Solving the Difficult Problem of Hard to Decarbonise Homes

Hard to Decarbonise homes represent a complex problem that has historically been neglected in favour of the lower hanging fruit of easier to treat properties. To enable an equitable net zero transition, we must understand these homes in a holistic manner that takes account of the impacts of different routes to decarbonisation on occupants.

Rokia Raslan*, Institute for Environmental Design and Engineering, University College London, London, UK, Aimee Ambrose, The Centre for Regional Economic and Social Research, Sheffield Hallam University, Sheffield, UK, *Corresponding Author Contact : r.raslan@ucl.ac.uk

Introduction

The term 'Hard-to-Decarbonise' has been mainly linked with energy-intensive, high carbon emitting activities such as heavy industry and aviation, where reducing carbon emissions is difficult because the solutions needed do not exist or are more costly than in other sectors. But more recently it has been used to describe something much closer to home: the houses that we live in.

The residential sector is the fourth-largest source of carbon emissions in the world. Globally, we estimate that on average one in four of our homes are Hard-to-Decarbonise (HtD)(based on data from , 1–5) Moreover, HtD homes are thought to be responsible for over 25% of all direct residential sector emissions [e.g., 1]. These homes have one or more physical, locational, and occupant-related characteristics that impact the feasibility of deploying available cost-effective decarbonisation solutions within them. These solutions include measures that improve energy efficiency and motivate better use of energy as well as low-carbon heating (and cooling) technology options.

The impetus for urgent research into HtD homes lies in the startling fact that while it is widely accepted that all homes will need to be fully decarbonised by 2050, we do not know how this will be achieved in a quarter of them – the HtD subset of the residential stock.

But the problem goes beyond the missed decarbonisation potential. It is also one of societal equity; occupants of HtD homes pay a high price to live in them. In the absence of effective and affordable decarbonisation solutions, occupants of HtD homes will be less likely to be able to escape fuel poverty and more likely to be excluded from the opportunity to access the benefits of the Net Zero Transition [6]. Fuel poverty is an inability to afford to heat and cool the home to a safe and comfortable level [7]. Fuel poverty affects single parents,

women, people of colour and the elderly the most and can therefore be seen as a consequence of and contributor to injustices linked to gender, ethnicity and age. Living in fuel poverty results in poorer health and mental wellbeing, poorer educational outcomes and social stigma and can ultimately lead to premature death [8], with hundreds of thousands of lives being lost each winter to cold homes across Europe alone [9].

Failing to address HtD homes will therefore lead to a lock-in of inequities and injustices, and contribute to the lock-in of building sector energy consumption and emissions for many decades to come [10]. It will also induce climate change related 'asset stranding' of HtD homes, where they are prematurely deemed redundant or obsolete and unappealing to occupants [11].

However, HtD homes and their occupants represent a complex problem and have historically been neglected in favour of the lower hanging fruit of easier to treat properties. To enable an equitable Net Zero Transition, we must understand the complex issues surrounding the decarbonisation of HtD homes and we must do so in a holistic manner that goes beyond the purely technological and takes account of the impacts of different routes to decarbonisation on occupants.

Defining Hard-to-Decarbonise homes

Generally speaking, the physical attributes that render a home HtD relate to its form, height and fabric. Locational attributes are constraints arising from where it is sited. Occupant attributes, as will be discussed below, relate to the socio-economic, behavioural and health related characteristics of those who live in these homes (and in some cases their landlords). The wide array of HtD typologies include, but are not limited to, multi-occupancy/high rise blocks; Hard-to-Treat homes (HTT) with uninsulated solid and non-standard cavity walls; homes with space constraints; homes that are off-grid or in rural, exposed, remote or inaccessible locations; those with heritage status or in conservation areas; and homes with fuel poor or Hard-to-Reach (HtR) occupants and/or owners, which in this context are those who are difficult to engage in decarbonisation efforts or discussions about decarbonisation options.

The incidence of one or more of these attributes are likely to make decarbonisation problematic when compared to 'standard' housing where they are not present. For example, standard air source heat pumps cannot be installed in homes with external space constraints. Meanwhile, multi-occupancy/high-rise residential blocks are notoriously difficult to insulate due to high costs, competing priorities of stakeholders, split incentives

[12] and, more recently, fire safety concerns [13], and landlords are hard to engage when intervention costs are likely to be high [14]. It is therefore not surprising that evidence from various contexts has pointed to the poor energy performance of HtD homes. In the UK, where the average Energy Performance Certificate (EPC) Rating of the housing stock is D, the incidence of the lowest EPC ratings F-G was estimated to be as high as 60%-80% for some HtD typologies [15,16].

Occupants of HtD homes

What we know about the characteristics of HtD homes provides indications about who is likely to live in them. Whilst not all occupants of HtD homes will be on a low income, we expect to see well above average levels of fuel poverty amongst these occupants due to the high energy costs associated with running these energy inefficient homes. Indeed, there are several ways in which HtD homes and fuel poverty are intrinsically linked. The HtD housing stock has a higher likelihood of poor EPC ratings and preponderance of older housing, exposing occupants to greater risk of fuel poverty. Living in a property with an EPC of E-G places occupants at increased risk of fuel poverty due to the higher cost of keeping warm in these energy inefficient properties and increased exposure to the attendant health and wellbeing risks associated with cold homes [17]. This risk is highest where an E-G rated home is occupied by a low-income household [18]. As some of the least desirable stock, E-G properties are more likely to be occupied by low-income households, who have the least choice in the housing market and who are vulnerable to fuel poverty.

We also see significant overlap, in many countries, between HtD homes and HtR groups, in particular within the private rented sector. Characteristics that can make occupants HtR include complex and chaotic lives, competing priorities, low or very high incomes, digital exclusion, cultural, language and literacy barriers, poor health and being very young or old [19]. Private landlords are also often identified as HtR in this context, as they have limited motivation to improve the energy efficiency of their properties as they do not usually benefit directly from these interventions because tenants pay the energy bills [14]. Moreover, tenants within this sector have minimal negotiating power to encourage landlords to improve energy performance, particularly in overheated housing markets [14].

The links between HtD homes and HtR occupants are underlined when definitions of being HtR incorporate being underserved, which means that a vital service or initiative either does not reach or encompass a particular

group or groups, or doesn't respond fully or at all to their needs [19]. In this sense, occupying a HtD home is being underserved because effective and affordable decarbonisation solutions are unlikely to be suitable for their properties or their budgets, and the fact that barriers associated with the engagement of occupants and owners, as outlined previously, is key challenge to accessing these solutions.

The HtD homes knowledge challenge

Even though energy efficiency has been a mainstay of built environment research since the 1970s, researchers within this domain have, until now, paid insufficient attention to HtD homes. A key reason for this is the path dependence within research agendas in this area. Path dependency occurs when the status quo persists because it is often easier to continue along an already set path than to create an entirely new one [20]. As research funding has, until now, favoured programmes that aim to solve the common problems of standard housing and 'pick the low hanging fruit' [21], the opportunity for researchers to deviate from this path and endeavour to tackle more complex and challenging segments of the building stock such as HtD homes has remained limited.

So, while a few existing studies have helped identify some broad patterns, such as general HtD typologies, indications of the prevalence of HtD homes around the world and their unrealised decarbonisation potential, important details are still missing [1,3–5]. The knowledge challenges here cluster around four areas.

The first is the general absence of reporting and data on HtD homes combined with the fact that what is known about them largely stems from single case study research. This means that we still do not fully understand many of the physical, locational and occupant related attributes that render a home HtD, the interplay between these characteristics or how they may vary across different contexts [22].

Second, understanding household characteristics as well as the preferences, habits, and routines of occupants – in addition to the barriers they face in decarbonising their homes – has been widely recognised as a research challenge across the residential sector. While we are starting to build an understanding of this, we still have very poor knowledge about how occupants live in HtD homes and how they interact with them.

Third, existing building stock models we use to understand the built environment, explore trajectories and the multiple impacts of decarbonisation largely rely on sampling methods that generate archetypes representative of 'standard' home characteristics. HtD homes are therefore inadequately represented within them [23].

Finally, the research agenda and corresponding methodological expertise in the built environment domain has become gradually skewed towards more data-rich areas of the stock. But HtD homes are at other end of that scale: they present the problem of 'scarce data', so in many ways we are still limited in our ability to effectively study them [24].

Overcoming the challenge

Achieving a zero-carbon future for HtD homes is a necessity, which will require a profound change of mindset starting from those who fund research to those who undertake it. This will entail supporting novel, field-building research that looks beyond disciplinary boundaries for approaches that address the above-mentioned scarce data challenges by fully deploying the capabilities of open science and enabling the gathering of datasets and creation of models that are richer and more inclusive. It also requires democratising research in this area and moving it beyond the purely technological.

A key priority for this research agenda will be to establish a precise profile of HtD occupants and develop occupant-centred approaches that engage them as partners in the co-creation of decarbonisation solutions for their homes. This promises to develop a much greater understanding of the costs to humans of living in HtD homes, while increasing the potential for fostering greater acceptance and impact of decarbonisation solutions and minimising the scope for adverse impacts on households.

The wider research landscape provides a number of examples, such as rare disease research, where such thinking has proven successful. In recent years, initiatives in rare disease research [25] have benefited from a change of perspective that encouraged the use of novel patient-centred approaches, leading to dramatic therapeutic advances that have not only impacted the lives of those living with these illnesses, but have also lead to discoveries that benefitted those with more common diseases.

Despite the complex challenges that HtD homes and their occupants present, we cannot afford to ignore them. The urgent research needed to support the discovery of decarbonisation solutions that specifically respond to HtD homes is vital not only for carbon reduction but also in terms of improving the health, wellbeing and social

inclusion of some of the most vulnerable in society. A change of mindset that places occupants at the heart of the research process promises to deliver benefits that will not only move research in this area forward but will lead to insights that can offer a significant source of hope in our quest to decarbonise all homes.

Competing interests

The authors declare no competing interests.

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