



Household energy use: Applying behavioural economics to understand consumer decision-making and behaviour



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ABSTRACT

Household energy conservation has emerged as a major challenge and opportunity for researchers, practitioners and policymakers. Consumers also seem to be gaining greater awareness of the value and need for sustainable energy practices, particularly amid growing public concerns over greenhouse gas emissions and climate change. Yet even with adequate knowledge of how to save energy and a professed desire to do so, many consumers still fail to take noticeable steps towards energy efficiency and conservation. There is often a sizeable discrepancy between peoples' self-reported knowledge, values, attitudes and intentions, and their observable behaviour—examples include the well-known 'knowledge-action gap' and 'value-action gap'. But neither is household energy consumption driven primarily by financial incentives and the rational pursuit of material interests. In fact, people sometimes respond in unexpected and undesirable ways to rewards and sanctions intended to shift consumers' cost-benefit calculus in favour of sustainable behaviours. Why is this so? Why is household energy consumption and conservation difficult to predict from either core values or material interests? By drawing on critical insights from behavioural economics and psychology, we illuminate the key cognitive biases and motivational factors that may explain why energy-related behaviour so often fails to align with either the personal values or material interests of consumers. Understanding these psychological phenomena can make household and community responses to public policy interventions less surprising, and in parallel, can help us design more cost-effective and mass-scalable behavioural solutions to encourage renewable and sustainable energy use among consumers.

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1. Introduction

Consumer behaviour is complex and rarely follows traditional economic theories of decision-making. When choosing what products to buy or what services to use, people often *think* they

are making smart decisions and behaving in ways that are highly rational and congruent with their values and intentions. However, daily life illustrates that this is often not the case. People routinely deviate from the 'rational choice' model of human behaviour, in which one objectively weighs up the costs and benefits of all alternatives before choosing the optimal course of action. But neither is human decision-making reliably predicted by what people know is the 'best' or feel is the 'right' thing to do. For example, so-called 'green' knowledge and values – such as knowing about or feeling positive towards the use of renewable resources, sustainable products, low-emission technology, public transportation, and so forth – do not

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reliably translate into pro-environmental choices when buying goods or using services that impact the environment. Many people still rely heavily on non-renewable resources, under-use public transport, fail to recycle, and engage in other everyday actions that harm or neglect the environment—actions they may themselves acknowledge as ‘wasteful’ and economists deem sub-optimal. Even consumers who face strong material incentives, and/or possess knowledge and motivation patently sufficient to act in more sustainable ways, may struggle to shift their behaviour in the desired direction, particularly over the longer term.

First, it is clear that what people say and what they do are sometimes very different things. In many domains of human behaviour, we see a *knowledge*-action gap [1–3], a *value*-action gap [4–7], an *attitude*-action gap [5], and/or an *intention*-action gap [8,9]. For example, people may know about, intrinsically value, hold positive attitudes towards, and/or genuinely intend to act in some socially desirable way. Yet often these things do not translate into actual behaviour. One domain of consumer behaviour where this disjuncture is evident is residential energy use [6,7,10,11]. Many people report that they are concerned about climate change and understand the importance of saving energy, yet this concern does not reliably translate into taking ongoing, practical steps to reduce household energy consumption. It is perhaps unsurprising, then, that traditional education programmes and mass media campaigns – which strive to promote pro-environmental knowledge and attitudes by simply disseminating information – often fail to produce the durable behaviour change that is intended [12–14].

At the same time, it is also clear that people’s behaviour does not generally fall short of their environmental concerns and commitments simply because they are pursuing material interests and extrinsic rewards. Even where energy-saving measures are demonstrably cost-effective (e.g., insulation, low-carbon technology) – making uptake of the technology or behaviour economically rational for the consumer – many people remain reluctant to introduce these things into their lives and homes. In fact, offering extrinsic rewards and financial incentives to encourage pro-social behaviour (e.g., volunteering, reciprocity, civic duty, charitable donations, or other ‘public good’ contributions), presumably by prompting more favourable cost–benefit appraisals, can sometimes backfire and decrease the desired behaviour by ‘crowding out’ intrinsic motivation to act altruistically [15–18].

Though not reliably predicted by either environmental concerns or material interests, individual choices around pro-environmental behaviour and resource consumption are, in fact, predictable—they are ‘predictably irrational’ [19]. As with much of human behaviour, energy-related practices are often influenced by certain cognitive biases and ‘irrational’ tendencies that, while producing decisions and actions that may be surprising from the standpoint of traditional economic models, are actually rather predictable (and even adaptive/functional) from the perspective of psychology and behavioural economics [20–23].

2. Applying psychology and behavioural economics to explain, predict and change consumer behaviour

Traditional economic theory postulates that human decision-making and behaviour are based on purely rational choice [24–26]. More recent neoclassical economic approaches³ also rest on several

³ Neoclassical approaches conceptualise the economy as consisting of profit-maximising organisations and utility-maximising consumers who interact in perfectly competitive markets. This approach has been defined as ‘economics based on maximization-with-equilibrium’ [27] and draws on principles of utility maximisation, equilibrium and efficiency. Neoclassical theorists view economic behaviour as highly rational and self-interested—e.g., firms strive to maximise

fundamental assumptions aligned with rational choice theory (for overviews, see [28–30])—namely, that people have rational preferences among outcomes, always strive to maximise utility, and act independently based on full and relevant information [31,32]. Based on these assumptions, traditional economic models predict that people will make decisions that yield the optimal result given budget constraints, and that behavioural choices can be improved by providing people with *more* information (i.e., by increasing knowledge/awareness) and/or *more* options (i.e., by increasing choices).

In stark contrast to such assumptions, a growing body of scientific research demonstrates that people are rarely the rational decision-makers envisaged by traditional economic models of human behaviour. Empirical evidence from psychology and behavioural economics shows that consumer choices and actions often deviate systematically from neoclassical economic assumptions of rationality, and there are certain fundamental and persistent biases in human decision-making that regularly produce behaviour that these assumptions cannot account for (see [22,23,33–35]). Many of these biases stem from simple ‘rules-of-thumb’, ‘heuristics’ and mental ‘shortcuts’ that alleviate the need for more effortful information processing, thereby hastening the speed of problem-solving and decision-making, particularly in situations characterised by high levels of complexity, choice, risk and uncertainty [36–39]⁴.

A comprehensive review of all cognitive biases and behavioural anomalies is beyond the scope of this paper, but several seem particularly relevant to understanding energy consumption, especially in terms of predicting and changing the behaviour of individuals and households. As outlined below, among the most powerful and pervasive biases to influence consumers’ patterns of energy usage include the status quo bias, loss and risk aversion, sunk-cost effects, temporal and spatial discounting, and the availability bias. In parallel, psychological phenomena such as normative social influence, intrinsic and extrinsic rewards, and trust may also play a key role. A large body of research shows that even where cost–benefit calculations would suggest more materially advantageous choices, people persist in displaying seemingly irrational, yet predictable tendencies to:

1. retain the *status quo*, stick to *default settings* or defer decision-making entirely (*inertia*), especially as the amount or complexity of information increases [43,44]. For example, people tend to resist change and ‘go with the flow’ of pre-set options, even where alternatives may yield better (e.g., more financially rewarding or materially advantageous) personal or collective outcomes. Providing a default not only saves people time (by relieving them of having to make an active choice), but it might also be viewed as the best option (since it is apparently being ‘recommended’ by the provider; [45]). Evidence of this status quo bias has been observed across a range of experimental and applied contexts, including residential energy consumption (for examples, see [45–47])⁵.

(footnote continued)

profit by producing and supplying goods/services, while householders strive to maximise utility by consuming these goods/services.

⁴ In daily life, people encounter vast amounts of information and a seemingly endless array of choices. Yet human beings are ‘boundedly rational’ [24,25]; they have limited cognitive resources, which naturally constrains optimal decision-making. As such, it is perhaps unsurprising that people prefer simplicity and rely on mental shortcuts to bypass more intensive information processing and conscious deliberation—it makes things easier, simpler and faster. At the same time, relying on decision-making heuristics may also lead to systematic biases and other cognitive errors, particularly when people are faced with too much information (cognitive overload) or too many options (choice overload) [37,40–42].

⁵ The status quo bias has been found to influence choices as diverse as car colour, health plans, retirement programs, budgeting and other financial decisions [44,48], as well as consumer valuations of unpriced products/services [47]. For example, Hartman et al. [47] found status quo effects in consumers’ estimates of the reliability of residential electrical services, with more recent studies finding

2. *satisfice* by exerting only the effort needed to achieve a satisfactory rather than an optimal result; that is, settling for 'good enough' rather than 'best' [24,25,49]. When overloaded with information or complexity, people are often incapable of 'optimising' (i.e., systematically processing all available information to maximise utility) and tend to choose not necessarily the best option or solution to a problem, but rather the first available option or solution that *suffices*, or *satisfies* the minimum requirements [34]. This tendency, known as *satisficing* [24,25], facilitates more rapid, less effortful information processing, problem-solving and decision-making, while also affording potential wellbeing benefits (see [50]). For example, people typically process only enough information to reach a satisfactory decision rather than processing all available information to reach an optimal decision, as the latter demands much more time, effort and resources than would ordinarily seem justified by the prospective increase in utility or satisfaction⁶. Yet this tendency to settle for 'good enough' may come at a price, with people often making worse decisions and poorer choices (or avoiding action altogether) when faced with more information and/or options [51,52].
3. be *loss averse* by weighing losses more heavily than equal-sized gains, particularly as the stakes rise [33,43]. For example, people typically focus on the risks, costs or losses associated with adopting a new behaviour, such as financial costs (what will it cost me?), physical risks (is it safe/healthy?), social costs (what do others think?), ecological risks (is it environmentally friendly?), time costs (will it take longer?), functional risks (does it fit my routine?), and even psychological costs (how will I feel?), and tend to discount equivalent gains and benefits. When faced with making a decision, people perceive the disutility of losing something as far greater than the utility of gaining something (i.e., they feel the pain of losses far more than the pleasure of gains). This tendency is reflected by contingent valuation studies that show that willingness to accept tends to be higher than willingness to pay [20,53].
4. be more *risk averse* when faced with certain (high probability) gains or uncertain (low probability) losses, but more *risk-seeking* when faced with certain losses or uncertain gains [54,55]. Generally speaking, people prefer to avoid risk given the prospect of positive outcomes (i.e., gains), but the reverse is true given the prospect of negative outcomes (i.e., losses). That is, people are more willing to gamble or take a chance (i.e., engage in risky behaviour) to avoid a certain loss than to secure an equal-sized gain [55–57]. Yet risk-seeking and risk aversion also depend on what is at stake, with risky decisions often more apparent for smaller-stakes gambles. This tendency to be less risk averse and more risk-seeking for small-stakes gambles than for large-stakes is known as the 'peanuts effect', i.e., people are more willing to take a chance when playing for 'peanuts' [58,59]. That is, risk-seeking decreases when the (loss) stakes are high, such that people are more risk-seeking for small losses than for large losses. And risk aversion decreases when the (gain) stakes are low, such that people are less risk averse for small gains than for large gains.
5. persist with an endeavour once valued resources such as time, effort and money (now 'sunk costs') have already been invested, a phenomenon known as the *sunk cost effect* [56,60,61]. People tend to become irrationally fixated on 'recovering' losses already suffered, discounting future costs and benefits. Once time, effort or money has been invested in a particular endeavour, they may persist with that course of action and 'throw good money after bad' even as it becomes riskier or increasingly unlikely to yield the desired result. Some researchers have attributed this tendency to an over-generalisation of the 'Don't waste' rule that many people have learned during childhood, i.e., the notion that avoiding waste is generally advisable, so abandoning a prior investment may seem to 'waste' the resources already expended [62]. Sunk-cost effects have been observed for both business and personal decision-making, and across a range of applied and experimental contexts [56,60,61,63]. For example, research suggests that paying for the right to use a good or service will increase the rate at which the good/service will be used, all else being equal (see [56]). In the residential energy domain, for instance, a consumer who outlays time, effort and money to purchase an electrical appliance (e.g., air conditioner, extra refrigerator) may tend to use it more, even when it is not necessarily required.
6. perceive things as less valuable or significant if further away in time (*temporal discounting*) or space (*spatial discounting*), even if such things afford long-term benefits [64–67]. For example, people often 'discount the future' by preferring smaller immediate rewards (e.g., \$5 now) over larger future rewards (e.g., \$10 next year), and they may avoid actions that are costly in the short-term (e.g., outlaying time and money to purchase new energy-efficient appliances or making an effort to switch energy retailers), despite offering longer-term benefits (e.g., reduced electricity bills). This tendency to be short-sighted and make time-inconsistent judgements often leads to procrastination, inertia and decreased cooperation in group settings [68,69].
7. make social comparisons, follow the behaviour of others, and *conform to social norms*, that is, the explicit and implicit 'rules', guidelines or behavioural expectations within a group or society that shape what is deemed normal or desirable [70–72]. People are generally influenced by the attitudes and behaviours of others, and tend to follow norms reflecting what is socially approved (i.e., injunctive norms, which motivate by providing social rewards/punishment) and/or common (i.e., descriptive norms, which motivate by providing suggestions about effective and adaptive behaviour). For example, merely communicating a descriptive norm, such as describing how *most* people behave in a given situation, can motivate conformity [73]. This normative social influence is powerful and pervasive, as reflected in the tendency to conform by 'following the herd' (herd behaviour) and 'jumping on the bandwagon' (the bandwagon effect) [74–76]. People also tend to make social comparisons and evaluate their own performance, possessions and wellbeing not in absolute terms, but *relative to others* [77,78].
8. be motivated by *rewards* and *incentives*, both intrinsic (e.g., achieving social equity/fairness, the 'warm glow' of acting altruistically)⁷ and extrinsic (e.g., money) [80,81]. In general,

(footnote continued)

that consumers are reluctant to switch brands or choose new electricity suppliers, even if doing so is beneficial or they are educated about product/service characteristics [45,46].

⁶ For example, householders may set themselves minimally acceptable, but not optimal, targets for saving energy (e.g., buying a single energy-efficient appliance; or registering for the bare minimum amount of 'green' electricity), and consumers may purchase products and services that satisfy basic needs, without necessarily being the most optimal choice (e.g., buying the first energy-saving device that seems suitable, rather than systematically evaluating the available options to select the most cost-effective and energy-efficient).

⁷ The 'warm-glow' effect [79] proposes that rather than acting solely on the basis of self-gain or self-interest, people are intrinsically motivated to behave in pro-social ways because it makes them feel 'better' about themselves (e.g., increased self-esteem from viewing oneself as selfless and socially responsible)

larger incentives or disincentives lead to greater behavioural responses [14]. However, the effects of financial incentives are often surprisingly short-lived and/or inconsistent, with behaviour reverting back to baseline levels upon removal of the reward [82,83]. People may even respond negatively to extrinsic rewards (e.g., showing loss of motivation, overjustification, moral licensing effects; see [84–87]), particularly if intrinsic motivation for the target behaviour is already high⁸. For example, if a person is intrinsically motivated to be altruistic, giving a piece-rate monetary reward to incentivise the desired behaviour may have a counteractive effect by ‘crowding out’ the intrinsic motivation [18,87–89]⁹.

9. reduce effort, withhold resources, or contribute less to the common good if they can gain the same benefits without paying for them, or believe others are enjoying benefits without contributing (*free-riding effect*) [92,93]. People also tend to exert less effort to achieve a goal when working in a group than when working independently (i.e., social loafing, see [94]), with motivation also declining the more dispensable one’s own efforts appear to group success [95].
10. use *trust* as a simple decision-making heuristic when assessing risk and making cost-benefit appraisals [96–101], with an entity’s trustworthiness resting on apparent expertise and experience (i.e., competence-based trust), as well as perceived openness, honesty, and concern for others (i.e., integrity-based trust) [102–104]. For example, the efficacy of public awareness campaigns and informational appeals can often depend on the perceived credibility of the communication source [105]. If the source of a message seems untrustworthy, unfair or incompetent, people can be wary or sceptical and either disengage, or react defensively to the information.
11. draw on readily available information that is easily accessible in memory and springs to mind quickly (*availability bias*), especially personal anecdotes of family/friends, customer testimonials, and recent, frequent, vivid, salient, emotive or concrete examples [38,106]. In particular, people tend to estimate the frequency of future events by drawing heavily on the information most readily available in memory, which inevitably produces biased estimates of the likelihood of different outcomes that are relevant to their decision-making [107].

3. Policy implications

These key insights from behavioural economics and psychology can guide the effective design and delivery of consumer-focused strategies and public policy interventions to improve residential energy conservation, particularly solutions that capitalise on message framing, choice architecture and incentivisation to shift

human behaviour. While an exhaustive summary of all possible implications is beyond the scope of this paper, we encourage practitioners and policymakers to consider the impact of – and the potential opportunities created by – these persistent cognitive biases and ‘irrationalities’ when determining how best to shift consumer behaviour in the desired direction. Some examples of these implications and opportunities follow, with an emphasis on identifying practical, cost-effective and mass-scalable solutions to encourage more renewable and sustainable energy use among consumers.

- *Status quo bias and defaults*: The effectiveness of behavioural interventions can be enhanced by directly targeting those energy-related practices that can easily and effortlessly be modified using default settings—for example, encourage householders to perform one-off actions such as setting a dishwasher or washing machine’s default program to ‘short-cycle’ and/or to ‘cold’ water (for an applied example, see [108]). Evidence from field studies and experimental trials also suggests that consumer acceptance of energy-related programmes and initiatives can be significantly improved by setting the participation default option to ‘opt-out’ (where all customers are automatically enrolled in the program/initiative and disinterested customers must actively withdraw from participating) rather than ‘opt-in’ (where interested customers must actively enrol if they wish to participate) [45–47,109]. For example, across several field studies and laboratory experiments, Pichert and Katsikopoulos [45] found that people use the kind of electricity that is offered to them as the default, that is, more participants chose a green (e.g., environmentally friendly) utility when it was the default than when ‘grey’ electricity (e.g., coal or atomic power) was the default. Ideally, strategies that target inertia and encourage people to shift from the status quo (e.g., offering ‘free trial’ periods or ‘try-before-you-buy’ programmes, or simply presenting options neutrally to elicit an active choice) should capitalise on salient ‘trigger points’ in peoples’ lives, that is, significant life events such as moving house, marriage or the birth of a child, when automatic, routine and habitual behaviour patterns are disrupted and people are more amenable to change [110,111].
- *Satisficing*: Since people rely on increasingly simple heuristics in the face of complexity and uncertainty (e.g., satisficing rather than optimising), various simplification strategies may help reduce cognitive overload and facilitate more effective decision-making in regard to energy consumption – such as making a desired action easier, quicker and more convenient (e.g., automating relevant technology), minimising the physical and psychological demands needed to perform the action (e.g., making it the default) and reducing perceived uncertainty (e.g., encouraging people to try a new activity in a risk-free environment) [14,112,113]. Unnecessary complexity and sensory overload should be avoided by framing messages in a clear, concise and comprehensible format. In terms of relaying information to consumers, keeping things short and simple is essential for effective communication. For example, avoid inundating people with too many energy-saving tips or too many choices, instead presenting smaller amounts of the most important information. Indeed, laboratory experiments and field studies have found that having more choices is not necessarily more desirable, appealing or intrinsically motivating, and people may even perform better in limited-choice contexts [42,114]. Simply providing large amounts of information, procedural instructions and other educational material may therefore fail to produce long-term behaviour change, particularly if such information is highly complex, delivered in isolation (i.e., without reference to social norms, goals,

(footnote continued)

and/or because they care about what others think of them (e.g., public recognition of altruism and philanthropy).

⁸ Over-justification effects occur when an external incentive decreases a person’s intrinsic motivation to perform a desired behaviour [84,87], such that the rate of that behaviour may fall below the baseline level following removal of the incentive. Moral licensing effects occur when a person who performs one type of desired or ‘good’ behaviour may subsequently be less likely to engage in other desired behaviours, or even more likely to engage in undesired or ‘bad’ behaviours [85,86,160].

⁹ Motivational crowding-out effects have been observed across laboratory and field settings [18]. For example, small financial payments have been found to reduce peoples’ willingness to donate [15,90], while in a test-taking setting, Gneezy and Rustichini [91] found that monetary compensation had monotonic effects on performance—larger incentives yielded higher performance when money was offered, but volunteers who were offered small monetary incentives actually performed worse than those who were not offered compensation.

feedback, rewards etc.) or if people already have the requisite knowledge needed to act accordingly¹⁰. Rather than delivering information-intensive campaigns and complicated consumer education programmes, behavioural strategies should instead focus on communicating simple messages that the average consumer can quickly and easily understand [22,42].

- *Loss aversion*: Frame energy-saving messages in terms of avoiding or minimising prospective costs and losses, as this may make the information more salient, memorable and motivating. Rather than only emphasising the payoffs of saving energy (a gain-framed message), focus on the costs (i.e., time, effort, money) associated with energy-wasting practices (a loss-framed message), and highlight how energy conservation activities and pro-environmental behaviour will prevent future losses and costs. Loss-framed messages often have a greater behavioural impact than gain-framed messages, particularly when a self-referencing frame (i.e., emphasising losses to oneself) is used and/or losses for the current generation are emphasised [115–118]. For example, Gonzales et al. [119] have suggested that when communicating messages to improve householders' energy efficiency (e.g., advocating retrofitting), framing recommendations in terms of loss (i.e., energy and money lost via inaction) rather than gain (i.e., energy or money gained via action) may be more effective. Thus, a statement such as, 'You are currently *losing* \$20 per billing quarter by not switching off your lights' is likely to be more motivating than stating, 'You could *save* \$20 per quarter by turning off your lights'. Likewise, stating, 'What you are currently doing is three times *less* efficient than doing *x*' is likely to be more motivating than, 'Doing *x* is three times *more* efficient than what you are currently doing'. However, various factors may moderate the motivational impact of a particular message frame (e.g., level of risk associated with target behaviour, who/what the reference point is, characteristics of target audience), and these should be taken into account to maximise the effectiveness of consumer-focused communication, particularly when tailoring messages to different customer segments (for a comprehensive summary, see [117]). For example, some evidence from persuasive social contexts suggests that while negative message frames may be more effective with self-referencing appeals, positive frames may be more effective given a self-other frame (i.e., emphasising the benefits to oneself and others) [116].
- *Risk aversion*: Focus on the low-risk of energy-saving practices and investments that are safe, stable and secure, particularly where energy-efficiency technology is new, expensive, or not yet mainstream. Uncertainty around electricity supply, market prices, government policies and long-term financial payoffs make investing in energy-saving products and services seem like a risky decision for many consumers [120,121], so marketing and communication to alleviate these perceived risks may increase energy-efficient action. Extensive research has examined the impact of different risk-reduction strategies ('risk relievers') on consumer behaviour, particularly in retail environments where perceived risk and uncertainty may prevent people from purchasing new products or services [122–128].

Particularly relevant to household energy efficiency and conservation are 'relievers' for financial risks (e.g., offering discounts, rebates, lowest-price and money-back guarantees, no-cost returns/refunds, payment security), time risks (e.g., making the purchase decision and product installation quick), and effort risks (e.g., simplified product design, 'user-friendly' operating instructions, helpful customer service). For example, offering consumers money-back guarantees on new energy-efficient technology (e.g., direct load control devices, smart meters) or obligation-free trials of new services (e.g., renewable or 'green' electricity) may increase consumer uptake by providing a 'safety net' – a sense of certainty and security – around any 'unknowns'. Other useful 'relievers' may include strategies to reduce perceived risks around product/service performance and functionality (e.g., offering free trials/samples, demonstrations, guarantees, extended warranties, free product installation and/or training), physical and safety risks (e.g., providing instructions, expert advice, safety certification, independent testing), the risk of product obsolescence (e.g., promising free or low-cost upgrades, product compatibility with earlier versions), social risks (e.g., securing positive word-of-mouth, customer testimonials, celebrity or expert endorsements, or promoting products or services as popular or socially desirable), and even psychological risks (e.g., building brand credibility, customer loyalty) [128].

- *Sunk costs*: Frame messages to reduce the salience of any large costs (e.g., time, effort, money) that consumers have already outlaid for old energy-inefficient items they are reluctant to discard, upgrade or replace, such as incandescent light bulbs or obsolete electrical appliances (e.g., defunct refrigerators, outdated air conditioning units). At the same time, draw attention to any ongoing costs, losses or risks associated with retaining inefficient items and wasteful energy practices—for example, increased consumption, greater carbon emissions, higher electricity bills, product wear-and-tear, and ongoing costs for repair and maintenance of outdated appliances. Research suggests that making the opportunity costs of persistence in the face of setbacks more salient (e.g., providing information about alternative opportunities for achieving returns on money that has been invested in unprofitable pursuits) may increase the likelihood of people writing-off sunk costs by highlighting the 'certain loss' of persisting with the status quo (thus exploiting the bias arising from peoples' aversion to sure losses) and making abandonment seem like a more positive option [129]. In parallel, it is important to reduce the salience of any perceived upfront costs/losses of switching to the desired course of action, e.g., taking steps towards energy conservation¹¹. Offering consumers incentives or rewards for investing in energy-saving measures – such as rebates for installing retrofits, cash-back bonuses for upgrading appliances, or discounts for subscribing to green electricity – may also be effective, by focusing attention on the potential benefits that can be gained from taking a different course of action (i.e., replacing old inefficient products/practices with new efficient ones) rather than the costs/losses that have already been incurred. Research has found that in certain conditions, sunk cost effects may be reduced when the decision-making

¹⁰ In many cases, standard information-intensive campaigns, factual messages and other educational programs do not directly target intrinsic or extrinsic motivation. For maximum effectiveness, such strategies are therefore best used when people are already motivated to act, and when there are few barriers to impede the target behaviour [14]. Since educational programs and mass media campaigns often rely heavily on procedural information, instructions and 'appeals' to shift behaviour, the effectiveness of these approaches may be increased by presenting information that is simple, salient, personally relevant (tailored), delivered by a credible and trusted source, and combined with other motivational strategies (e.g., goal-setting, feedback, incentives, and structural changes to the situation/environment/context that 'make it easy' to perform the new behaviour).

¹¹ To maximise its salience, a cost/loss should be presented in isolation; but to minimise its salience, the cost/loss should be combined or embedded in a larger one. Thus, if the costs/losses of a desired energy-saving action are large (e.g., if upgrading to a new efficient appliance is expensive, time-consuming and effortful), combining or aggregating small savings/benefits may be effective. For example, saying 'You can save \$150 per year by purchasing a new energy-efficient refrigerator' is likely to be more motivating than 'You can save 40¢ per day by purchasing a new energy-efficient refrigerator'.

- scenario includes explicit estimates of the future returns (e.g., projected sales/income) the given options might yield, possibly by way of reducing the amount of attention people direct toward sunk costs [130]. It has also been found that although asking people to carefully consider the ‘pros and cons’ of all available options after incurring sunk costs may not reduce the bias, setting minimal targets for performance (i.e., goal-setting) and inducing people to evaluate performance against such targets may be effective [131].
- *Temporal and spatial discounting*: Because the costs of investing in energy-efficiency measures (e.g., buying new low-emission technology) are often immediate and large, whereas the benefits are delayed and gradually accrue over time, one should draw attention to the longer-term payoffs of energy conservation when framing customer-focused messages. Research suggests that various factors may diminish temporal discounting, reduce impulsivity and/or encourage delayed gratification and self-control—including pre-commitment [132,133]; experiencing ‘power’ (a sense of asymmetric control over valued outcomes and resources) [134]; a technique called ‘episodic future thinking’, which involves imagining hypothetical future events [135]; and providing a more concrete construal of future events (describing specific details and features of future events, so they appear more vivid, certain and tangible) [136]. Recently, Hershfield et al. [137] found that connecting people to their ‘future selves’ (via interaction with photorealistic age-processed renderings of themselves) led to lower discounting of future rewards and higher contributions to saving accounts. Such insights should be considered when designing consumer-focused strategies to incentivise the long-term benefits of energy conservation. In parallel, consumers should also be more immediately rewarded for taking positive actions *now* that will yield greater benefits (e.g., save energy) in the long-term. For example, consider offering immediate intrinsic rewards (e.g., praise, commendation, recognition, acceptance etc.) or even extrinsic incentives (e.g., in-kind gifts) for those actions that ordinarily have little immediate payoff.
 - *Normative social influence*: Where possible, frame energy-saving practices as both common and socially desirable. For example, advising consumers that people similar to them (e.g., peers, neighbours) are using *less* energy or taking certain energy-saving actions, in addition to conveying social approval of such actions, will likely motivate them to conform to these positive ‘energy saving’ norms and reduce their consumption accordingly. Extensive research supports the efficacy of social normative information for motivating pro-social and altruistic behaviour, including energy conservation [14,138–147]. For instance, Nolan et al. [141] found that consumers who received descriptive normative messages (e.g., information comparing a household’s energy usage to that of neighbours) used significantly less energy in the short-term compared to householders who only received energy saving ‘tips’. Schultz [14] has recently argued that the behavioural impact of social norms is greatest when the target behaviour is relatively simple and easy to perform (i.e., few barriers impede action) and people perceive few benefits from engaging in the behaviour (i.e., individual motivation is low). Research also suggests that the behavioural impact of normative messages is greater when social norms are contextualised with personally relevant, meaningful or localised information (e.g., ‘provincial norms’ about how people are behaving in one’s immediate social group can be more powerful than distal or global norms; see [148]) and when congruent descriptive and injunctive normative messages are combined [146,149]. For people who are already performing *better* than the norm, it is particularly important to include an injunctive norm (e.g., a smiley-face emoticon, to serve as positive reinforcement) with the descriptive norm message to prevent a ‘boomerang effect’, where those who learn they have been *under-estimating* the prevalence of an undesired behaviour may then increase that undesired behaviour (for examples in the residential energy domain, see [138,146,147]). Because people tend to shift their behaviour toward the norm, it is particularly important to focus on positive norms (desirable behaviours) rather than negative norms (undesirable behaviours).
 - *Intrinsic and extrinsic rewards*: Since monetary rewards often yield inconsistent and temporary effects, and may even backfire by undermining (‘crowding out’) intrinsic motivation, non-pecuniary rewards such as praise, recognition and social approval should be capitalised on to incentivise energy conservation. While financial incentives are often used in efforts to promote pro-environmental behaviour [81,112], research suggests that such approaches may compare unfavourably to non-monetary interventions in terms of producing durable behaviour change over the longer term [14,22]. For example, people may be more motivated to act altruistically simply because it makes them feel good about themselves (e.g., yielding increased self-esteem and the ‘warm glow’ that arises from feeling selfless and socially responsible) and because they care about what others think of them (e.g., public recognition of altruism and philanthropy). Consistent with this notion, Ostrom [150] has argued that reciprocity, trust and reputation can overcome short-term self-interest, with evidence from public good experiments showing that many people are conditional co-operators, that is, they will contribute to the provision of public goods if they trust others to do the same [161]. Other research suggests that intrinsic rewards in the form of commendation, public recognition and praise may have stronger and more consistent behavioural effects than monetary rewards [89,151]. Focusing on these intrinsic rewards, or even providing an ‘in-kind’ gift coupled with suggestions to conserve energy, may therefore prove more impactful than relying solely on financial incentives to encourage sustainable behaviour.
 - *Free-riding and social loafing*: Creating a shared group identity where people can feel their individual contribution is important, and emphasising that many other consumers are also actively saving energy (i.e., capitalising on descriptive social norms), may help reduce free-riding and social loafing in group settings. Making any shared outcomes or collective achievements more salient (e.g., ‘Many of your neighbours are saving energy, and together this community has achieved a marked reduction in the average electricity bill’), and publicly acknowledging the efforts of individuals, may also help motivate people to contribute to the greater good. Experimental work also suggests that embedding social dilemmas and intragroup conflict in intergroup competition may reduce free-riding (see [152]) and inducing a sense of social inclusion may increase pro-social behaviour by fostering empathetic concern for others [153].
 - *Perceived trust*: Since trust serves as a decision-making tool for reducing cognitive complexity [96] and may influence how people respond to various risks [97,98], information and incentives are likely to be more motivating – and therefore have greater behavioural impact – if they stem from credible, trustworthy sources. In support of this notion, Craig and McCann [154] found that messages identified as originating from a high-credibility source (e.g., public service commission) were associated with significantly more customer requests for energy conservation information, as well as greater actual electricity savings, than the same messages originating from a low-credibility source (e.g., local electrical utility). Costanzo et al. [105], in their social-psychological view of energy

conservation behaviour, also suggest that credibility – which is a function of expertise and perceived trustworthiness – plays a key role in how consumers evaluate and respond to large-scale information campaigns, messages and appeals about energy conservation. This previous research underscores how important it is for behavioural interventions that promote energy conservation to be delivered by individuals and/or organisations seen to possess attributes conducive to trust such as competence, reliability, objectivity, openness, fairness, consistency, faith and good will [97,98,155]. When framing and delivering energy-saving messages to consumers, attention should be paid to establishing two broad types of trust in the message source: competence-based trust (i.e., perceived expertise and experience) and integrity-based trust (i.e., perceived honesty, fairness, openness, and concern for public interest).

- **Availability heuristics:** Since people place disproportionate weight on information that is more recent and readily available, consumer-focused messages should incorporate examples of energy-saving actions that are easily available in consumers' memories (e.g., recent, frequent, concrete, personally relevant) and especially salient (e.g., vivid, emotionally charged). Referring to energy-saving behaviours that are topical or well-publicised in the media, and drawing on favourable customer testimonials, may bring energy conservation to the forefront of consumers' consciousness and make it appear more socially normative (i.e., common). In situations where people simply forget to perform energy-efficient behaviours, basic visual or auditory reminders can prompt consumers to act. Studies have found that simple prompts and reminders can increase a range of pro-environmental behaviours, including energy conservation [112,156,157]. Schultz [14] suggests that prompts tend to work best for behaviours that are simple, easy, effortless and repetitive, and for people who are already motivated to engage in the desired action. Where possible, visual cues and vivid descriptions should be used because people are more heavily influenced by salient information. For example, Thaler and Sunstein [158] have reported that giving customers an 'Ambient Orb' – a light bulb that provides a simple yet salient signal of energy consumption by changing colour (glowing red when consumption is high, but green when consumption is low) – reduced peak energy consumption by 40 per cent.

4. Directions for future research

Decades of research in psychology and behavioural economics have yielded a range of valuable insights for understanding consumer decision-making and behaviour, however some theoretical and empirical gaps inevitably remain. These gaps in the literature offer potentially fruitful avenues for future scientific enquiry. For example, there is still great scope to advance our understanding of the critical determinants (predictors, moderators and mediators) of energy consumption, as well as the precise impact that public policy interventions have on consumers making optimal shifts in behaviour. In particular, questions remain over the utility, scalability and cost-effectiveness of the various behavioural interventions intended to influence energy consumers, as well as the contexts, contingencies and boundary conditions that either constrain or facilitate the impact of such interventions. Because human behaviour varies across time and situations, and within and between individuals, there are limits to the generalisability of research findings. Future research should therefore focus more on understanding not only *what* predicts consumers' behaviour – and importantly, what predicts *changes* in such behaviour across time and place – but also *when, where, how, why* and *for whom* these effects occur. Gaining greater insights into

such complexities can best be achieved by conducting more rigorous scientific research—namely, randomised controlled trials with larger samples of participants, more objective measures of actual behaviour, and longitudinal data collected over extended timeframes. To date, most empirical research on residential energy consumption has involved non-randomised and/or non-experimental studies, which are inadequate for testing *causal* relationships and determining the direct effects of predictor on outcome variables, including the precise causal impact of various interventions on changes in behaviour. In summary, researchers, practitioners and policymakers will profit greatly from conducting more rigorous experiments, designing interventions that actually seek to exploit these cognitive biases that diverge from neoclassical economic assumptions, and testing the impact and cost-effectiveness of these interventions for promoting residential energy conservation.

More broadly, there is also vast scope to enhance the conceptual frameworks and empirical measurement of key behavioural economic principles as they are applied to energy policy. There is a growing call among researchers for a consistent framework that synthesises these behavioural anomalies [23,159], alongside greater reliance on empirical research and impact evaluation (to test reliability and generalisability), more studies with large-scale interventions (to test scalability), and further research on the durability of effects (to test both short- and long-run behavioural changes). From a theoretical standpoint, researchers should aim to develop simple yet general models that explain a large portion of the psychological phenomena we have cited herein, including the additive and interactive effects of different cognitive biases. Some critics of behavioural economics have claimed it is merely a collection of ad hoc examples and convincing anecdotes about economic choices, with no overarching framework to unify and integrate the various theories, concepts and principles. There is clearly value in developing more systematic theoretical models that not only explain previous findings, but can also make accurate predictions about future outcomes—for different people, places and points in time.

5. Conclusions

In this paper we have highlighted the complexity of household energy consumption and conservation behaviour, and shown the utility of applying key principles from psychology and behavioural economics to explain, predict and change such behaviour. Consumers are far from the purely rational decision-makers assumed by traditional economic models, and there is often a wide gap between peoples' values and material interests, and their actual behaviour. Put simply, people often act in ways that both fail to align with their knowledge, values, attitudes and intentions, and fall short of maximising their material interests. A growing body of research indicates that consumer choices and behaviour are, to a large extent, driven by cognitive biases, heuristics and other 'predictably irrational' tendencies—for example, people use mental shortcuts to cut through complexity, dislike losses more than they like gains, prefer lower-value certainties over higher-value risks, evaluate things in relative rather than absolute terms, and are heavily influenced by the people around them. Yet these cognitive biases and motivational factors are often overlooked by practitioners and policymakers seeking to promote energy efficiency and conservation. To ensure cost-effectiveness and maximise return on investment, it is important to take these phenomena into account when developing strategies for encouraging renewable and sustainable energy use, and for motivating pro-environmental behaviour more broadly. By understanding these predictable deviations from economically rational behaviour, policymakers will be better placed to craft interventions that successfully bridge the gap between pro-environmental knowledge, values,

attitudes and intentions, and the everyday energy-related behaviour of consumers. This paper has highlighted the value of applying insights from psychology and behavioural economics to inform the effective design and delivery of consumer-focused communication, messages, and other behavioural interventions aimed at encouraging household energy conservation.

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