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Comfort Taking

Evidence Review

Completed by London Economics for the Department for Energy Security and Net Zero prior to the 2024 general election in the UK. As such, any references to government policies, commitments, or initiatives may reflect the stance of the previous administration and were accurate at the time of writing.

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Views expressed in this report are from the relevant research agencies, based on data collected from research participants and other evidence, and not necessarily those of the UK government.

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Executive Summary

‘Comfort taking’ is a phenomenon that occurs following improvements to the energy efficiency of a property (and corresponding energy bill savings). The resident takes advantage (either knowingly or unknowingly) of their more efficient home by heating it more frequently and/or to a higher temperature, rather than heating it to the same temperature as before.

A Rapid Evidence Assessment (REA) was conducted to consolidate estimates of comfort taking, explore the types of households that are more likely to comfort take, and understand the drivers of comfort taking and any known mitigations to limit comfort taking where appropriate. The REA was conducted in March 2024. Through following a rigorously designed search and screening strategy, 28 academic papers were included in the analysis and two papers from the grey literature (i.e. high-level policy or institutional reports).

Comfort taking can be a positive and desirable outcome, for example, where households could not previously achieve sufficient thermal comfort in their homes. Therefore, policy solutions designed to limit comfort taking should focus only on those households who could already heat their homes to sufficient levels for their needs.

Findings

The extent of ‘comfort taking’

The term ‘comfort taking’ is not widely used in the literature, therefore we consider the phenomenon of comfort taking to be synonymous with the direct rebound effect specific to the context of energy efficiency, heating, and thermal comfort. Therefore, the REA included papers that estimate the **direct rebound effect specific to domestic heating**. Direct rebound effects occur when improved energy efficiency in the home leads to increased demand for lower cost energy services.

Evidence from the REA finds that the direct rebound effect generally occurs in domestic properties. However, each of the methodologies adopted in the literature to estimate direct rebound effects has caveats and limitations, and there is no consensus on the most appropriate methodology to estimate direct rebound effects. There are also differences in how direct rebound effects are defined. Due to the wide range of estimates and the methodological limitations, the REA did not draw conclusions about the size of the direct rebound effect.

Characteristics of households who ‘comfort take’

Differences across households are noted in the literature as a key driver of direct rebound effects. Specifically, higher direct rebound effects for heating are associated with tenants compared to homeowners. Lower income households tend to have higher direct rebound effects than higher income households, and a higher level of education is associated with lower direct rebound effects.

Main drivers and motivators to 'comfort taking'

Economic argument

When the energy efficiency of a dwelling improves, through the installation of an energy efficiency measure or through installing a new heating system, the relative cost of heating falls and it is cheaper to heat the dwelling to the same temperature. People may 'consume' more heating as it is now cheaper relative to other goods and services, and any financial benefits from energy bill savings will be re-invested in increased demand/consumption.

However, 'rebound sceptics' argue that consumers' demand for energy services (e.g. indoor temperatures) remains more or less constant over time, and is unresponsive to changes in the energy efficiency of their home. As such, they assume rebound effects are small if not negligible.

Behavioural drivers

Comfort taking behaviour may be deliberate or inadvertent. Drivers and motivators to comfort taking are rooted in people's behaviour, heuristics, habits and values, which are interrupted when installing an energy efficiency measure in the home.

The **desire to increase comfort** in the home is linked to higher indoor temperatures following a retrofit. **Pro-environmental values** strongly impact comfort taking, with those advocating for protecting nature from human harm having a lower rebound effect. **Changes in heating habits or preferences** also affect comfort taking by changing the way occupants use heating in their home (e.g. switching from heating individual rooms to heating the whole house). **Habits** may influence comfort taking. For example, a habit of maintaining specific temperatures can limit comfort taking, while people may form new habits post-energy efficiency improvement which increases comfort taking. **Personal norms** may influence comfort taking, for example voluntary frugality may reduce comfort taking.[1] **Social norms** may also have an impact, as it is desirable to have a comfortably heated house for visitors, which may increase comfort taking.[2]

Non-behavioural drivers include a **lack of energy-related advice or occupant awareness** on how to heat the home following a retrofit and the **physical state of the building** or **technical faults in the installation** of a new system or energy efficiency measure.

Mitigations to comfort taking

The literature clearly sets out that the rebound effect should be actively considered by policy makers, to address comfort taking in households that already achieve sufficient thermal comfort and/or households that do not contain anyone with a vulnerability.

[1] Personal norms refers to an individual's own beliefs and values and relate to feelings of moral obligation to act in a certain way.
[2] Social norms refer to shared beliefs and values that are considered acceptable in a social group.

Fiscal / economic interventions

Fiscal incentives, such as environmental taxes, could counteract the direct rebound effect by increasing the cost of 'comfort taking'. However, such taxes might discourage adopting more efficient measures and negatively impact households struggling to heat their homes adequately. **Regulatory interventions** could ensure sufficient information provision to enhance consumer awareness about energy efficiency technologies. The literature also suggests subsidy programmes to promote energy efficiency measures could **prioritise households less likely to comfort take**.

Behavioural interventions

These included **making people aware of changes in their energy use** through feedback mechanisms (e.g. using smart meters to circumvent habits and therefore limit comfort taking). **Tailored communication and advice on energy use** and using behavioural techniques such as **social norms** (e.g. relative comparisons to other households) or **loss aversion** (e.g. framing energy savings as a lost savings rather than gains) were also mentioned as interventions that may limit comfort taking.

Evidence gaps

The most substantial evidence gap is the lack of an agreed estimate on the extent of comfort taking and a lack of consensus on the most appropriate methodology for estimating the extent of comfort taking. There is also limited understanding of who is most prone to comfort taking, and there is no evidence on how the extent of comfort taking evolves over time post-energy efficiency upgrade. While motivations for comfort taking are explored in the literature, there is a lack of understanding on which of these are most important, necessitating further primary research. While potential mitigations are suggested, there is very little evidence or examples of the effectiveness of solutions. Furthermore, there is limited evidence on how behavioural science can inform policy to mitigate comfort taking.

Introduction

In February 2024, the Department for Energy Security & Net Zero (DESNZ) commissioned London Economics, Basis Social and Cambridge University to conduct an evidence review on comfort taking. The main objective of this study for DESNZ is to consolidate estimates of comfort taking, explore the types of households that comfort take, and understand the drivers of comfort taking and any known mitigations to limit comfort taking.

In some circumstances comfort taking is a positive outcome, for example, in the scenario where households could not previously heat their homes to a sufficient and healthy level. Therefore, any policy solutions designed to limit comfort taking should focus only on those households that already achieve sufficient thermal comfort prior to installation of energy efficiency measures and/or households that do not contain anyone with a vulnerability.

Specifically, the study addresses the following research questions:

- What is the estimated extent of comfort taking after energy efficiency (EE) measures have been installed?
    - To what extent do estimates vary?
    - What are the different approaches to measuring comfort taking and its effect?
    - How robust and reliable are the estimates available?
    - How does comfort taking vary over time?
    - Is there any evidence on whether comfort taking varies depending on the type of EE measure installed and if so, how does it vary?
- What are the characteristics of households that comfort take?
    - Are there differences in comfort taking between lower income and higher income (“able-to-pay”) households?
    - Are there differences in tenure (e.g. do people who own the home they live in behave differently to tenants, when it comes to comfort taking)?
- What are the main drivers/initial motivations to comfort take?
    - Is initial motivation associated with reduced costs or ability to increase warmth of household?
    - Do drivers/motivations vary by household characteristics?
- What are the known mitigations to limit comfort taking?
    - What is the nature of each mitigation i.e. technology, fiscal or behavioural?
    - Do mitigations vary by household characteristics?
- How can policy makers use behavioural science to limit comfort taking for households where it may not be deemed appropriate/necessary?

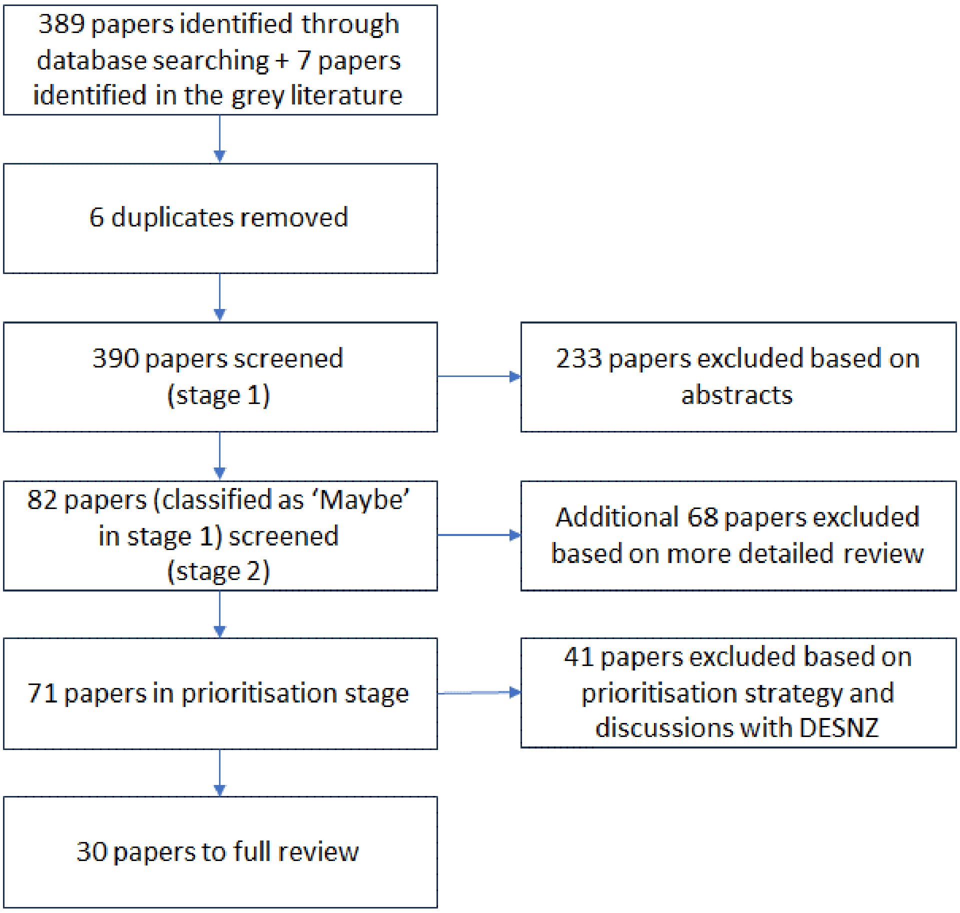
  - What, if any, government interventions may be required to reduce comfort taking?
- What are the evidence gaps?

Method

A **rapid evidence assessment (REA)** was conducted to collect evidence on the key research questions. An REA is a systematic and rigorous approach to quickly provide an overview and synthesis of existing evidence, while not being as exhaustive or comprehensive as a full systematic literature review.

The REA was conducted in March 2024. The search strategy included testing of different combinations of complex search strings to ensure the optimal strategy was used to identify relevant literature. The REA search identified 389 academic papers. Through several rounds of abstract screening, more in-depth review and prioritisation, 28 academic papers were included in the analysis. An additional seven papers from the grey literature were reviewed and two were included in the analysis. The REA protocol was designed and developed in collaboration with Cambridge University. Methodological details and limitations are provided in the Appendix.

Figure 1 PRISMA diagram of REA



What is 'Comfort Taking'?

Within this report we define 'comfort taking' as a phenomenon whereby following the increase in the energy efficiency of a property (and corresponding energy bill savings) the resident takes advantage (either knowingly or unknowingly) of their more efficient home by heating it more frequently and/or to a higher temperature, rather than heating it to the same temperature as before. This is part of a wider phenomenon known as the 'rebound effect' where an increase in energy efficiency may lead to less energy savings than expected. In some circumstances comfort taking is a positive outcome, for example, in the scenario where households could not previously heat their homes to a sufficient and healthy level.

The rebound effect is comprised of two distinct effects: a direct and an indirect effect. This study focuses on the direct effects. Direct rebound effects occur when improved energy efficiency in the home leads to increased demand for lower cost energy services. For example, if a household installs wall insulation, it should become cheaper to heat their home to the same temperature. Therefore, their energy bills fall and, in turn, they may decide to heat their home more and/or for longer periods. This leads to a situation in which energy savings are lower than expected. Indirect rebound effects occur when the savings from installing wall insulation are spent on other goods and services which consume energy (e.g. lighting the home to a greater degree), leading to an overall increase in energy demand.[3]

'Comfort taking' is not a widely used term in the literature, therefore we consider the phenomenon of comfort taking to be synonymous with the direct rebound effect specific to the context of energy efficiency, heating, and thermal comfort. We include all fabric measures (i.e. insulation) which increase energy efficiency in the home and create energy savings through the reduction of heat loss.

As well as fabric measures, this report also considers the relationship between heat pumps and the direct rebound effect. This is considered separately to the definition of comfort taking as there are differences between the effects of replacing a heat system (with a heat pump) and installing fabric efficiency measures (i.e. insulation) in terms of energy efficiency and consumer usage. There are also other complexities relating to the differences between how heat pumps should be run compared to fossil fuel boilers. For example, heat pumps need to be on for longer periods of time to deliver similar energy services due to the increase in space heating demand that comes from a lower temperature heating system.

[3] Chitnis and Sorrell (2014), 'Who rebounds the most? Estimating direct and indirect rebound effects for different UK socioeconomic groups' Ecological Economics (106) pp.12-32

The estimated extent of 'comfort taking'

As noted previously, 'comfort taking' is not widely used in the literature. Therefore, to investigate the extent of comfort taking for this study we considered papers that estimate the extent of the direct rebound effect specific to heating. Within the academic and grey literature, there is no consensus on the most appropriate methodology for estimating the size and extent of the direct rebound effect. As a result, there tends to be large variations in the estimates reported in the literature.

This section explores the methodologies used to estimate the direct rebound effect, the magnitude of the estimated direct rebound effect, the robustness of these estimates and how estimates vary based on the energy efficiency measure studied and methodology used.

Methodologies used to estimate the rebound effect

A range of methodologies and research strategies have been developed across the literature to measure the direct rebound effect for heating. In the studies reviewed, the methodologies can generally be categorised into the following:

- Evaluation methods (comparing before and after energy efficiency improvements).
- Theoretical models based on using the own-price elasticity of demand for heating.[4]
- Stated preference methodologies.

Evaluation methods

One common approach in the literature to estimate the direct rebound effect for heating is to measure heating consumption before and after an energy efficiency improvement.[5] This involves calculating the gap between predicted energy savings and actual energy savings. The main issue with this approach is the difficulty in accurately estimating predicted energy savings, which are typically based on the physical dimensions and construction of the property.[6] Due to the challenges associated with energy savings predictions, it is acknowledged in the literature that predicted energy savings tend to be overestimated, and therefore overestimate the direct rebound effect.[7]

[4] Own-price elasticity in this context refers to the change in the quantity of heating demanded/consumed as the cost of energy changes.
[5] Sorrell, S. (2007) The rebound effect: An assessment of the evidence for economy-wide energy savings from improved energy efficiency. UK Energy Research Centre; Hediger (2022) Rebound effects in residential heating: How much does an extra degree matter? IRENE Working Papers 22-05, IRENE Institute of Economic Research
[6] Bardsley et al. (2019) Domestic thermal upgrades, community action and energy saving: A three-year experimental study of prosperous households. Energy Policy, 127. 475-485
[7] Hediger (2022) Rebound effects in residential heating: How much does an extra degree matter? IRENE Working Papers 22-05, IRENE Institute of Economic Research

Another key limitation of these evaluation methods identified in the literature occurs when external factors are not sufficiently accounted for.[8] For example, changes in the price of heating, household income, and size of the household. Without accounting for these factors, it is difficult to isolate the real contribution of the installation from the changes in these external factors.

To overcome these issues of estimating the potential savings from installing energy efficiency measures, several studies compare the energy savings of households that have had energy efficiency measures installed and households that have not. The latter act as a 'control group' to observe the level of heating consumption in the absence of an energy efficiency measure. However, if the differences between the two groups of households (i.e. those who have had the installation and those who have not) are not accounted for, it can lead to bias in the estimation of the direct rebound effect.[9] For example, households who invest in energy efficiency measures may have more pro-environmental values or different preferences for temperature compared to those who do not install energy efficiency measures. These differences are difficult to observe and can result in self-selection bias.[10]

In the literature, these methods (estimating "before-after" or "with-without" an energy efficiency measure) are commonly used in the context of evaluations of past energy efficiency programmes (e.g. a local subsidy to install an energy efficiency measure),[11] [12] or in an experimental setting (where a treatment and control group are selected pre-installation where some households receive an energy efficiency measure and some do not).[13]

Mardones (2021) overcomes the main issues outlined above to some extent through a "matched difference-in-differences" method.[14] This method first matches households based on observable characteristics (e.g. household income, number and ages of people in the household etc.), so that the sample is as similar as possible and then compares the before and after heating consumption of those who have had an energy efficiency measure (specifically wall insulation) installed and those who have not. This type of methodology overcomes some of the limitations of the methods described above but can be challenging to conduct.

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[8] Mardones (2021) Ex-post evaluation of residential insulation program in the city of Temuco, Chile. Energy for Sustainable Development (62) pp. 126-135

[9] Mardones (2021) Ex-post evaluation of residential insulation program in the city of Temuco, Chile. Energy for Sustainable Development (62) pp. 126-135

[10] Selection bias in this context refers to a situation where households who install EE measures have different personal preferences towards heating as compared to households who do not install EE measures, making a true comparison between the two groups difficult.

[11] Aydin et al. (2017) Energy efficiency and household behaviour: the rebound effect in the residential sector. The RAND Journal of Economics, 48(3), pp 749-782

[12] Mardones (2021) Ex-post evaluation of residential insulation program in the city of Temuco, Chile. Energy for Sustainable Development (62) pp. 126-135

[13] Reynaud et al. (2016) Evidence of an indirect rebound effect with reversible heat pumps: having air conditioning but not using it? Energy Efficiency, (9), pp.847-860

[14] Mardones (2021) Ex-post evaluation of residential insulation program in the city of Temuco, Chile. Energy for Sustainable Development (62) pp. 126-135

Theoretical models (using own-price elasticities)

Own-price elasticities are used to measure the direct rebound effect of heating.[15] In this context, own-price elasticity refers to the percentage change in demand for heating, following a percentage change in the price of heating. When the energy efficiency of a dwelling improves, the relative price of heating falls (as it is now cheaper to heat the home to the same temperature), effectively lowering its price. Therefore, this method treats an improvement in energy efficiency and a reduction in the price of heating as equivalent. As such, the own-price elasticity can be considered as the change in demand for heating when energy efficiency improves.

This method typically uses secondary data on changes in heating consumption and price of heating over time in households.[16] One of the main issues with this method is that it assumes elasticities are static, that is, the way in which households respond to changes in the price of heating does not change over time, which is unlikely to hold in reality.[17] Consumer demand for energy in response to changes in the price of energy is known to vary for several reasons, including why the price has changed.

Stated preference methods

Whilst not commonly used, a small number of studies employed a stated preference approach to estimate the rebound effect. This involved conducting a choice experiment survey in which respondents made a series of choices under different hypothetical scenarios. For example, Hediger (2018) designed a choice experiment where respondents were presented with scenarios in which the efficiency of their home had increased by a certain percentage and they were asked to what extent it would change their heating usage.[18] This was measured on a sliding scale of how much of the potential savings they would allocate to increasing heating usage in their home. The average proportion of potential savings allocated to increasing heating usage was used as an estimate of the direct rebound effect. This method faces similar limitations to all self-report methods in that stated behaviour may be very different from actual behaviour.[19]

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[15] Galvin (2014) Making the 'rebound effect' more useful for performance evaluation of thermal retrofits of existing homes: Defining the 'energy savings deficit' and the 'energy performance gap'. Energy and Buildings (69), pp.515-524; Chitnis et al. (2020) Rebound Effects for Household Energy Services in UK. The Energy Journal, 41(4)

[16] Sorrell, S. (2007) The rebound effect: An assessment of the evidence for economy-wide energy savings from improved energy efficiency. UK Energy Research Centre

[17] Sorrell, S. (2007) The rebound effect: An assessment of the evidence for economy-wide energy savings from improved energy efficiency. UK Energy Research Centre

[18] Hediger et al. (2018) Turn it up and open the window: on the rebound effects in residential heating. Ecological Economics, (149), pp. 21-39

[19] However, it should be noted that HM Treasury guidance for evaluation techniques in the public sector, recognises that stated preference approaches are an established alternative method if robust revealed preference data is not available. The Green Book 2022, HM Treasury, https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-government/the-green-book-2020

Other methodological issues

Another key methodological issue highlighted in the literature is that different definitions of direct rebound effects are often used.[20] In some cases the direct rebound effect is calculated as the proportion of the total expected energy savings from the installation of an energy efficiency measure that is not realised. However, in other cases, the direct rebound effect is defined as the percentage increase in demand for energy services (e.g. indoor temperature) as a result of a percentage increase in energy efficiency.[21]

Error! Reference source not found. categorises all relevant papers by methodology type and provides the estimated direct rebound effect. Given the variation in methodologies and contexts of the studies, it is not possible to compare estimates or calculate an average. Rather, the table demonstrates the wide range of estimates and the level of uncertainty of the size and extent of the direct rebound effect. See the Appendix for a more detailed description of papers and methodologies.

Table 1: Estimates of the direct rebound effect

Author & Year	Methodology Type	Country	Direct Rebound Effect
Hediger (2022)	Theoretical models (using elasticities)	Switzerland	4% - 7%
Galvin (2014)	Theoretical models (using elasticities)	Germany	30%
Chitnis et al. (2020)	Theoretical models (using elasticities)	UK	70%
Mardones (2021)	Evaluation (non-experimental)	Chile	Not statistically significant
Raynaud et al. (2016)	Evaluation (non-experimental)	Southern Europe	Not statistically significant
Aydin et al. (2017)	Evaluation (non-experimental)	Netherlands	27%
Calì et al. (2016)	Evaluation (experimental)	Germany	15% - 30%

[20] Galvin (2014) Making the ‘rebound effect’ more useful for performance evaluation of thermal retrofits of existing homes: Defining the ‘energy savings deficit’ and the ‘energy performance gap’. Energy and Buildings (69), pp.515-524

[21] Galvin (2014) Making the ‘rebound effect’ more useful for performance evaluation of thermal retrofits of existing homes: Defining the ‘energy savings deficit’ and the ‘energy performance gap’. Energy and Buildings (69), pp.515-524

Bardsley et al. (2019)	Evaluation (experimental)	UK	40%
Hediger et al. (2018)	Stated preference	Switzerland	12%

Note: See the Appendix for full biometric methodological information of the papers

Estimates for the direct rebound effect

The literature reviewed in this study also included meta-analyses of studies that estimate the direct rebound effect. A common range for direct rebound effects of 10-30% is often quoted in the literature.[22] However, this is not specific to heating, and encapsulates a wide range of methodologies.

There are limited conclusions that can be drawn from the estimates presented in Table 1 due to a small sample and the methodological challenges of estimating direct rebound effects.

Variation by energy efficiency measure

The energy efficiency measures identified by the literature can be grouped into three main categories:

- Insulation - referring to properties which have had loft and/or cavity wall insulation installed.
- Windows – referring to properties which have had double glazing and/or new windows installed.
- Heating systems – referring to properties which have had new heating systems installed, i.e. a new boiler (excluding heat pumps).

Insulation was the most common energy efficiency measure amongst the literature reviewed. However, it is not possible to make comparisons or draw conclusions for direct rebound effects by energy efficiency measure.

[22] Sorrell, S. (2007) The rebound effect: An assessment of the evidence for economy-wide energy savings from improved energy efficiency. UK Energy Research Centre; European Environment Agency (2022) Behavioural factors influencing the uptake of energy efficiency in residential buildings. Available here.

Characteristics of households who ‘comfort take’

While it is difficult to assess the size and extent of comfort taking due to the wide range of estimates, heterogeneity across households has been noted in the literature as a key driver of varying levels of direct rebound effects. Based on the reviewed literature, some trends can be drawn along the following household characteristics.

- Ownership status
- Income
- Education
- Environmental values.

Ownership status refers to the relationship an inhabitant has to a particular property. Within the literature, three common consumer types were explored: homeowners, landlords and tenants. The literature suggests that tenants tend to demonstrate a higher rebound effect compared to homeowners.[23] For example, Aydin et al. (2017) found that, using data from households in the Netherlands, the direct rebound effect among homeowners was 26.7% whilst the direct rebound effect for heating for tenants was considerably higher at 41.3%.[24]

One potential explanation may come from a disconnect between tenants and energy savings. For example, in some cases, landlords offer rental agreements which include bills as part of the rental payment. As a result, tenants’ energy consumption has no impact on their energy bills and therefore the financial cost of comfort taking is not a mitigating factor. The motivation to not comfort take may also be lower if the rental price includes bills that are fixed and do not vary with consumption of energy.[25]

Another potential explanation for this may be the high proportion of fuel poor homes in the rental sector. In 2022, the proportion of households in fuel poverty was highest for private renters, at around 24%.[26] Generally lower income households tend to have larger rebound effects, and tenants are more likely to have lower incomes compared to homeowners.

Hediger (2022) and Elsharkawy and Rutherford (2018) both find that **low-income households** have higher direct rebound effects following an energy efficiency retrofit.[27] However, it is important to note that a key driver of this effect is fuel poverty. A household is considered to be

[23] Hediger et al. (2018) Turn it up and open the window: on the rebound effects in residential heating. Ecological Economics, (149), pp. 21-39
[24] Aydin et al. (2017) Energy efficiency and household behaviour: the rebound effect in the residential sector. The RAND Journal of Economics, 48(3), pp 749-782
[25] Aydin et al. (2017) Energy efficiency and household behaviour: the rebound effect in the residential sector. The RAND Journal of Economics, 48(3), pp 749-782
[26] DESNZ (2023) Annual Fuel Poverty Statistics for England, 2013 (2022 data). Available here.
[27] Hediger (2022) Rebound effects in residential heating: How much does an extra degree matter? IRENE Working Papers 22-05, IRENE Institute of Economic Research

in fuel poverty if they are living in a property with an energy efficiency rating of band D or below and their available income, after energy costs to heat their home to a satisfactory level, places them below the poverty line.[28] Elsharkawy and Rutherford (2018) find that households in fuel poverty tend to increase their heating usage post-retrofit to help raise internal living standards. This is because the new levels of energy efficiency allow for these households to heat to a higher temperature at a relatively lower cost.[29] As a result, households of this type are likely to have a different relationship with energy usage and consumption than higher income households. It is important to note that, in the case of fuel poor households who are unable to heat their homes to a sufficient level, comfort taking is a desirable outcome. Therefore, limiting comfort taking for this group would not align with policy objectives.

Education level was also observed to be correlated with extent of the direct rebound effect. In one study, education was found to be negatively associated with the likelihood and extent of the rebound effect.[30] Individuals who have achieved a higher education level may be more aware of energy conservation issues and, as a result, tend to have a greater appreciation and desire for increased energy efficiency and reduction in energy usage.[31] Households with higher levels of education are also likely to have higher levels of income and therefore be above the fuel poverty line. As such, these households are likely to be thermally comfortable pre-retrofit and able to achieve the same level of comfort with less energy consumption post-retrofit, leading to lower rebound effects.[32]

The socio-economic characteristics of individuals who exhibit the highest levels of comfort taking behaviour are often positively correlated, that is, income level, education and property ownership: higher levels of education tend to drive higher income and earning potential which ultimately can be considered a driver of homeownership. However, it is not well understood which of these factors is the key driver for comfort taking, or indeed by another correlated factor. It is often observed that higher levels of education are associated with greater environmental concern (however there is limited causal evidence).[33]

[28] DESNZ (2023), 'Fuel poverty statistics', Accessed: Fuel poverty statistics - GOV.UK (www.gov.uk)
[29] Elsharkawy and Rutherford (2018) Energy efficient retrofit of social housing in the UK: Lessons learned from a community energy saving programme (CESP) in Nottingham. Energy and Buildings, 172(1), 295-306
[30] Elsharkawy and Rutherford (2018) Energy efficient retrofit of social housing in the UK: Lessons learned from a community energy saving programme (CESP) in Nottingham. Energy and Buildings, 172(1), 295-306

[31] Hediger (2022) Rebound effects in residential heating: How much does an extra degree matter? IRENE Working Papers 22-05, IRENE Institute of Economic Research
[32] Hediger et al. (2018) Turn it up and open the window: on the rebound effects in residential heating. Ecological Economics, (149), pp. 21-39
[33] Meyer, A. (2015) Does education increase pro-environmental behaviour? Ecological Economics. 116, 108-121

Main drivers and motivations to ‘comfort take’

This section outlines the main drivers and motivations to comfort taking as identified in the literature. These have been grouped into economic drivers, behavioural drivers and non-behavioural drivers.

Economic argument for the rebound effect and ‘comfort taking’

When the energy efficiency of a property improves, either through the installation of an energy efficiency measure or through installing a more efficient heating system, it should be cheaper to heat the dwelling to the same temperature, therefore the relative cost of heating has fallen. This economic argument for the motivation behind ‘comfort taking’ sets out that, people will ‘consume’ more heating as it is now cheaper relative to all other goods and services people consume.[34] [35] This is known as the substitution effect. The substitution effect is likely to be greater when many substitutable options for a good/service exist. Domestic heating does not have many close substitutes, however, one example might be substituting an electric fan heater for turning on central heating. As traditional sources of heating (i.e. gas, oil and LPG) are greenhouse gas-intensive, this may offset some of the expected emission savings.[36]

Another effect, known as the income effect, can also lead to an increase in comfort taking. The increase in disposable income after energy costs that is achieved by the energy efficiency improvement can allow for greater consumption of heating.[37] The substitution effect and income effect together can explain the rebound effect from a micro-economics perspective.[38]

A rational choice model of behaviour and the increase in demand for consumption of energy,[39] following a reduction in the total cost to heat the home to the same temperature, may determine rebound effects to a large extent.[40] The rational choice model of behaviour is an economic theory which states that individuals use all available information and will always make decisions that maximise their utility (i.e. happiness and satisfaction). Under this

[34] Santarius & Soland (2018) How Technological Efficiency Improvements Change Consumer Preferences: Towards a Psychological Theory of Rebound Effects. Ecological Economics, 146, 414-424
[35] Sorrell (2007) The rebound effect: An assessment of the evidence for economy-wide energy savings from improved energy efficiency. UK Energy Research Centre
[36] Chitnis & Sorrell (2015) Living up to expectations: Estimating direct and indirect rebound effects for UK households. Energy Economics, Elsevier, vol. 52(S1), 100-116
[37] Sorrell (2007) The rebound effect: An assessment of the evidence for economy-wide energy savings from improved energy efficiency. UK Energy Research Centre
[38] Santarius & Soland (2018) How Technological Efficiency Improvements Change Consumer Preferences: Towards a Psychological Theory of Rebound Effects. Ecological Economics, 146, 414-424
[39] The rational choice model of behaviour is an economic theory which states that individuals use all available information and will always make decisions that maximise their utility (i.e. happiness and satisfaction).
[40] Santarius & Soland (2018) How Technological Efficiency Improvements Change Consumer Preferences: Towards a Psychological Theory of Rebound Effects. Ecological Economics, 146, 414-424

assumption, any financial benefits from investing in energy efficiency measures would eventually be re-invested in increased demand which would mean rebound effects are large.[41]

However, this (fully) rational model of behaviour has been criticised in the literature in many domains. In relation to the direct rebound effect, in a rational model, consumers could be expected to spend all savings on increased thermal comfort. However, 'rebound sceptics' argue that consumers' needs and preferences in terms of energy services (e.g. indoor temperatures) remain more or less constant over time and will not increase demand beyond this need. Therefore, their demand does not respond to changes in the energy efficiency of their home and any energy efficiency improvements would result in less energy being used for heating.[42] Under this view, energy efficiency improvements result in small if not negligible rebound effects.

Behavioural drivers

Under neoclassical economic assumptions, a rational consumer is expected to respond to an improvement in energy efficiency of their heating by consuming more. However, the behavioural and psychological literature assumes people have a limited ability to process information and therefore their rationality is bounded.[43] This means that people rely on heuristics (mental shortcuts that help people make quick decisions) which are driven by values, habits, preferences and personal and social norms.[44] [45]

From a psychological perspective, installing an energy efficiency measure (e.g. home insulation) can be regarded as an intervention that interrupts previous routines and can lead to behavioural change.[46] Findings suggest that the drivers and motivators to comfort taking are also rooted in both the planned and unplanned changes in lifestyles related to occupants' behaviours, heuristics and values.[47]

These findings are summarised below.

- The **desire to increase comfort** has been found to be positively associated with higher indoor temperatures following a retrofit. For example, one study conducted a discrete choice experiment (DCE) to explore households' values associated with retrofits. Respondents preferred higher indoor temperatures following a retrofit compared to

[41] Santarius & Soland (2018) How Technological Efficiency Improvements Change Consumer Preferences: Towards a Psychological Theory of Rebound Effects. Ecological Economics, 146, 414-424
[42] Santarius & Soland (2018) How Technological Efficiency Improvements Change Consumer Preferences: Towards a Psychological Theory of Rebound Effects. Ecological Economics, 146, 414-424
[43] European Environment Agency (2022) Behavioural factors influencing the uptake of energy efficiency in residential buildings. Available here.
[44] Personal norms refers to an individual's own beliefs and values and relate to feelings of moral obligation to act in a certain way. Social norms refer to shared beliefs and values that are considered acceptable in a social group.
[45] Seebauer (2018) The psychology of rebound effects: Explaining energy efficiency rebound behaviours with electric vehicles and building insulation in Austria. Energy Research & Social Science, Volume 46, 311-320
[46] Dutschke et al. (2018) Moral licensing-Another source of rebound? Front. Energy Res. 6:38
[47] Galassi and Madlener (2017) The Role of Environmental Concern and Comfort Expectations in Energy Retrofit Decisions. Ecological Economics, 141(C) 53-65

scenarios where indoor temperatures remained the same, indicating a preference for 'comfort taking'.[48]

- **Pro-environmental values** can have an impact on comfort taking behaviour. One study estimated the rebound effect associated with a subsidy provided for building insulation (i.e. for retrofitting walls, roof or basement ceiling with thermal insulation material, and for installing double- or triple glazed windows), where those who had received a subsidy were invited to take part in an online survey (if they had completed at least one full winter since their retrofit/installation).[49] It was found that pro-environmental values had the strongest impact on the direct rebound effect, that is, the more a person advocates protecting nature from human harm, the lower the rebound effect. Another study noted that rebound effects are less likely to occur if energy efficiency improvement is a motivation for the retrofit or it is in line with salient pro-environmental values held by the consumer, and/or it is perceived to be connected with self-worth and identity.[50] However, this might not apply if choosing the more efficient product or service is more strongly motivated by other goals e.g. cost saving, safety, or comfort.[51]
- **Changing habits or preferences around heating** can lead to comfort taking. One study based in the UK explored home heating patterns of occupants before and after retrofits. Before retrofits, tenants were tactical about the rooms that they heated; that is, only heating those rooms that were essential for their daily lives. After renovation, occupants were more inclined to heat all rooms all of the time (a change from 20% of respondents reporting that they heat all rooms to 63.5%) and less inclined to heat specific rooms individually.[52]
- **Habits** are the automatic repetition of past behaviours and may contribute to comfort taking in several ways. On the one hand, habits may limit the rebound effect as they stabilise consumption patterns (i.e. the household will not necessarily consume more after installation). For example, if a household consistently sets their thermostat to a specific temperature, this behaviour may remain unchanged after installing an energy efficiency measure. On the other hand, habits may increase the rebound effect if people adopt new habits, such as setting their thermostat to a higher temperature.[53] Habits may also lead to households unconsciously comfort taking, for example, by keeping their heating schedule consistent. While their behaviour is unchanged, they will be unconsciously comfort taking as the property is more energy efficient resulting in lower heat loss, and heating the home for the same amount of time each day will result in higher indoor temperatures.[54]

[48] Galassi and Madlener (2017) The Role of Environmental Concern and Comfort Expectations in Energy Retrofit Decisions. Ecological Economics, 141(C) 53-65
[49] Galassi. and Madlener (2017) The Role of Environmental Concern and Comfort Expectations in Energy Retrofit Decisions. Ecological Economics, 141(C) 53-65
[50] Dutschke et al. (2018) Moral licensing-Another source of rebound? Front. Energy Res. 6:38
[51] Dutschke et al. (2018) Moral licensing-Another source of rebound? Front. Energy Res. 6:38
[52] Elsharkawy and Rutherford (2018) Energy efficient retrofit of social housing in the UK: Lessons learned from a community energy saving programme (CESP) in Nottingham. Energy and Buildings, 172(1), 295-306
[53] Seebauer (2018) The psychology of rebound effects: Explaining energy efficiency rebound behaviours with electric vehicles and building insulation in Austria. Energy Research & Social Science, Volume 46, 311-320
[54] Seebauer (2018) The psychology of rebound effects: Explaining energy efficiency rebound behaviours with electric vehicles and building insulation in Austria. Energy Research & Social Science, Volume 46, 311-320

- **Personal norms** can also impact comfort taking. For example, voluntary frugality is a value that may reduce comfort taking, with a preference for wearing more layers over increasing heating.[55]
- **Social norms** can be a driver of comfort taking, which may move in both positive and negative directions. People may want to project a pro-environmental image by reducing their consumption. On the other hand, social norms may drive an increase in comfort taking. For example, one study found that social norms had a positive relationship with the direct rebound effect.[56] One potential explanation is that having a comfortably heated home for visitors is desirable and people increase indoor temperatures for the benefit of others, now it is cheaper for them to do so.
- **Moral licencing** has also been identified as a potential driver of the direct rebound effect. This is the cognitive process by which individuals justify 'immoral' behaviour (e.g. turning their heating up) by having previously engaged in moral behaviour (e.g. installing energy efficient measures).[57] While moral licencing has been observed in environment-related domains (e.g. purchases of environmental goods), it has not been widely studied or observed in the context of energy efficiency and the rebound effect.

Non-behavioural drivers

The literature also identified other non-behavioural drivers that can impact the extent of comfort taking.

- Several studies mention the difficulties adapting to new heating controls or making the most out of new energy efficiency measures. This is often related to a **lack of energy-related advice or level of occupant awareness** which can lead to a rebound effect phenomenon due to lack of sufficient understanding.[58]
- Several studies also mention that the behavioural drivers around the rebound effect or 'comfort taking' cannot be considered in isolation from the **physical state of the building** and **technical faults in the design or installation of energy efficiency measures**. A study of individual dwellings in Newcastle-upon-Tyne, found that the physical state of the building was the biggest factor impacting the extent of comfort taking, and thus individual comfort taking (i.e. turning on the heating more often) was less relevant than the physical factors.[59]

[55] Seebauer (2018) The psychology of rebound effects: Explaining energy efficiency rebound behaviours with electric vehicles and building insulation in Austria. Energy Research & Social Science, Volume 46, 311-320
[56] Seebauer (2018) The psychology of rebound effects: Explaining energy efficiency rebound behaviours with electric vehicles and building insulation in Austria. Energy Research & Social Science, Volume 46, 311-320
[57] Dutschke et al. (2018) Moral licensing-Another source of rebound? Front. Energy Res. 6:38
[58] Elsharkawy and Rutherford (2018) Energy efficient retrofit of social housing in the UK: Lessons learned from a community energy saving programme (CESP) in Nottingham. Energy and Buildings, 172(1), 295-306
[59] Calderon (2018) Effects of fabric retrofit insulation in a UK high-rise social housing building on temperature take back. Energy and Buildings, 173, 470-488

Mitigations to limit 'comfort taking'

The identified literature clearly sets out that the rebound effect should be actively considered by policy makers in the development of energy efficiency improvement policies.[60] [61] Potential mitigation measures as identified in the REA relate to both the rational economic choice model of behaviour (i.e. fiscal/economic interventions) and other behavioural drivers. Mitigation measures, as previously stated, should address comfort taking in households that already achieve sufficient thermal comfort prior to any energy efficiency measures and/or households that do not contain anyone with a vulnerability.

Mitigation measures identified in the REA are summarised below.

Fiscal / economic interventions

- Financial incentives such as an **environmental tax** could be used to mitigate increasing consumption following installation.[62] The main objective of a tax would be to increase the cost of 'comfort taking' for households and compensate for the rebound effect. That is, the tax would increase the cost of energy (e.g. gas or electricity) to compensate for the reduction in cost due to the improvement in energy efficiency. However, this may have perverse consequences on incentives to install energy efficiency measures and could have harmful impacts on households that currently do not heat their homes to sufficient levels.
- **Regulations or legal interventions** targeting providers of energy efficiency technologies were suggested by one study to address improving consumer information on the use of these technologies and hence reduce the extent of comfort taking.[63]
- When developing policies which provide funding in the form of **subsidies to install energy efficiency measures**, one study suggests that the funding criteria in subsidy programmes could prioritise the consumer segments which have a lower risk of rebound.[64] However, given that low income families are more likely to comfort take, such an approach could negatively impact vulnerable households for whom comfort taking would be a desirable outcome of installing energy efficiency measures.

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[60] Aydin et al. (2017) Energy efficiency and household behaviour: the rebound effect in the residential sector. The RAND Journal of Economics, 48(3), pp 749-782

[61] Freire-González and Puig-Ventosa (2015) Energy efficiency policies and the Jevons paradox. International Journal of Energy Economics and Policy, 5(1), 69–79

[62] Freire-González and Puig-Ventosa (2015) Energy efficiency policies and the Jevons paradox. International Journal of Energy Economics and Policy, 5(1), 69–79

[63] Freire-González and Puig-Ventosa (2015) Energy efficiency policies and the Jevons paradox. International Journal of Energy Economics and Policy, 5(1), 69–79

[64] Seebauer (2018) The psychology of rebound effects: Explaining energy efficiency rebound behaviours with electric vehicles and building insulation in Austria. Energy Research & Social Science, Volume 46, 311-320

Behavioural interventions

Consideration of household behaviours and values is crucial when designing and implementing policies aimed at improving energy efficiency. The Green Deal demonstrated that relying on rational economic assumptions was not enough to encourage households to act.[65] The 'golden rule' of the Green Deal was that loan repayments would be no higher than the energy bill savings made from installing energy efficiency measures (however this was not guaranteed). Despite the economic benefits, uptake was low. The literature cites low levels of awareness and low personal engagement and communication as key reasons for low uptake.[66] Therefore, it is generally important to understand behavioural drivers, engage stakeholders at all levels and tailor programmes and communications to people's values and beliefs.[67]

There is a limited amount of evidence in the literature on how behavioural science can be used in policy making to limit 'comfort taking'. The majority of findings in the literature relate to the use of behavioural science in policies related to improving energy efficiency behaviours in residential settings generally rather than specifically comfort taking.

Most of the interventions relate **to communication and information provision campaigns**. Common behavioural biases which have been considered in policy settings in the residential sector include status quo bias, loss aversion, and framing. These have typically been addressed using legislative measures including information provision to promote changes in behaviour and energy performance standards.[68]

Table 2 Behavioural concepts/biases

Behavioural concept/bias	Definition
Status quo bias	People tend to value the current state of affairs (i.e. the status quo) highly, meaning they disproportionately stick to what they currently have or do.
Loss aversion	People tend to feel losses more strongly than gains of equal size.
Framing	People perceive information and draw different conclusions from information depending on how the information is presented.
Salience	The degree to which information is noticeable and stands out to people.

[65] The Green Deal was a government scheme launched in 2013 in the UK with the objective of improving the energy efficiency of the existing building stock in the UK by offering new financing mechanisms to remove the barrier of high upfront costs.
[66] DESNZ (2024) Green Home Finance Expert Analysis from a Behavioural Perspective. Available here.
[67] Galvin and Sunikka-Blank (2017) Ten questions concerning sustainable domestic thermal retrofit policy research. Building and Environment, 118, 377-388
[68] European Environment Agency (2022) Behavioural factors influencing the uptake of energy efficiency in residential buildings. Available here.

Potential behavioural interventions to limit comfort taking identified in the literature are summarised below:

- **Making people aware of changes in their use of energy** following efficiency upgrades has been suggested as a way of mitigating rebound effects. For example, increasing the feedback mechanism on smart meters or through energy bills could circumvent habits and lead to a lower rebound effect.[69] **Feedback mechanisms** may be improved by the implementation of more sophisticated monitoring systems to track real energy consumption against expected energy consumption that was estimated prior to the installation of an energy efficiency measure.[70] This gap could then be communicated with the occupants. The more salient this information is, the more likely it will be to have a greater impact on behaviour.
- **Communication and providing advice** on energy use was also mentioned in the literature as a potential mitigation for comfort taking. For example, one study found that before home improvements, 47% of respondents in their survey were keen on receiving energy advice in the future. After home improvements, this rose to 57%, suggesting that for those respondents, their positive experience with their home improvements may have encouraged them to be more receptive to energy advice.[71] Generally, the literature suggests that energy-related communication and advice should be tailored, as people tend to have a greater response to personalisation. There is not a one-size-fits-all approach, therefore a considered and tailored means of communicating energy-related advice should be planned.[72] [73]
- An **integrated approach to interventions** is suggested by Elsharkawy and Rutherford (2018) whereby awareness-raising in combination with other types of interventions should be implemented.[74] The paper suggests that behavioural change could be achieved by engaging people through home energy audits followed by tailored advice, media campaigns, combined with financial incentives where possible.
- **Social norms** can also be employed in messaging. One example of an intervention was informing households about their energy consumption in relation to that of their neighbourhood. Households were either informed that their consumption was above average, or praised that their consumption was below average.[75] In the context of energy efficiency measures and 'comfort taking', this could involve informing

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69 Seebauer (2018) The psychology of rebound effects: Explaining energy efficiency rebound behaviours with electric vehicles and building insulation in Austria. Energy Research & Social Science, Volume 46, 311-320

70 Calì et al..(2016) Energy performance gap in refurbished German dwellings: Lesson learned from a field test. Energy and Buildings. 127, 1146-1158

71 Elsharkawy and Rutherford (2018) Energy efficient retrofit of social housing in the UK: Lessons learned from a community energy saving programme (CESP) in Nottingham. Energy and Buildings, 172(1), 295-306

72 Elsharkawy and Rutherford (2018) Energy efficient retrofit of social housing in the UK: Lessons learned from a community energy saving programme (CESP) in Nottingham. Energy and Buildings, 172(1), 295-306

73 Seebauer (2018) The psychology of rebound effects: Explaining energy efficiency rebound behaviours with electric vehicles and building insulation in Austria. Energy Research & Social Science, Volume 46, 311-320

74 Elsharkawy and Rutherford (2018) Energy efficient retrofit of social housing in the UK: Lessons learned from a community energy saving programme (CESP) in Nottingham. Energy and Buildings, 172(1), 295-306

75 Shultz et al. (2007) cited in Elsharkawy and Rutherford (2018) Energy efficient retrofit of social housing in the UK: Lessons learned from a community energy saving programme (CESP) in Nottingham. Energy and Buildings, 172(1), 295-306

households who have installed these measures of their relative energy savings to others who have also recently installed energy efficiency measures. This would only be appropriate to the target group of interest, rather than vulnerable households and/or those who could not already heat their homes to a sufficient temperature.

- **Visual prompts** are another means of encouraging sustainable energy consumption. One paper mentions that the use of prompts and nudges has demonstrated effectiveness in promoting pro-environmental behaviours. Prompts work by reminding people engaged in habitual behaviours that they have the capability to change their lifestyles to become more environmentally sustainable.[76] Examples of visual prompts to reduce energy consumption may include the use of colours to indicate heating usage (such as on smart meters), stickers on new heating systems (e.g. on boilers) or visual stimuli incorporated into apps. However, people also tend to habituate prompts so any such prompts may need to be changed regularly to remain salient.
- One paper provides a summary of EU policies which have leveraged behavioural science applications to promote desired energy behaviours. Examples include the use of **loss aversion** and **framing**, as observed in initiatives related to smart meter installation. One study found that loss-framed information tends to be more successful at engaging stakeholders in the context of installing smart meters.[77] This may suggest that messages framing the lower actual energy savings, following the installation of an energy efficiency measures (due to comfort taking), as losses, may limit comfort taking behaviour.
- **Pro-environmental values** are identified in the literature as being a potentially strong mitigation against comfort taking behaviours.[78] Utilising the moment energy efficiency measures are purchased to bring pro-environmental values to the forefront could be a way to mitigate against less environmental behaviours. For example, at the point of purchase or installation of energy efficiency measures, highlighting the environmental benefit of these measures in terms of the potential energy savings. This would likely be more effective for those who purchased energy efficiency measures due to their pro-environmental values.
- The **timing of information provision** is also an important factor. The formation of habits and the difficulty breaking them suggests that communicating information as closely aligned with the time of installation as possible, whether just before, during, or shortly after, can cultivate pro-environmental habits or mitigate potential comfort taking behaviour.

[76] Elsharkawy and Rutherford (2018) Energy efficient retrofit of social housing in the UK: Lessons learned from a community energy saving programme (CESP) in Nottingham. Energy and Buildings, 172(1), 295-306
[77] Bager and Mundaca (2017) cited in European Environment Agency (2022) Behavioural factors influencing the uptake of energy efficiency in residential buildings. Available here.
[78] Seebauer, S. (2018) The psychology of rebound effects: Explaining energy efficiency rebound behaviours with electric vehicles and building insulation in Austria. Energy Research & Social Science, Volume 46, 311-320

Success of mitigation strategies

There is very little evidence in the reviewed literature on the success of mitigation strategies to limit comfort taking. Bardsley et al. (2019) estimate the direct rebound effect and the impact of behavioural interventions by a community environmental group on the rebound effect in a field experiment of 185 affluent households in the UK.[79] Both the treatment and control group were given free insultation. However, the treatment group also participated in community activities and events organised by an environment group whereas the control group did not). The take-home message of the community group engagement activities was to conserve heating energy and turn the heating down by 1 degree. The study, however, found that the behavioural interventions had no impact on the rebound effect. The authors noted this may be due to certain aspects of the interventions themselves. For example, events were held somewhat infrequently (once a year) and information provided to households was not personalised.

[79] Bardsley et al. (2019) Domestic thermal upgrades, community action and energy saving: A three-year experimental study of prosperous households. Energy Policy, 127. 475-485

Evidence gaps

There is a wide body of literature on direct rebound effects from various energy efficiency measures, however the literature on comfort taking (or the direct rebound effect specific to domestic heating) was found to be more limited. Specifically, the following gaps in the evidence base were identified.

- A key evidence gap is that there is no agreed upon estimate for the extent of comfort taking nor a consensus on the most appropriate methodology for estimating comfort taking (or the direct rebound effect).
- There is a small amount of evidence on the extent of the direct rebound effect (and specifically comfort taking) for certain demographic groups, for example, high income vs. low income households. The literature that does address the rebound effect for different groups suggests that rebound effects are higher amongst those lower income groups. There is also limited evidence with respect to other household characteristics. Therefore, the evidence on who is most prone to comfort taking is limited.
- There is limited evidence on how comfort taking varies over time. Namely, whether comfort taking behaviour tends to increase or decrease in the years following installation of energy efficiency measures.
- While there is a good amount of evidence on the different drivers and motivators for comfort taking, there is limited evidence on the most important drivers. For example, whether costs (lower energy bills) or the desire to increase comfort is generally more important. Primary research may need to be carried out to understand the relative importance of different drivers. There is also limited evidence on how drivers vary across household characteristics.
- Known mitigations for comfort taking is a more substantial evidence gap. While there is some literature on potential or suggested mitigations, there is little evidence in the identified literature of the types of strategies (including examples) that have been used to limit comfort taking (or the direct rebound effect more generally), and whether they have been successful.
- How behavioural science can and has been used in the policy setting to limit comfort taking is also a substantial evidence gap in the literature.

Conclusion

‘Comfort taking’ is defined as a phenomenon whereby following the increase in the energy efficiency of a property (and corresponding energy bill savings) the resident takes advantage (either knowingly or unknowingly) of their more efficient home by heating it more frequently and/or to a higher temperature, rather than heating it to the same temperature as before. This is part of a wider phenomenon known as the ‘rebound effect’ where an increase in energy efficiency may lead to less energy savings than expected. ‘Comfort taking’ is not a widely used term in the literature, therefore we consider the phenomenon of comfort taking to be synonymous with the direct rebound effect specific to the context of energy efficiency, heating, and thermal comfort.

The estimated extent of ‘comfort taking’

Estimates for the direct rebound effect in domestic heating (and thus ‘comfort taking’) vary widely due to the variation in methodologies used to estimate the rebound effect and contextual factors (i.e. the setting and country in which estimates are made). There is currently no consensus on the most appropriate methodological approach to estimate direct rebound effects, and the most common methods used carry significant challenges. Therefore, it is not possible to compare estimates across studies or draw conclusions on the estimated size of rebound effects for heating.

Studies based in Europe found evidence of a direct rebound effect occurring following the installation of energy efficiency measures. A consistent finding across studies is that the direct rebound effect for heating tends to be greater for lower income households compared to higher income households. This is typically explained by lower income households often starting from a lower comfort level and therefore have greater behavioural changes (i.e. in terms of heating their homes more) than higher income households who are more likely to be at their preferred comfort level prior to the installation of energy efficiency measures.

Main drivers and motivators for ‘comfort taking’

The economic argument behind 'comfort taking' and the rebound effect is characterised by the rational choice model of behaviour, where reduced energy costs after energy efficiency improvements lead to increased consumption. However, the behavioural and psychological literature argues that people’s behaviour is driven by their values, preferences, habits and heuristics. For example, the desire to increase comfort levels in homes leads people to heat their homes to higher temperatures and/or more often. The extent of individual’s pro-environmental values and the connection of those values to their self-identity can also influence comfort taking behaviour. The installation of a new energy efficiency measure in the home can also be seen as an intervention which changes people’s heating habits, which could either increase or limit comfort taking. Other behavioural biases such as personal and social norms and moral licensing can also influence heating behaviour. Awareness and education about the rebound effect and how to use heating in an efficient way following home upgrades can also further impact the extent of comfort taking.

Mitigations to limit ‘comfort taking’

The literature provides some insights into potential mitigations that could be used to limit comfort taking for the groups of interest. That is, those households who can already heat their home to a sufficient level prior to installing energy efficiency measures and/or do not contain someone with a vulnerability. The consistent message in the identified literature is that it is important for rebound effects to be explicitly considered in domestic energy efficiency policy design and implementation, and that it should not be overlooked. While the literature does not provide a lot of evidence on successful mitigations, there are some suggestions for interventions that may limit the rebound effect. These include fiscal/economic interventions such as environmental taxes and/or regulating to ensure sufficient consumer information on energy efficiency technology, as well as targeting subsidies for domestic energy efficiency improvements to groups with a lower risk of comfort taking. However, targeted subsidies could have a negative effect on low income households in fuel poverty who are more likely to comfort take and for whom this would be a desirable outcome of installing energy efficiency measures. Behavioural interventions involve raising awareness of energy use changes post-installation, for example through employing feedback mechanisms (e.g. using energy bills and smart meters) and leveraging pro-environmental values and behavioural science insights.

In terms of using insights from behavioural science, some evidence from the literature focuses primarily on communication and information provision strategies. For example, these may utilise social norms, visual prompts, and framing to encourage positive behavioural changes. Overall, an integrated approach, tailoring information through diverse methods is recommended by the literature. However, it should be noted that the evidence on the success of known mitigations is limited.

This publication is available from: www.gov.uk/government/publications/comfort-taking-evidence-review

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