'Eco Is Just Marketing': Unraveling Everyday Barriers to the Adoption of Energy-Saving Features in Major Home Appliances

ALBIN ZEQIRI, Institute of Media Informatics, Ulm University, Germany
PASCAL JANSEN, Institute of Media Informatics, Ulm University, Germany
JAN OLE RIXEN, Institute of Media Informatics, Ulm University, Karlsruhe Institute of Technology, Germany
MICHAEL RIETZLER, Institute of Media Informatics, Ulm University, Germany
ENRICO RUKZIO, Institute of Media Informatics, Ulm University, Germany

Energy-saving features (ESFs) represent a simple way to reduce the resource consumption of home appliances (HAs), yet they remain under-utilized. While prior research focused on increasing the use of ESFs through behavior change interventions, there is currently no clarity on the barriers that restrict their utilization in the first place. To bridge this gap, we conducted a qualitative analysis of 349 Amazon product reviews and 98 Reddit discussions, yielding three qualitative themes that showcase how users perceive, interact with, and evaluate ESFs in HAs. Based on these themes, we derived frequent barriers to ESF adoption, which guided a subsequent expert focus group (N=5) to assess the suitability of behavior change interventions and potential alternative strategies for ESF adoption. Our findings deepen the understanding of everyday barriers surrounding ESFs and enable the targeted design and assessment of interventions for future HAs.

CCS Concepts: • **Human-centered computing → Interaction design theory, concepts and paradigms**.

Additional Key Words and Phrases: energy-saving mechanisms, home appliances, sustainability

ACM Reference Format:
Albin Zeqiri, Pascal Jansen, Jan Ole Rixen, Michael Rietzler, and Enrico Rukzio. 2024. 'Eco Is Just Marketing': Unraveling Everyday Barriers to the Adoption of Energy-Saving Features in Major Home Appliances. *Proc. ACM Interact. Mob. Wearable Ubiquitous Technol.* 8, 1, Article 27 (January 2024), 27 pages. https://doi.org/10.1145/3643558

1 INTRODUCTION

The growing global demand for residential energy, coupled with its environmental implications, has intensified the need for energy conservation efforts [46, 49, 76]. To reduce these demands, top-down measures such as policy changes (e.g., [38, 77]) and bottom-up individual behavioral improvements towards eco-friendliness (e.g., [42]) have been highlighted as possible levers. In this regard, major HAs account for a considerable portion of energy consumption, and many of these appliances come equipped with ESFs such as dedicated energy-saving modes, automated load sensing, and auto-shutoffs [50]. Utilizing these features provides a simple opportunity to lessen one's environmental footprint. However, despite the ubiquitous presence of ESFs in today's HAs, industrial user reports and previous user studies indicate that users oftentimes do not use these features, leading to a loss of easily realizable energy-savings [42, 91, 99]. The field of Sustainable Human-Computer Interaction (SHCI)

Authors' addresses: Albin Zeqiri, albin.zeqiri@uni-ulm.de, Institute of Media Informatics, Ulm University, Ulm, Germany; Pascal Jansen, pascal.jansen@uni-ulm.de, Institute of Media Informatics, Ulm University, Ulm, Germany; Jan Ole Rixen, jan.rixen@uni-ulm.de, Institute of Media Informatics, Ulm University, Karlsruhe Institute of Technology, Karlsruhe, Germany; Michael Rietzler, michael.rietzler@uni-ulm.de, Institute of Media Informatics, Ulm University, Ulm, Germany; Enrico Rukzio, enrico.rukzio@uni-ulm.de, Institute of Media Informatics, Ulm University, Ulm, Germany.

ACM 2474-9567/2024/1-ART27
https://doi.org/10.1145/3643558

has extensively explored strategies to promote behavioral changes related to residential energy conservation. Numerous design interventions have been introduced to address environmental behaviors in households, such as waste disposal [35] and resource conservation [26]. Common mechanisms include persuasive technology [34] and nudges [98], which promote sustainable actions through methods such as eco-feedback [97], behavioral prompts [14, 87], and incentives [47, 56]. Yet, the success of these interventions in ensuring sustained behavioral change has been variable [1, 18]. The efficacy of persuasive technology interventions has been criticized (e.g., [18]), as they often address behaviors in isolation, overlooking the complex web of interconnected contextual factors known to be interwoven in behavioral decision-making. Prior research on appliance-level ESFs has drawn on theoretical knowledge of user behavior and cognitive processing to guide intervention designs (e.g., [42, 99]). While theoretical models provide broader overviews of factors influencing pro-environmental behavior, their broader framing makes it difficult to capture practical nuances affecting users' daily interactions [44]. Consequently, the design of interventions that specifically address everyday barriers to ESF adoption and assessing when these interventions are a viable strategy remains unclear. With our work, we aim to address this gap and, in particular, answer the following research questions (RQs):

RQ1 How do users explain and reason about their use of appliance-level ESFs in major HAs?
RQ2 What barriers prevent the use of appliance-level ESFs in major HAs?
RQ3 To what extent do behavior change interventions such as persuasive technology and nudging represent feasible approaches to increase ESF adoption in everyday scenarios?

We employ a data-driven approach to answer these RQs, leveraging the diverse lived experiences expressed in 349 Amazon product reviews and 98 Reddit discussions surrounding the use of ESFs in major HAs. Earlier examinations of domestic energy use patterns primarily relied on ethnographic studies (e.g., [21, 22, 80]). These studies offer the advantage of observing interactions within their natural settings. However, potential biases like observer bias can emerge, a limitation highlighted in prior research (e.g., [22, 80]). Utilizing a dataset of Amazon product reviews and Reddit discussions provides a novel perspective by offering unfiltered insights into user perceptions and approaches behind their use of ESFs on a larger scale. We qualitatively analyze these user opinions using reflexive thematic analysis [12, 13] to develop qualitative themes that reflect how users perceive, interact with, and evaluate ESFs. Based on the qualitative themes, we clustered daily barriers that may prevent the use of ESFs. In doing so, we derived six barriers. Our results indicate that users often perceive ESFs as sub-optimal features, prioritized mainly for monetary savings. Additionally, skepticism towards energy-efficient technology, coupled with a limited grasp of inner device operations and conflicting user priorities, potentially hinders ESF adoption. To refine our findings and draw out practical implications, we then conducted an expert focus group (N=5) with HCI researchers, in which we critically assessed the feasibility of behavior change interventions to increase ESF adoption and discussed potential alternative strategies. In summary, we contribute:

(1) Insights into a comprehensive analysis of user perspectives on ESFs in major HAs reported in 394 Amazon product reviews and 98 Reddit discussions, shedding light on real-world challenges and perceptions.
(2) Identification and detailed exploration of six specific barriers that currently prevent ESF adoption, providing a deeper understanding of the underlying reasons for user resistance and skepticism.
(3) Insights from an expert focus group (N=5) in which we critically assessed the feasibility of behavior change interventions to increase ESF adoption and give an outlook on alternative strategies.

2 BACKGROUND & RELATED WORK

Our work is grounded in previous environmental psychology and SHCI research surrounding domestic energy conservation interventions and perspectives on behaviors and approaches towards energy-conserving technology, such as ESFs in HAs.

2.1 Residential Energy Conservation

First, we give an overview of ESFs associated with major HAs, followed by a review of past approaches targeting domestic energy use. We explore the rationales behind intervention designs and emphasize the importance of tailoring the design of interventions to specific daily barriers.

2.1.1 ESFs in Major Home Appliances. Major HAs are large devices, either electric or gas-powered, designed to facilitate essential household activities [2]. These include refrigerators, washing machines, dryers, ovens, dishwashers, and HVAC systems. With growing concerns about energy consumption and environmental impact, manufacturers have incorporated various ESFs into these devices. In the EU, the inclusion of ESFs in appliances is mandatory, adhering to specific guidelines and standards, such as for washing machines [31]. These features vary from user-controlled ESFs, like energy-saving modes, to autonomous ESFs not explicitly labeled for energy conservation. Energy-saving modes, for example, allow appliances to operate at reduced power or pause non-essential functions [99]. Modern refrigerators might limit defrost cycles or adjust cooling during low usage periods [30]. Modes like "Auto" or "Sleep", though not labeled as energy-saving, optimize energy use by adjusting device activation or turning off features like constant display lighting. Autonomous ESFs, on the other hand, include sensor-driven functions, such as load detection in washing machines [31]. Additionally, smart home technology allows appliances to adapt operations based on user behavior and customized routines [48]. This technology bridges the gap between user-controlled and autonomous ESFs. Consequently, ESFs can be categorized based on user control, with dedicated energy-saving modes offering high user control and automated ESFs offering low control. Figure 1 depicts common ESFs on this spectrum. Despite the availability of low-effort ESFs in major HAs, their usage remains limited [91], indicating a lost opportunity for energy conservation. In prior research, various methods have been suggested to influence domestic energy consumption. We will discuss these interventions and their design rationales in the subsequent sections.

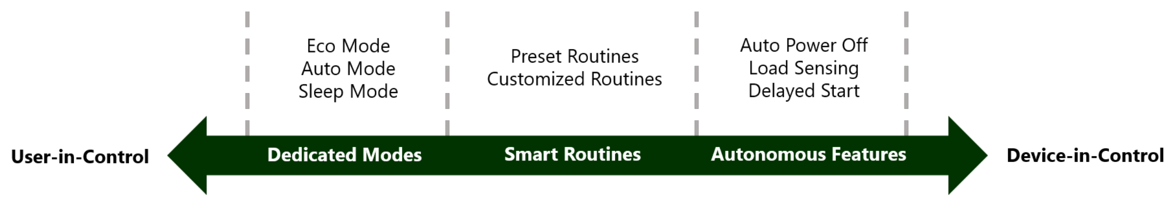

Fig. 1. Common home appliance ESFs categorized according to the level of user control they provide. ESFs that provide the most user control are dedicated modes integrated into the device. Contrary, autonomous functions are commonly entirely controlled by the appliance. Smart functions provide the ability to select predefined smart routines or create customized routines.

2.1.2 SHCI Approaches to Residential Energy Conservation. Over the years, SHCI has proposed various behavior change approaches tailored to domestic contexts. The primary objectives of these approaches have been to encourage resource conservation behaviors, encompassing resources such as electricity or water and promoting waste separation [16, 26]. A considerable portion of the proposed approaches falls under the broad category of persuasive technology [16, 18, 26, 90]. Within this domain, there has been a pronounced emphasis on eco-feedback (e.g., [36, 97]) and eco-visualizations [19, 74, 86]. Eco-feedback systems provide users with real-time information about their resource consumption, enabling them to make informed decisions and adopt more sustainable behaviors [35]. Likewise, eco-visualizations represent this data in visually engaging formats by leveraging metaphors and narratives to enhance comprehension [86]. Beyond feedback, other mechanisms, such as goal-setting, suggestions, setting incentives, and green defaults, have been thoroughly investigated for steering residential resource consumption [1]. Moreover, proposed approaches vary in the range of behaviors they address, depending on whether the aim of the intervention was a general reduction of consumption across residential contexts (e.g., [35, 78, 79]) or consumption reduction for specific energy-intensive behaviors [10, 24, 52, 53, 64].

Recently, Grönewald et al. [42] have examined how persuasive and situated approaches can be leveraged to increase the use of ESFs, specifically eco-programs, in washing machines. Their study reported an increased likelihood of ESF adoption with persuasive and situated interventions compared to a standard baseline interface. Similarly, Visser and Schoormans [99] evaluated the effectiveness of coercion and feedback mechanisms in increasing the likelihood of resource-friendly program choices in washing machines. They also reported an increase in energy savings when users were presented with feedback or coercion mechanisms [99]. Mechanisms leveraged for the design of behavior change interventions are oftentimes grounded in behavioral theory [44], which permits their adaptation to various factors that are understood to impact behavioral decision-making. While a design rationale grounded in well-established theoretical models allows for incorporating existing knowledge into the design process, specific practical barriers and the contexts in which the technology will be used may not be specifically indicated in such models [44]. Further, past work underscores that energy conservation interventions are unlikely to succeed if they're not aligned with users' actual daily circumstances [38]. For conservation mechanisms to be effective in everyday contexts, a user-centered understanding of perceptions and prevalent barriers is essential.

2.2 Understanding Behavior and Tailoring Design

This section reviews various methods used in previous research to comprehend users' domestic energy-saving actions. We stress the importance of a detailed, use-case-specific grasp of user views on ESFs and underscore the advantages of using online user-generated content to analyze user leanings and perceptions.

2.2.1 Theory-supported Understanding of Behavior and Context. Previous research has aimed to understand the factors influencing energy conservation behaviors [26]. This has led to the incorporation of behavioral theories and models in studies on pro-environmental behavior (e.g., [85, 89]). These constructs can guide the design of interventions for sustainability and health-related behaviors [44]. Fogg's persuasive technology theory [34] and behavior model [33] have been central to numerous persuasive approaches in the past [26]. Other studies have drawn from cognitive psychology, including theories like the Theory of Planned Behavior (TPB)[3], which highlights factors like attitudes, subjective norms, and perceived behavioral control. The Transtheoretical Model of Behavior Change [81] and the Behavior Change Wheel [70] have also been used to guide intervention design. Dual-Process Models [69, 93] have informed behavior change interventions for tasks like laundry [42]. However, while these models provide foundational insights, their broad scope can limit the understanding of specific contextual barriers [44].

2.2.2 Understanding Behavior and Context through Ethnography. Beyond theory-driven interpretations of behavior, prior research further comprises works that derive their understanding from ethnographic studies of user behavior [16, 26]. Ethnographic studies allow researchers to immerse themselves in the communities or groups they study to gain a deep understanding of the people, their routines, behaviors, and underlying motivations [17] and have been used in various contexts, for instance, to examine roles involved in agriculture [63, 66], e-waste management [83], and community-building [7]. Similarly, ethnographic accounts of user experiences related to domestic energy consumption behavior can be found in prior SHCI work (e.g., [5, 22, 80, 101]). Pierce et al. [80] identified unawareness of appliance-integrated ESFs, unsustainable habits, and a consistent preference for convenience over potential financial savings as everyday barriers. Since earlier work that explored domestic energy consumption, the landscape of HA energy efficiency has advanced, and recent studies suggest a more pronounced emphasis on energy conservation in contemporary society [72]. However, the under-utilization of

ESFs still persists, signaling an ongoing ambiguity regarding the specific barriers deterring users from adopting ESFs.

Moreover, while ethnographic approaches allow for contextualized perspectives into users' daily practices, they encompass their own set of limitations. Researchers have expressed potential drawbacks of ethnographic studies such as study length, limited sample sizes, and the resulting reduction of generalizability [41, 75]. Additionally, as these methods are built around the involvement of close interactions with participants, they may heighten the potential for observer biases as indicated previously [22, 65, 88]. While rich in contextual depth, ethnographic approaches focus on specific communities or groups. Alternatively, analyzing user-generated content enables the examination of larger sample sizes and may include a broader range of user perspectives.

2.2.3 Understanding Behavior through Analyses of User-Created Artifacts. Content analysis is a research method used to systematically analyze textual, visual, or auditory content (e.g., [25, 57, 61, 85]). Traditional content analysis involves quantifying the presence of certain words, themes, or concepts within a given dataset, turning subjective content into structured data [28]. Previous work surrounding the topic of sustainability has leveraged different sources for qualitative analysis of content. For instance, Sadeghian et al. [85] leveraged Reddit comments to analyze opinions and leanings towards sustainable mobility, while Kim and Li [57] explored Amazon product reviews to derive design attributes relevant to the design of effective air quality monitoring. While user-generated content has been employed to understand various aspects of sustainability, it has, to the best of our knowledge, not been employed to explore ESF adoption, despite the richness and authenticity of insights that such data can offer. By leveraging Amazon product reviews and Reddit discussions, we not only complement prior ethnographic household studies but also offer a fresh, expansive perspective on the challenges and motivations users face when interacting with ESFs. By understanding the nuanced barriers and motivations associated with ESF adoption, designers can more effectively tailor their interventions, ensuring they resonate with users' actual needs and experiences.

3 UNDERSTANDING HOW USERS PERCEIVE AND INTERACT WITH ESFS

Our study employs a qualitative method to examine user-generated content sourced from Amazon and Reddit, utilizing reflexive thematic analysis similar to Braun and Clarke [12, 13]. We divided our dataset generation into three stages: *Identification*, *Acquisition*, and *Screening*. Accordingly, the following sections first describe our reasoning behind using Amazon product reviews and Reddit discussions (*Identification*) to build up our dataset and detail the steps taken to collect (*Acquisition*) and select (*Screening*) items for inclusion. Lastly, we detail the qualitative analysis procedure.

3.1 Identification

We analyzed Amazon reviews and Reddit discussions on ESFs in HAs to understand user experiences. Both platforms have been used for qualitative research in various fields due to their extensive, diverse user base (e.g., [57, 82, 85]). Amazon product reviews offer direct consumer feedback after product interaction, while Reddit provides a broader context of user experiences, topics they struggle with, and their needs, complementing the more hardware-specific feedback common on Amazon. Figure 2 illustrates the search and screening process for both platforms, elaborated further in the following sections.

3.2 Acquisition

3.2.1 Amazon Product Reviews. Previous studies that aimed at increasing ESF adoption primarily targeted specific appliances, like washing machines [42, 99]. Since perceptions of ESFs may vary between device types, understanding users' views across various major HAs is crucial. As shown in Figure 2 the search methods for Amazon and Reddit had minor differences, attributed to their unique information structures and search

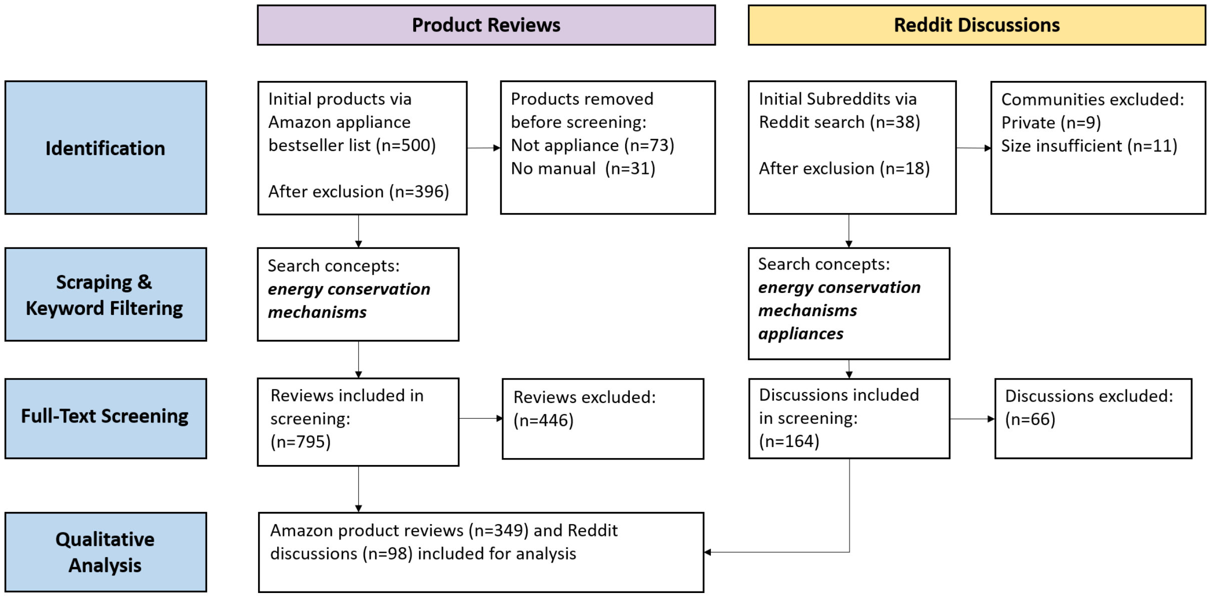

Fig. 2. Flowcharts detailing our methods for curating a dataset of product reviews and online discussions, which were later subjected to qualitative analysis. The left flowchart outlines the process for gathering product reviews, while the right one depicts the procedure for collecting online discussions.

functionalities. Our searches on both platforms were conducted in June and July 2023. For Amazon, we exclusively sampled *Amazon.com*, as the US represents the largest market for Amazon[1].

To obtain relevant product reviews, we started by sampling a list of products from Amazon's major HA departments, specifically: *refrigerators & freezers*, *laundry appliances*, *dishwashers*, *ranges & ovens*, and *HVAC* appliances. We selected all products from the bestseller list within these categories, focusing on the most popular items during our search. This approach yielded 500 products. We excluded 73 as they were only accessories like detergents or replacement parts. To obtain an overview of the integrated ESFs, we sourced product manuals for each item. For 31 products, no manual was publicly available, leading to their exclusion. The final list comprised 396 products, distributed as follows: *washing machines & dryers* 16.16%, *ovens* 14.65%, *dishwashers* 21.72%, *refrigerators & freezers* 25.25%, and *HVAC* 21.21%.

In line with previous work that leveraged Amazon product reviews (e.g., [57]), we closely followed Amazon's terms and conditions for the review scraping process, scraping only the titles, ratings, and review bodies for each product review over short sessions with cool-down times of five seconds between requests to limit demand on Amazon's infrastructure. As product reviews on Amazon do not necessarily stem from users who purchased a product, we constrained our scraping process to verified purchases. Moreover, product reviews often cover various topics, including product design, ease of use, and customer service. Therefore, we introduced a keyword filtering scheme and applied it during scraping to exclude items completely unrelated to the topic of ESFs. To derive our keywords, we developed search concepts describing the topics of interest (ENERGY CONSERVATION and MECHANISM). For ENERGY CONSERVATION, keywords like `["eco", "efficient", "smart"]`, indicative of resource-saving features, were used. For MECHANISM, we focused on terms like `["function", "mode", "feature"]`, addressing device mechanisms. These terms were derived from preliminary manual examinations of

[1]https://www.statista.com/statistics/672782/net-sales-of-amazon-leading-markets/ Last-Accessed: 10-November-2023

product reviews. Keywords within each concept were combined using the logical `OR`-operator, and the concepts were joined with the `AND`-operator. We used Python 3.11.3 for the scraping and filtering process, storing the reviews as JSON objects with titles, ratings, and review bodies.

3.2.2 Reddit Discussions. Reddit is a social media platform with millions of monthly active users[2] and encompasses over 3.3 million communities[3], known as Subreddits. We chose Reddit over other social media platforms for two reasons. Firstly, it offers an official Python API, PRAW[4], facilitating efficient data access. Secondly, in contrast to the focus on personal updates and self-portrayal common on platforms like Instagram or Facebook, Reddit is driven by community discussions between anonymous users with specific interests, which aligns with our research aims.

Sampling Reddit differed mainly in the use of its platform features and search tools. Leveraging PRAW, Reddit's search function permitted direct keyword queries. We expanded the earlier Amazon query by adding an APPLIANCE concept to pinpoint discussions surrounding major HAs. As indicated in Table 1, this search concept encompassed the same range of appliance categories that we used in our initial Amazon search. Preliminary searches revealed users referenced HAs with different spellings, prompting us to include variations like `"dish washer"`, `"washer"`, and `"drying machine"` for comprehensive data collection.

Concept	**Keywords**
ENERGY CONSERVATION	"eco" OR "saving" OR "efficient" OR "efficiency" OR "intelligent" OR "smart" OR "auto"
MECHANISM	"function" OR "mode" OR "setting" OR "management" OR "option" OR "feature" OR "configuration"
APPLIANCE	"dishwasher" OR "dish washer" OR "washer" OR "drying machine" OR "washing machine" OR "dryer" OR "oven" OR "refrigerator" OR "fridge" OR "freezer" OR "air conditioner" OR "air conditioning" OR "heater" OR "stove"

Table 1. Search queries spanning three search concepts to filter results based on our research aims.

Following methodologies from previous studies on Reddit discussions (e.g., [82, 85]), we compiled a list of relevant Reddit communities for our search. Direct keyword searches might yield results from unrelated communities that only briefly mention the topic of interest. Therefore, we focused on Subreddits linked to sustainability, home, and domestic appliance topics. Preliminary searches were conducted using our designated query, selecting communities with over 30,000 members to ensure sufficient discourse (i.e. engagement with posts in the form of comments). As Figure 2 illustrates, after excluding private communities, we settled on 18 Subreddits for our study. Within each selected Subreddit, we then searched for posts using our established query, leading to 164 relevant discussions. We only considered the original post title and body for filtering. Each qualifying post, along with its top-level comments, was included to ensure that posts and comments could be evaluated in the context they were written. In line with previous work, we excluded sub-comments since they may deviate from

[2]https://www.statista.com/statistics/1309791/reddit-mau-worldwide/ Last-Accessed: 27-October-2023
[3]https://frontpagemetrics.com/month/ Last-Accessed: 27-October-2023
[4]https://praw.readthedocs.io/en/stable/index.html Last-Accessed: 27-October-2023

the main topic [85]. The collected Reddit data was stored as JSON objects, capturing the title, post body, and all top-level comments linked to that post.

3.3 Screening

While keyword filtering was applied to both Amazon and Reddit searches, the dataset still included entries not directly related to ESFs in HAs. For example, Reddit data sometimes discussed general eco-friendly habits or briefly mentioned ESFs in larger contexts like home renovations. Amazon product reviews also occasionally listed ESFs among general functions without much detail. To ensure data relevance, we initiated an additional screening phase, applying exclusion criteria for entries where ESFs weren't central or when the main topic was entirely unrelated to HA efficiency. Specifically, we omitted entries that: ***(E1)*** were completely unrelated to ESFs in major HAs, or ***(E2)*** only briefly mentioned appliance ESFs without further detail. The screening was conducted by the first and second author. Initially, both collaborated on 20 dataset items to align on the exclusion criteria. Subsequently, we separately assessed a random 20% (192 items) of the dataset and met to evaluate our agreement on exclusions. We assessed inter-rater agreement using Cohen's Kappa [23], which indicated a near-perfect agreement (κ = .81, $p0$=90.90%) according to Landis and Koch [62]. The first author then screened the remaining 747 items, excluding a total of 512. The primary exclusion reason was a weak relation to the main theme of ESFs in HAs ***(E1)***.

3.4 Datset Overview

Our resulting dataset was distilled to 98 Reddit discussions and 349 Amazon product reviews. Figure 3 shows how major HA types were represented in our dataset. Further, it illustrates the distribution of origin Subreddits for included Reddit discussions. Included Amazon product reviews had an average body length of M=353.14

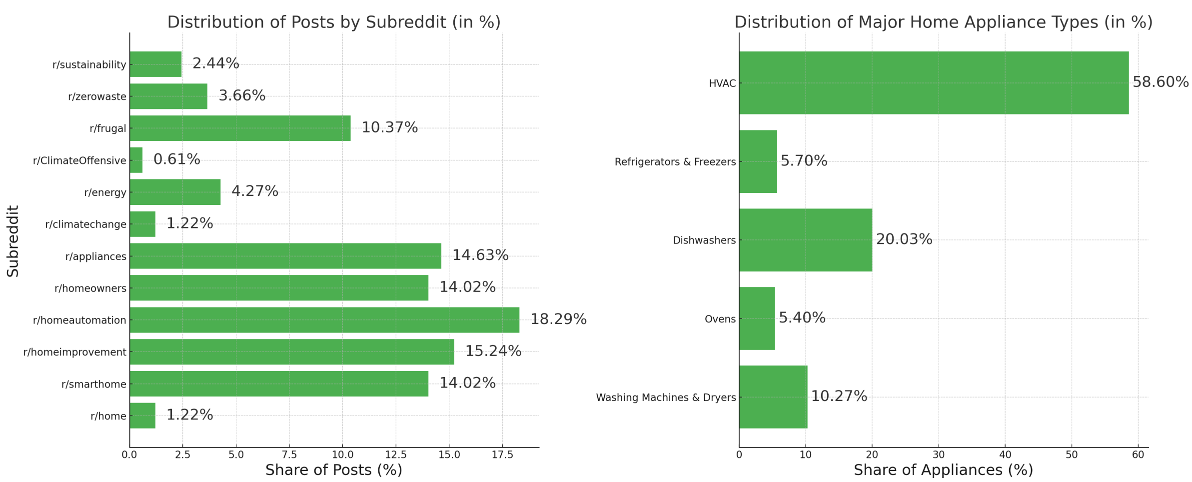

Fig. 3. Bar plots illustrating the representation of major HA types in our dataset on the right. The distribution of included posts on the different Subreddits is shown on the left. The plots indicate that Reddit discussions about HA ESFs were mainly found in Subreddits related to homes and appliances. Across the entire dataset, HVAC appliances were mentioned the most in relation to ESFs.

words (SD=344.67). The included Reddit discussions comprised M=43.53 items (the post itself and all connected top-level comments) (SD=97.33). Posts had a mean length of M=357.24 words (SD=535.83), while comments had a mean length of M=53.55 words (SD=70.74). Our initial data sampling encompassed 18 subreddits, but through the screening process, we excluded data from 6 subreddits. The discussions analyzed thereafter originated from the remaining 12 subreddits, as depicted in Figure 3. In addition to the descriptive analysis, we performed sentiment analysis. While the anonymity of users on Amazon and Reddit increases the authenticity of user-created artifacts, it could also lead to exaggerations, as indicated in previous studies [82]. Therefore, we leveraged sentiment analysis using the Natural Language Toolkit (nltk) [8, 9] and Textblob [67] Python packages to get a general overview of leanings in our dataset. Sentiments are represented as a tuple of two values where the first value represents the polarity (-1=negative, 1=positive) and the second represents the subjectivity (-1=very objective, 1=very subjective). As Table 2 suggests, product reviews and online discussions achieved neutral to positive mean polarity and subjectivity scores, indicating that items from both data sources largely represented neutral views and the content was more subjective than objective.

Data Source	**Item Type**	**Length (M, SD)**	**Sentiment (M, SD)**
Amazon	Product Review	M=353.14 (SD=344.67)	Polarity: M=0.15 (SD=0.13) Subjectivity: M=0.51 (SD=0.08)
Reddit	Discussion Post Comment	M = 43.53 (SD = 97.33) M = 357.24 (SD = 535.83) M = 53.55 (SD = 70.74)	Polarity: M=0.11 (SD=0.21) Subjectivity: M=0.43 (SD=0.25)

Table 2. Overview of data sources, item types, and their characteristics.

3.5 Qualitative Analysis

To achieve a nuanced understanding of user approaches towards ESFs, their concerns, and the barriers arising within everyday scenarios, we used reflexive thematic analysis [12, 13]. Previous research has employed thematic analysis to develop qualitative themes from various data sources such as interviews [73], academic literature [20, 58], and user-generated artifacts such as Amazon product reviews [57]. For analysis of user-generated content, alternative qualitative methods such as content [59] or discourse analysis [39] exist. While content analysis primarily quantifies and categorizes communication content and discourse analysis focuses on the linguistic nuances of texts [37], the flexibility of thematic analysis allows for more nuanced insights into reoccurring patterns and perceptions. This approach was more aligned with our RQs.

3.5.1 Inductive Coding. We iteratively annotated data items with inductive codes for the initial coding phase. Before coding the data, however, we first took one session to familiarize ourselves with the two different item types included in the dataset, in line with the six stages for thematic analysis by Braun and Clarke [13]. Reddit discussions commonly describe user characteristics, approaches, and opinions, while Amazon product reviews frequently contain information specifically related to interaction, interface, and hardware design. Both coders then coded a random subset of 20% without discussion to generate an initial inductive codebook. During the initial coding process, both coders further noted how and why they defined codes to retain an adequate understanding throughout the process. After the subsets were coded, both coders met and discussed their initial codes using the notes written during the coding process to resolve any misalignments in understanding. This codebook was then used in the following coding sessions. After each coding session, any new emerging codes or re-definitions of existing ones were discussed between the coders. We conducted multiple sessions until the inductive codes for all data items were created.

3.5.2 Deductive & Axial Coding. Similar to recent qualitative studies (e.g., [45, 71, 100]), after the inductive coding phase, we transitioned to deductive coding and then axial coding, to categorize established codes guided by theoretical knowledge of factors that are involved in behavioral decision-making. Specifically, deductive coding was conducted in reference to theoretical models of pro-environmental behavior [60] and previous studies on domestic energy consumption behaviors [21, 22, 80]. In doing so, we aimed at incorporating existing knowledge into our coding process, such that novel concepts thus far not covered in the literature could be detected. The resulting categories provided an overview of factors and topics surrounding the use of ESFs in HAs. To understand the relations between the different factors and their impact on the central behavior of ESF use, we used axial coding [40]. Unlike the inductive coding phase, we jointly analyzed both product reviews and online discussions in the axial coding sessions, aiming to interrelate the combined concepts of both datasets. The results after this step were two-fold. For one, all initial codes were categorized, and secondly, the categories were related to one another using axial coding, which resulted in a visual representation showcasing the main factors and their interplay. The supplementary material contains the complete list of initial codes and their categorizations, as outlined.

3.5.3 Theme Generation. Lastly, we concluded our qualitative analysis by developing overarching themes supported by the previous coding step. To do so, we formed themes that describe the key aspects of the categories they encompass. We iteratively refined our themes by checking them against our initial dataset to ensure an accurate representation of experiences and perspectives expressed in our data, following Braun and Clark's recommendations for good quality [11, 12].

4 FINDINGS

We analyzed Amazon product reviews and Reddit discussions, distilling insights into three main themes that detail users' perceptions and interactions with ESFs in HAs. Figure 4 shows an overview of topics that were discussed for every theme. We conclude by presenting barriers from our data that potentially impeded ESF usage, categorized in Table 3. For clarity, excerpts from reviews are labeled *A-ReviewNumber*, while Reddit discussions use *R-PostNumber-CommentNumber*. While we excluded numerous items from our dataset during the screening, we did not relabel the remaining ones, which is why item identifiers in the following exceed the total number of remaining items reported in Section 3.4. Lastly, in the following, the term "user" encompasses both Amazon reviewers and Reddit contributors.

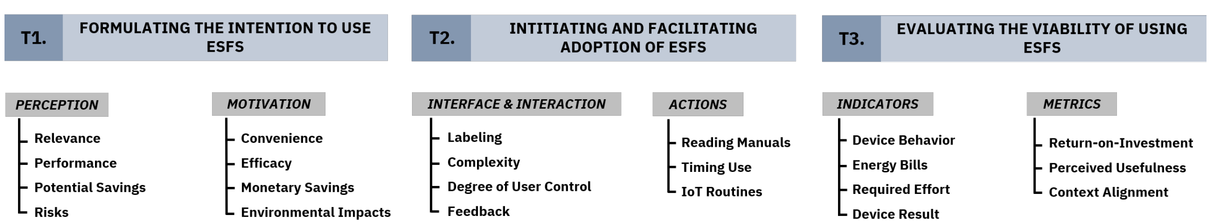

Fig. 4. This Figure shows an overview of the themes developed during the qualitative analysis. For each theme, the main topics are listed to provide a better picture of the overall discourse in our dataset. Themes are denoted with **T**.

4.1 Theme 1: Formulating the Intention to Use ESFs

Our initial theme focuses on how users perceive and determine the importance of ESFs and suggests that users consider multiple factors to estimate whether using their device's ESFs is relevant to them. First and foremost, users' personal priorities dictated their views on energy efficiency and ESFs. Users oftentimes described being aware of specifically eco modes integrated into their devices, but their personal goals in using the device frequently did not align with the expectations they had about the use of ESFs. The primary objective of most users was to increase their personal comfort and convenience, as expressed in statements such as *"There's no point in saving money just to be uncomfortable"*[R-116-32]. For many users, this was closely tied to whether they expected the device to produce the desired results when using ESFs.

This became apparent throughout a majority of the analyzed excerpts, where device results were in part explicitly stated to be of more relevance than resource conservation *"After all, the purpose of a washing machine is to get clothes clean not to save water! (I could save even more water by wearing dirty clothes!)."* [A-64]. Despite the frequently more outcome and comfort-focused priorities, we also found that the topic of energy conservation was present in most excerpts. However, it was consistently tied to the aim of reducing energy bills by decreasing operational costs. *"Energy efficiency was an important factor for me, and this unit delivers. It doesn't consume excessive electricity, which is great for my utility bills."* [A-101].*"If you're trying to conserve energy/money [..], you can just put the unit [AC] in eco mode, and it will only run the fan for 2min, once every 10min cycle when it's not actively cooling."* [R-578-1]. With respect to the achievable performance with ESFs, users held more reserved or even skeptical beliefs, perceiving them as lower-performance alternatives: *"One big con about this A/C is that every time it turns on it stays in eco mode until you turn it off from the A/C itself [..]. Let's say you have it on a timer to come on at 6 PM for 68 degrees, well no matter what, on eco mode, it'll never get to 68 degrees, maybe 72 at best."* [A-357]. Moreover, we found that it was difficult for users to grasp why dedicated functions or modes for energy conservation exist.

Users held the belief that broader advances in renewable energy will render ESFs irrelevant and that industrial resource consumption is much higher than individual energy demands: *"The amount of electricity or water used by a residential homeowner is literally a drop in the bucket compared to commercial use. Not saying not to be green, but the electricity and water used by a factory to make a new appliance is never going to be made up by using a more efficient appliance with energy saving instead of a still-working older one."* [R-347-261] and *"The old assumption that energy saving can mainly be done with a timer that turns on at 12:30 and turns off at 7:30 will hold true less and less as the energy mix changes."* [R-730-11]. Depending on users' general attitudes towards energy-efficient technology, these assumptions varied between slight uncertainty (*"What about the new washers using less electricity and less water? Do you think those advancements are worth it for the environment?"* [R-347-8]) and generally negative perceptions *"Energy-efficient washing machines are tested to ensure satisfactory washing performance. They are also designed to fail in a few years, planned obsolescence, and end up in a landfill. So all of the eco-friendly features are offset by having to replace the appliance every few years. Eco is just marketing, using less water and damaging fabrics."* [R-56-6].

Summary: While most users seemed aware of how they could reduce their energy consumption, their primary concern was personal comfort and the expected performance of the device. Though energy conservation was also considered important, this was mainly linked to financial savings rather than environmental considerations. Further, users perceived energy-saving modes as low-performance alternatives and questioned their necessity, given broader advances in energy-efficient technology and renewable energy sources. The overarching sentiment suggests that while options to conserve energy are acknowledged and seen as a lever to reduce utility costs, they still take a backseat to comfort, convenience, and device performance expectations.

4.2 Theme 2: Initiating and Facilitating Adoption of ESFs

The second theme encompasses the actions and strategies users adopt to facilitate the use of ESFs in their daily routines, as well as their preferences and views on factors such as preferred degree of user control and perceived effort. Our analysis suggests a range of behavioral adaptations users may undertake to facilitate ESF usage.

The adaptations suggested by the reports in our data range from engaging with appliance manuals for clarity, strategically timing device usage to ensure ESFs don't disrupt daily routines, and even crafting tailored Internet of Things (IoT) routines that synchronize device behaviors with personal schedules.

The first step in interacting with ESFs is discerning which user interface (UI) elements are linked to energy conservation functions. In our dataset, this was closely related to the overall interface complexity of users' HAs. For lower-end appliances, figuring out which functions are associated with energy conservation seemed more straightforward, thanks to minimalist interfaces with limited UI elements: *"One of the features is Eco mode, which is simple enough to engage using the one Eco button with the leaf symbol on the remote.* [R-2-1]. The clarity of ESF labeling emerged as another factor influencing the initiation of ESF use. While universally recognized terms like "eco mode" or "energy-saving mode" were easily understood as energy-conserving modes, the introduced complexity caused by an abundance of options on the interfaces still caused confusion for some appliances: *"I have an [washing machine brand], and I really can't figure out (after doing research) what the difference is between the following dry programs: Normal dry, Normal eco, and Eco Hybrid."* [R-686-0]. Features that were not explicitly labeled as ESFs, such as "auto mode", "sleep mode", or "standby" but do aid in conserving energy, were more frequently associated with convenience rather than energy conservation and thus perceived more positively.

Moreover, we found that users frequently expressed a desire for less complex interfaces with simpler navigation schemes, as they reported using only a subset of available functions. *"Our new [brand] washer is good so far but wayyyy too many options. Same with our other dryer from [brand], it is annoying!* [R-347-125]. For devices with IoT capabilities, several features were transferred to mobile applications, simplifying the appliance-level interfaces. Regarding IoT and automation, users portrayed varying perspectives on their preferences related to the degree of user control they preferred for ESFs: *"Nice basic machine with no frills. I would prefer one that was even simpler where I could just set my own water level instead of the "auto", which is just one more thing to go wrong"* [A-64], *"On automatic mode it will maintain the temperature utilizing heating mode and cooling mode as necessary. Set it and forget it... excellent."* [A-243].

Beyond the initial activation of ESFs, users also highlighted the proactive steps they undertake to ensure the sustained use of these features. A recurring theme was the consultation of appliance manuals, especially when faced with gaps in appliance-related knowledge: *"People complain the washing modes don't make a difference. Read the manual - the heavy-duty runs longer and at a slightly higher temperature. The eco-friendly runs shorter and at a slightly lower temp (it's more like a delicate wash). So each has their purpose and advantage, and they are different, but actually read the manual. Don't just assume how it works."* [A-877]. Additionally, certain ESFs, like energy-saving programs, often translate to longer operational durations or altered device behavior. To navigate these changes, some users reported having embraced strategies like timing their device use around times when they know they won't need device results immediately: *"At night I put it on ECO mode, and it comes on and off and keeps the room cool. Perfect for sleeping or watching TV. Pretty neat and it saves money too."*[A-916] While our reports suggest that users, for one, adjusted their routines to accommodate ESFs, others indicated taking a more proactive approach, customizing their device interactions to align with their schedules, primarily by creating personalized IoT routines that incorporate ESFs: *"Just think of it. If you like to come back to your home and not wait for your place to cool. Yet you don't wanna run it all day and waste electricity. Problem solved. Before you hit the road for your home. Just open the mobile app. Tell it to cool the place to the desired temp. Just set up a customized schedule."* [A-855].

Summary: The second theme explores users' strategies for ESF integration in daily routines. Interactions with ESFs begin with understanding the device's interface, which varies in complexity. While IoT capabilities simplify some device interfaces, they introduce new challenges. Users' preferences on ESF control differ, with some favoring automation and others manual control. Clear ESF labeling and understanding of device functions are vital for sustained use. Nevertheless, our findings suggest that characterizing features, that positively impact energy consumption as convenience functions, may increase interest in ESFs even among initially hesitant users. To optimize ESF usage, users tend to consult manuals, adjust their routines, and sometimes employ IoT customization, so long as the required effort is acceptable to the user.

4.3 Theme 3: Evaluating the Viability of ESF Adoption

The third and final theme encompasses how users evaluate the viability of using appliance-level ESFs. We found that users primarily focus on how they perceive device behavior, ease of use, and how these factors align with their living constraints (e.g., social dynamics, health conditions, or schedules). Upon activation of ESFs such as eco-modes, users reported detecting noticeable changes in their devices, such as altered operational duration or unfamiliar sounds. Here, how these changes were perceived varied based on users' expertise and understanding of the underlying inner mechanisms of their appliances. For instance, the extended operational times in eco modes of washing machines were misinterpreted, caused confusion, and consequently led to skepticism regarding realized energy savings: *"I just find it confusing how a program on, for example, my dishwasher takes twice as long as a different program, yet supposedly saves energy or water while still getting a somewhat similar result as the faster program."* [R-2-0] Furthermore, users expressed their inability to validate the efficiency claims of their appliances, often citing energy bills as one of the few tangible feedback mechanisms they have access to. While some appliances might not offer comprehensive eco-feedback due to their simplistic interfaces, those integrated with IoT often provide richer insights. These detailed feedback mechanisms were generally well-received. However, a recurring sentiment among users was the frustration of needing a mobile application to fully access all functions. *I do not want to be fiddling with my [HVAC] appliance and its features/app all the time. [..] I don't need the forecast, I don't need stupid integrations with Google Home or Alexa. I just need it to be user-friendly, low maintenance, and simple programming.* [R-18-14].

When describing their use of ESFs, users' evaluations were primarily anchored in outcome-related criteria, in line with Section 4.1. Our analysis revealed two dominant patterns in user behavior and perception. Firstly, when devices met or exceeded user expectations by delivering satisfactory results (such as effectively cleaned clothes, optimal cooling, or thorough drying) and the integration of ESFs into daily routines was seamless, users perceived the energy savings as a value addition to their overall experience: *"It's amazing! Game changer!!! I'm so happy. I'm running on the eco-wash setting. It seems to be getting everything well-cleaned."* [A-21]. In essence, for many users, the adoption of ESFs is acceptable upon the assurance that the overall user experience remains uncompromised. However, there exists a belief that ESFs often equate to reduced performance, which can be a deterrent for users who feel they've invested in a product for its optimal performance. Conversely, if users found that a device's performance was subpar when using ESFs or if the process of adapting to these features was overly complex or demanding, our data implies that they may abandon the use of ESFs. Such negative experiences, especially when considered in relation to users' initial attitudes and assumptions about ESFs, can solidify their skepticism.

Summary: Users primarily gauge the viability of ESFs based on perceived device behavior, ease of use, and alignment with personal living constraints. Notable changes in device operation upon ESF activation, such as extended durations or unfamiliar sounds, often lead to confusion or skepticism, especially when users lack an understanding of the device's mechanisms. While some users appreciate detailed feedback from IoT-integrated appliances, there's a sentiment of frustration over the need for mobile applications to access full eco-friendly features. The decision to adopt ESFs is largely influenced by the device's ability to meet user expectations without compromising on performance. Positive experiences with ESFs encourage continued use, while negative experiences, compounded by pre-existing skepticism, may deter users from future ESF engagement.

4.4 Barriers

The previous section provided a thorough analysis of users' perceptions, interactions, and evaluations related to appliance-integrated ESFs, structured around our identified themes. To pinpoint specific obstacles potentially

Cognitive Barriers			
Code	**Category**	**Concepts**	**Definition**
B1	Expertise & Understanding	Insufficient Energy Literacy	Limited understanding of how ESFs contribute to energy conservation, involved resources, and their broader environmental impact.
		Insufficient Device Knowledge	A lack of awareness or understanding of prevalent ESFs and associated inner mechanisms.
B2	Attitude & Assumptions	Resentment	Displeasure stemming from past negative experiences with ESFs, leading to reluctance in using them again.
		Skepticism	Doubt about the actual energy-saving and environmental benefits or effectiveness of ESFs.
		Irrelevance	The belief that ESFs are insignificant compared to technical advancements and industrial resource consumption.
		Inferiority	The belief that activating ESFs compromises the device's performance or quality.
		Risks	Concerns about potential outcomes like device malfunction or damaged goods, when using ESFs.
B3	Priorities & Goals	Convenience-focused	A preference for device settings that prioritize ease and simplicity, potentially at the expense of energy conservation.
		Efficacy-focused	Emphasis on the device's optimal performance, which might be perceived as being in conflict with ESFs.
B4	Tolerance	Effort Tolerance	The amount of effort users are willing to invest to understand and integrate ESFs in their everyday lives.
		Outcome Tolerance	The degree of variation in the quality of device results users are willing to accept when using ESFs.
Practical Barriers			
Code	**Category**	**Concepts**	**Definition**
B5	External Constraints	Health	Concerns that ESFs might impact health-related factors, such as air purifiers not filtering as effectively.
		Social Dynamics	Not being able to adopt ESFs due to other actors that rely on device results (e.g., pets relying on constant high-output cooling).
		Schedule	Busy schedules making effective and time-efficient execution of household tasks necessary when HAs are used.
B6	Interface & Interaction Design	Unintuitive Labeling	ESF indicators or labels on a device that are ambiguous or unclear, leading to confusion.
		Interface Complexity	The challenge in navigating a device's interface to locate and activate ESFs given an abundance of options.
		Missing Feedback	The absence of clear indicators on the device showing the benefits of ESF utilization.
		Outsourced Feedback	Information about the benefits or status of ESFs that is available only through external sources, like mobile applications.
		Unrelatable Feedback	Feedback from a device about energy consumption that isn't understandable or perceived as irrelevant by the user.

Table 3. Cognitive and practical barriers that we identified in our data. In total, the analysis revealed six barrier categories, **B1: Expertise & Understanding**, **B2: Perception**, **B3: Priorities & Goals**, **B4: Tolerance**, **B5: External Constraints**, **B6: Interface & Interaction Design**. For each category, we included the encompassed concepts with their definitions.

hindering ESF adoption, using our codes and axial coding as a foundation, we clustered similar concepts that could serve as potential barriers and categorized them in a subsequent step. The resulting six barrier categories are detailed in Table 3.

4.4.1 B1: Expertise & Understanding. Central to the barriers is the role of expertise and understanding, as energy literacy, awareness of ESFs, and specific knowledge about inner appliance mechanisms have the potential to influence users' interactions with ESFs in all three presented themes. A robust understanding empowers users to harness ESFs effectively, while gaps in knowledge can lead to misconceptions and misinterpretations. This complicates the interaction and evaluation and might lead users to ignore ESFs, thinking they're already conserving energy: *"It has an eco-setting, but we use the quick wash option, which saves energy but still leaves the dishes perfectly clean."* [A-407].

4.4.2 B2: Attitudes & Assumptions. We found frequent examples of negative leanings and assumptions impacting users' willingness to engage with ESFs. Particularly, anti-eco and skeptical attitudes, which manifest as general reservations about energy-efficient technology, can be impeding. This inherent distrust or apathy may stifle users' willingness to explore or trust ESFs. *"Ever since the Eco-friendly stuff started, window A/C units just aren't what they used to be, when I was a kid I had a window unit that lasted 10 years in this same room, never had an issue. Now they last 2 summers tops because they are all made to rate high on efficiency."* [A-176]. In the same way, users' assumptions, particularly those that paint ESFs as irrelevant or inferior, may serve as a deterrent to their adoption. If users perceive ESFs as offering diminished performance or being inconsequential, their motivation to engage may dwindle, potentially resulting in a reduced likelihood of adoption. Such assumptions themselves are intertwined with users' attitudes and their expertise and understanding as described in *B1*: *"The energy efficiency claim is an exaggeration, but the [AC] does have an eco setting that could help save on energy costs"* [A-507].

4.4.3 B3: Priorities & Goals. Users' primary goals and priorities when using devices can clash with energy conservation objectives. For many, the allure of comfort and device efficacy trumps energy-saving considerations. If ESFs are perceived as compromising these primary goals, they're potentially less likely to be embraced. *"What you actually want is to have it in the "Normal Cooling" mode where it blows out lots of wonderful cold air. Like duh, that's why we buy air conditioners. I get it, the manufacturer wants to start in the energy-saving mode to help reduce costs and the overall energy demand. Like I say, I get it. But this is an AIR CONDITIONER, it comes with a known higher cost for our electricity bill."* [A-696].

4.4.4 B4: Tolerance. While some users might be amenable to ESFs, their tolerance levels for inconvenience and additional effort play a crucial role. If ESFs demand efforts that exceed a user's threshold of acceptance, it becomes a barrier. This tolerance varies among users, with some willing to invest more time and effort than others. *"This [AC] unit in eco mode cools the room to the set temperature and then completely shuts off so you have to manually turn it back on. I guess that makes it extra eco-friendly but at the cost of making it very user-friendly. Very VERY annoying."* [A-889].

4.4.5 B5: External Constraints. External factors, such as social dynamics at home or potential health conditions, can also impede ESF usage. In certain scenarios, these constraints may entirely preclude ESF adoption. For instance, specific environmental conditions might render certain ESFs impractical. *"My apartment has a relatively new dishwasher so it must be water-efficient, but the problem is my water supply develops a weird smell to it as time goes on. So when I use the dishwasher, I HAVE to use the highest heat settings to prevent the water from sitting overnight and starting to smell."* [R-868-0].

4.4.6 B6: Interface & Interaction Design. The design of interfaces and interactions can either facilitate or hinder ESF usage. For one, unintuitive labeling, convoluted interfaces, and complex navigation concepts reduce the general usability of the appliance, which can lead the user to spend as little time as possible interacting with the device. Additionally, evaluating the impact of energy conservation is difficult to grasp if eco-feedback is absent or integrated into external components such as IoT applications that are not necessarily used by all users. Some appliances already integrate nudging mechanisms, such as setting the energy-saving program per default. Here, limited awareness and knowledge of device mechanisms might lead users to misinterpret default ESFs as bugs or glitches: *"The only glitch it seems to revert to eco mode sometimes when I didn't intend to use that setting which is a little aggravating."* [A-32].

5 FEASIBILITY OF BEHAVIOR CHANGE INTERVENTIONS: EXPERT FOCUS GROUP

The qualitative themes and barriers derived in the previous analysis showcase users' perceptions and common reasons for potential non-adoption of ESFs. To derive practical implications and understand how to address the identified challenges, we conducted a semi-structured focus group with N=5 HCI researchers in which we assessed the suitability of behavior change interventions in addressing the potential barriers and discussed alternative strategies.

5.1 Participants & Procedure

We employed convenience and snowball sampling [29, 32] to recruit five HCI researchers (4 male, 1 female) aged M=28.8 (SD=2.56) years old with M=5.2 (SD=1.94) years of academic experience developing and evaluating UI concepts (see Table 4). All participants had a primary computer science background, while one participant had specifically published research on energy conservation interventions before participating in the focus group.

PID	Age	Gender	Experience	Sector
1	29 yrs	Female	8 yrs	Academia
2	32 yrs	Male	6 yrs	Academia/Industry
3	31 yrs	Male	6 yrs	Academia/Industry
4	27 yrs	Male	3 yrs	Academia
5	25 yrs	Male	3 yrs	Academia/Industry

Table 4. The participants' demographics and backgrounds. Participants possessed a primary background in computer science, with two of them also having a significant psychological background. Moreover, one participant had prior experience in developing and evaluating energy conservation interventions before the focus group.

The focus group lasted 90 minutes, and participation was voluntary. Initially, participants were familiarized with the subject of ESF adoption in HAs. After establishing a clear understanding of the topic and our qualitative findings, the session moved to a priming task (see the supplementary material for a protocol of the focus group and materials). The task was meant to familiarize participants with designing behavior change interventions for ESF adoption, given the mechanisms provided in prior work and the findings regarding user perceptions and barriers from our qualitative analysis, such that all participants had a deeper understanding of the topic. We presented a practical washing machine scenario along with three distinct personas. The personas were crafted based on various attributes, such as energy conservation attitudes, knowledge of energy-efficient tech, and living conditions, reflecting actual user perspectives from our dataset. The persona attributes were chosen such that they spanned a range from more likely (priority in energy conservation, sufficient knowledge) to more unlikely ESF users (skeptical of energy-efficient tech, low understanding of energy and device mechanisms). In the scenario task, participants brainstormed interventions to enhance ESF adoption for each persona in timed 10-minute sessions. They were provided with the list of barriers from our qualitative analysis, as well as a list of design interventions curated from prior residential energy conservation research (see [1, 42, 97, 99]), as a reference toolbox. However, they were also encouraged to propose new intervention mechanisms if existing ones seemed insufficient to them. All participants were familiar with behavior change mechanisms such as persuasion or nudges but had not designed such features for energy conservation in a home context before. Following the priming task, participants discussed the suitability of their chosen interventions for the three personas, considering their understanding of user viewpoints and barriers. This evaluation took the form of a group discussion. Participants were also asked to discuss potential alternative approaches they believed might be more effective at increasing ESF adoption in everyday scenarios. The discussion was recorded for later analysis.

5.2 Insights

To synthesize insights from the focus group, we conducted a thematic analysis of focus group transcripts [13]. For transcription, we used WhisperX [6]. After familiarizing ourselves with the transcribed data, we generated open codes, which were categorized and formed into overarching themes, encapsulating perspectives on behavior change interventions for ESF adoption and alternative strategies. Herein, we present the three resultant themes supported by participant references and excerpts from their responses.

5.2.1 Theme 1: The Importance of the Nature of HA Interactions. The focus group participants unanimously stated that to properly assess the adequacy of any intervention to increase ESF adoption, the general nature of interactions with HAs has to be considered (P1-P5). They highlighted that HA interactions are typically task-driven and that users generally interact with these appliances *"not because they necessarily want to but because they have to since most major HAs are connected to household chores"* (P3). As such, it must be considered that interactions *"are likely not frequent and only as long as they need to be to execute the household task"* (P3). Based on this, addressing cognitive barriers such as a lack of expertise due to insufficient energy literacy or unfavorable perceptions of energy efficiency is difficult to achieve using the appliance alone. Participants further noted that this task-driven and infrequent nature of HA interactions necessitates a combination of multiple external strategies (directed at increasing energy literacy) in addition to purely device-based interventions such as eco-feedback or visualization.

5.2.2 Theme 2: Suitability of Behavior Change Interventions to Increase ESF Adoption. Two participants stated that behavior change interventions can have merits if the goal is simply to increase the use of ESFs (P1, P4). They specifically perceived green defaults to be an option that bridges factors such as expertise and attitude (P1-P5). However, concerns were expressed that simple interventions might neglect the root causes of ESF under-utilization expressed in the presented barriers. Moreover, it was discussed how mechanisms that inform the user about their energy consumption (e.g., eco-feedback, eco-visualization) to address barriers, such as *B1: Expertise & Understanding* or *B2: Attitude & Assumptions*, implicitly assume that users already attribute a higher meaning to the topic of energy conservation (P1, P2). Focusing on barriers *B1-B4*, participants were skeptical about whether nudges or persuasive methods can address them long-term, given the nature of HA interactions. P1 stated that issues such as lacking energy literacy (*B1*) or unfavorable outlooks on energy-efficient technology (*B2*) are *"issues that did not originate from the HA, so it is difficult to address them from a HA interface"* (P4). A unanimous sentiment among participants was that appliance-level interventions to increase ESF adoption could be limited in their effectiveness by the fact that they require careful crafting to address the widely varying personal characteristics (P1-P5). They proposed that effective interventions should be able to consider users' personal priorities, which requires a dynamic and adaptable approach. They highlighted the importance of *B4* in this regard, stating that interventions that attempt to convince users to do something that requires more effort or diverges too much from their initial personal priorities might cause the opposite effect of users developing negative sentiments (P2-P4).

5.2.3 Theme 3: Alternative Strategies to Foster Residential Energy Conservation. In discussing the suitability of common nudges or persuasive approaches for ESF adoption, participants were asked to also contemplate alternative approaches. P5 articulated a concern, noting that "the foundational design of current HAs poses challenges for HCI interventions in general." The use of ESFs in appliances often results in compromised performance, which, as identified by P2 and P3, risks conflating design and energy conservation with frustration when users are encouraged to use ESFs but are not satisfied with the results. P4, drawing upon an earlier remark on *B4: Tolerance*, suggested, *"HAs shouldn't predominantly rely on users making energy-efficient choices"*. Instead, they should be designed such that users delineate their operational preferences in terms of desired time frames and envisioned outcomes, with the appliance then autonomously managing energy conservation within those bounds.

This perspective resonated unanimously among participants. Under this framework, interfaces wouldn't overtly prompt users towards energy conservation but would transparently communicate the tangible benefits of innate energy-saving processes. Such an approach could potentially align energy conservation with user gratification.

6 DISCUSSION & IMPLICATIONS

In the following, we discuss the findings of our thematic analysis of 349 Amazon product reviews and 98 Reddit discussions, along with the results from an expert focus group (N=5) where we discussed the suitability of appliance-level behavior change interventions for ESF adoption in major HAs and explored alternative strategies. We show how our qualitative themes and barriers allowed for a targeted discussion of promising strategies for ESF adoption.

6.1 How Users Perceive, Interact with, and Evaluate ESFs in HAs

Our first research question (RQ1) was aimed at understanding how users reason about their use of ESFs in major HAs. In contrast to previous work, which frequently employed ethnographic methods to understand residential user behavior (e.g., [21, 80, 101]), we took a different approach to answer our RQs by conducting a thematic analysis of HA product reviews on Amazon and HA-related Reddit discussions. Our analysis yielded three qualitative themes *(1) Formulating the Intention to use ESFs (2) Initiating and Facilitating the Use of ESFs (3) Evaluating the Viability of ESF Adoption*.

Our findings suggest that users tend to follow a pragmatic approach when interacting with their HAs, where they primarily base their ESF use on the extent to which energy conservation is a relevant priority that does not interfere with more outcome and convenience-related goals. Furthermore, there was a pronounced preference among users for major HAs with automated energy-saving capabilities, particularly features like automated load sensing, auto-shutoffs, and automated soil level sensing, which could also be attributed to the more convenience and outcome-driven goals reported in our data. Consistent with prior research on automated energy conservation mechanisms (e.g., [54]), users expressed a desire to retain some degree of control over their devices, emphasizing their need to comprehend ongoing processes and potentially intervene if required. However, these varying desires for control indicate that a gap that requires systematic exploration is the question of user-agency in energy conservation. Specifically, exploring who desires to be in control, when they desire to be in control, and what experiences they hope to achieve. Despite the increasing societal attention energy conservation has received in the last years [72], our findings indicate that comfort and convenience continue to be users' main priorities when using their appliances, consistent with previous studies on domestic consumption behaviors (e.g., [22, 80]) and recent work by Strengers [95].

Diverging from previous studies on domestic consumption behavior, user experiences expressed in our data suggested that frequent reasons for the undervaluation of ESFs were skepticism and distrust stemming from personal experience, misinformation, and assumptions users made regarding the relevance and performance of their devices when using ESFs. In reports where the use of ESFs was explicitly denied, we found expressions of negative attitudes and assumptions surrounding energy-efficient technology. While previous studies have also identified neutral or ignorant attitudes towards energy conservation [80], openly negative outlooks were thus far underreported. One reason for this could be the data sampling method we employed in our study. As users remain anonymous when writing product reviews on Amazon or discussing energy-related topics on Reddit, they are more likely to share opinions that would otherwise be seen as socially undesirable [43]. Our research complements earlier studies by providing new insights into user perceptions and experiences with ESFs. It indicates that users are generally open to using ESFs provided they don't increase the effort to achieve desired device results. Additionally, our findings reveal a previously underreported level of skepticism and mistrust towards ESFs or "green tech" among users, a factor not typically considered in prior energy conservation interventions.

6.2 Barriers to ESF Adoption

To address our second research question (RQ2), we focused on identifying the specific obstacles that hinder routine ESF usage. Using our established themes, user data, and axial coding as a foundation, we specifically looked for user descriptions of obstacles that could be categorized as reoccurring barriers. Through this approach, we discerned six primary barriers. Within these barriers, users’ levels of expertise and understanding (*B1*) were frequently responsible for the implied non-adoption of ESFs in our dataset. Our data further suggests that users frequently found it challenging to correlate device functions with their associated energy implications, resulting in a reduced recognition of energy-saving possibilities. This observation resonates with the findings of Pierce et al. [80], who linked such discrepancies to non-intuitive interface designs. Numerous articles (e.g., [60, 68]) have identified a deficit in energy literacy as a substantial barrier to a multitude of eco-friendly behaviors. In the context of ESF adoption, our results emphasize the critical role of user expertise and knowledge, especially pertaining to misconceptions and misunderstandings.

Alongside expertise, users’ perceptions of energy-efficient technology emerged as another barrier (*B2*). Impacted by assumptions, attitudes, and device knowledge, these perceptions seemed to dictate users’ engagement with ESFs. The significance of attitudes and beliefs in shaping pro-environmental behavior is well-documented in behavioral models [3, 60]. In this regard, our findings highlight a skepticism and, at times, pronounced negativity toward ESFs. Such skepticism or negative attitudes frequently served as barriers, influencing users’ decisions regarding ESF use. This reluctance, in part, stemmed from views about ESFs being irrelevant, inferior, or even posing risks like damaging clothes or shortening the device’s lifespan. As previously highlighted, interface design plays a crucial role in enhancing ESF awareness. In our dataset, users frequently discussed unintuitive labeling and the complexity of the interfaces in which ESFs were embedded (*B3*). The rising trend of IoT integration in devices offers an avenue for more structured mobile application interfaces and incorporated feedback to provide users with sufficient information about the impacts of their device behavior. However, our findings suggest that while users appreciate automated ESFs, they are hesitant to engage in more complex IoT setups or rely on mobile devices for basic household tasks. This reluctance can be attributed to a misalignment with comfort and outcome-focused priorities (*B4*) and an aversion to any inconvenience associated with energy conservation (*B5*).

While previous research has underscored the influence of social norms, schedules, and financial constraints as barriers [51, 60], our study additionally found health status and environmental conditions as barriers that fall under the category of external constraints (*B6*). The broader barriers to pro-environmental behavior have been extensively discussed in disciplines like environmental psychology (e.g., James Blake [51]). Our research adds to the existing body of knowledge by providing a detailed, user-centered examination of the obstacles users face during day-to-day interactions with ESFs. By understanding these nuanced challenges, HCI researchers and practitioners can craft interventions that are more precisely tailored to address specific user needs and concerns, thereby enhancing the likelihood of successful ESF adoption. Moreover, a deeper knowledge of the barriers specific to ESF adoption enables a more effective evaluation of possible interventions, as they can be contrasted against frequently occurring failure points in everyday scenarios.

6.3 Alternative Strategies and Implications

Our third and final RQ aimed at assessing the feasibility of previously proposed design interventions to increase the likelihood of ESF adoption. To answer this question, we organized a focus group with (N=5) HCI experts, guided by our qualitative themes and identified barriers, as detailed in Section 5. Here we discuss when common behavior change interventions for increased ESF use may be feasible, what they can be realistically expected to achieve, and broader implications for alternative strategies.

Interventions based on nudging, which subtly guide users towards desirable behaviors, align well with the hectic nature of daily life. Nudges in the context of ESFs might include default settings, gentle reminders, or simplifying the process of activating energy-saving modes. However, as our analyses suggest, some HAs already implement various nudging mechanisms to steer user interactions towards less resource consumption, yet their effectiveness can vary as users do not necessarily prioritize energy conservation and even if they do, they might misinterpret nudging mechanisms as device malfunctions. Likewise, persuasive approaches using mechanisms such as eco-feedback, comparisons, or gamification can enhance users' understanding of inner HA mechanisms involved in energy conservation and thus steer interactions with ESFs.

In existing SHCI research, behavior change technology has been viewed critically over the years due to the pronounced focus on the individual and the minor expected savings even under optimal conditions (e.g., [18, 26, 27]). Our study recognizes the hesitance in concentrating exclusively on individual energy conservation behaviors, considering the wider, more systemic challenges in the transition towards sustainability. Nonetheless, our findings suggest that efforts to enhance conservation behaviors, such as the use of ESFs, should still play a part in a more comprehensive set of strategies. Promoting individual conservation itself can catalyze shifts towards sustainability, as these behaviors become normalized. This could also be relevant from a policy perspective to ensure that citizens are satisfied with green policies such as limits on consumption or produced carbon emissions [92]. Furthermore, involving individuals in energy-saving measures increases their awareness about personal resource use, which represents a relevant factor in making well-informed choices.

Currently, the fact that specific modes for energy conservation are still integrated into today's HAs puts the agency in energy conservation on the individual users, thereby expecting them to actively consider the advantages and disadvantages of using ESFs and act upon them if they deem conservation a priority. As highlighted in previous research (e.g., [80, 94]) and supported by our qualitative data, it may be unrealistic to expect such consistent consideration and conscious action from users given the common tendency to favor performance and comfort over energy conservation. It remains to be explored when and to what extent users actually would like to be involved in resource conservation, yet, our analyses suggest that for energy-saving practices to become a regular part of interactions with HAs, they likely need to be embedded within their current expectations of comfort.

As participants in our focus group indicated, this will remain challenging given the way that current HAs are constructed. Even if behavior change interventions succeed at promoting energy conservation through ESFs in current domestic devices, users' dissatisfaction with potentially reduced performance remains a hurdle, inadvertently linking energy conservation to user frustration through design.

Achieving a dynamic balance between conservation and comfort may require more advanced HAs with predefined conservation constraints defined by policymakers and manufacturers as a basis. Assuming HAs allow users to set personal priorities with the device autonomously managing energy conservation, design interventions could be given a novel purpose. For instance, they could be leveraged to explain and underscore background energy savings, thus embedding energy conservation within a positive user experience during HA interactions and enhancing awareness of carbon emissions and resource use. Building on the assumption of conservation targets established by authoritative entities, this strategy shares similarities with approaches such as 'Green Policy informatics' [16] and could further enable HCI practitioners and manufacturers to implement appliance-level interventions like eco-feedback with greater efficacy.

It should be noted that the concept of deploying automation for energy conservation in residential settings has been of interest since the advent of smart home technologies (e.g., [54, 84]). Nevertheless, the uptake of these technologies has been notably gradual (e.g., [55]). Previous research also indicates that the automation features in current HAs may not fully meet the diverse needs of different user groups [96]. We found similar reports of user experiences in our analyses with some users seeing smart features as useful while others viewed them with more skepticism. Furthermore, some smart home strategies aimed at conservation have led to an increase in energy usage due to savings spent on other more resource-intensive services or other lifestyle changes induced by automation [15].

We propose that embedding energy conservation into advanced automated HAs, supported by policy mandates for manufacturers and enhanced by developments in computational optimization, can more effectively balance comfort and conservation. Nonetheless, acknowledging the potential for rebound effects and shifts in user expectations towards unlimited comfort due to such automation, we recommend centering the evaluation of proposed prototypes around potential rebound effects and comprehending how one's prototypes may affect users' perspectives on desirable experiences in everyday scenarios.

7 LIMITATIONS

In this study, we utilized a dataset comprising Amazon product reviews and Reddit discussions to undertake a qualitative analysis. Our objective was to delineate user perceptions and interactions with ESFs in major HAs and identify barriers that hinder their routine use.

Leveraging user-generated content aimed to capture authentic user experiences but may have introduced certain biases. For one, specific demographic information of users, whose comments and posts we analyzed could not be obtained. Secondly, the anonymity inherent to the platforms we sampled data from, may have biased our data to include more radical views. Additionally, our dataset predominantly represents products owned in the US, limiting the generalizability of our findings to other regions. Unlike ethnographic studies, which allow for rich insights into the routines, habits, and challenges of a sample, our study does not allow for analysis of demographic attributes, however, leveraging user-created artifacts allowed us to analyze a larger sample size and provide thus far underreported perspectives. It should be noted however that platforms such as Reddit and Amazon portray a specific demographic which has been found to impact generalizability in previous analyses of user-generated content stemming from these platforms [4, 82]

Our thematic analysis was a two-stage process: an initial inductive phase followed by a theory-informed deductive stage with subsequent axial coding. This methodological choice meant that our themes were allowed to emerge organically only up to a point, after which they were structured based on theoretical insights from previous research. A purely inductive approach might have led to alternative interpretations. While we took measures to minimize coder biases and ensure consistency in our coding process, the inherent subjectivity in theme development means that coders' backgrounds and knowledge likely influenced how data was interpreted.

The participants in our expert focus group were all familiar with research regarding design interventions for behavioral change, however, only one of them had experience specific to the topic of energy conservation. Lastly, the focus group was semi-structured to provide participants with our preliminary findings as a foundation for discussion. This ensured a focused conversation, but a more open-ended workshop format might have elicited different insights from participants.

8 CONCLUSION

This work presents an analysis of user perceptions and experiences surrounding the use of ESFs in major HAs. We conducted reflexive thematic analysis on a dataset of 349 Amazon product reviews and 98 Reddit discussions, yielding three qualitative themes that describe user perceptions and approaches towards ESF adoption. Our findings suggest that, while users value energy efficiency in their devices, they often view ESFs as secondary features, mainly valued for potential utility cost savings. As such, users are willing to integrate the use of ESFs into their routines as long as they do not represent a severe reduction in device efficacy or convenience. To understand everyday hindrances that prevent the adoption of ESFs, we derived various concepts implied to have impeded the use of ESFs in our dataset. These concepts were clustered, resulting in a total of six barrier categories. We found that ESF adoption is commonly impacted by a lack of energy literacy and device-specific knowledge, which fuels skepticism towards energy-efficient technologies and reduces users' ability to appropriately evaluate the use of ESFs. To refine our findings and draw practical implications for the design and assessment of appliance-level interventions, we organized an expert focus group with (N=5) HCI researchers guided by our qualitative themes and derived barriers. We evaluated the potential of common behavior change technology to boost ESF adoption and explored alternative approaches, which indicates that interventions such as persuasive technology or nudging are feasible strategies to break habits and inform users, however, they bear the risk of connecting energy conservation with frustration in case HAs are not able to provide the expected convenience and comfort. To address this, advanced HAs, which balance user comfort and energy conservation based on conservation targets set by manufacturers or policymakers, are highlighted as a potential basis that bears increased versatility given current advances in computational optimization. By focusing on these future appliances, HCI practitioners can employ known tools such as eco-feedback to positively highlight energy savings and reframe the status of resource conservation in everyday scenarios. In conclusion, our research provides a comprehensive perspective into the challenges and barriers users face in their daily interactions with ESFs. By identifying these obstacles, we facilitate the development of more tailored design solutions and interventions.

ACKNOWLEDGMENTS

We thank the reviewers for their valuable feedback and suggestions. This work was supported by the Landesgraduiertenförderung (LGFG) Scholarship for PhD students.

REFERENCES

[1] Ifeoma Adaji and Mikhail Adisa. 2022. A Review of the Use of Persuasive Technologies to Influence Sustainable Behaviour. In *Adjunct Proceedings of the 30th ACM Conference on User Modeling, Adaptation and Personalization* (Barcelona, Spain) *(UMAP '22 Adjunct)*. Association for Computing Machinery, New York, NY, USA, 317–325. https://doi.org/10.1145/3511047.3537653

[2] U.S. Energy Information Administration. 2023. Glossary. Retrieved November 6, 2023 from https://www.eia.gov/tools/glossary/index.php?id=a

[3] Icek Ajzen. 1991. The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes* 50, 2 (1991), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

[4] Ashley Amaya, Ruben Bach, Florian Keusch, and Frauke Kreuter. 2021. New data sources in social science research: Things to know before working with Reddit data. *Social science computer review* 39, 5 (2021), 943–960.

[5] Thorhildur Asgeirsdottir and Rob Comber. 2023. Making Energy Matter: Soma Design for Ethical Relations in Energy Systems. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI '23)*. Association for Computing Machinery, New York, NY, USA, Article 4, 14 pages. https://doi.org/10.1145/3544548.3581160

[6] Max Bain, Jaesung Huh, Tengda Han, and Andrew Zisserman. 2023. WhisperX: Time-Accurate Speech Transcription of Long-Form Audio. *INTERSPEECH 2023* "", "" (2023), "".

[7] Jeffrey Bardzell, Shaowen Bardzell, and Ann Light. 2021. Wanting To Live Here: Design After Anthropocentric Functionalism. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 293, 24 pages. https://doi.org/10.1145/3411764.3445167

[8] Edward Loper Bird, Steven and Ewan Klein. 2009. *Natural Language Processing with Python.* O'Reilly Media Inc., Sebastopol, CA.

[9] Edward Loper Bird, Steven and Ewan Klein. 2009. NLTK Project. Retrieved November 7, 2023 from https://www.nltk.org/

[10] Jacky Bourgeois, Janet van der Linden, Gerd Kortuem, Blaine A. Price, and Christopher Rimmer. 2014. Conversations with My Washing Machine: An in-the-Wild Study of Demand Shifting with Self-Generated Energy. In *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing* (Seattle, Washington) *(UbiComp '14)*. Association for Computing Machinery, New York, NY, USA, 459–470. https://doi.org/10.1145/2632048.2632106

[11] Virginia Braun and Victoria Clarke. 2021. Can I use TA? Should I use TA? Should I not use TA? Comparing reflexive thematic analysis and other pattern-based qualitative analytic approaches. *Counselling and psychotherapy research* 21, 1 (2021), 37–47.

[12] Virginia Braun and Victoria Clarke. 2021. One Size Fits All? What Counts as Quality Practice in (Reflexive) Thematic Analysis? *Qualitative Research in Psychology* 18, 3 (2021), 328–352. https://doi.org/10.1080/14780887.2020.1769238 arXiv:https://doi.org/10.1080/14780887.2020.1769238

[13] Virginia Braun and Victoria Clarke. 2006. Using Thematic Analysis in Psychology. *Qualitative Research in Psychology* 3, 2 (2006), 77–101. https://doi.org/10.1191/1478088706qp063oa arXiv:https://www.tandfonline.com/doi/pdf/10.1191/1478088706qp063oa

[14] Christina Bremer. 2020. Not (B)Interested? Using Persuasive Technology to Promote Sustainable Household Recycling Behavior. In *Persuasive Technology. Designing for Future Change*, Sandra Burri Gram-Hansen, Tanja Svarre Jonasen, and Cees Midden (Eds.). Springer International Publishing, Cham, 195–207.

[15] Christina Bremer, Harshit Gujral, Michelle Lin, Lily Hinkers, Christoph Becker, and Vlad C. Coroamă. 2023. How Viable Are Energy Savings in Smart Homes? A Call to Embrace Rebound Effects in Sustainable HCI. *ACM J. Comput. Sustain. Soc.* "", "" (aug 2023), "". https://doi.org/10.1145/3608115 Just Accepted.

[16] Christina Bremer, Bran Knowles, and Adrian Friday. 2022. Have We Taken On Too Much?: A Critical Review of the Sustainable HCI Landscape. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems* (New Orleans, LA, USA) *(CHI '22)*. Association for Computing Machinery, New York, NY, USA, Article 41, 11 pages. https://doi.org/10.1145/3491102.3517609

[17] John Brewer. 2000. *Ethnography.* McGraw-Hill Education (UK), Bristol.

[18] Hronn Brynjarsdottir, Maria Håkansson, James Pierce, Eric Baumer, Carl DiSalvo, and Phoebe Sengers. 2012. Sustainably Unpersuaded: How Persuasion Narrows Our Vision of Sustainability. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Austin, Texas, USA) *(CHI '12)*. Association for Computing Machinery, New York, NY, USA, 947–956. https://doi.org/10.1145/2207676.2208539

[19] M. L. Chalal, B. Medjdoub, N. Bezai, R. Bull, and M. Zune. 2022. Visualisation in Energy Eco-Feedback Systems: A Systematic Review of Good Practice. *Renewable and Sustainable Energy Reviews* 162 (2022), 112447. https://doi.org/10.1016/j.rser.2022.112447

[20] Connie W. Chau and Elizabeth M. Gerber. 2023. On Hackathons: A Multidisciplinary Literature Review. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI '23)*. Association for Computing Machinery, New York, NY, USA, Article 637, 21 pages. https://doi.org/10.1145/3544548.3581234

[21] Marshini Chetty, A.J. Bernheim Brush, Brian R. Meyers, and Paul Johns. 2009. It's Not Easy Being Green: Understanding Home Computer Power Management. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Boston, MA, USA) *(CHI '09)*. Association for Computing Machinery, New York, NY, USA, 1033–1042. https://doi.org/10.1145/1518701.1518860

[22] Marshini Chetty, David Tran, and Rebecca E. Grinter. 2008. Getting to Green: Understanding Resource Consumption in the Home. In *Proceedings of the 10th International Conference on Ubiquitous Computing* (Seoul, Korea) *(UbiComp '08)*. Association for Computing Machinery, New York, NY, USA, 242–251. https://doi.org/10.1145/1409635.1409668

[23] Jacob Cohen. 1960. A coefficient of agreement for nominal scales. *Educational and psychological measurement* 20, 1 (1960), 37–46.

[24] Enrico Costanza, Joel E. Fischer, James A. Colley, Tom Rodden, Sarvapali D. Ramchurn, and Nicholas R. Jennings. 2014. Doing the Laundry with Agents: A Field Trial of a Future Smart Energy System in the Home. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Toronto, Ontario, Canada) *(CHI '14)*. Association for Computing Machinery, New York, NY, USA, 813–822. https://doi.org/10.1145/2556288.2557167

[25] Emily Dao, Andreea Muresan, Kasper Hornbæk, and Jarrod Knibbe. 2021. Bad Breakdowns, Useful Seams, and Face Slapping: Analysis of VR Fails on YouTube. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 526, 14 pages. https://doi.org/10.1145/3411764.3445435

[26] Carl DiSalvo, Phoebe Sengers, and Hrönn Brynjarsdóttir. 2010. Mapping the Landscape of Sustainable HCI. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Atlanta, Georgia, USA) *(CHI '10)*. Association for Computing Machinery, New York, NY, USA, 1975–1984. https://doi.org/10.1145/1753326.1753625

[27] Paul Dourish. 2010. HCI and environmental sustainability: the politics of design and the design of politics. In *Proceedings of the 8th ACM Conference on Designing Interactive Systems* (Aarhus, Denmark) *(DIS '10)*. Association for Computing Machinery, New York, NY, USA, 1–10. https://doi.org/10.1145/1858171.1858173

[28] James W Drisko and Tina Maschi. 2016. *Content Analysis.* Pocket Guides to Social Work Research Methods, New York, NY.

[29] Ilker Etikan, Sulaiman Abubakar Musa, and Rukayya Alkassim. 2016. Comparison of Convenience Sampling and Purposive Sampling. *American Journal of Theoretical and Applied Statistics* 5 (2016), 1. https://api.semanticscholar.org/CorpusID:10664685

[30] Commission Regulation (EU). 2019. Commission Regulation (EU) 2019/2019 of 1 October 2019 Laying down Ecodesign Requirements for Refrigerating Appliances Pursuant to Directive 2009/125/EC of the European Parliament and of the Council and Repealing Commission Regulation (EC) No 643/2009 (Text with EEA Relevance.). Retrieved November 8, 2023 from http://data.europa.eu/eli/reg/2019/2019/oj/eng

[31] Commission Regulation (EU). 2021. Commission Regulation (EU) 2019/2023 of 1 October 2019 Laying down Ecodesign Requirements for Household Washing Machines and Household Washer-Dryers Pursuant to Directive 2009/125/EC of the European Parliament and of the Council, Amending Commission Regulation (EC) No 1275/2008 and Repealing Commission Regulation (EU) No 1015/2010 (Text with EEA Relevance)Text with EEA Relevance. Retrieved November 6, 2023 from http://data.europa.eu/eli/reg/2019/2023/2021-05-01/eng

[32] A. Fink. 2005. *Conducting Research Literature Reviews: From the Internet to Paper.* SAGE Publications. https://books.google.de/books?id=VyROaw-hLJMC

[33] BJ Fogg. 2009. A Behavior Model for Persuasive Design. In *Proceedings of the 4th International Conference on Persuasive Technology* (Claremont, California, USA) *(Persuasive '09)*. Association for Computing Machinery, New York, NY, USA, Article 40, 7 pages. https://doi.org/10.1145/1541948.1541999

[34] B. J. Fogg. 2002. Persuasive Technology: Using Computers to Change What We Think and Do. *Ubiquity* 2002, December, Article 5 (dec 2002), 32 pages. https://doi.org/10.1145/764008.763957

[35] Jon Froehlich, Leah Findlater, and James Landay. 2010. The Design of Eco-Feedback Technology. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Atlanta, Georgia, USA) *(CHI '10)*. Association for Computing Machinery, New York, NY, USA, 1999–2008. https://doi.org/10.1145/1753326.1753629

[36] Jon Froehlich, Leah Findlater, Marilyn Ostergren, Solai Ramanathan, Josh Peterson, Inness Wragg, Eric Larson, Fabia Fu, Mazhengmin Bai, Shwetak Patel, and James A. Landay. 2012. The Design and Evaluation of Prototype Eco-Feedback Displays for Fixture-Level Water Usage Data. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Austin, Texas, USA) *(CHI '12)*. Association for Computing Machinery, New York, NY, USA, 2367–2376. https://doi.org/10.1145/2207676.2208397

[37] Dominic Furniss, Ann Blandford, and Paul Curzon. 2011. Confessions from a Grounded Theory PhD: Experiences and Lessons Learnt. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Vancouver, BC, Canada) *(CHI '11)*. Association for Computing Machinery, New York, NY, USA, 113–122. https://doi.org/10.1145/1978942.1978960

[38] Eva Ganglbauer, Wolfgang Reitberger, and Geraldine Fitzpatrick. 2013. An Activist Lens for Sustainability: From Changing Individuals to Changing the Environment. In *Persuasive Technology*, Shlomo Berkovsky and Jill Freyne (Eds.). Springer Berlin Heidelberg, Berlin, Heidelberg, 63–68.

[39] James Paul Gee. 2014. *An Introduction to Discourse Analysis: Theory and Method* (4 ed.). Routledge, London. https://doi.org/10.4324/9781315819679

[40] Barney Glaser and Anselm Strauss. 2017. *Discovery of grounded theory: Strategies for qualitative research.* Routledge, Ney York, NY.

[41] Leigh Goodson and Matt Vassar. 2011. An Overview of Ethnography in Healthcare and Medical Education Research. *Journal of educational evaluation for health professions* 8 (2011), 4. https://doi.org/10.3352/jeehp.2011.8.4 pmid:21637319

[42] Laura Grönewald, Julian Weiblen, Matthias Laschke, Lara Christoforakos, and Marc Hassenzahl. 2023. Sustainability by Design. How to Encourage Users to Choose Energy-Saving Programs and Settings When Washing Laundry. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI '23)*. Association for Computing Machinery, New York, NY, USA, Article 524, 14 pages. https://doi.org/10.1145/3544548.3581150

[43] Russell P. Haines, Jill R. Hough, Lan Cao, and Douglas Haines. 2014. Anonymity in Computer-Mediated Communication: More Contrarian Ideas with Less Influence. *Group Decision and Negotiation* 23 (2014), 765–786. https://api.semanticscholar.org/CorpusID:144977751

[44] Eric B. Hekler, Predrag Klasnja, Jon E. Froehlich, and Matthew P. Buman. 2013. Mind the Theoretical Gap: Interpreting, Using, and Developing Behavioral Theory in HCI Research. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Paris, France) *(CHI '13)*. Association for Computing Machinery, New York, NY, USA, 3307–3316. https://doi.org/10.1145/2470654.2466452

[45] Erin Higgins, Jennifer Posada, Quinlan Kimble-Brown, Susanna Abler, Andrew Coy, and Foad Hamidi. 2023. Investigating an Equity-Based Participatory Approach to Technology-Rich Learning in Community Recreation Centers. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI '23)*. Association for Computing Machinery, New York, NY, USA, Article 443, 18 pages. https://doi.org/10.1145/3544548.3581567

[46] Roland Hischier, Francesca Reale, Valentina Castellani, and Serenella Sala. 2020. Environmental impacts of household appliances in Europe and scenarios for their impact reduction. *Journal of cleaner production* 267 (2020), 121952.

[47] Nurulhuda Ibrahim, Ang Bei Wen, and Chong Hooi Khee. 2020. Casual Gaming to Encourage Reuse of Waste Materials for Environmental Sustainability. In *2020 Second International Sustainability and Resilience Conference: Technology and Innovation in Building Designs(51154)*. IEEE, Bahrain, 1–3. https://doi.org/10.1109/IEEECONF51154.2020.9319963

[48] IEA. 2022. Residential behaviour changes lead to a reduction in heating and cooling energy use by 2030. Retrieved November 6, 2023 from https://www.iea.org/reports/residential-behaviour-changes-lead-to-a-reduction-in-heating-and-cooling-energy-use-by-2030

[49] International Energy Agency (IEA). 2020. Shares of Residential Energy Consumption by End Use in Selected IEA Countries, 2018 – Charts – Data & Statistics. Retrieved August 22 2023 from https://www.iea.org/data-and-statistics/charts/shares-of-residential-energy-consumption-by-end-use-in-selected-iea-countries-2018

[50] International Energy Agency (IEA). 2022. Appliances & Equipment. Retrieved August 22 2023 from https://www.iea.org/energy-system/buildings/appliances-and-equipment

[51] James Blake. 1999. Overcoming the 'Value-action Gap' in Environmental Policy: Tensions between National Policy and Local Experience. *Local Environment* 4, 3 (1999), 257–278. https://doi.org/10.1080/13549839908725599 arXiv:https://doi.org/10.1080/13549839908725599

[52] Rikke Hagensby Jensen, Jesper Kjeldskov, and Mikael B. Skov. 2016. HeatDial: Beyond User Scheduling in Eco-Interaction. In *Proceedings of the 9th Nordic Conference on Human-Computer Interaction* (Gothenburg, Sweden) *(NordiCHI '16)*. Association for Computing Machinery, New York, NY, USA, Article 74, 10 pages. https://doi.org/10.1145/2971485.2971525

[53] Rikke Hagensby Jensen, Dimitrios Raptis, Jesper Kjeldskov, and Mikael B. Skov. 2018. Washing with the Wind: A Study of Scripting towards Sustainability. In *Proceedings of the 2018 Designing Interactive Systems Conference* (Hong Kong, China) *(DIS '18)*. Association for Computing Machinery, New York, NY, USA, 1387–1400. https://doi.org/10.1145/3196709.3196779

[54] Rikke Hagensby Jensen, Yolande Strengers, Jesper Kjeldskov, Larissa Nicholls, and Mikael B. Skov. 2018. Designing the Desirable Smart Home: A Study of Household Experiences and Energy Consumption Impacts. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (Montreal QC, Canada) *(CHI '18)*. Association for Computing Machinery, New York, NY, USA, 1–14. https://doi.org/10.1145/3173574.3173578

[55] Norliza Katuk, Ku Ruhana Ku-Mahamud, Nur Haryani Zakaria, and Mohd Aizaini Maarof. 2018. Implementation and recent progress in cloud-based smart home automation systems. In *2018 IEEE Symposium on Computer Applications & Industrial Electronics (ISCAIE)*. 71–77. https://doi.org/10.1109/ISCAIE.2018.8405447

[56] Raman Kazhamiakin, Annapaola Marconi, Alberto Martinelli, Marco Pistore, and Giuseppe Valetto. 2016. A gamification framework for the long-term engagement of smart citizens. In *2016 IEEE International Smart Cities Conference (ISC2)*. IEEE, Trento, Italy, 1–7. https://doi.org/10.1109/ISC2.2016.7580746

[57] Sunyoung Kim and Muyang Li. 2020. Awareness, Understanding, and Action: A Conceptual Framework of User Experiences and Expectations about Indoor Air Quality Visualizations. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) *(CHI '20)*. Association for Computing Machinery, New York, NY, USA, 1–12. https://doi.org/10.1145/3313831.3376521

[58] Bran Knowles, Lynne Blair, Mike Hazas, and Stuart Walker. 2013. Exploring Sustainability Research in Computing: Where We Are and Where We Go Next. In *Proceedings of the 2013 ACM International Joint Conference on Pervasive and Ubiquitous Computing* (Zurich, Switzerland) *(UbiComp '13)*. Association for Computing Machinery, New York, NY, USA, 305–314. https://doi.org/10.1145/2493432.2493474

[59] Florian Kohlbacher. 2006. The use of qualitative content analysis in case study research. *Forum qualitative sozialforschung/forum* 7 (2006), 1–30.

[60] Anja Kollmuss and Julian Agyeman. 2002. Mind the Gap: Why Do People Act Environmentally and What Are the Barriers to pro-Environmental Behavior? *Environmental Education Research* 8, 3 (2002), 239–260. https://doi.org/10.1080/13504620220145401 arXiv:https://doi.org/10.1080/13504620220145401

[61] Kevin Krings, Nino S. Bohn, Nora Anna Luise Hille, and Thomas Ludwig. 2023. "What If Everyone is Able to Program?" – Exploring the Role of Software Development in Science Fiction. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI '23)*. Association for Computing Machinery, New York, NY, USA, Article 597, 13 pages. https://doi.org/10.1145/3544548.3581436

[62] J Richard Landis and Gary G Koch. 1977. The measurement of observer agreement for categorical data. *biometrics* 33, 1 (1977), 159–174.

[63] Marvin Landwehr, Philip Engelbutzeder, and Volker Wulf. 2021. Community Supported Agriculture: The Concept of Solidarity in Mitigating Between Harvests and Needs. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI '21)*. Association for Computing Machinery, New York, NY, USA, Article 299, 13 pages. https://doi.org/10.1145/3411764.3445268

[64] Matthias Laschke, Sarah Diefenbach, and Marc Hassenzahl. 2015. "Annoying, but in a nice way": an inquiry into the experience of frictional feedback. *International Journal of Design* 9, 2 (2015), 129–140.

[65] Margaret D LeCompte and Judith Preissle Goetz. 1982. Problems of reliability and validity in ethnographic research. *Review of educational research* 52, 1 (1982), 31–60.

[66] Szu-Yu (Cyn) Liu, Shaowen Bardzell, and Jeffrey Bardzell. 2019. Symbiotic Encounters: HCI and Sustainable Agriculture. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI '19)*. Association for Computing Machinery, New York, NY, USA, 1–13. https://doi.org/10.1145/3290605.3300547

[67] S. Loria. 2018. TextBlob Documentation. Retrieved August 21, 2023 from https://textblob.readthedocs.io/en/dev/

[68] Ana Martins, Mara Madaleno, and Marta Ferreira Dias. 2020. Energy Literacy: What Is out There to Know? *Energy Reports* 6 (2020), 454–459. https://doi.org/10.1016/j.egyr.2019.09.007

[69] Janet Metcalfe and Walter Mischel. 1999. A Hot/Cool-System Analysis of Delay of Gratification: Dynamics of Willpower. *Psychological Review* 106, 1 (1999), 3–19. https://doi.org/10.1037/0033-295X.106.1.3

[70] Susan Michie, Maartje M., and Robert West. 2011. The Behaviour Change Wheel: A New Method for Characterising and Designing Behaviour Change Interventions. *Implementation Science* 6, 1 (2011), 42. https://doi.org/10.1186/1748-5908-6-42

[71] Thomas Mildner, Gian-Luca Savino, Philip R. Doyle, Benjamin R. Cowan, and Rainer Malaka. 2023. About Engaging and Governing Strategies: A Thematic Analysis of Dark Patterns in Social Networking Services. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI '23)*. Association for Computing Machinery, New York, NY, USA, Article 192, 15 pages. https://doi.org/10.1145/3544548.3580695

[72] Taciano L. Milfont, Elena Zubielevitch, Petar Milojev, and Chris G. Sibley. 2021-07-06. Ten-Year Panel Data Confirm Generation Gap but Climate Beliefs Increase at Similar Rates across Ages. *Nature Communications* 12, 1 (2021-07-06), 4038. https://doi.org/10.1038/s41467-

021-24245-y
[73] Tom Mudd. 2023. Playing with Feedback: Unpredictability, Immediacy, and Entangled Agency in the No-Input Mixing Desk. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI '23)*. Association for Computing Machinery, New York, NY, USA, Article 243, 11 pages. https://doi.org/10.1145/3544548.3580662
[74] Latha Karthigaa Murugesan, Rashina Hoda, and Zoran Salcic. 2015. Design Criteria for Visualization of Energy Consumption: A Systematic Literature Review. *Sustainable Cities and Society* 18 (2015), 1–12. https://doi.org/10.1016/j.scs.2015.04.009
[75] Michael D Myers. 1999. Investigating information systems with ethnographic research. *Communications of the Association for Information Systems* 2, 1 (1999), 23.
[76] Payam Nejat, Fatemeh Jomehzadeh, Mohammad Mahdi Taheri, Mohammad Gohari, and Muhd Zaimi Abd Majid. 2015. A global review of energy consumption, CO2 emissions and policy in the residential sector (with an overview of the top ten CO2 emitting countries). *Renewable and sustainable energy reviews* 43 (2015), 843–862.
[77] Dominic A. Notter, Reto Meyer, and Hans-Jörg Althaus. 2013. The Western Lifestyle and Its Long Way to Sustainability. *Environmental Science & Technology* 47, 9 (2013), 4014–4021. https://doi.org/10.1021/es3037548 arXiv:https://doi.org/10.1021/es3037548
[78] Dane Petersen, Jay Steele, and Joe Wilkerson. 2009. WattBot: A Residential Electricity Monitoring and Feedback System. In *CHI '09 Extended Abstracts on Human Factors in Computing Systems* (Boston, MA, USA) *(CHI EA '09)*. Association for Computing Machinery, New York, NY, USA, 2847–2852. https://doi.org/10.1145/1520340.1520413
[79] Petromil Petkov, Suparna Goswami, Felix Köbler, and Helmut Krcmar. 2012. Personalised Eco-Feedback as a Design Technique for Motivating Energy Saving Behaviour at Home. In *Proceedings of the 7th Nordic Conference on Human-Computer Interaction: Making Sense Through Design* (Copenhagen, Denmark) *(NordiCHI '12)*. Association for Computing Machinery, New York, NY, USA, 587–596. https://doi.org/10.1145/2399016.2399106
[80] James Pierce, Diane J. Schiano, and Eric Paulos. 2010. Home, Habits, and Energy: Examining Domestic Interactions and Energy Consumption. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Atlanta, Georgia, USA) *(CHI '10)*. Association for Computing Machinery, New York, NY, USA, 1985–1994. https://doi.org/10.1145/1753326.1753627
[81] James O. Prochaska and Wayne F. Velicer. 1997. The Transtheoretical Model of Health Behavior Change. *American Journal of Health Promotion* 12, 1 (1997), 38–48. https://doi.org/10.4278/0890-1171-12.1.38 arXiv:https://doi.org/10.4278/0890-1171-12.1.38
[82] Nicholas Proferes, Naiyan Jones, Sarah Gilbert, Casey Fiesler, and Michael Zimmer. 2021. Studying reddit: A systematic overview of disciplines, approaches, methods, and ethics. *Social Media+ Society* 7, 2 (2021), 20563051211019004.
[83] Mohammad Rashidujjaman Rifat, Hasan Mahmud Prottoy, and Syed Ishtiaque Ahmed. 2019. The Breaking Hand: Skills, Care, and Sufferings of the Hands of an Electronic Waste Worker in Bangladesh. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI '19)*. Association for Computing Machinery, New York, NY, USA, 1–14. https://doi.org/10.1145/3290605.3300253
[84] Johnny Rodgers and Lyn Bartram. 2010. ALIS: An Interactive Ecosystem for Sustainable Living. In *Proceedings of the 12th ACM International Conference Adjunct Papers on Ubiquitous Computing - Adjunct* (Copenhagen, Denmark) *(UbiComp '10 Adjunct)*. Association for Computing Machinery, New York, NY, USA, 421–422. https://doi.org/10.1145/1864431.1864467
[85] Shadan Sadeghian, Philipp Wintersberger, Matthias Laschke, and Marc Hassenzahl. 2022. Designing Sustainable Mobility: Understanding Users' Behavior. In *Proceedings of the 14th International Conference on Automotive User Interfaces and Interactive Vehicular Applications* (Seoul, Republic of Korea) *(AutomotiveUI '22)*. Association for Computing Machinery, New York, NY, USA, 34–44. https://doi.org/10.1145/3543174.3546833
[86] Angela Sanguinetti, Kelsea Dombrovski, and Suhaila Sikand. 2018. Information, Timing, and Display: A Design-Behavior Framework for Improving the Effectiveness of Eco-Feedback. *Energy Research & Social Science* 39 (2018), 55–68. https://doi.org/10.1016/j.erss.2017.10.001
[87] Abdus Sattar, Md. Jamal Hosen Shohel, Fahima Sultana Banni, and Amit Kumar Bala Antu. 2019. A Conceptual Design to Encourage Sustainable Grocery Shopping: A Perspective in Bangladesh. In *2019 8th International Conference System Modeling and Advancement in Research Trends (SMART)*. IEEE, Moradabad, India, 91–97. https://doi.org/10.1109/SMART46866.2019.9117292
[88] Daniel Schwartz, Baruch Fischhoff, Tamar Krishnamurti, and Fallaw Sowell. 2013. The Hawthorne Effect and Energy Awareness. *Proceedings of the National Academy of Sciences* 110, 38 (2013), 15242–15246. https://doi.org/10.1073/pnas.1301687110 arXiv:https://www.pnas.org/doi/pdf/10.1073/pnas.1301687110
[89] Gözel Shakeri and Claire H McCallum. 2021. Envirofy your Shop: Development of a Real-time Tool to Support Eco-friendly Food Purchases Online. In *Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems* (Yokohama, Japan) *(CHI EA '21)*. Association for Computing Machinery, New York, NY, USA, Article 390, 10 pages. https://doi.org/10.1145/3411763.3451713
[90] M. Six Silberman, Lisa Nathan, Bran Knowles, Roy Bendor, Adrian Clear, Maria Håkansson, Tawanna Dillahunt, and Jennifer Mankoff. 2014. Next Steps for Sustainable HCI. *Interactions* 21, 5 (sep 2014), 66–69. https://doi.org/10.1145/2651820
[91] Der Spiegel. 2022. Stromsparmodus von Waschmaschinen wird kaum genutzt. Retrieved July 21 2023 from https://www.spiegel.de/wirtschaft/stromsparmodus-bei-waschmaschinen-kaum-genutzt-daten-von-hersteller-miele-a-c156d10e-4b1d-4459-b5f8-16884e150174

[92] Leah C. Stokes and Christopher Warshaw. 2017. Renewable Energy Policy Design and Framing Influence Public Support in the United States. *Nature Energy* 2, 8 (2017), 17107. https://doi.org/10.1038/nenergy.2017.107

[93] Fritz Strack and Roland Deutsch. 2004. Reflective and Impulsive Determinants of Social Behavior. *Personality and social psychology review : an official journal of the Society for Personality and Social Psychology, Inc* 8, 3 (2004), 220–247. https://doi.org/10.1207/s15327957pspr0803_1 pmid:15454347

[94] Yolande Strengers. 2014. Smart Energy in Everyday Life: Are You Designing for Resource Man? *interactions* 21, 4 (2014), 24–31. https://doi.org/10.1145/2621931

[95] Yolande Strengers. 2023. Resource Man and the Smart Wife: Implications for Sustainability in the Home. *Interactions* 30, 2 (feb 2023), 36–40. https://doi.org/10.1145/3582566

[96] Yolande Strengers, Jenny Kennedy, Paula Arcari, Larissa Nicholls, and Melissa Gregg. 2019. Protection, Productivity and Pleasure in the Smart Home: Emerging Expectations and Gendered Insights from Australian Early Adopters. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI '19)*. Association for Computing Machinery, New York, NY, USA, 1–13. https://doi.org/10.1145/3290605.3300875

[97] Yolande A.A. Strengers. 2011. Designing Eco-Feedback Systems for Everyday Life. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Vancouver, BC, Canada) *(CHI '11)*. Association for Computing Machinery, New York, NY, USA, 2135–2144. https://doi.org/10.1145/1978942.1979252

[98] Richard H. Thaler and Cass R. Sunstein. 2008. *Nudge.* Yale University Press, New Haven, CT and London.

[99] Mirjam Visser and Jan Schoormans. 2023. Get rid of the eco-button! Design interventions to steer sustainable use of washing machines. *Cleaner and Responsible Consumption* 8 (2023), 100096.

[100] Katy Williams, Alex Bigelow, and Katherine E. Isaacs. 2023. Data Abstraction Elephants: The Initial Diversity of Data Representations and Mental Models. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (Hamburg, Germany) *(CHI '23)*. Association for Computing Machinery, New York, NY, USA, Article 803, 24 pages. https://doi.org/10.1145/3544548.3580669

[101] Allison Woodruff, Jay Hasbrouck, and Sally Augustin. 2008. A Bright Green Perspective on Sustainable Choices. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Florence, Italy) *(CHI '08)*. Association for Computing Machinery, New York, NY, USA, 313–322. https://doi.org/10.1145/1357054.1357109