User-Centred Energy Systems

User-Centred Energy Systems TCP: HTR Annex

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Chapter 1 - Background

Overview of Project

One key outcome of the DSM *Task 24: Behaviour Change in DSM – Phase I and Phase II* project (see Rotmann, 2017; 2018, for a summary of outputs) was that 'Behaviour Changers' (i.e. those agencies or individuals tasked with changing energy user behaviours via policies, programmes or pilots) often struggle to effectively engage some audiences, commonly-termed 'hard-to-reach' (HTR) (Rotmann, 2016). In light of this finding, the *Users TCP HTR Annex* by the International Energy Agency (IEA) seeks to characterise the various audience segments that are commonly, but also vaguely, referred to as "Hard-to-Reach (HTR) in both the residential and non-residential (primarily commercial) sectors. In particular, it aims to uncover the barriers, needs, and opportunities for more effectively engaging HTR segments in energy-saving behavioural changes. Overall, the *Users TCP HTR Annex* follows and tests a research process based on the so-called "Building Blocks of Behaviour Change" (Karlin et al, forthcoming). In a nutshell, this approach focuses on formalising the process of creating a behaviour change intervention, rather than specifying a one-size-fits-all procedure. This process is flexible - the exact methodologies and approaches will vary depending on the goals of the programme or policy manager and constraints of the organisation - but also systematic, by constructing these efforts as a set of building blocks and process phases, which require a holistic consideration of how each effort fits together. In this process, the first two phases are specifically designed to:

1. *Discover*, via stakeholder engagement (see Ashby et al, 2020a and b) and landscape analysis (see Rotmann et al, forthcoming)
2. *Define* target audiences and behaviours (Rotmann et al, forthcoming).

The document at hand summarises the findings associated with the implementation of these two steps. The document is based on a much more extensive, detailed study (see Rotmann et al, forthcoming) that the *Users TCP HTR Annex* has developed. As whole, these documents form the basis of the wider landscape analysis and provide audience and behaviour definitions.

Motivation for Engaging HTR Audiences

In the U.S. and Canada, energy efficiency (EE) programme administrators aim to better engage HTR audiences to fulfil both a moral equity imperative and regulatory mandates. In contrast, in New Zealand (NZ), the main impetus underlying government efforts to engage HTR audiences is improved health, particularly for vulnerable populations (e.g. *Healthy Homes Initiative*) as well as equity (Allen + Clarke, 2018). The United Kingdom (UK) has similar goals to NZ as its key drivers to engage HTR groups are the moral imperative to promote equity across different socio-economic groups and the reduction of negative health consequences for inhabitants of homes that are cold and unaffordable to heat. In Sweden (SWE), the primary motivations for HTR-related initiatives are increased energy efficiency and climate neutrality. Despite some national differences (see Ashby et al, 2020a), the primary motivators of most HTR programmes are *equity, improved health and wellbeing* and *sustainable energy use*. In the context of the COVID-19 pandemic and its disproportionate impact on vulnerable populations, it is worth noting that equity and energy justice considerations are likely to become increasingly relevant to policy makers, researchers and programme managers.

Overall, the primary goal of this HTR Annex is to: *“identify, define, and prioritise HTR audiences; and design, measure and share effective strategies to engage those audiences to achieve energy, demand response and climate targets while meeting access, equity and energy service needs.”*

Additionally, and with due limitations, this study seeks to test the hypothesis that underserved energy users may account for a large percentage of all energy users (>30%). Thus far, this has been done via audience size estimates based on available statistics in the reviewed HTR audiences and/or participating countries.

In summary, the main objective of the literature review was to assess existing HTR research in order to:

- Identify and define priority HTR audiences
- Characterise and describe these HTR audiences using demographic and psychographic data, as well as audience barriers and needs assessments
- Understand the wider contexts and dimensions influencing these audiences
- Identify specific energy-saving behaviours to target for these audiences
- Estimate the size of these audiences, which may have changed due to COVID-19
- Undertake a gap analysis of the research on HTR energy users.

Chapter 2 – Methodology and Glossary

As mentioned previously, this document is based entirely on a 2020 international critical literature review on the topic of HTR (Rotmann et al, *forthcoming*). Due to its extensive length (250+ pages) and cited literature (almost 1000 citations), we have synthesised key details here. We will only highlight seminal references in this text, as additional references can be sought via the main document. The methodology described below outlines the process used for the original literature review. The approach used to create this current document was to condense the full 250+ page literature review down into a concise summary that still captures the essential findings. The primary method for the original literature review was a full, integrative, narrative literature review. Using personal networks, extensive google searching (on *SCOPUS* and *Google Scholar*), and backward and forward reference searches using keywords (e.g. 'hard to reach', 'vulnerable households') this review includes information from 871 different publications and over a 1,000 total sources. As such, and to the best of our knowledge, this review is likely to represent the most comprehensive collection of literature that characterises and defines HTR energy users and the wider contexts surrounding them. In addition to the general literature on HTR energy users, this review also focused on (English-only) HTR-related publications on Canada ($n = 8$), New Zealand ($n = 50$), Sweden ($n = 40$), the UK ($n = 113$) and the U.S. ($n = 127$).

Scope and Limitations

This literature review focuses specifically on the following audiences:

- Vulnerable households (including low income and energy-poor households, residential sector)
- High-income energy users in the residential sector
- Renters and landlords in both the residential and commercial sector
- Various commercial sub-sectors
- Small to medium enterprises (SMEs, commercial).

These audience segments were selected based on the priorities of the funding countries and the segments that appeared most frequently in the literature on HTR. The primary limitation of this literature review is that it surveyed English-language literature only. As such, relevant research conducted in other languages (e.g. Swedish) may not be captured. Furthermore, and with the aim to provide a tangible, workable framework, conceptual choices were necessary. Some of these concepts are introduced in the following sections.

HTR Definitions and Alternatives

There is some concern that using an umbrella term such as HTR implies a homogeneity within groups that does not exist (Brackertz & Meredyth, 2008). For instance, the terms HTR and energy poor or fuel poor are often used interchangeably, whereas the term HTR refers to many more categories of individuals than just those whose fuel costs are substantially disproportionate to their incomes. Additionally, it is important to acknowledge that the term HTR may implicitly put the onus on the given audience(s) for being difficult to engage, whereas this project asserts that the focus ought to be on the 'Behaviour Changers' and their (in)abilities to reach these audiences (Rotmann, 2016).

Given the potential difficulties with the term HTR, alternatives in the literature include *underserved, disadvantaged communities, socially disadvantaged, socially excluded, hard-to-help, hidden* *populations/hard-to-hear, illegalised, criminalised and stigmatised populations, under-represented/invisible/service resistant, unchangeable, hard-to-engage/motivate, hard-to-count, understudied, hard-to-treat,* and *hard-to-heat*. The last two terms relate more to the homes, than the occupants, though there are significant overlaps between hard-to-treat/heat homes and their users being also hard-to-reach. But again, each of these terms includes different implications for where the onus for action lies. A specific HTR definition was created for this project. With the recognition that it is imperfect and will likely evolve over the course of this three-year project, the Annex working definition of HTR is:

"In this Annex, a hard-to-reach energy user is any energy user from the residential & non-residential sectors, who uses any type of energy or fuel, and who is typically either hard-to-reach physically, underserved, or hard-to-engage or -motivate in behaviour change, energy efficiency, and demand response interventions that are intended to serve our mutual needs."

Chapter 3 – Vulnerable Households

Background and Definition

Although low-income and energy-poor households were the most commonly mentioned HTR group in the literature, income is often compounded with other factors such as *race, gender, age, education, disability,* and *language*. Unfortunately, these intersections are underrepresented in the literature. There are three primary types of vulnerability:

1. *Financial,*
2. *Health and capacity-related*, and
3. *Location-based*.

Energy poverty and *energy burden/hardship* are generally defined as "the inability of a household to achieve sufficient energy services, which inherently leads to vulnerability." That said, energy poverty and *vulnerability* are two distinct issues that may require different policy interventions (Bouzarovski & Petrova 2015).

Audience Characteristics

Demographics

Given the scope and intersections with multiple factors, the demographics of this HTR group are very diverse and the implications for energy usage are varied. For example, in many European countries, urban migration has led to *older, single women* being the predominant *rural* demographic, although *poor male* (often unmarried) farmers are also prevalent (European Commission, 2008). Many *vulnerable women* are also already disadvantaged due to the gender pay gap, and corresponding higher rates of debt, homelessness, and poverty (WBG, 2020). Many of the effects of the COVID-19 pandemic may also disproportionally impact women (Ibid). *Indigenous populations* are also considered HTR and still confront the after-effects of colonisation, suffering from poverty and bearing an increased energy burden relative to their means (Cornell, 2005). *Black and Hispanic minorities* are another demographic that is often considered HTR. They face high poverty rates and, consequently, high energy insecurity (Ganong et al, 2020). *Migrant and refugee populations* suffer from high rates of poverty and homelessness and are particularly vulnerable to energy poverty (WBG, 2020). Those with *mental and physical disabilities* also face distinct energy difficulties, often, but not always related to income (Snell et al, 2015; Wood et al, 2011). Disabled people are generally less likely to be employed and less likely to have savings, factors leading to a higher renter population, limited capacity to invest in EE technologies, and generally poorer housing stock (Parckar, 2008). Surveys and interviews also indicate that the *formerly incarcerated, drug addicts, and sex workers* face many similar barriers, and suffer from societal prejudice, high poverty rates, and high rates of physical and mental health issues (Lee et al, 2014; Reid et al, 2015). Other vulnerable groups include the *elderly* (Willand et al, 2017), *households with children* and especially *single parents* (Jessel et al, 2019), and *pregnant women* (WBG, 2020), all of whom experience increased rates of poverty and increased health needs.

Psychographics

A key variable in energy poverty (which is often, but not always related to also being HTR due to other intersectionalities such as being a renter, mistrustful of authorities due to stigma, or not being a native speaker) is the social relations of vulnerable populations (Middlemiss et al, 2019). Those who face social isolation or insurmountable structural barriers are often at higher risk of energy poverty, whereas good social relations can both enable access to energy services and be a product of such access. Other important psychographic variables found among vulnerable households are tolerance for thermal comfort, price-sensitivity, competence and confidence to manage their energy use, and attitude towards authorities (Russell-Bennett et al, 2017). There is a great deal more information on demographics than psychographics of all HTR audiences in the literature.

Barriers

In vulnerable households, cultural diversity, language barriers, lack of energy knowledge, low income and low self-efficacy (a lack of perceived ability to act to influence circumstances) all act as significant barriers (Ibid). When profit plays a role in energy programmes, it can be inefficient to target vulnerable groups. Discounting the non-energy benefits (e.g. health) of EE programmes can also act as a barrier, underestimating benefits for vulnerable populations (IEA, 2011). Especially in the U.S., there is a lack of federal priority in addressing energy poverty (Bednar & Reames, 2020). Prepayment has also emerged as a barrier in the EU and NZ, where it offers few customer protections, and the price per kWh may actually be higher (Mummery & Reilly, 2010; O'Sullivan et al, 2013). Insufficient data can also inhibit effective intervention design, resulting in programme offerings that are divorced from audience needs (e.g. offering smart technology to older consumers sceptical of these technologies; Cappers et al, 2018). Finally, distrust of the government and utilities can make vulnerable populations wary of authorities who may discriminate against them (NEA, 2020).

Needs and Opportunities

The literature on HTR vulnerable households focuses more on barriers rather than needs. Previous work in this area has largely involved dispatching social workers to assess a household's (in)ability to meet a minimum level of energy services. However, these new measures should focus on prevention rather than on mitigation (Scarpellini et al, 2017). Improved training for social workers could improve this approach. Another important area of development is educating young (vulnerable) children in energy literacy (Aguirre-Bielschowsky et al, 2018). Additionally, studies on indigenous support of sustainable energy projects reveal that key roles are played by community familiarity, association with previous projects, energy security impacts, and relationships with culture and sustenance (Mercer et al, 2020). For rural populations, community-based approaches in which local residents are hired and trained as part of the EE workforce may help address both the rural EE gap and also local work shortages (e.g. Mundaca et al, 2018).

Dimensions

Research on vulnerable populations has revealed three primary dimensions affecting energy-insecure households: *economic* (financial hardship), *physical* (deficiencies in the infrastructure of the home that impact thermal comfort, induce harmful indoor exposures and increase energy costs), and *behavioural* energy insecurity (behavioural coping strategies). For many low-income households, these coping strategies can include utility bills being considered a lower priority than expenses like housing and food, aka the "heat or eat dilemma" (Hernandez, 2016).

Audience Size

Estimating the size of vulnerable households is exceptionally difficult as many subsegments overlap. Despite this, there are some estimates that are informative. In relation to energy poverty, Bird et al (2010) estimated that there are 150 million people in energy poverty in the EU alone. In the UK, the proportion of households in fuel poverty was estimated to have decreased to 10.3% in 2018 (approximately 2.4 million households; BEIS, 2020). Out of a total of 118.2 million U.S. households, an estimated 17 million received an energy disconnect notice and 25 million had to forgo food and medicine to pay energy bills in 2015 (EIA, 2018). Additionally, the median energy burden for African American households was found to be 43% higher than for white households in the U.S., and the median energy burden for *Hispanic* households was found to be 20% higher than that of white households (Drehobl et al, 2020).

In regard to rural populations, it is estimated that one in every five Americans lives in a rural area and about 41% of U.S. households in rural communities have incomes below 200% of the federal poverty level, which varies by number of individuals in a household (Shoemaker et al, 2018). In both New Zealand and the UK, the percentage of low-income people is relatively lower in rural areas than urban. It is estimated that over 214 million people worldwide are immigrants (Horakova, 2013). The estimated population of indigenous people in the world is at about 302 million, most of whom live in India and China (Anderson et al, 2016). More specifically, indigenous peoples account for approximately 1.5% of the overall U.S. population, just over 2% of that of Australia, >4% of that of Canada, and close to 15% of the NZ population (Cornell, 2005). Additionally, 13% of UK households with a resident with a long-term illness or disability also live in energy poverty (UKERC et al, 2018).

The elderly and single parents are also a substantial percentage of energy poor populations. Royston et al (2014) found that families with children make up over 45% of UK households in fuel poverty. In New Zealand, 33.6% of households that report using no heating include children (O'Sullivan et al, 2016). In the U.S., about 23% of children live in a single-parent household (Pew, 2019). Among the estimated 11.6 million single parents living with their children in 2009, 9.9 million were single mothers, who were more likely to live in poverty than the 1.7 million single fathers (Lu et al, 2019). In the U.S., over 25 million seniors are economically insecure (Pew, 2019). In Sweden, 20% are over age 65, with the migrant elderly population at around 250,000 people.[1] Homeless populations include around 1% of the population in New Zealand, 6.2% in the U.S., and 7.7% in the UK.[2] Even in Sweden, where the government provides numerous supports for the elderly and retired, there were 34,000 homeless in 2011.[3]

Target Behaviours

There is very limited literature on vulnerable households, which qualify as HTR, that describes specific energy-saving behaviours (ESBs). ESBs in vulnerable households have the power to not only influence energy efficiency and conservation, but also the risks of suffering energy poverty. The existing literature has found interactions with family and trusted peers to be an important source of support in addressing energy poverty and influential in behaviours such as heating and financial management (Kearns et al, 2019). No-cost ESBs encouraged by state and local governments include restricting heating and increased layering clothes in winter, behaviours that are often already prevalent among the vulnerable and elderly and don't always support overall health.

In contrast to relatively well-researched heating behaviours, summer cooling behaviours (which

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[1] https://www.statista.com/statistics/525637/sweden-elderly-share-of-the-total-population-by-age-group/#:~:text=The%20population%20in%20Sweden%20increased,were%2090%20years%20or%20older
[2] https://ourworldindata.org/homelessness
[3] https://www.thelocal.se/20150115/a-portrait-of-sweden-in-ten-statistics

disproportionately affect African American and poor households in the U.S. (IEA, 2018), are understudied. Comfort often supersedes environmental preferences, increasing energy use (Osunmuyiwa et al, 2020). There are also some distinct gender differences: while men often acknowledge responsibility for installing EE measures, it is usually women who change (or are in charge of) daily behaviours (e.g. limiting vacuuming and lighting, hand-washing clothes and adjusting radiators; Petrova & Simock, 2019). One related issue highlighted by Petrova & Simcock (2019) and Robinson (2019) is that women are more likely to stay at home caring for children and are thus more exposed to the negative consequences of inefficient energy use and inadequate heating or cooling.

Conclusion

The research reviewed here highlights how a combination of low incomes and higher energy bills can increase the vulnerability of households, increasing the risks to become energy poor. Despite efforts to better target the energy poor using demographic data (e.g. Hills, 2012), government assistance often prioritises older people. This focus does not take into account the many important intersectionalities compounding energy hardship, particularly for women of colour and minorities. Overall, there has been little targeted research based on audience characteristics, barriers and needs to help vulnerable households reduce their energy bills through ESBs.

Chapter 4 – High-Income Households

Background and Definition

Generally, energy use per capita increases as a function of income or level of expenditure, resulting in large energy use disparities. The reviewed literature does not provide any specific definition of high-income households in the context of energy use or HTR energy users. However, as income inequality rises, energy disparities typically increase (Sovacool, 2011). These energy use disparities, in both direct and indirect energy use, exist not only within but across countries (Yeager et al, 2012). The reviewed literature on this subject emphasises that increasing income disparities within rich countries negatively impact four energy-related areas: *homeownership, energy poverty, carbon emissions* and *gender inequality*. The exact definition of a high-income audience varies across countries and is usually country-specific (e.g. twice the median income; Törmäletho, 2017). Irrespective of geographical boundaries, stark differences in energy use globally exist if only top and bottom income deciles are compared: whereas the lowest decile uses 2% of total final energy, the top income decile uses 39% (Oswald et al, 2020).

Audience Characteristics

Demographics and Psychographics

There is very limited literature examining high-income groups as an HTR audience for energy use or energy efficiency improvements, thus we have combined the demographic and psychographic summaries here. Identified aspects seem to be very context-specific. While perceived behavioural control and moral responsibility can increase efficiency in high-income households, energy use still appears to be more strongly correlated with income than with environmental attitudes (Gatersleben et al, 2002). High-income segments living in detached houses or multifamily buildings exhibit the lowest probability of saving energy compared to middle or low income segments (Martinsson et al, 2011). Other studies have shown that dwelling size increases with income, leading to higher energy use and related costs (Yohanis et al, 2008). However, the literature stresses that not all high-income households can be qualified as inefficient energy users.

Barriers

One barrier to programme engagement for high-income individuals is that they tend to be less price-sensitive and, thus, are less swayed by financial incentives. High-income households also appear reject the idea of increasing electricity prices to encourage energy conservation (Mah et al, 2012). Research in the UK has found that high-income households are less likely to engage with smart meters and report behaviour change (BEIS, 2018). Low levels of participation (~2%) among high-income households are also shown for a variety of energy-efficiency activities in Oregon (NPCC, 2018). Analysing the effectiveness of real-time feedback, a significant negative correlation between upper income and attitudes and social norms towards less energy use is found (e.g. the higher the income the less people reduce energy use (Tedenvall & Mundaca, 2016). That said, one study found that high-income households were more likely to purchase subsidised energy-efficient technologies (Yang & Zhao, 2015). As with many other audiences, knowledge, perceptions and cognitive processes also all seem to pose a barrier and deserve further research (Attari et al, 2010).

Needs and Opportunities

There is no explicit literature addressing the needs of high-income households in the context of energy use. Energy prices play a relatively low level of importance among high-income households and energy-related needs (e.g. food, home energy services) are always satisfied (Anker-Nilssen, 2003). Additionally, high-income households tend to spend more on appliances and leisure, which leads to an accumulation of energy-intensive appliances. Cognitive needs (e.g. curiosity about new technologies) and conspicuous consumption are also identified as areas that may reveal further needs or opportunities for policy intervention.

Dimensions

For high-income households, the obvious dimension that applies is the economic one. The literature generally acknowledges that demand for energy use and transport correlate positively with income and household size (Lutzenhiser, 1993). However, the review also indicates that a geographical dimension is relevant, particularly when analysing income and energy use disparities in urban versus rural settings (Druckman & Jackson, 2008). Finally, and given the lack of understanding of values, attitudes, motivations and behaviours among high-income households in relation to energy use, one can also claim that there is a strong need to understand the psychological and behavioural dimensions of this audience.

Audience Size

From a global perspective, the World Bank (2020) estimates that the high-income population reached 1.21 billion in 2018. In their global energy inequality study, Oswald et al (2020) estimate that approximately 550 million people are in each income decile (e.g. roughly equivalent to the combined population of the U.S., Germany and Russia), and that the top decile uses 39% of all total energy.

Target Behaviours

The literature suggests that high-income household behaviours that impact energy use are mostly related to mobility, appliances, communication and recreation. There is relatively little literature in this area, but one key behaviour to target for high-income individuals is the adoption of energy-efficient technology, given their affordability for this audience. In addition, and considering the size of dwellings in this audience, targeting thermostat settings and insulation could also yield substantial results.

Conclusions

Overall, the literature reveals that higher income is strongly correlated with lifestyle choices and consumption patterns leading to higher energy use. Income-driven energy use inequalities exist both across and within countries. Although a variety of potential barriers and target behaviours have been identified, substantially more research must be done in order to better understand high-income energy behaviours and related (response to) policy interventions aiming at energy efficiency and conservation for this specific HTR segment.

Chapter 5 – Landlords and Tenants

Background and Definition

There are two distinct HTR audiences in the rental market, both with their separate characteristics, barriers and needs: tenants and landlords (residential and commercial, respectively). The housing sector has a large carbon footprint, accounting for about 22% of U.S. energy consumption (Joint Center for Housing Studies, 2015). Within this sector, renters account for around a quarter of total energy consumption. Renters are lower income than property owners, and nearly 16.5 million renter households in the U.S. are likely to have suffered loss of income during the pandemic (Kneebone & Murray, 2020). Renters also overlap heavily with other potentially vulnerable groups, as children (27%) and young adults (16%) make up a disproportionate share of this population. While Hispanic and African American residents make up 18% and 12% of the U.S. population, they account for 28% and 18% of renters, respectively. Multi-tenant commercial rentals share many similarities with multi-family residential buildings (Bell et al, 2013). In particular, both experience the split-incentive problem, in which the cost of EE capital improvements is covered by one party (usually the landlord) and benefits of energy savings are enjoyed by the other party (the renter). However, some differences arise given that commercial leases are typically longer-term than residential ones.

The multifamily sector is often underserved by EE programmes due to its diversity, complexity and unique set of challenges. In fact, most EE programmes focus on owner-occupied homes because these buildings face smaller barriers than do rentals (Ramsay & Pett, 2003). Despite this, it is estimated that if multifamily EE programmes were expanded nationwide in the U.S., they could save up to $3.4 billion per year (McKibbin, 2013). These potential savings, along with tenant comfort and rent increases in places in which the market determines rental pricing, provide solid incentives for both residential and commercial landlords to invest in EE.

Before addressing the features of this HTR audience, there are some important aspects to highlight about housing infrastructure. In Sweden, for example, the *housing stock* is generally good and there are few deeply impoverished areas. In the U.S., rental stock is generally in good condition, with only 3% considered severely inadequate and another 6% moderately inadequate. However, the median renter in the U.S. spends $130 per month on utilities, with utilities accounting for 4% of income and 14% of housing costs (American Community Survey, 2014). In New Zealand, the housing stock is amongst the poorest quality and hardest-to-heat of comparable countries and private rental housing has the worst condition of the national housing stock (Howden-Chapman et al, 2009). This leads to excess winter mortality of an additional 1,600 deaths every winter (Howden-Chapman, 2015). Other important considerations include house size, and vacancy rates, which influence the balance of power between renters and landlords and impact tenants' ability to successfully request EE measures (Williams, 2008).

Audience Characteristics

Demographics

Energy use in dwellings is generally affected by *household demographics* (age, gender, household composition), *socioeconomics* (education level, income) and *lifestyle* (retirement, full-time work, unemployment). The most commonly used socio-economic characteristics are the household’s size and composition and age, income, education level, and employment status. In the UK, the most prevalent group in the social rented sector are households aged 65 or over (27%). Additionally, about a third of private (35%) and social (33%) renters had children (UK Government, 2018). As highlighted in the Vulnerable Households Chapter above, those households may also be more likely to live in energy poverty. In the U.S., 49% of renters were cost burdened in 2014, including 26% with severe burdens (Joint Center for Housing Studies, 2015). The households most likely to be severely cost-burdened have dependent children and/or rely on a single income, including 38% of single-parent families and 32% of persons living alone. By age group, renters aged 75 and over have the highest incidence of severe energy cost burdens, at 33%. Approximately 33% of African Americans and 30% of Hispanics are severely burdened, compared with 23% of whites (Ibid). New Zealand has an increasing proportion of highly inefficient private rentals, and 49% of those *under 65* and in *poverty* live in this housing (Barton, 2012). Rising housing costs have also contributed to declining home ownership rates, greater housing instability, and high rates of Māori and Pacific peoples living in poor quality housing. In Sweden, 2 million apartments are in single-dwelling houses, almost 2.4 million are in multi-dwelling buildings, and slightly more than 230,000 are apartments in special housing (e.g. nursing homes; Boverket, 2015). However, these renters would not all be considered HTR, at least in Sweden.

Psychographics

Unsurprisingly, there is an observed positive relationship between pro-environmental attitudes and energy-efficient behaviour in renters. However, many renters face basic financial and social challenges that supersede environmental considerations (Williams, 2008). Renters tend to have less agency when it comes to negotiating EE upgrades with their landlords. Renters are often hesitant to ask their landlord for improvements, for fear (or lack of knowledge) that the landlord will retaliate via raised rent or even eviction if the law permits (Ibid). Renters' lease agreements also limit their avenues to pursue EE independently as they may lack the necessary capital, or the payback period is too long to make economic sense given their short-term occupancy. Additional psychographic barriers to EE improvements include mistrust between renters and landlords, a lack of knowledge, and competing priorities (e.g. work; Janda et al, 2017).

Three primary variables impact landlords' attitudes and perceptions about EE: the building's metering type, size of the landlord's holdings, and investment time horizon (Levine et al, 1982). Segmenting landlords by these variables can help EE programmes properly target different landlords. That said, there is generally reluctance amongst private landlords to reinvest profit into improving the thermal performance of their properties in the absence of any legal requirement (Ambrose, 2015). However, when the landlord pays for utilities, EE upgrades may be motivated by cost savings – provided transaction costs are relatively low. In contrast, when the tenant pays for utilities, the landlord's motivation is to attract and retain "good" tenants, a somewhat weaker incentive (Williams, 2008).

Barriers

The primary obstacles to rental EE include lack of information, fragmentation of housing markets, lack of capital and misaligned incentives. Of these, the most intractable has been the split-incentive problem (Ibid), in which the agent (landlord) is able to make decisions or take actions (e.g. about appliances, building envelope) on behalf of, and that have an impact on, the principal (renter). A classic example occurs when, driven by financial incentives, the landlord supplies cheap inefficient appliances or poor wall insulation, but it is the renter that pays the utility bills. Approximately 31% of homes in the U.S. are rented and the vast majority of tenants pay for heating, meaning that in principle almost all renters face the split-incentive problem. This problem is exacerbated by a persistent information asymmetry and power imbalance between renters and landlords. For landlords, the most significant barriers are cost, lack of capital, low return on investment (ROI), mistrust of technology, and transaction costs (ibid). There are also some implicit barriers that include individual metering (which removes the landlord's cost-saving incentive) and a general lack of awareness or knowledge of EE. The financial barriers for landlords arise from the initial outlay of capital generally required for EE improvements, the cost of hiring a contractor/technician, and taxes. For renters, a primary concern is rent increases (relative to their lease agreement) and hassle (Cook, 2013). As with many audiences, lack of information is also a key barrier for both renters and landlords. Many are unaware of positive externalities, can't spare the time to seek more information, or are simply unaware of the existence of EE programmes. Another crucial aspect is the credibility of new EE information, which can act as a barrier if renters or landlords distrust the source. Many landlords feel that there is no benefit to installing EE and may have existing code violations serving as a strong disincentive to allowing auditors or public agencies on the property (Coleman, 2011).

Multi-family apartments (MFAs), are particularly HTR as they often involve the twin challenges of multiple decision makers *and* the split-incentive problem. Thus, defining the target audience in an MFA is rarely straightforward. In addition, as with commercial buildings, MFAs also often have technically complex HVAC systems, resulting in high uncertainty regarding predicted energy savings from specific measures and, consequently, increased reluctance in EE investments (Ross et al, 2016). This is especially true for sub-segments such as affordable MFAs for low-income households. An additional potential barrier to savings is the Jevon's paradox (also known as the "rebound effect"), in which the benefits of increased energy efficiency improvements are offset by increased energy used. For example, recipients of energy improvements may not save on their energy costs and instead use the potential savings to increase thermal comfort at no extra cost. Regardless, even small improvements in thermal comfort can often lead to substantial health benefits, as seen in New Zealand (Grimes et al, 2011).

Varied building characteristics, heating and lighting systems, fuels, climate zones, and appliances also lead to a high degree of heterogeneity, segmentation, and increased transaction costs and market fragmentation (Granade & McKinsey, 2009). The diversity of property owners, which includes individuals, general or limited partnerships, and corporations, only exacerbates this issue. The establishment of a national landlord association in Sweden has been crucial for distributing EE information (Myhren et al, 2018). Most EE programmes in the rental sector focus on large-scale retrofits and weatherisation instead of changing behaviour. Behavioural interventions aside from home energy reports are rare, meaning there is significant untapped potential for altering ESBs in the rental sector (Kennedy et al, 2014). As with renters and landlords, a lack of information is also an issue for Behaviour Changers, especially for occupancy patterns and actual occupant behaviour. As such, most studies of the impact of occupants on energy use behaviour are derived from engineering-economic models, simulations, or surveys rather than actual human-driven energy use data (Reina & Kontokosta, 2017). Overall, while there are many barriers specific to each sub-audience involved, the failure to account for the multiple benefits of EE (IEA, 2014), presence of high transaction costs, lack of information, and general lack of interest are common barriers for the entire rental sector (e.g. Hamilton et al, 2016).

Needs and Opportunities

While there has been improvement in EE programme offerings for MFAs recently, total spending on multifamily programmes in the U.S. accounts for no more than 6% of total EE spending. Consequently, low-income renters in MFAs continue to be among the most underserved audiences. As with most programmes targeting the HTR, there is also a need for better data/information, multiple benefits/health and safety assessments, increased financial incentives, and overall process improvements for EE measures.

Audience Size

Approximately 37% of American households were renters in 2015 (Fredman et al, 2018). More than 20 million U.S. households, almost 18% of households nationwide, live in apartments and condominiums in multifamily buildings. High-rise multi-unit residential buildings (MURBs) are the most prevalent source of housing in urban regions and represent almost 12% of all dwellings in Canada (Stopps & Touchie, 2019). In the UK in 2017-18, the private rented sector accounted for 4.5 million or 19% of households (UK Government, 2018). The social rented sector, at 4.0 million households (17%), remained the smallest tenure. In NZ in 2018, about 1.1 million, or 62%, owned their own homes and 34% rented their homes (Statistics NZ, 2019). Renters were about twice as likely as homeowners to spend 40% or more of their household income on housing costs. In Sweden as of 2016, 43% lived in one- or two-dwelling buildings, 51% in multi-dwelling buildings, 5% in special housing, and 2% in other buildings (Statistics Sweden, 2016). Commercial buildings account for 20% of all U.S. energy use, and 50% of commercial buildings are leased (DOE, 2016). In the UK, approximately 1.1 million non-domestic buildings, or 60%, are rented, and account for approximately 35% of the UK energy consumption (BEIS, 2019). The sectors with the highest proportion of rented buildings are retail (68%), storage (66%), industry (65%), hospitality (64%), and offices (63%). Estimates indicate that split incentives affect 30.4 million households in the U.S. and 31% of residential primary energy use for four end uses (refrigerators, water heaters, space heating, lighting).

Target Behaviours

Two types of energy end-uses have been defined in the residential sector as primary sources for target behaviours: building-related and user-related (Guerra-Santin et al, 2018). Building-related energy consumption is the energy used for services related to the building itself, such as space heating and cooling, ventilation and lighting. Within user-related consumption, the most common energy-using behaviours are cooking, domestic hot water, and use of electric equipment and appliances. Target behaviours are also likely to depend on the climate, which will determine whether the greatest efficiency opportunities are in heating, cooling, or hot water. Landlord behavioural underinvestment in EE occurs in multiple residential categories, particularly: space heating, water heating, window thickness, insulation, and weatherisation.

There have been few pilot programmes focused on encouraging behavioural change in MFAs, and those that do exist typically fall into three primary categories: direct installation and related low-cost services to occupants, rebates for common measures such as new HVAC systems and building envelope improvements, and comprehensive whole-building retrofits (York, 2015). Understanding energy occupant behaviour is essential to building design optimisation, energy modelling, and performance evaluation. This is because heating (or cooling) and hot tap water, lighting, and domestic appliance use account for the vast majority of residential energy use. Finally, in commercial spaces, conditioning (heating and cooling) and lighting represent over 50% of energy consumption and, as such, are the primary targets for behavioural programmes (e.g. optimal thermostat settings).

Conclusion

Rentals make up over 60% of residential (private and public housing), and over 50% of commercial space in our participating countries. As the COVID-19 pandemic continues, rental populations are likely to become more vulnerable, increasing the impact of energy costs on renters and making the split incentive issue increasingly difficult to overcome. Overall, there are a variety of audiences, barriers, and target behaviours that have been identified in the literature, yet more work needs to be done to identify and target each audience, need, and behaviour.

Chapter 6 – Commercial Sector HTR

Background and Definition

Although the commercial sector accounts for nearly as much energy use as the residential one, the amount of research, governmental initiatives, and advice for targeted behavioural interventions is far more limited in this sector. This disparity suggests that significant untapped opportunities exist for energy savings (Chester et al, 2020). Commercial HTR audiences can be highly complex, with different barriers, motivations and opportunities for ESBs. To the California Public Utilities Commission (CPUC), for example, non-residential HTR customers are "1) small customers that have fewer than 10 employees; 2) businesses in leased space; 3) rural customers; 4) strip malls; 5) local chain or single-location restaurants; 6) 'mom and pop' restaurants and stores; and 7) convenience stores" (CPUC, 2020).

Audience Characteristics

Types of Audiences

Compared with the residential sector, it is less straightforward to identify which HTR audiences are targeted in non-residential EE (policy) efforts. Given the different loci and foci of decision-making, instead it is important to differentiate between types of audiences, such as 'External Behaviour Changers' (e.g. boards, policy makers, building owners, etc.), 'Internal Behaviour Changers' (e.g. senior management, building operators and facility managers), and 'Energy Users' (employees/clients). Each of these audiences have different mandates, knowledge and impact on energy use/management in commercial facilities (Chester et al, 2020). An organisation's energy behaviour can be shaped by five levels of activity (CSE & ECI, 2012): decision-making and activity of individuals; interactions between the various subcultures within an organisation; independent 'life' of the organisation inscribed in its procedures, history and ethos; relationships that the organisation maintains with other organisations in its supply chain; and socio-technical context.

Understanding the internal and external audiences is key to improving EE in the commercial sector. For example, in offices, engaging internal energy users (i.e. employees) and, particularly, *office* management is key (Staddon et al, 2016). In *lodging*, much of the onus falls on an external energy user, the customer. As a result, the lodging sector has responded by automating some procedures and leveraging social norms and nudges (Goldstein et al, 2008). It is argued that substantially less effort has been put into influencing the behaviour of internal energy users (housekeepers, managers etc.).[4] In *restaurants*, most energy use comes from internal users through food preparation. Employees often possess a great deal of agency over energy use but little incentive to reduce it, as many energy saving behaviours may be inconvenient in a kitchen (e.g. turning off burners; Chester et al, 2020). *Healthcare* is a sector where energy use is not a primary motivator as the priority is (rightfully) the health, comfort, and wellbeing of patients (Cowen et al, 2017). As such, very little weight is placed on energy conservation in hospitals. *Education* is the second-largest consumer of energy in the service sector in the U.S. (Gormally et al, 2019); both students and staff are key internal energy users. In schools, energy costs are the second largest operational expense after personnel. However, the U.S. Department of Energy (DOE, 2019) has found that at least 25% of energy consumed in schools is wasted, and that between 5-15% of that wasted energy could be saved with

[4] https://www.facilitiesnet.com/green/article/Hospitality-Employees-Play-Big-Role-In-Sustainability-Efforts-Facilities-Management-Green-Feature--13929

no-cost behaviour change measures. *Grocery store* facilities are among the top three facility types for energy use intensity and number one for electrical use intensity in the U.S. (EIA, 2013). However, low profit margins impede large investments in energy efficiency. In *retail stores*, conflict between energy conservation and customer comfort is an ongoing challenge (Christina et al, 2015). For the *warehouse* sub-sector, there are substantial savings opportunities from internal energy users who are generally easier to reach and motivate (Chester et al, 2020). The *manufacturing* sector is highly under-researched, but there is cause for some optimism based on preliminary evidence from a Swedish Volvo manufacturing plant where worker behaviour change caused a 10% reduction in plant energy use (Mahapatra et al, 2018). Finally, when dealing with *local government and municipalities*, one study indicated that a centralised Sustainability Office can be the most useful Behaviour Changer to drive change across organisations and locations (Ambrose et al, 2014).

Barriers

Multiple types of barriers can be found in the commercial sector, but they vary considerably across sub-sectors. The generic barriers fall into the following categories: information and transaction costs; bounded rationality; capital constraints; uncertainty and risk; and investor/user dilemma (split incentives; Schleich & Gruber, 2008). Other relevant barriers include staff compliance with energy management approaches, building condition, perceived lack of control over energy use and the ability to demonstrate impact.

One of the greatest challenges for behaviour change interventions in the commercial sector is simply gaining access to participants, all of whom have jobs to do, and few of whom have EE as their main mandate (Goulden & Spence, 2015). Another hurdle is that much of a building's energy performance is related to decisions made by stakeholders (e.g. architects, engineers, contractors) during planning, design, and construction and there is a distinct lack of incentives for these stakeholders to focus on EE. In existing buildings, agency issues (e.g. split-incentive problem) are the primary barrier, as those who might have the most control over energy use during operation (e.g. lower-level employees) often have no incentives to engage in conservation. Another challenge is that behaviour could hinder, or even erase, efficiency gains from technological investments. Consequently, there is merit to interventions that encourage occupants to adopt efficient practices. Information asymmetry between management levels also leads to suboptimal investment decisions, especially around payback for EE. Lack of a dedicated energy manager acts as a barrier, as many organisations assign this duty to facility manager(s) busy with higher priorities. Importantly, behavioural EE interventions can co-generate non-energy benefits in client experience, employee satisfaction and morale, and organisational image (Pellegrini-Masini & Leishman, 2011), which are not always captured in evaluations.

Needs

As is the case with other HTR audiences, literature identifying specific audience needs in the commercial sector is exceedingly rare. From the scant literature that does exist, the main drivers of EE are utility costs, perceptions as a sustainable organisation, equipment refurbishment/replacement and improving staff comfort. Drivers of EE success include senior-level support, an internal coordinator and successful measurement demonstrating programme efficacy. There are also some distinct research needs in this sector, particularly around integrating individual and organisational variables into analyses, using sample sizes larger than one organisation (Miller, 2013). Relevant information may include when building is occupied, firmographics and whether other companies occupy the same building. In addition, knowledge on staff comfort and perceptions around technology (e.g. via experiments) is important before designing and implementing interventions in full, and there are many co-benefits in commercial settings that can drive ESBs (e.g. productivity, staff retention, comfort, fewer sick days, loyalty, and corporate pride). Some programmes targeting low-income community organisations have specific sub goals and targeted co-benefits that include reducing capital and maintenance costs, minimising time spent on upkeep, decreasing monthly utility costs, increasing available capital, improving indoor air quality and comfort, scaling up programmes, reducing greenhouse gas emissions, benefitting environmental justice and improving community economic stability (Drehobl & Tanabe, 2019).

Dimensions

Important dimensions that shape or frame this audience relate to economics, psychology (from an organisational perspective), and geography. In addition, key elements for energy use in the commercial sector also include social and institutional dimensions. Individual perceptions around, for example, thermal comfort (which can be related to demographic factors, as women may report feeling cold more easily) and need for self-efficacy over workplace temperature (psychographic factor) play an important role.

Audience Size Estimates

A 2001 study on Californian non-residential utility customers using under 500kW found that renters comprised 40%, small businesses 38% (with 10 or fewer employees), local chain or single-location restaurants 7%, strip malls 10%, convenience stores just only 1%, rural customers 22%, and ‘Mom and Pop’ restaurants/groceries around 5% (Quantum Consulting, 2001). U.S. office buildings make up only about 18% of commercial buildings and are on the lower end of commercial building energy-use intensity at an average of 77.8 Btu/square foot compared with *food service* at 282.7 Btu/square foot, *healthcare* at 172.7 Btu/square foot and *lodging* at 96.9 Btu/square foot (EIA, 2012). *Retail* buildings in the US represent 11% of all commercial buildings and 14% of all commercial electricity consumption. In the UK, the retail sector is the largest commercial property sector, accounting for 1 in 12 companies and employing 1 in 9 people (ibid). *Hotels* are one of the most energy-intensive facilities in the U.S. and are ranked among the top five in terms of energy consumption in the commercial sector; hotels are thought to have at least 20% energy-saving potential (Cingoski & Petrevska, 2016). *Educational* facilities in the U.S. represent 14% of commercial buildings, 7% of commercial electricity consumption and 8% of commercial natural gas consumption (EIA, 2012). *Small businesses* in the U.S. represent 23% of businesses with peak demand less than 20 kW, 3% of which are *restaurants* and *groceries* (Quantum Consulting, 2001). However, those restaurants use an average of 590,000 Btu per square foot annually, twice as much per square foot as the next largest commercial user. Thus, there are significant opportunities for savings, and one study identified behavioural factors and poor maintenance as major contributors to excessive electricity usage with potential savings of 70% and 45%, respectively (Mudie et al, 2016).

Target Behaviours

It is difficult to extract potential ESBs from their wider socio-technical context, yet some of the most relevant occupant behaviours may include adjusting thermostat settings, opening/closing windows, dimming/switching lights, adjusting blinds, adjusting HVAC systems, and moving between spaces.

Most behavioural interventions in *office* settings are low/no cost and achievable with already-available technologies. However, ESB opportunities often depend on the climatic conditions and building size, along with occupants' perceptions (or needs) of indoor comfort and control of thermostat settings (Miller, 2013). There is substantial opportunity for energy savings during night-time, weekends, and holidays, via shutting down equipment and lighting before leaving the office and automating temperature controls (Masoso & Grobler, 2010). For *restaurants*, strict maintenance protocols and more appropriate sizing of refrigeration would be of great benefit. Additionally, the layout of kitchens can also be improved, as placing refrigeration in close proximity to a heat source raises energy consumption by around 30% (Mudie et al, 2016). The reduction of energy use from food preparation is seen as the largest challenge for catering establishments, as they are determined by operator behaviour, who have other priorities (Miller & Othmer, 1994). In the *healthcare* sector, control of the use of the openings (windows and doors) between spaces in different thermal conditions, boiler maintenance, heat pump control and maintenance, and closure of dampers were found to be potential low-cost target behaviours (Morgenstern, 2016). Reducing the after-hour use of lighting, equipment, and space conditioning systems are also areas for potential improvement. In the *education* sector, most of the energy used comes from HVAC and lighting. Behavioural programmes working with students and teachers targeting these areas have been effective, yet are often not recognised by U.S. Investor Owned Utilities' regulators as Demand-Side Management (DSM) Resource projects.[5]

In a typical *hotel*, lighting, air conditioning and water heating represent up to 70% of energy use, suggesting great savings potential from automated controls (Said et al, 2017). Laundry is considered one of the largest consumption segments, which explains the plethora of behavioural interventions in hotels that have focused on towel use. In the *retail* sector, aesthetic goals may interfere with many EE efforts (e.g. dimming lighting or turning lights off at night may not be appropriate for certain mercantile sectors who display their wares in shop windows at all hours; Chester et al, 2020). The two biggest energy consumers in *warehouses* (~76% of energy use) are lighting and temperature control (heating, cooling and refrigeration).[6] Many solutions are technical and automated, although closing warehouse doors can greatly help reduce energy use. For *industry and manufacturing*, low-cost measures such as staff training and reducing idle electricity use have been effective (Mahapatra et al, 2018). Finally, in a review of *low-income community* EE programmes, changes to lighting/lighting use were the most common measures, followed by heating and cooling upgrades and education and programme support (Drehobl & Tanabe, 2019).

Conclusion

The commercial sector is highly heterogeneous in regard to business purpose and building types. This presents many challenges for EE. Yet the literature indicates that behaviour change interventions are ultimately more likely to be successful if they are compatible with the work interests, rules and procedures, and the corporate culture of an organisation (Miller, 2013). One particularly important area of focus in this sector is the locus of decision-making. However, as with many other audiences in this literature review, more work and research are needed to properly design and customise behavioural EE interventions for maximum impact.

[5] https://www.ase.org/blog/funding-efficiency-programs-schools-behavior-counts
[6] https://www.facilitiesnet.com/energyefficiency/article/Stock-Up-on-Energy-Savings--5388

Chapter 7 – Small to Medium Enterprises (SMEs)

Background

Small to medium enterprises (SMEs, typically referred to as Small to Medium Businesses, or SMBs, in the U.S.) are a crucial HTR group as they represent 17% of U.S. national electric usage and an estimated 13% of global energy use (Meyers & Guthrie, 2006). Collectively, SMEs use about 2.5 times the amount of energy as large enterprises (IFC, 2012). SMEs are often active members of their local community and may be particularly open to energy-saving programmes as they are not inhibited by corporate approval. As a market segment that has been hard hit by COVID-19 (Bartik et al, 2020), their recovery, safeguards and their continued existence can be aided by reducing their energy expenses. SMEs are largely considered HTR in part due to their diversity; they operate in every sector, in all property types, and vary from one-person service operations with no business premises, to manufacturers with up to 1,000 employees in the US; a figure much higher than the classification used in the European Union, where it is up to 250 employees.[7] The particulars of SME energy use - where, how, by whom or what, and how much - are poorly understood (Hampton & Fawcett, 2017). This is compounded by the fact that many SMEs operate out of homes, particularly in certain countries such as New Zealand, where 70% of SMEs have zero employees (i.e. “sole traders”).

Audience Characteristics

The defining characteristic of the SME sector is diversity, and each SME subsector has unique energy and technology requirements. Of all SMEs, small *grocery and retail* stores have been given particular attention in the literature. Small *grocery* stores are somewhat unique as refrigeration accounts for over 50% of their energy use (Billhymer, 2016). There is a relatively low cost to establish a business in this category; these low barriers to enter the industry make it attractive for first time business owners, including immigrants. For small *retail* stores, the need to be welcoming to new customers (climate, lights, signs etc.) has EE implications (Kenington et al, 2020). In the *manufacturing* domain, SMEs and small-medium manufacturers (SMMs) make up around 90% of the U.S. market and consume about 50% of the energy (Trombley, 2014). Micro and small enterprises (MSEs) such as *grain millers* or *metal fabricators* use vast amounts of energy, making them ideal candidates for EE interventions (Never, 2016). *Restaurants* and *construction* represent another set of HTR SMEs as EE is often superseded by other priorities (e.g. keeping burners hot). The sparse research on *tourism* and *hospitality* SMEs suggests that the rate of uptake for EE programmes for them depends on perceived benefits, payback periods, the capacity for innovation, the nature of the buildings, governance structures and regulatory regimes and the value sets of entrepreneurs (Coles et al, 2016).

Demographics, Psychographics, and Firmographics

When segmenting SMEs for EE interventions, the IEA recommends considering company size, ownership structure, industry sector, energy intensity, energy supply issues and geographic location (IEA, 2015). In many ways, “small businesses and their decision-making process are much more akin to those of residential customers than they are to commercial or industrial customers” (Van de Grift et al, 2014). Similar to residential customers, small business owners manage constrained budgets and are driven primarily by the threat of a higher electricity bill. They often operate with limited resources that makes them more vulnerable to business cycles and also less prone to risk-taking. In turn, these

[7] https://ec.europa.eu/growth/smes/sme-definition_en

aspects can frame their (perceived) assessment of EE technologies (e.g. in relation to their technical and financial [un]certainties). There are also distinct opportunities in the lifecycle of SMEs, as investments in EE technology are much more likely during shop fitouts and equipment replacement/maintenance.

Barriers

Overall, SMEs with low energy use or demand are often overlooked by utility-led EE programmes, as they may not pass cost-effectiveness tests (Meyers & Guthrie, 2006). SMEs are also considered to have limited capacity for economies of scale; to suffer from lack of information, time, knowledge or expertise to deal with EE and related policy frameworks (e.g. regulations). SMEs also find it more complex or expensive to access capital than larger organisations (BEIS, 2019). Many SMEs report that they do not monitor their energy use, and only receive usage information via their utility bill; highlighting that energy use is not a top priority. Many SME owners worry that their actual savings will be less than estimated savings for new measures (e.g. done via engineering studies that neglect the human dimension of SMEs), and report distrust about the *reliability of information* provided and a lack of bandwidth to evaluate realistic opportunities (Quantum Consulting & Xenergy, 2001). In terms of barriers within specific SME subsectors, the *small grocery and retail* sectors both face a lack of time and human resources, distrust, outdated equipment; many owners are also renters (split-incentive; Billhymer, 2016). In *manufacturing*, lack of capital and time, incomplete information and communication systems, and low priority for EE were cited as the most common barriers (Fleiter et al, 2012). Additionally, the tendency to discount the future more heavily and the endowment effect, in which people place a high value on what they already possess relative to what they don't, were found to impede progress towards improved EE. For *restaurants* and *construction*, other priorities act as a main barrier (e.g. customer comfort) with a lack of energy-literacy and short-term capital costs playing a role in the construction sector as well (Revell & Blackburn, 2007). Finally, for the *tourism* and *hospitality* sector, time stressors, competing priorities, and energy illiteracy are found to be primary barriers (Coles et al, 2016).

Needs and Opportunities

While including credible and customised energy usage information and communication systems are undoubtedly key for all audiences, it may be particularly so for SMEs. Another important determinant of SME engagement with EE programmes is direct, first-hand experience with the related technologies and existing knowledge. Peer learning has been shown to be particularly effective in this domain and could help address a need for energy illiteracy in SMEs (Never, 2016). One main motivation for improved EE for SMEs are the prospects it may confer in terms of financial gains and a competitive advantage. Additionally, a business culture that is receptive to EE concepts and practices can play a key role in programme participation (DECC, 2014).

Audience Size Estimates

On a global scale, the vast majority of commercial enterprises can be considered SMEs (~99% of businesses). There are almost 154,000 small grocery stores in the U.S. (Billhymer, 2016). In the UK, *retail* energy use comprises 17% of the non-domestic sector, of which small shops comprise the largest sub-sector (42% of total) - the retail sector also has a large energy abatement potential of 34% (Kenington et al, 2020). In 2013, there were 169,000 SMEs involved in *accommodation* and *foodservice* in the UK and the SME *tourism* sector is estimated to account for 5% of global greenhouse gas emissions (Coles et al, 2016). In Sweden, SMEs account for 30% of total *industrial* energy use. Both the relative EE potential and the cost-effectiveness for implementing EE measures in industrial SMEs is higher as compared with large companies (Paramonova et al, 2014).

Target Behaviours

SMEs EE programmes have generally focused on ESBs in the categories of lighting, refrigeration, HVAC, envelope and plug load. Some SME programmes also focus on energy education and those that combine education with other specific behaviour change interventions can often achieve longer-lasting savings (Drehobl & Tanabe, 2019). In general, most SME programmes in the literature focus on technologies, rather than the specific behavioural changes that could be associated with those technologies. A potential reason for is the tendency to bundle SMEs together, neglecting the heterogeneity of barriers and behaviours that characterise SMEs of different sizes and sectors.

Conclusion

Due to the diversity and complexity of SMEs, this audience may be particularly HTR. At the risk of over generalising, shared barriers across SMEs typically include lack of information and internal expertise, mistrust in external consultants, limited resources, competing priorities, split incentives and present bias. Given that SMEs have been heavily impacted by COVID-19, which has only added to their existing financial burdens and uncertainties, their motivation or interest in EE programme participation may be hindered in the near term.

Chapter 8 – Gap Analysis

While there is an extensive HTR literature that has been highlighted in this review, there are some notable and significant knowledge gaps that merit further research to support EE programmes and related policy interventions.

Residential

From a demographic perspective, the vast majority of residential HTR literature focuses on low-income and otherwise vulnerable populations (e.g. *fuel poor, and, to a much lesser extent also mentally or physically disabled, minorities, rural, indigenous, refugees and immigrants, very young or elderly)*. There is substantially less research on high (or medium) income households (e.g. on values, attitudes and motivations affecting energy use). There is also a distinct lack of EE programmes targeting groups based on education level, age, income or ethnicity. Of all these demographic and socio-economics are not well represented in the existing literature. Overall, the literature skims over detailed ESBs and, instead, focuses more heavily on energy-saving technologies. This gap is particularly prominent for mobility and transport. Finally, there is a distinct dearth of literature focusing on residential non-energy benefits given that programme administrators cannot typically receive credit for them in the U.S. and Canada. However, considering the significant non-energy benefits possible from EE programmes (e.g. improved health, higher disposable income and improved social equity), this is a knowledge gap in need of addressing.

Commercial

While the commercial sector accounts for relatively less energy use, the overall information available on the commercial sector is dwarfed by the HTR research on the residential sector. Due to the diversity of commercial subsectors and building types, many commercial programmes choose to focus on building characteristics such as size, age, and location, ignoring the challenge of catering programmes to specific business types. Most commercial behavioural programmes focus on three main technologies (lighting, HVAC, and plug load) and often fail to specify which behaviours to change given their engineering (and/ or financial) orientation. If commercial EE programmes are to be more successful, identifying and targeting specific ESBs for each aspect of the commercial sector - and unbundling SMEs in terms of size, sector, building types and businesses - is an essential step.

Another notable gap in the commercial literature relates to the disconnect between agency and capacity in the commercial sector. Those who are most likely to be able to implement change (e.g. CEOs) often lack the motivation, time and resources to prioritise energy use management and/ or EE improvements. Edison Energy (2016) found that 45% of the companies surveyed cited a *lack of executive interest* as a major barrier to energy-related action, only 6% of companies believed they had already exhausted all opportunities for energy savings, and 24% of companies did not have an accurate sense of their energy usage. Thus, future work should aim to identify the proper external and internal actors within the commercial setting to engage in ESBs; including the (dynamic) relationships between barriers and behaviours across heterogeneous SMEs. Finally, the literature primarily focuses on offices, ignoring other potentially high-impact industries (retail, hospitality, manufacturing, etc.) and significant EE improvements and resulting emissions reductions.

Chapter 9 – Conclusions

The reviewed literature reveals a great deal of heterogeneity *across* and *within* HTR audiences. In addition to limited knowledge in various areas (e.g. psychographics), it is safe to conclude that audience characteristics, sizes, related dimensions and target behaviours pose important challenges to Behaviour Changers seeking to effectively engage HTR energy users.

Households are one of the most promising areas for potential emission reductions, as changing energy-using behaviour may be easier in households (especially relative to commercial and industry settings) due to the smaller number of decision-makers. In the extensive literature focusing on HTR in the residential sector, some authors estimate that greater than 50% of energy users fall into one or more of the HTR audience categories outlined above (Ramsay & Pett, 2003). In the commercial sector, office buildings seem to be properly represented in the literature, leaving a vast section of the commercial sector under-investigated. While these large HTR audiences in the commercial and residential sectors indicate an enormous potential for decreased emissions, a substantial amount of research and work must be done in order to properly engage each HTR audience, lower audience-specific barriers, and foster sustainable behaviours.

Key takeaways

- Although existing literature provides *some estimates of the size* of some of these groups, it's often unclear what proportion of total energy users in a region or country are accounted for by these various audiences - or how much they will have changed post-COVID-19.
- There are *many definitions and methods of measuring* energy / fuel poverty or energy hardship / burden / insecurity, and they often vary with geography and research discipline. Energy poverty and vulnerability, while related, are two distinct issues which are context dependent.
- We have identified *vulnerable households* based on *low income*, *minority* (race / ethnicity, disability, gender), *geographic isolation, age* (elderly and young, including single parents or pregnant mothers), as well as *socially stigmatized and criminalized* groups.
- The *intersectionality* of vulnerabilities causes additional complexities, which have been underexplored in the literature to date.
- As we found with all literature, outlining *audience characteristics* (see **Chapters 3-7**), there is a lot more emphasis on the *barriers* they face, rather than in-depth *needs-based audience analysis*.
- Only a few specific *target energy-saving behaviours* are outlined in the literature, most studies focus on energy-efficient technologies or services.
- Even though the main dimension affecting low-income and energy poor households is *economic*, there are many others (e.g. *geographic* for rural (indigenous); *psychological* for disabled or stigmatized people; *technological* for the elderly) that play important roles.
- *Income, and related affluence*, *lifestyles* and *consumption patterns* play a critical role in large energy use disparities. Income-driven energy use inequalities were identified across and within countries. Depending on the metrics, the potential size of this high-income audience can be substantial, yet they are very under-researched.
- Multifamily buildings are difficult to reach, and they often *combine the more challenging aspects* of single-family homes and commercial buildings.

- As an aggregation of single-family homes, multi-family buildings are occupied by *multiple decision-makers* who are apt to make diverse choices about how to live in their space, making it difficult to achieve consensus on whether and how to improve the building. Defining the *actual audience to target* in an MFA can itself be a challenge.
- Although the *split incentive* remains prominent in rental housing, other significant barriers are also fairly unique to this sector, e.g. *power imbalances* between renters and landlords.
- *Transportation costs* are often an additional burden for low-income renters, especially in MFA on the outskirts of large cities.
- *Renters* (both residential and commercial) make up the majority of building energy users on the planet. They are also under-researched, especially in the commercial and SME sectors.
- There is a vast range of *energy-saving behaviours* to consider that are highly specific to subsets of the total commercial sector. The most extensive list to date, of almost 600 of them, is still only a subset (Chester et al, 2020).
- Different *commercial sub-sectors* have quite unique energy needs and uses, even if they are sometimes housed in relatively similar building types.
- *Locus of decision-making* is also a very important factor that needs to be carefully assessed and understood for specific businesses and interventions.
- *Heterogeneity of audiences and behaviours* needs to be highlighted and teased out for specific sub-sectors and business (and sometimes, building) types.
- *Co-benefits* are huge potential drivers for EE and behaviour change, yet they are rarely measured and communicated in the commercial sector.
- *Equity considerations* are even more underexplored in the commercial sector than the residential one.
- The *SME market* may just be the most hard-to-reach sector of all audience groups, especially in the developing world.
- Much more research is needed into *different SME sub-segments*, both within and between cultural contexts.
- There is more 'individuality' and more *overlap with the residential sector*, in many ways, especially once we take into account that a large number of small businesses are run out of residential properties.
- The *estimated size and impact* of this SME audience on energy use and communities is vast and they are very likely to be some of the hardest-hit following the COVID-19 pandemic.

This summary has shown that the vast majority of energy users that are generally classified as HTR (e.g. vulnerable, low and high-income households, renters and landlords, SMEs) make up the majority of energy users, a majority which will only grow as the COVID-19 pandemic continues. Embedding long-term individual behaviour changes and creating changes that incorporate equity and social inclusion will create multiple benefits, socially, environmentally, and economically, for many around the globe. Years 2 & 3 of our research will focus on what such efforts could look like in practice.

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