assessed that the average Irish household uses just over 50 kWh daily. By this measurement, Irish homes are the second worst performing in Europe, after Finland. These metrics couple with the long lifespan of homes highlights the role of home energy retrofit. SEAI discussed the energy underperformance of Irish homes in its Residential Roadmap to 2050. The roadmap plans to reduce the 2010 average household energy use (22,500 kWh/year) by 60–65% before 2050, predicated on at least one million home retrofits.

Approach

This study evaluates a 2014 retrofit of Irish social housing. It analyses gas meter data from housing owned by Respond! Housing Association. The meter data extends across three calendar years 2013 – 2015. During 2014, Respond! carried out home energy retrofits, with funding from SEAI. Thus 2013 precedes the retrofit, and 2015 follows the retrofit. Thanks goes to ESRI who stored the meter data, all of which was anonymized. Having two empirical data sets, control and retrofit household gas meters, allowed three main research objectives.

1. Quantify and test for differences in annual gas consumption per home
2. Plot the density of gas consumption by semi-detached home type
3. Quantify the prebound effect (underuse of energy, often by occupant self-rationing of heat)

The data processing started by selecting gas meters that reported the primary heating fuel to a home. Next, the gas consumption is allocated and shaped to find the total gas consumption per calendar year. To allow comparison between years, 2015 gas consumption is weather corrected by a 3% to account for colder weather during 2013.

Results and Analysis

Results for 2013 and 2015 annual gas consumptions by each home appear side by side, grouped into retrofit homes and control homes. The mean difference in gas consumption by 20 retrofitted homes between 2013 and 2015 is 2512 kWh. Without a control group the 2512 kWh average difference appears large; equating to over 27% of the 2013 mean consumption 9253 kWh. However, 25 control group homes

simultaneously reduced mean gas consumption by 1235 kWh, almost half of the retrofit group mean reduction. Such a high ratio of control to retrofit reductions was unexpected after the application of weather correction to 2015 metered data.

Increased annual gas prices may explain the control group's reduced gas consumption during 2015. Gas prices are 3% higher; 2013: €0.0653/kWh and 2015: €0.0673/kWh. Residential consumption of Irish networked gas reduced 6.7% between 2013 and 2015. Moreover, low gas consumption during the average price peak of 2014 may have influenced gas consumption behavior during 2015.

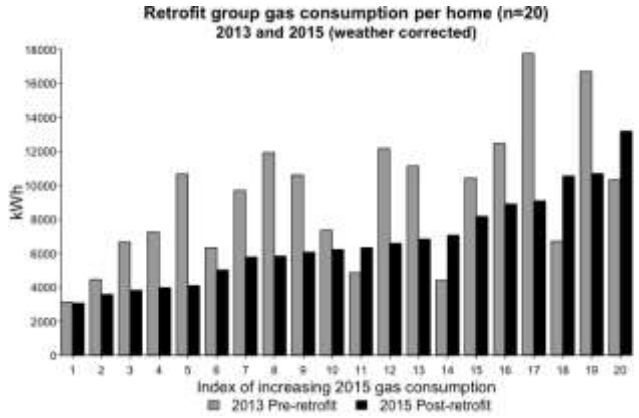

Figure 1. Retrofit group gas consumption: 2013 and 2015.

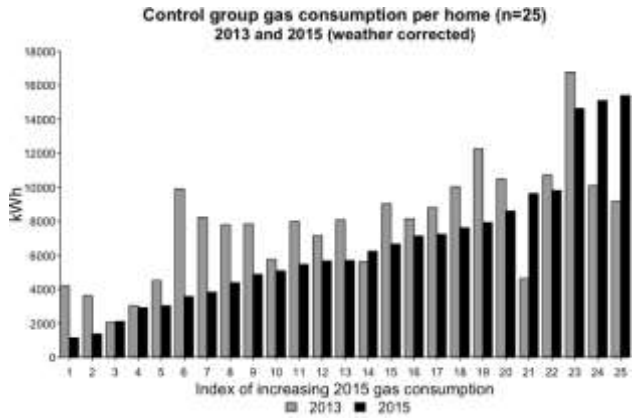

Figure 2. Control group gas consumption: 2013 and 2015.

The difference between the retrofit and control groups is 1277 kWh (2512 kWh - 1235 kWh). The null hypothesis of no difference between the retrofit group differences and the control group differences is rejected at 10% significance, but not at 5% significance.

The second research objective is to find the distribution of gas consumption values by similar semi-detached homes. Gas consumptions by the same 16 retrofitted homes during 2013 and 2015 are smoothed into two solid lines (Fig. 3; 2013 grey line, 2015 black line). The 2013 distribution (mean 10,137 kWh, standard deviation 3678 kWh), plateaus at 18,000 kWh. After retrofit, the 2015 distribution (mean 7105 kWh, standard deviation 2688 kWh), approaches a symmetric normal distribution with a small skew. Increasing the number of retrofitted semi-detached homes to 42, produces a similar distribution of slightly lower mean and higher standard deviation (Fig. 3). Thus, a neighbourhood of similar homes is expected to consume natural gas with a lower mean and variation *after* retrofit.

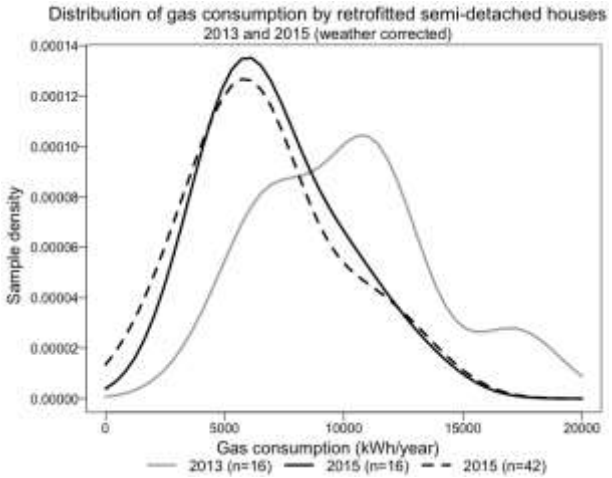

Figure 3. Distribution of 2013 and 2015 gas consumption by semi-detached houses.

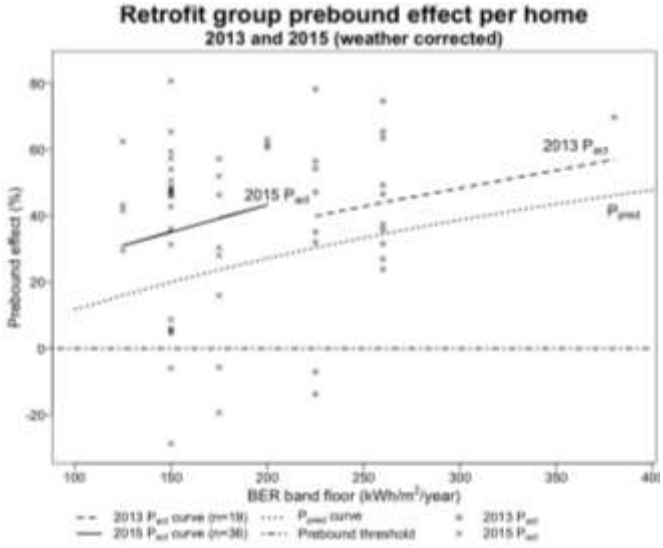

Figure 4: Retrofit group prebound effect 2013 and 2015, reduced by retrofit but above predictions for German housing

The third objective is to measure the prebound effect before and after retrofit. Prebound effect is the underuse of heat energy by occupants compared to the building's calculated energy rating (BER in Ireland). This phenomenon increases with the low performing homes, whereas the well-known rebound effect tends to occur for high performing homes when occupants consume more energy than the rating. Measured prebound values are expressed as percentages, often averaging 30% or 40%. After retrofit, the 2015 actual prebound (P_{act}) curve is lower than the 2013 P_{act} curve (Fig. 4). The implied

reduction in fuel poverty by this alleviation of prebound is welcome. However, predicted prebound (P_{pred}) found in Germany is lower than the P_{act} curves of this Irish housing.

Key Takeaways

- Social housing retrofit reduced a minority of the metered gas demand to below the houshold average
- Retrofit moves the distribution of house gas demands towards a normal curve, albeit slightly skewed
- The retrofits alleviated the prebound effect and potential self-rationing of heat associated with fuel poverty
- Pre-payment intervals increased after retrofit, reducing household transaction costs (Figure not shown)

This research summary highlights key findings from recent Energy Institute paper: Beagon, P., Boland, F. & O'Donnell, J., 2018. "Quantitative evaluation of deep retrofitted social housing using metered gas data". *Energy and Buildings*, 170, pp.242–256. http://doi.org/10.1016/j.enbuild.2018.04.022