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Promoting Energy Efficiency: Barriers, Societal Needs and Policies

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The Climate Change urgency requires a swift reduction of energy consumption. One way to achieve this is through increased energy efficiency. Over the past decades, the debate on how to encourage energy efficiency has been guided by the physical–technical–economic model, which has a strong focus on technologies and cost savings, and in which human behaviour has been seen as a trivial factor. However, the advent of behavioural economics has started enabling the integration of the human factor also into energy efficiency policy. Still, this integration is only in its infancy. While the perspectives taken by economics and behavioural sciences enable to capture the individual dimension of energy efficiency as a problem of individual choice, the collective and social aspect of energy efficiency is still largely overlooked on the energy policy agenda. With its emphasis on how social structures interpenetrate individual actions and construction of reality, sociology offers an additional important insight that goes beyond the identification of barriers-drivers underlying investment choices. This paper aims to increase policy makers' awareness of complementary disciplinary resources, on which they can draw to better define and address the problems associated to energy efficiency. Second, it provides a case to develop an interdisciplinary perspective as a basis to develop a more scientifically valid and socially relevant energy efficiency policy advice.

Keywords: energy policy, economics, sociology, behavioural sciences, interdisciplinarity

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INTRODUCTION

The Paris Agreement calls for a stabilisation of global temperature within this century well below 2 C. This will require a swift reduction of energy consumption. In this fight against climate change, the pivotal role that energy efficiency (EE) plays is recognised worldwide. In particular, EE is seen as a "win-win" solution, enabling not only to reduce greenhouse emissions and investments in energy infrastructures, but also to improve citizens' budgeting capacities (Stadelmann, 2017; Taylor et al., 2010) and wellbeing, including the reduction of energy poverty (Fawcett and Killip, 2019). Prominent institutions, such as the IPCC[1] and the IEA[2], have acknowledged EE as a means to curb energy demand and enhance energy savings. Notably, the European Union has identified EE as a priority in the decarbonisation scenarios advanced in the Energy Roadmap 2050[3] and in the European Green Deal[4], where a 50% reduction of the final energy consumed is expected compared to

[1]https://www.ipcc.ch/sr15/chapter/chapter-4/.
[2]https://www.iea.org/reports/energy-efficiency-2020.
[3]https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52011DC0885.
[4]https://ec.europa.eu/info/sites/info/files/european-green-deal-communication_en.pdf.

2005. A large portion of this reduction is expected to be achieved in the building sector, in particular in the residential sector. This is due to the fact that 40% of the total EU final consumption is associated to the building sector, where residential buildings account for 25% (Tsemekidi Tzeiranaki et al., 2019).

The EE policy goal is not free from challenges. In particular, the actual rate of adoption of EE lags far behind the rate suggested by cost and potential studies and the cost/benefits analyses, which assume that citizens always choose the most profitable option for themselves (Nauclér and Enkvist, 2009), the so-called *energy efficiency gap* (Hirst and Brown, 1990; Jaffe and Stavins, 1994). However, as Stern (Stern and Stern, 2007) stated, 'it is difficult to explain low take up of EE as purely a rational response to investment under uncertainty'.

Being unable to explain this gap as a purely economic phenomenon, scientists have extensively investigated the decision-making process related to EE investments, especially at individual level, adopting different disciplinary perspectives (reviewed by, e.g., (Lutzenhiser, 1993; Wilson and Dowlatabadi, 2007; Lopes et al., 2012; Schleich et al., 2016). However, despite such multidisciplinary contributions, EE policy has mostly been guided by perspectives focusing on costs, discount rates, drivers and barriers, disregarding other factors accounting for the interconnection between social systems and people (Lutzenhiser, 2014) or overlooking how citizens actually think about the problem of efficiency in energy use (Labanca and Bertoldi, 2018). This suggests that EE policy would highly benefit from including sociological perspectives.

Without a lens enabling to capture the connection between social structures (like social classes) and justice, EE policy interventions might not only worsen existing inequalities (Sovacool, 2021), but also fail to reflect society's needs (Pereira and Saltelli, 2017). Therefore, EE policy should also aim to be guided by perspectives explicitly accounting for social issues, like those retaining knowledge as socially constructed (Lutzenhiser, 2014). However, integrating multiple perspectives and translating them into practice is challenging, because of an "information gap" in policy on how to best apply policy (Axon et al., 2018).

This paper aims to contribute to close this "information gap" by increasing policy makers' awareness of the co-existence of complementary disciplinary social science perspectives to better define and address EE challenges at individual level[5].

The paper first outlines the current concepts and interventions used to understand and promote EE investments. Then, in **Section 3**, it introduces the sociological perspective as a complementary perspective on which EE policy-makers can draw. **Section 4** outlines a call for a more interdisciplinary perspective to inform EE policy. Finally **Section 5** concludes.

THE CURRENT APPROACH TO EE POLICY-MAKING

The problem of the EE gap has been a prominent topic in energy policy debates, given that its reduction is assumed to provide "win-win" opportunities, creating a need to identify the potential causes and select the right instrument for policy interventions (Allcott and Greenstone, 2012; Schubert and Stadelmann, 2015). As an example, in the European Union the focus on the EE gap has been dominating since the nineties, resulting in the adoption of several programmes to remove barriers to optimal energy efficiency investments (Labanca and Bertoldi, 2018; Economidou et al., 2020).

Within this frame, policy makers strived to adopt the scientific approach to policy-making, informed both by the evidence provided by scientific theories to understand how to address the EE gap (the so-called *evidence-based* approach), and stakeholders' consultation and lobbying mediated with policy priorities.

These official policy-making narratives, assuming citizens' participation in the public sphere through optimal decisions that policy makers should enable, not only placed emphasis on individual behaviour change (Lennon et al., 2020), but also shaped the demand for useful scientific insights, in particular those assuming the individual as an abstract entity reacting to policies with changes in their discount rate and disjointed from a complex society (Batel et al., 2016).

For decades, energy policy has been mainly informed by science, technology, engineering and mathematics (STEM) disciplines, as a response to the diffused narrative pushing for technology development (Sovacool et al., 2015), discounting other studies in energy-related social sciences highlighting how fundamental the human and social factors are in shaping energy demand (Lutzenhiser, 1993; Wilhite et al., 2000).

Fortunately, with the exception of (neoclassical) economics, which has always been treated as the most "sciency" of the social sciences and thus entitled to inform the policy table as a STEM subject, social science disciplines (such as behavioural sciences) have now recently started feeding into the energy policy debates by incorporating the human factor (Foulds and Robison, 2018).

Because EE adoption is understood as an optimal investment decision that individuals often fail to make (Schubert and Stadelmann, 2015), the insights from economics and lately also from behavioural sciences[6] (Foulds and Robison, 2018; Loewenstein and Chater, 2017) have been instrumental to identify the decisional barriers and drivers underlying the EE gap, and the instruments required to close it. In the following subsections, we present an overview of these barriers and drivers (*see* **Table 1**, **Section 2.1** and **Section 2.2**), and instruments (*see* **Tables 2**, **3** and **Section 2.3**), resulting from a narrative review based on the categorizations of previous studies (e.g. Jackson, 2005; Wilson and Dowlatabadi, 2007; Gillingham et al., 2009; Gillingham and Palmer, 2014; Bertoldi, 2020) and the authors' experience working at the interface between science and energy efficiency policy for 30 years.

Barriers to EE Investments

Market Failures

In neoclassical economics, investing in EE is assumed to be a discrete choice, and individuals are *assumed* to choose the appliance only if that is the most rational option available. In doing so, individuals are

[5]The paper does not focus on organizations.

[6]i.e. the disciplines that systematically study human behaviour, such as behavioural economics and psychology.

TABLE 1 | "Summary of barriers and drivers".

	Barriers	Drivers
Neoclassical Economics	Imperfect information Split Incentives Credit Constraints Regulatory Failures	Economic Savings
Behavioural Economics	Present-biased and Reference-dependent preferences Incorrect Beliefs Status quo bias, limited Attention	Pro-Environmental Preferences
Psychology		Intentions Values, norms and morals Emotions

TABLE 2 | "Summary of Traditional Interventions promoting EE adoption".

	Category	Augmented with insights from behavioural sciences
Financial Instruments	Subsidies, Rebates	Targeting based on motivations
	Tax credits and reductions	Framing based on level of loss aversion
	Loan rebates	Reducing loss perceptions from investment
Regulatory Instruments	EE Standards	Accounting for time preferences in the estimation to improve evaluation of welfare effects
Information Instruments	Energy Labels	Simplifying and making relevant information visible
	Energy Audits	Referring to a descriptive norm
	Information Programs	

TABLE 3 | "Summary of nudges and boosts promoting EE".

	Category	Example
Nudges	Changing Defaults	Setting by default the furnishing of new buildings with energy-saving light bulbs
	Changing option-related effort	Decreasing financial effort by enabling to pay EE measures with generated savings
	Changing option consequences	Providing options to self-present when EE measures increase social status
	Providing reminder	Reminding with information about the visit date and time of the energy audit
	Promoting commitment	Embedding mild commitment to reach saving targets in dedicated accounts
Boosts	Promoting core competencies	Training on energy-financial literacy
	Reducing cognitive costs	Presenting information in a graphical way, rather than in a numerical way

assumed to be capable to take into account the benefits that the service accrues, even though these energy savings are delayed in the future. An implication of these assumptions is that completely rational individuals would always choose to invest in EE, given that this is economically optimal. However, they fail to invest in EE because of the way the market is structured (Gillingham et al., 2009). Some of the current market barriers are the result of "market failures," which are assumed to need to be corrected (Bertoldi, 2020):

i) *imperfect information* (individuals lack or have *imperfect knowledge* on EE, and collecting information is generally not free (transaction costs (Sanstad and Howarth, 1994));
ii) *split incentives* (these arise when the tenant has incomplete information about the service (EE of the building), and the landlord underinvests in the EE of the property, for fear of being unable to recoup the costs of investments through rent (Gillingham et al., 2012; Palm and Reindl, 2018; Cattaneo, 2019));
iii) *credit constraints* (individuals do not have enough financial resources or access to the necessary credit to sustain the high up-front costs (Golove and Eto, 1996));
iv) *regulatory failures* (energy prices might fail to reflect their true cost, due to regulatory failures or non-inclusion of negative externalities, like pollution (Brown, 2001)).

Yet, market failures are not the sole reason why individuals fail to invest in EE (Stern and Stern, 2007).

Behavioural Failures

Neoclassical economics proved to model human behaviour unsatisfactorily and to be invalid to make policy predictions. Therefore, for the past few decades, the scientific and policy debates have started exploiting a new framework that explains the factors that cause behaviour: behavioural economics (Camerer, 2003). Within this framework, additional barriers emerged as factors preventing individuals to invest in EE: "behavioural failures"[7]. These are the result of the way individuals cope with complex decisions (Tversky and Kahneman, 1974). In

[7]i.e. deviations from the assumptions of rational choice (Shogren and Taylor, 2008).

particular, as individuals are bounded rational (Simon, 1955, 1957), they use shortcuts, the so-called *heuristics*, but often these lead individuals to make suboptimal decisions, such as failing to optimally invest in EE. Here, we provide an overview of the behavioural failures explaining why individuals do not invest in EE (under the categorisation of (DellaVigna, 2009), *non-standard preferences, non-standard beliefs and non-standard decision-making*).

Non-Standard Preferences (Reference-Dependent Preferences, Present-Biased Preferences)

Due to loss aversion[8], individuals are less willing to invest in EE if they perceive the investment could generate a potential loss (such as less comfort, or lack of energy savings (Heutel, 2019)). Individuals can also be less willing to invest in EE because of their limited ability of planning ahead (Ballinger et al., 2003) or debt aversion (Schleich et al., 2019), given that investing in EE is associated to benefits that will materialize in the future.

Non-Standard Decision-Making (Status Quo Bias, Limited Attention)

Due to status quo bias[9], individuals might prefer to maintain and overuse the current stock of appliances instead of investing in EE (Schubert and Stadelmann, 2015). This is particularly true when a psychological commitment to costly investments exists (*sunk cost fallacy*), culminating in an overuse of current appliances to amortize investment costs (Blasch and Daminato, 2020). In addition, individuals might decide not to invest in EE because their choice is driven by the salient attributes of the available information (DellaVigna, 2009), like high up-front prices.

Non-Standard Beliefs (Incorrect Beliefs About the Future)

Individuals are less likely to invest in EE, when they have incorrect beliefs over the future benefits of an energy efficient technology (Allcott and Greenstone, 2012).

Drivers of EE Investments

Pro-Environmental Preferences

The empirical and experimental evidence underlying behavioural economics proved that, in addition to displaying cognitive deviations from rational choice assumptions, individuals also display motivational deviations: namely their degree of self-interest and motivations can differ (Sacco and Zarri, 2003). For the EE case, this heterogeneity in motivations suggests that there might be additional non-economic drivers of the decision to invest. More specifically, a difference can occur in the ways individuals care about the environment (i.e. they display "pro-environmental preferences") (Schleich et al., 2016), due to (Frey and Stutzer, 2006)) *1*) impure altruism ("warm glow"[10] (Andreoni, 1989)), *2*) pure altruism ("pro-social orientation"[11] (Bénabou and Tirole, 2006)), *3*) personal norms[12], (Festinger, 1957; Akerlof and Kranton, 2000) and *4*) social norms[13] (Elster, 1989; Bicchieri, 2005).

Assessing the underlying motivations behind why individuals care about the environment is also crucial to understanding sources of **rebound effects** (Ruzzenenti and Bertoldi, 2017; Belaïd et al., 2020). For example, in addition to the reduced service cost arising from technological improvements, an additional potential source of rebound effects is **moral licensing** (Dütschke et al., 2018), which "occurs when past moral behaviour makes people more likely to do potentially immoral things without worrying about feeling or appearing immoral" (Monin and Jordan, 2009). Therefore, if individuals are motivated to invest in EE because they attach a moral value to it (i.e. they think that is the right thing to do), it is likely that there will be higher rebound effects following their investment decision (i.e. they will feel entitled to consume more electricity to heat their apartment or to adopt an inefficient appliance later on).

Antecedents

While the (neoclassical and behavioural) economic models focus on the features characterising the decision situation and the incentive structure that might promote or inhibit the decision to invest in EE, the psychological perspective often focuses on uncovering the antecedents driving behaviour. Below we provide an overview of the antecedents, which fits the categorisation of (Steg and Vlek, 2009) (intentions, moral and norms, and emotions). In doing so, we focus only on some exemplary psychological theories.

Intentions

Within the Theory of Planned Behaviour (TPB, (Ajzen, 1991)), behaviour is the result of a deliberate process where individuals compare the costs and benefits associated to a certain choice, and the key driver of behaviour is the "intention" to act. More specifically, "intention to act" is influenced by:

- *Attitude* towards behaviour, which results from the individual beliefs and the evaluation of consequences associated to the behaviour;
- *Perceived behavioural control*, which is the perceived difficulty to engage in behaviour;
- *Subjective norm,* which is the perceived (dis)approval of behaviour by relevant reference persons (e.g. family, friends, colleagues).

Under this theory, individuals are more willing to invest in EE if *1*) their beliefs and evaluation of the consequences of EE are positive, *2*) they perceive the investment as a doable task, and *3*) they think their relevant peers will approve of it.

[8]i.e., individuals evaluate decision outcomes in terms of gains and losses relative to a reference point, usually the status quo, and evaluate losses to be larger than equal-sized gains(Tversky and Kahneman, 1979, 1981).

[9]i.e., a tendency to choose options that maintain the current situation.

[10]i.e. individuals receive a positive emotional response from the mere act of adopting measures that benefit the environment.

[11]i.e. individuals care about the level of actual environmental protection achieved.

[12]i.e. individuals are willing to protect the environment because they think it is a good way to comply with the scripts of their identity.

[13]i.e. individuals think that their relevant group thinks it is appropriate to protect the environment, and anticipate social disapproval if they decide otherwise.

Values, Norms and Morals

Another key driver of pro-environmental behaviour according to Stern and Dietz (Stern and Dietz, 1994), and Schultz (Schultz, 2001) are "values." In particular, individuals who display altruistic, prosocial, self-transcendent and biospheric values (Nordlund and Garvill, 2002; De Groot and Steg, 2010); Schultz and Zelezny, 1999, Ateş, 2020) are more willing to invest in EE.

Similarly, individuals who display moral obligation towards the environment are more willing to invest in EE (Value Beliefs Norms Theory, VBN (Stern, 2000)). This is activated by the level of responsibility that one wants to assume towards the environment, prompted by the awareness of the consequences of his/her own action on the environment, which is directly related to one's core values.

A driver related to personal norms and values is social norms. According to the theory of Normative Conduct (Cialdini et al., 1990, 1991), social norms operate through two distinct channels: descriptive (what most people do) and injunctive (what ought to be done). When these norms are salient, they can drive EE investments, e.g. when individuals know that their relevant peers have already invested in EE (Cialdini and Goldstein, 2004).

Emotions

By acting as filters for new information, "emotions" enable to focus attention on goals, needs and values, and set the stage for subsequent behaviours. Therefore, when information prompts positive emotions, it can lead individuals to engage in pro-environmental behaviours, such as investing in EE (Brosch et al., 2014).

Encouraging EE Investments

The extensive literature on EE policy evaluation (for reviews of this literature, *see*, e.g., (Gillingham et al., 2009; Tietenberg, 2009; Gillingham and Palmer, 2014) proves that several public policies have been implemented to promote EE mainly informed by insights from economics and more recently from behavioural sciences too (Schubert and Stadelmann, 2015; Foulds and Robison, 2018).

In particular, with the advent of behavioural economics, the reasons for intervening at the policy level could rely no longer only on economic grounds (to correct market failures), but also on behavioural grounds (to correct behavioural failures) (Loewenstein and Chater, 2017; Belaïd and Joumni, 2020). Since then, across the world, including in Europe (Baggio et al., 2021), insights from behavioural sciences started to be incorporated in the implementation of traditional instruments to augment their efficacy (Loewenstein and Chater, 2017), and to enrich the policy toolbox with additional instruments in several policy areas (Sousa Lourenco et al., 2016). However, these approaches often take individuals in isolation from specific contexts (Foulds and Robison, 2018). In the following section we provide an overview of the instruments promoting EE.

Financial Instruments

Financial incentives consist of subsidies, tax credits, tax deductions, rebates or loan subsidies (Gillingham et al., 2009; Bertoldi et al., 2021.). Traditionally, these were implemented with the assumption that individuals would be more willing to invest in EE if financial motivation was provided to cope with high-up front costs. However, insights from behavioural sciences suggest that individuals are not only sensitive to monetary incentives of taxes and subsidies, but also to how these are framed. As an example, subsidies and tax credits can be more effective than an equivalent tax (Hassett and Metcalf, 1995; Bertoldi et al., 2013).

Insights from behavioural sciences also suggest that the effectiveness of financial incentives depends on the motivations they target. As an example, the provision of an extrinsic (monetary) motivation to invest in EE could have a backfiring effect on those individuals who are already intrinsically motivated (e.g. because of altruism and warm glow) to invest in EE (Frey and others, 1997; Gneezy and Rustichini, 2000). Therefore, an effective intervention preventing such a crowding-out effect would complement financial incentives with messages that crowd-in intrinsic motivation, like those encouraging to invest in EE as a way to protect the environment (Hilton et al., 2014).

Regulatory Instruments

By imposing bans on products that do not meet certain criteria, regulatory instruments change the options available to consumers. In the context of EE, these have been implemented as product standards, in order to set a minimum level of EE, like for HVAC systems and insulation measures (Cass and Shove, 2018), and light bulbs (Frondel and Lohmann, 2011). As standards are usually implemented based on ex-ante estimates of cost and benefits (i.e. energy savings) resulting from implicit modelling assumptions on individual behaviour, they do not usually consider welfare losses from reduced available options or the rebound effect. Insights from behavioural sciences, like that individuals display non-standard time preferences, can be incorporated in the evaluation of welfare effects and better informs the choice of standards (Tsvetanov and Segerson, 2014).

Informational Instruments

Information instruments disclose technical information, such as energy savings, mainly through labels, audits and information programs. These were traditionally implemented with the assumption that individuals would be more willing to invest in EE if provided with more information. However, insights from behavioural sciences point that individuals are not only sensitive to the availability of relevant information, but also to how it is framed. These insights from behavioural sciences can magnify the impact of informational interventions, by improving the presentation of "decision-relevant information" (Münscher et al., 2016), such as making operating costs salient at the point of purchase (Newell and Siikamäki, 2014).

Nudges

Insights from behavioural sciences have enriched the policy toolbox with additional instruments, such as nudges[14]. These

[14]i.e. interventions that target "any aspect of the choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives" (Thaler and Sunstein, 2008).

enable to directly address the behavioural failures preventing individuals to execute on their intentions to invest in EE, by altering the decision structure or by assisting the decision (Münscher et al., 2016). An exemplary nudge is changing the effort required to select the desired policy option. This can be achieved for example by furnishing new buildings with energy-saving light bulbs by default (Alberini et al., 2013), or by decreasing the perceived financial effort to invest in EE (Münscher et al., 2016). Changing the decision structure by connecting the choice of options with social consequences (Münscher et al., 2016), like enabling to increase social status (Griskevicius et al., 2010), can also be an effective nudge to promote EE investments. Nudges that assist decision makers are commitment devices, reminders and goal settings (Münscher et al., 2016). As an example, sending reminders with information on the date and time of energy audits can be an effective way to increase the final audit uptake (Gillingham and Tsvetanov, 2018). Also, providing individuals with a planning aid or prompting them to make a plan can be effective at helping individuals switch to more energy efficient appliances (Madrian, 2014).

Boosts

Differently from nudges, boosts are interventions that do not target behaviour, but competencies, with the aim to empower individuals to make complex decisions (Grüne-Yanoff and Hertwig, 2016; Hertwig, 2017; Hertwig and Ryall, 2020), like investing in EE. As an example, training providing some basic financial concepts, in addition to knowledge on energy-related issues, can boost the necessary skills to make complex calculations, helping appreciate the benefits of EE and make a well-informed investment decision (Blasch et al., 2017).

A COMPLEMENTARY APPROACH TO INFORM EE POLICY-MAKING

Scientists' and policy makers' debates so far have predominantly focused on the EE problem of suboptimal adoption (Schubert and Stadelmann, 2015). Reflecting a positivist approach to social problems, where the aim is to find their causal factors and potential cure (Harris, 2013), these debates aimed to identify the factors that cause individuals to (fail to) invest in EE (Shove, 2010), focusing on individual choice. However, positivism is not the only approach to understand reality. The constructionist approach advanced by the sociological analysis of social problems seeks to understand how problems are socially constructed (Heiner, 2002). As an example, the problem that citizens are expected to make optimal consumption decisions for themselves and the environment can be constructed by the institutionalization of individualizing approaches (Batel et al., 2016).

The sociological perspective underlines that, having evolved to live in societies, individuals are not actors that make decisions independently from their context, but "encultured" actors (Hoff and Stiglitz, 2016). Preferences, perceptions and values are not exogenously given, but endogenously shaped by the places to which individuals are accustomed. These places produce mental models, meanings, worldviews and narratives that "shape the way we attend to, interpret, remember, and respond emotionally to the information we encounter and possess" ((DiMaggio, 1997), p. 274).

In sociology, the focus is, thus, not on individual choice, but on social structures, such as laws, cultures and habitual practices of meaningful groups, and socially-designed physical structures (Galvin, 2020), as these shape how individuals think, what they want and what they do (Giddens, 1979, 1984). With its emphasis on the construction of reality and generation of meanings, the constructivist approach contrasts the positivist one, which assumes reality as objective (Alvesson and Skoldberg, 2009). In particular, by opining that reality is constructed by the observer, it suggests that there might be a multiplicity of constructed, even contradictory, realities (Aliyu et al., 2014). As for the problem of EE, not only different experts, but also laypeople, might have different perspectives on EE, shaped by the meanings and representations of the groups they are part of (Batel et al., 2016). Similarly to scientists, who see problems through their intellectual frameworks made of scientific norms that shape their way of knowing (Mauser et al., 2013), the knowledge of laypeople is not necessarily idiosyncratic, but mediated by their specific-context experience (Ingold, 2011). Therefore, uncovering the multiplicity of these perspectives on EE might enable to provide a deeper understanding of how EE can be conceived as a problem or solution.

By tracking how social structures interpenetrate individual actions and social issues, the sociological lens can enable policy makers to become more aware of the connection between social structures and justice issues (Sovacool and Dworkin, 2015). As an example, policy makers can recognise that certain groups of individuals are disproportionately affected by the legacy of an unjust social structure (e.g. classes, identities) and thus advance more justice-aware policies (Sovacool et al., 2017).

The following section illustrates how focusing on social structures enables to capture the social construction of how individuals understand and practice EE. To do so, we use two exemplary social structures, which have received particular attention in the energy-sociological academic debate.

Social Structures

Practices

Practices are an example of social structures and the focus of Social practice theory (Shove et al., 2012). While the words "behaviour" and "practice" are often used interchangeably (Shove, 2010), and recently behaviour change has also been approached through the adoption of "a practice lens" (DellaValle et al., 2018), practices differ from the positivist conceptualisation of behaviour, being emergent, endogenous and dynamic social entities that capture their carriers (people) and that, at the same time, need a sufficient number of carriers to constantly reproduce them (Shove, 2003).

There are different approaches to understand the key elements of practices and among those that have received great attention in the energy-sociological debate the one advanced by Shove stands out. Within this approach, energy is not used for its own sake, but is part of accomplishing practices, like keeping warm and cool, which people value as aspects of their everyday life (Warde, 2005). Therefore, rather than seeing one-shot decisions as

decontextualised, the practices associated to EE are analysed through the lens of the routines and activities shared with family and friends that constitute life at home (Wilson et al., 2015). In particular, practices can be understood by looking at the physical aspects of performing a practice (*material-structure*), *meanings* associated to the practice, and *competences* needed to perform the practice (Shove and Pantzar, 2005).

Tracking the constituents of socially shared energy practices might enable policy makers not only to acknowledge different representations underlying energy demand (Hargreaves and Middlemiss, 2020), but also to understand how to reorganise technological outputs and associated shared meanings and competences in a socially relevant way (Labanca and Bertoldi, 2018). When a practice is socially valid, people need to feel competent in performing it, under the fear of being stigmatised (Hards, 2013). As an example, in warm (cold) climates, it is key for a host to being able to keep their home cold(warm) (Wilhite and Lutzenhiser, 1999; Hitchings and Lee, 2008). Therefore, when practices are technologically mediated it is crucial to acknowledge that changes to infrastructures and technologies might reconfigure individuals' interpretations of values, meanings, competences and, in turn, their practices (Shove Ea, 2003).

Regulations and changes in material structures, such as those enabled by technological innovation in lighting and ventilation, have the potential to construct more sustainable practices related to indoor comfort (Shove E., 2003). But this process can be inhibited if previous practices filled with socially shared meanings, competences and values are not taken into account (i.e. lights do not only illuminate but also create ambience and safety (Crosbie and Guy, 2008); airing rooms in the morning is perceived as healthy (DellaValle et al., 2018)).

Also, when accounted for, social practices might explain several phenomena, like the prebound effect. As an example, the energy poor might moderate the effects of heat (cold) by performing a range of practices that are often ignored in the one-size-fits-all response with appliances (Strengers and Maller, 2011). As a result, the energy poor might consume far less energy than predicted by techno-centric estimates(i.e. they are forced to underheat (undercool) their homes to save money (Sunikka-Blank and Galvin, 2012)).

Social Classes

Another prominent social structure is social class. The class, determined by the individual's resources (capital)[15], produces a character (i.e. dispositions, sense of self) (habitus) that elicits certain behaviours in the social reality (fields) where agents seek profit or status (Bourdieu, 1987). The primary class division is between those who have high and low total capital (Bourdieu, 1987). According to the social theories of vertical and horizontal diffusion (Bartiaux et al., 2016), highly visible practices[16] (such as installing solar panels (Keirstead, 2007)) diffuse from the upper to the middle and the lower class for status concerns (Bartiaux, 2008). The vertical diffusion of status has been applied to explain the adoption of socially visible and costly energy-saving practices, wherein lower class individuals, who wish to ascend to a higher class, adopt practices usually performed by the upper class (McMeekin and Tomlinson, 1997; Jensen, 2005; Bartiaux, 2008).

Conversely, non-visible practices (such as insulating one's home) diffuse horizontally, namely they diffuse among individuals connected in the same network (Rogers, 2010), through casual conversation, and thanks to reciprocal feeling of trust (Berelson et al., 1968). In particular, interpersonal communication can boost both energy conservation behaviours (Yavas and Riecken, 1981; Shama, 1983), and engagement in EE (Emirbayer and Mische, 1998; McMichael and Shipworth, 2013).

Understanding how EE investments diffuse across and within social classes can help advance justice-aware energy policy (Sovacool et al., 2017), by allowing for more comprehensive policy choices (Sovacool and Dworkin, 2015). As an example, costly non-visible practices (such as insulating one's home) might not diffuse easily horizontally among lower classes because of unequal access to finance and information (e.g. they face more hurdles due to power and cognitive constrains in the acquisition of information and subsidies (DellaValle and Sareen, 2020)). To avoid policies worsening these inequalities, it is thus crucial to adopt a lens capturing the connection between social classes and justice (Sovacool, 2021). As an example, renovation projects that disregard potential distributional effects might yield the "renoviction" effect: lower class households are more likely to live in energy-inefficient houses (Poortinga et al., 2003) but after renovation they become less affordable, and households are forced to dislocate to more affordable but less efficient housing (Grossmann, 2019).

DISCUSSION

The dominant problem in contemporary EE policy is framed as a one of individual choice (Lutzenhiser, 2014). Such a frame positions policy makers as enablers, whose role is to create the conditions for citizens to optimally invest in EE (Shove, 2010). Within this frame, policy makers face the challenge to identify which insights from the available scientific knowledge are more appropriate to reach the objective of "closing the EE gap" by changing behaviour (Schubert and Stadelmann, 2015). However, this particular representation of the EE problem may not be as socially relevant as it could be.

At the same time, this frame positions the insights from economics and behavioural sciences as useful at identifying factors underlying the EE gap, and those from sociology at "taking social norms a bit more seriously as influences on behaviour" ((Jackson, 2005), p.55).

As suggested by Whitmarsh et al. (Whitmarsh et al., 2011), the fact that concept of practices reminds that action is partly due to norms and institutions suggests a point of intersection between sociological and individualizing approaches (i.e. behavioural

[15]a social group that is defined in a social space by the quantity and the proportion of available social, cultural and economic resources (Bourdieu, 1987).

[16]Practices are here understood as practices that involve consumption, conservation, or generation of energy, as synonymous of behaviour, rather than social practices.

sciences also acknowledge that social norms and identities affect behaviour (Whitmarsh et al., 2011)). This puts forward the possibility to integrate these different perspectives and to address more effectively the problem of the EE gap, something that has already proven successful in the contexts of energy consumption and sustainable transition (Nye et al., 2010). The constructivist paradigm underlying the sociological perspective highlights that reality and problems, including the EE gap issue, can be socially constructed (Harris, 2013).

By bringing about unique perspectives that enable to see a problem from different angles (Whitmarsh et al., 2011), the fundamental differences between sociology, economics and behavioural sciences enable to better capture the complexity surrounding EE. As an example, by focusing on the types of heuristics that individuals use to make decisions under complexity, the behavioural science perspective may help policy-makers become aware whether their perceptions of social problems are accurate or whether they form judgements about citizens' needs overrelying on specific heuristics or interpretations of the world (Bergan and Fitzpatrick, 2021). The constructivist paradigm underlying the sociological perspective highlights that reality and problems, including the EE gap issue, can be socially constructed (Harris, 2013).

For example, citizens' experiences, values and meanings connected with their homes might shape their understanding about how to achieve coolth and warmth (Chersoni et al., forthcoming; Harputlugil and de Wilde, 2021), e.g. the energy poor might perform a range of practices to moderate the effects of heat (cold) (Strengers and Maller, 2011). Disregarding these needs and practices will lead to dismiss critical factors useful not only to determine what is relevant to solve the problem (e.g. How to promote the uptake of renovation and other EE measures?), but also for a better understanding of the problem itself (e.g. Is EE the only solution to improve comfort?). Therefore, to give EE policy advice more scientific validity and more social relevance, it is paramount to be mindful of which evidence is used in EE policy making. Practically, to make political decisions that are scientifically valid and socially relevant, policy makers can initiate a reflexive process that closely examines the paradigms of current policy agendas through the lenses of different social science perspectives, with representatives of different social sciences disciplines. This process will not only enable them to become more aware of the different intellectual resources but also of the different societal perspectives that could inform policy solutions and provide additional evidence about society's needs (Funtowicz and Ravetz, 1993).

There are, however, challenges that need to be considered. As an example, scientists need to engage in critical thinking to become aware of their disciplinary guiding epistemological assumptions and methodological practices (Ramadier, 2004). While these challenges might keep this call an unfulfilled project, practical examples suggest that in some contexts there are examples of progress along these lines. In particular, there have been attempts to nurture critical thinking - through the implementation of strategies fostering multi-disciplinary collaborations across teams (Pereira and Saltelli, 2017) and conversations challenging current narratives.

CONCLUSION

The Climate Change challenge calls for a swift reduction of energy consumption. One way to achieve this is through increased energy efficiency.

So far the debate on how to encourage energy efficiency has been guided by scientific insights that help understand how to remove barriers and promote drivers of the decision to optimally invest in EE.

Only recently, the integration of the human factor started being integrated into energy efficiency policy, complementing the physical–technical–economic approach, which has a strong focus on technologies and cost savings.

However, not only the integration of the human factor through the use of social sciences is at its infancy, but also the representation of the problem of EE adoption only as a problem of individual choice might be partial and socially irrelevant.

While the perspectives taken by economics and behavioural sciences enable to capture the individual dimension of energy efficiency as a problem of individual choice, the collective and social aspect of energy efficiency is still largely overlooked on the EE policy agenda.

By using a narrative review approach, this paper presented key energy-related social science concepts, to increase policy makers' awareness of complementary disciplinary resources, on which they can draw to better define and address the problems associated to EE. First, it presents sociology as an approach that complements the dominant economic-behavioural science one, which policy makers can draw from to better define and address the problems associated to EE. In particular, by highlighting that problems can be socially constructed, the sociological perspective warns that as social structures interpenetrate individual actions and construction of reality, EE policy needs to look beyond barriers, market and behavioural failures.

Second, this paper highlighted the need for a critical account of evidence use in EE policy, and that an interdisciplinary endeavour, through the exploitation of insights from complementary social sciences, is likely to give policy advice more scientific validity and more social relevance. While developing such an approach is not free from challenges, some promising examples suggest that this project could already be tested in some contexts.

To accomplish the goal of translating different theoretical insights in a workable way for policy makers, this paper synthetized different academic works using the narrative review approach. Because of that, the resulting findings could be biased towards the authors' experience in the field (Sovacool et al., 2018). Therefore, future research should adopt other methodologies, such as expert interviews with representatives of different disciplines. This would also enable to better explore the feasibility of such an interdisciplinary endeavour.

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Conception and design of study: NDV and PB. Writing—Original Draft: NDV. Writing—Review and Editing: PB.

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