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REVIEW ARTICLE

# The role of gender, age, and income in demand-side management acceptance: A literature review

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**Abstract** Demand-side management (DSM) programs aiming to both reduce and render household consumption more flexible are becoming increasingly essential due to ongoing energy crises and the growing integration of renewable energy into energy production. The active involvement of households and energy users is crucial to fully unlock the potential of DSM programs. As this paper demonstrates, despite more than thirty years of feminist scholarly work focusing on the home as an important site of the production of gender inequality, few of these insights have been taken into account by DSM designers. Additionally, we note a broader pattern concerning gaps in knowledge regarding the diverse perspectives of energy users and their domestic contexts, all of which create obstacles to successful roll-out and scalability. This paper uses the concepts of the social license to automate and intersectionality to analyze the existing literature on DSM programs. We find that three primary barriers in household DSM programs have been addressed: 1) there is an unresolved tension between DSM technology being perceived as a masculine domain and the home as a feminine domain; 2) low-income households face challenges in accessing the technology needed to enable both flexibility and savings; and 3) disparities in opportunities for youth and the elderly to participate in DSM programs are insufficiently considered. Based on these findings we argue that user diversity—not only conceived of as separate identity category variables but also as implicating overlapping and possible mutually reinforcing marginalizations– is needed to form a starting point in DSM program design for fair and scalable solutions.

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## Introduction

The world is currently facing a global energy transition from fossil fuels to renewable energy sources. The electrification of various sectors, from transportation to heavy industry, is driving an increasing demand for renewable energy, which adds pressure to the transitional process. At the same time, energy transition has become more urgent in the context of current shortages in energy supply due to global developments such as Russia's invasion of the Ukraine and associated price escalation. In a system characterized by a high proportion of renewable energy sources, end-users possess the potential to play a significant role in ensuring the stability of the grid (Gelazanskas & Gamage, 2014). Successfully engaged as active participants in the grid, they can become a source of flexibility through close coordination of energy availability and consumption (Ballo, 2015). At the same time, so-called flexible energy consumption does interfere with the everyday life practices of consumers, posing a challenge to the availability of end-user flexibility as a resource (Silvast et al., 2018; Skjølsvold et al., 2017) and grid companies may overestimate public acceptance to shift their energy demand (Winther & Sundet, 2023).

Research in the field of promoting flexible energy consumption among households has primarily concentrated on the provision of economic signals as incentives, often coupled with technological interventions to facilitate the transmission of these signals, with the objective of encouraging individual households to modify their energy consumption patterns. This approach is commonly known as demand-side response (DSR) or demand-side management (DSM). DSM can be done in several ways: manually by using electricity when the price is low, manually by setting up the automation of appliances or by installing a Home Energy Manegment System (HEMS) which allows a third party to manage use (Adams et al., 2021). It is assumed that individuals' willingness to adapt their energy consumption is driven by economic advantages and rational decision-making (Fell et al., 2014; Fjellså et al., 2021a, 2021b; Throndsen, 2017). This assumption comes from a technical energy utility perspective where the main motivation is to stabilize the grid (Ballo, 2015) and is often based on the vision of the 'resource man': a smart energy consumer interested in his own energy data and who acts on price signals to optimize savings (Strengers, 2014). This vision represents the energy industry's resource bias projected into energy consumers that make the home into a "resource control station" (Strengers, 2014, p. 26). Another similar concept used to describe this set of assumptions made on behalf of users by designers of technology and policy is the concept of 'imagined lay persons' (ILP) whereby the expectation of a version of the future—like that of the flexible consumer—creates certain types of innovation projects that yet again facilitate certain action strategies and politics (Maranta et al., 2003).

When it comes to end user flexibility, the imagined lay person becomes a representation affected by unconscious bias about who the user is: "usually white, male, privileged, well-off, and young" (Maranta et al., 2003; Strengers & Kennedy, 2021), leading to the development of solutions that exclude or simply do not appeal to many other energy users. This bias has been addressed by social science researchers who have called for more heterogeneity among participating energy consumers in pilots and studies (Silvast et al., 2018; Skjølsvold et al., 2017; Strengers, 2014), and underlined the need to pay more attention to social relations in energy consumption patterns (Hargreaves & Middlemiss, 2020). These studies are part of an increasing body of research that critically reflects on the complex identities, use patterns, and social contexts of end users (Forlano, 2017). In this way, a houshold's economic situation and compostion has an impact of its acceptance of DSM.

Through the analysis presented in this paper, we further contribute to this line of research by scrutinizing published studies on automated DSM and the ways in which they engage with end users. Additionally, we propose moving beyond mere critical reflection and advocate for employing intersectionality as a means to expand the scope of the social license to automate concept, making it more inclusive, tangible and usable for the furthering of a socially just energy transition.

## Theoretical framing: Social license to automate in dialogue with intersectionality

The concept of the 'social license to automate' refers to the circumstances under which energy users might accept automation within their households. As such, it brings to light the potential gaps between the expectations of energy actors and users' perspectives and aspirations (Adams et al., 2021). The concept of a *social license to automate* recognizes that many demand side management (DSM) programs will require intervention at faster speeds than systems of individual decision-making will allow. For example, Frequency Control Ancillary Services at the milli-second level require pre-set permissions, which raises the question as to who provides these permissions as they relate to home appliances, batteries, HVAC systems, electric vehicle charging and more. Granting permissions has important social and political implications insofar as DSM requires users to modify their practices. The social licences to automate concept gives us three key boundaries: legitimacy for acceptance, credibility for approval, and trust for psychological identification with the DSM. In this way, DSM is not merely a question of personal choice but is rather the subject of social conditions required by community stakeholders to address these three barriers of boundaries to gain social license (Boutilier & Thompson, 2011). One of the current limitations of the social license to automate is that it lacks a means to understand the complex, social situatedness of energy users.

To bridge this gap, we combine the social license to automate with an *intersectional* analytical sensitivity that foregrounds the complex identities of social subjects. When combining SLA with intersectionality, we gain the means to analyse the potentially overlapping ways in which social inequality is produced and reproduced in household contexts and through energy transitions. This is of particular interest to a field like STS where techno-experiences are best understood as shaped by various enactments of gender, class, race, age and disability (Moser, 2006). In this paper we utilize intersectional thinking as a tool to map out the DSM literature in terms of insights and knowledge gaps related to understanding the social situatedness of energy consumers in their household contexts. In other words, it allows us to analyze the review and "become answerable for what we learn how to see" (Haraway, 1988: 583).

Intersectionality is a term coined by Kimberlé Crenshaw in 1989 to describe mutually reinforcing forms of social oppression related to race, class and gender. This novel thinking about identity as being situated at intersections rather than grounded in single categories has since become what some scholars have referred to as the most important insight to emerge from women's and gender studies in the past thirty years. Since its beginnings, this framework has travelled beyond women's and gender studies into many other academic disciplines, with little consensus on how it may be used. While intersectionality is commonly understood as an 'analytical sensitivity' that spotlights the mutually reinforcing nature of social inequalities grounded in gender, class, race, ability, and ethnicity (to name a few), an intersectional perspective also offers ways to foreground so-called 'critical inquiry,' which is what we pursue in this literature review (Collins, 2019). Grzanka et al. (2023) have also noted that although intersectionality is now a widespread framework for "understanding, critiquing, and intervening in complex social inequalities" that has travelled from women's studies to other disciplines, its potential remains underutilized in STS. Sharing similar social justice priorities, the concept of *Social License to Automate* allows us to focus on a diverse community of users and the social processes implicated in energy management. Power is critical to most social processes, and energy management is no exception. Intersectional approaches – which seek to combine gender with other axes of difference – have much to offer here. Intersectionality aims to go beyond single category analysis (gender *or* social class, for example) and instead aims to make visible the unique locations of individuals experiencing compounding marginalisations in what Collins (2019) refers to as the 'matrix of domination'. Translated into practical terms, we do not aim to suggest that DSM technologies must take into consideration each and every possible intersection of social identity. Rather, it is our aim to highlight the possible risk of DSM to reinforce inequalities or marginalization if intersectional thinking about social difference is not taken into account. In the context of energy consumption for example, an analysis based on the category of 'gender' alone may fail to account for the fact that 'women' is hardly a homogeneous category and that there are distinct

challenges that face different groups of women. Elderly women, for example, may be more often situated by social forces related to age, physical ability and reduced income levels due to loss of a partner. Intersectionality therefore "offers expertise in the study of power, one that is under-utilized yet applicable to many aspects of energy system design, planning, exchange, and use." (Bell et al., 2020).

Through this literature review, we aim to understand which perspectives are included in the literature on DSM and to what extent these perspectives reflect intersectional thinking. With these insights, different motivations and conditions for crossing the social license boundaries of legitimacy, credibility and trust might be identified and highlighted, allowing for the emergence of a more inclusive and tangible social license to automate. Only by recognizing these social issues can DSM scale up from resource man to a broader range of everyday users. Our review of the literature on DSM has therefore been carried out using intersectionality's complex thinking about social inequality. This framework allows us to gain insights into three key aspects of home energy consumption:

1. Gender Inequalities within the Household: We explore how flexible energy consumption is affected by gender disparities within households.
2. Power Dynamics in DSM Technology Development: We investigate the power imbalances that grant certain social groups a privileged position as initial users in the development of DSM technology.
3. Cumulative Burden on Marginalized Identities: Going beyond single-category thinking, we examine how individuals or households with multiple marginalized identities may face a greater burden when it comes to adapting to flexible energy consumption.

By adopting this analytical approach that foregrounds gender, power and marginalized identities, we move beyond traditional areas of research, such as those that analyze the experiences of tech-savvy, white, and privileged men as pilot users of DSM and aim to promote energy justice through the lens of recognition justice (Jenkins et al., 2016).

Intersectionality is now one of the most widely used frameworks for understanding social inequality; it therefore plays a crucial role in providing a more nuanced perspective on user experiences, needs, and opportunities within the context of social justice. This approach directs our attention to how program design, when informed by single category thinking, can inadvertently reinforce existing injustices and further marginalize already vulnerable groups during the transition to sustainable energy sources. When we examine the SLA concept through the lenses of intersectionality we expand the concept's scope to encompass fairness and justice as important dimensions of program development. This expansion enriches its utility as a tool to promote the democratization of energy systems. Furthermore, it allows us to consider how gender and other social inequalities may emerge and persist in relation to Demand-Side Management (DSM) and can inform program design aimed at mitigating such disparities.

Essentially, for an equitable transition to sustainable energy solutions that incorporate automation, we need an SLA in dialogue with intersectionality's critical inquiry to understand gendered dynamics and the experiences of women, but we also need more insight into the experiences of different kinds of women—those groups whose everyday realities are particularly susceptible to the unpredictable fluctuations in energy prices. It is this intersectional thinking that brings inequality and power to the forefront of the review process, giving us the possibility to critically revisit the existing literature on demand-side management (DSM) with a specific focus on narratives outside of those of the dominant group (e.g., the resource man). Lived experiences can then be considered as part of the pathways leading towards the three social license boundaries (legitimacy, credibility and trust), their possible crossing and translated into concrete recommendations.

## Methods of the review

In this review, we have used intersectional thinking to pursue complex rather than simplistic thinking about background variables like age, gender, and housing type in the context of DSM. We build from these insights to outline differing motivations and conditions for crossing the social license boundaries of legitimacy, credibility, and trust. In other words, we use intersectionality as a theoretical orientation and framework for examining interconnections and interdependencies between social categories and

systems (Atewologun, 2018). The approach of a narrative review was chosen to allow for an exploratory evaluation of the literature and to synthesize in-depth qualitative insights from a variety of perspectives and disciplines (Sovacool et al., 2018).

The review is conducted by an interdisciplinary group of researchers in collaboration within the User-Centred Energy Systems Technology Collaboration Programme under the auspices of the International Energy Agency. The first step was to identify relevant literature, and the researchers initially discussed potential issues in implementing automated DSM in relation to the more complex understanding of identity that intersectionality calls for (Schiebinger et al., (2011–2020)). Through these discussions, the search query was formulated, and the literature search carried out through the scientific databases W*eb of Science* and *Scopu*s between January and March 2023. We searched for articles in English published in peer-reviewed, scholarly journals and conference proceedings. We proceeded with search terms related to social categories that we hypothesized might experience marginalization in the DSM literature. We knew, for example, that gender, age, and income or economic status have been previously addressed in the literature, but we were also curious whether there were any papers on households with disabled users, minority groups and which possibly examined race as a factor in user acceptance. Our keyword search therefore left open the possibility to discover new intersections. Papers were therefore targeted for review if they contained empirical studies (both quantitative and qualitative) explicitly related to all three of the following topics:

- domestic energy consumption (search terms: energy OR electric*, household* OR home OR homes OR consumer* OR domestic)
- flexibility or DSM (search terms: "automated flexibility" OR "energy flexibility" OR "load management" OR "demand side management" OR "load control" OR "demand response" OR "smart home")
- potentially marginalized groups (search terms: gender OR woman OR women OR class OR "low income" OR socioeconomic OR poverty OR vulnerab* OR age OR "elderly people" OR "old people" OR "young people" OR disability* OR disabled OR intersectional* OR minority OR race OR racial OR ethnicity)

Papers were excluded if they i) focused on non-domestic sectors (industry, or individuals as employees), ii) concerned non-empirical results (e.g. modelling or theoretical work), iii) focused solely on technological solutions or demonstrations of technical solutions, and iv) did not include any analysis based on marginalized groups (only simple reporting of such groups in the context of sample description). After removing duplicates, the search produced 255 documents for initial screening outlined in the PRISMA (Page et al., 2021) flow diagram (see Fig. 1).

The second step was to screen the search results based on the abstracts. The selection of papers was done independently by the two first authors, who then compared selections and discussed deviations, agreeing on the final list. A close reading of these texts was conducted. The reading was guided by a pre-defined template, where the reader noted for example important aspects of the user/target group, methodology employed, geographical context, and type of flexibility studied. Most importantly for this review, the reader also isolated which marginalised groups and intersections where considered (e.g. female and low income, or age and high income, etc.), and which insights were produced regarding their experiences with DSM: willingness and ability to participate as well as potential consequences of doing so. In this second step of the analysis, we included papers that differed significantly in the extent to which intersectional perspectives or approaches were applied. Three levels could be seen: level one categorization was used to describe the least intersectional studies featuring analysis that simply described socio-demographic factors; level two was used for papers where marginalization and social inequality were theory-based and referenced in the background literature only; and level three was given to those where analysis of marginalized groups is theory-based and serves as the central focus of the paper's analysis. Table 1 (in appendix) gives an overview of the categorized articles by geographic context, methodology, perspectives, and analytical levels of intersectionality. This analysis yielded clusters of papers based on how the DSM literature had addressed gender, economic status and age. Within these analysis categories, we looked at the extent to which intersectionality came into play (Sect. 4.0). Our literature search confirmed that gender,

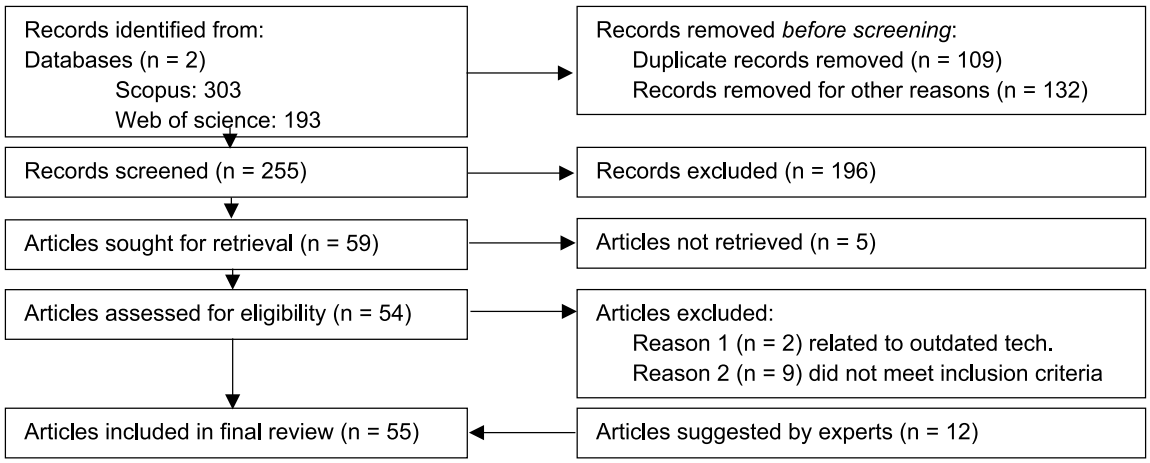


**Fig. 1** PRISMA flow diagram for the literature search and screening

age, and socio-economic status were indeed social categories covered in the literature – albeit in a way that primarily addresses them as single variables – and in addition, we found that there is a knowledge gap on DSM technology's use by persons living with disabilities and racialized minority groups.

In a third step, additional articles suggested by reviewers and commentators on the draft were incorporated and further analysis was carried out to uncover the nuances and themes related to each perspective, specifically focusing on the articles that had incorporated an intersectional thinking to the greatest extent. The implications with regards to the social license concept are considered throughout the analysis and recommendations building on these are discussed as part of the conclusions.

We did not define any geographical scope, however most papers were published in a western context including Europe, USA, and Australia. Additional studies carried out outside of a western context are also included (see Table 1 (in appendix)). The methods include both quantitative and qualitative but in general with a mix of qualitative approaches dominating those papers with some form of intersectional analysis. Surveys are most commonly used in papers that have engaged to a lesser degree with marginalised perspectives. This is unsurprising as qualitative research is most often used in intersectionality's aim to 'give voice' to such groups.

## Findings: gender, income, and age in the DSM world

The reviewed literature reveals that few articles have engaged with or sought out marginalized perspectives in an in-depth, qualitative manner in their analysis. Less than a third of the articles (17 out of 55) included detailed analysis focusing on marginalized groups and their experiences. The analysis revealed that three main perspectives have been considered in the literature: (1) gender, (2) economic capital, and (3) age. Out of these, most focus has been on gender. The following sections will present findings from the literature related to those three categories.

### Gendered narratives in DSM

Studies report that women may be more willing to engage with energy conservation behaviors and flexibility practices (Clancy & Roehr, 2003; Grünewald & Diakonova, 2020; Khalid & Razem, 2022), or at least more willing to follow through on their intention (Tjørring et al., 2018), than men. However, in practice, the realities of family life present create obstacles to such behaviors, including efforts undermined by other members (Johnson, 2020).

## Women, household labor and DSM disruption

In an early study of smart homes, Berg emphasized the intersection of technology as a masculine domain and the home as a feminine domain as the most compelling aspect of domestic technology (Berg, 1992). This dichotomy between the home as a feminine realm, where women are often responsible for energy-consuming housework, and the masculine realm of Demand Side Management (DSM) and Direct Load Control (DLC) as automated DSM, has been identified in several studies. Grünewald and Diakonova (2020) for example showed that women in high income families undertake most of the household chores that require energy while Elnakat and Gomez (2015) show that women regardless of income level in the household use more energy than men because they undertake more household chores. Finally, Mechlenborg and Gram-Hanssen (2022) demonstrated that monitoring PV output and other energy systems was almost always undertaken by men. These papers point to a pattern in who does the household labor and who adopts the role of controlling surveillant.

The installation of energy systems and monitoring done by technology-interested men often serves as a leisure activity for men but has consequences for the routine household tasks carried out by women in family households (Håkansson et al., 2022) and can lead to the reinforcement of traditional gender roles when technology interest is unequally distributed (Aagaard & Madsen, 2022). In addition, women, particularly mothers, tend to operate in an "always on" mode, resulting in a fragmented experience of time rather than distinct segments dedicated to work, family, and leisure, leaving less opportunity for the women to experiment with sustainability practices and technology on their own terms (Organo et al., 2013).

Furthermore, household labour is also related to gender difference in acceptance and responsivity to DSM. For example, the acceptance of automated DSM is higher for devices such as heat pumps and PV systems compared to appliances such as washing machines and dishwashers (Yilmaz et al., 2020). Households tend to prefer automation of appliances that do not disrupt their daily routine – disruptions which typically affect women more directly. Additionally, men tend to be more accepting of automated DSM for electric vehicles while women are more likely to reject it. Women generally required lower compensation to participate in the DR program than men respondents, suggesting that the latter might, from a relative perspective, care more about pricing while the former might be driven more by non-price factors (Srivastava et al., 2020).

A study of text message prompts for manual load shifting showed that men and women had similar intentions to engage but men carried out fewer shifting activities than women (Tjørring et al., 2018). Responsivity was higher when the person responsible for most of the household chores – typically the woman – was also the receiver of the prompts. Women were to a higher degree responsible for laundry and cleaning while cooking and dishwasher use were shared responsibilities with dishwasher use being shifted most often. The authors conclude that to use the full potential of load shifting it is important to consider chore division and interactions within households but also underline the risk of making flexibility 'women's work' through such a focus, while additionally reinforcing traditional gender roles. This would increase the risk that women produce value for the energy system through additional under-valued domestic labour (Johnson, 2020).

Practice theory suggests that energy peaks are bound up with family routines, and therefore have low possibility to be flexible (Nicholls & Strengers, 2015), but on the other hand, households with overlapping practices, shared perspectives and competencies use DSM technology more efficiently and build up new flexible practices together (Aagaard & Madsen, 2022; Mechlenborg & Gram-Hanssen, 2022).

Strengers et al. (2019) did point to three motivations regarding smart house protection, productivity and pleasure enhancements. Protection is a form for gendered caregiving, productivity is about making multi-tasking opportunities, and pleasure is about the playfulness.

The highlighted differences in engagement with DSM, impact of DSM on activities and access to relevant information point to an impact on legitimacy building as there is a need to consider different consequences on men's and women's lives in terms of demands for flexibility and different motivations, leading to differing benefit perceptions. Further, potentially more limited access to provided information due to DSM technology being perceived as a male domain, which regularly requires men to

function as intermediaries, is likely to negatively impact building credibility perception and trust for women.

### Resource men and their DSM man caves

The concept of the 'resource man,' refers the idealised subject of 'smart home' energy management technologies: "an individual who is technologically inclined, information-oriented, and economically rational when it comes to smart utopia consumption" (Strengers, 2014, p. 36). Strengers calls our attention to the way the resource man's identity is created: "Resource Man is a male, not because he is always directly identified as one, but because he is cast in the image of the male-dominated industries of engineering and economics that permeate energy management. Moreover, visions of him exclude much of the productive work of the home, which is still carried out by women" (Strengers, 2014, p. 26). This individual, often a man, exhibits a keen interest in his energy data and dedicates time to optimizing energy usage. PV providers often assume that their customers are knowledgeable males, addressing them directly and expecting limited knowledge from women (Håkansson et al., 2022).

In 2022, Strengers and colleagues moved from critique to intervention, conducting a large-scale project with energy network (DNSP) and government partners. This in-depth ethnographic study of Australian households explored, among other things, spaces where different forms of masculinity are performed. "Man caves" were discovered in some of their participating households, serving as a refuge for men in contrast to the feminine domestic sphere comprising the rest of the house. These man caves, often located in sheds, emerged as essential spaces for personal withdrawal, creative pursuits, and activities like device charging. Strengers and colleagues (2019, 2022) emphasize the relevance of these man caves as important areas for "digital housekeeping," as described by Tolmie et al. (2007). They also highlight the potential for including these spaces in energy efficiency efforts and promoting sustainable practices. The man cave is also often connected virtually to broader internet communities (forums of heat pump knowledge exchange, for example) where public peer discourse becomes a key part of legitimating technologies (Hyysalo & Juntunen, 2024).

Men caves and the digital communities surrounding them are likely to come with increased information access, feelings of connectedness and shared interests and goals, bringing the chance of increased credibility, perception and trust building with respect to sustainable energy transitions.

### The masculinity bias of DSM

It is important to challenge ingrained gendered assumptions surrounding active home design and operation, where technology is often considered a masculine-coded artifact best operated by experts outside the feminine context of the home (Shirani et al., 2022). This is exemplified by technologies like PV, which are often viewed as being in alignment with traditional masculinity, associated with masculine approaches to homemaking and considered forms of self-expression and status symbols (Håkansson et al., 2022; Mechlenborg & Gram-Hanssen, 2022; Standal et al., 2020). A study from Portugal on PV imaginaries sheds further light on two imaginaries of masculinity associated with PV. The first, referred to as the ecomodernist masculinity imaginary, is rooted in notions such as power and control over nature and people through technology and market forces. This contrasts with the ecological masculinity perspective, which challenges the current global economic and political reliance on extensive exploitation of nature. In contrast to the ecomodernist imaginary, ecological masculinity values care practices and collective responsibilities in addressing environmental issues (Scharnigg & Martin, 2024).

To address these gender biases researchers recommend engaging female consumers in a more targeted manner, considering their often more impactful role in household energy consumption (Elnakat & Gomez, 2015). Engaging female consumers would include practices like creating brands that directly speak to women and equipping devices with features and settings that better align with their needs and priorities. Additionally, incorporating feedback mechanisms with a stronger emotional tone that is encouraging and rewarding can help improve women's engagement (Elnakat & Gomez, 2015).

To tackle the masculinity bias of DSM, some suggest expanding the communicated reasons to purchase PV technology beyond economic advantages

(Håkansson et al., 2022). By highlighting benefits such as self-sufficiency, resiliency, and environmental considerations, a broader audience, including women, may be attracted to PV adoption. It is also important to make visible customer journeys and narratives that do not rely on existing in-depth technical knowledge, offering different starting points for purchase intentions, such as larger retrofitting projects or the purchase of electric vehicles (Håkansson et al., 2022).

The masculinity bias of DSM technology carries the risk of building legitimacy that gives more consideration to motives most often found among men aligned with traditional ideals of masculinity. Technology aimed at male customers will again support credibility and trust building among men while simultaneously rendering access for women more difficult.

*Economic capital and DSM*

Literature analyzing preferences for automated DSM in Switzerland suggests that preferences are quite heterogeneous and vary by socio-demographic and household characteristics, as well as by technology. Employment status, presence of children, gender, and age were significant factors for accepting the automation of their appliances by a grid operator (e.g., washing machines, EVs, dishwasher) which are more linked to activities and daily routines. Dwelling type and education level were a significant factor for specific devices such as PV, heat pumps and batteries (Yilmaz et al., 2020). These findings emphasize the diversity of DSR preferences, suggesting that perceived control and socio-technical dynamics play a crucial role in achieving high participation in such programs.

*Accessing low-income DSM*

As we have seen, the resource man is an economically privileged subject, so it is unsurprising that DSM designed with this particular subject in mind omits many hard-to-reach consumers. Demand-side management was highlighted as a way for people who are limited in their conservation possibilities to participate in the energy transition by shifting loads rather than reducing them overall but while still contributing and accessing the possibility of savings. But load shifting also risks putting pressure on low-income households to carry out manually what high-income households pass on to smart energy management systems in the home. Additionally, manual load shifting excludes them from participation in smart home systems, creating a risk of "being too poor to access the cheapest electricity" (Johnson, 2020). On this particular topic we see that income intersects with gender as the need for manual load shifting asks women as the primary domestic laborer to become "flexibility women" (as opposed to the more privileged "resource man" from 4.1.2). Therefore, to get low-income households on board with DSM, it is important that they have access to affordable DSM technology (Crawley et al., 2021; Ponce de Leon Barido et al., 2018).

Access to energy information had more impact than cash when incentivizing flexible demands for low and low-middle income communities in Latin America. This kind of intervention reduces energy consumption, but temporal and financial resource scarcity at household level formed a barrier for scaling up (Ponce de Leon Barido et al., 2018). Without access to affordable technology or information and conditions that allow sufficient response, legitimacy building may be considered difficult as access to benefits would be largely denied.

The acceptance of device-specific automated DSM is influenced by other factors that tend to be associated with income, such as dwelling type, ownership, and education level (Yilmaz et al., 2020). For example, people who live in houses and own their homes are less likely to accept the automation of their devices and appliances, possibly due to a greater sense of control over their own systems.

*Energy poverty and the question of flexibility capital*

There is a lack of knowledge regarding the interplay of energy poverty and DSM. At present, mainly single aspects supporting DSM have been analyzed. The perception of smart home technologies as depending on income levels has been researched by Sovacool et al. (2021) and reveals no differences among income levels. Studies from the U.S. find that engagement of low-income households in energy efficiency programs is 10.2% lower compared to medium- and high-income households, and that accessibility and affordability are the main barriers (Xu & Chen, 2019). Smart meter adoption has also been found to be 8.8% lower for low-income compared to high-income

groups. However, these studies rely on a purely quantitative assessment of energy poverty using a narrow definition with set income limits, only one factor in the complex situation of energy-poor households. On the other hand, energy poverty can be more comprehensively understood by including aspects such as health, household size and composition. For example, people with health conditions show less potential for DSM since their energy consumption must cover more core needs. The same applies for multi-person households due to higher social constraints (Calver & Simcock, 2021). The elderly in particular often face more health challenges making visible an intersecting vulnerability with age and income level. Two-income households had greater energy use per capita than in households where the female partner did not work or where they were comprised of a working woman living alone (Clancy & Roehr, 2003, p. 46).

When introducing their concept *flexibility capital,* Powells and Fell (2019) show that affluent households can derive their flexibility from ownership of technology such as batteries and smart appliances that can directly afford them flexibility and large loads to shift, while less affluent households have to rely on changes of routines to be flexible. This also means that affluent households minimize the impact of flexibility on their comfort and convenience and have the freedom to do so on their own terms, while "the less affluent are subject to a greater financial pressure as to when and how to economize their flexibility" (Powells & Fell, 2019, p. 57). Von Platten (2022) used national survey data from Sweden when prices peaked across Europe at the end of 2021 to capture energy vulnerability. Her study finds that low flexibility capital increases the risk for negative financial effects of energy poverty. She also finds that high flexibility capital increases the risk of other effects of energy poverty, such as loss of comfort, convenience and well-being, for example when not all rooms in a home are heated. Ribó-Pérez et al. (2021) calculated flexibility differences in relation to different consumer types, which were defined based on income and regional criteria for households in Spain. With regards to flexibility, the authors differentiated between shiftable loads (manual or automated) such as dishwashers, and thermostatically controlled loads that operate within a temperature range and do not affect the comfort levels of consumers. Results show winter to be the least flexible period due to heating requirements, spring as particularly flexible and summer as holding high power-up capacities in the form of cooling technologies. The households of high-income consumers were typically better equipped regarding both types of loads and due to occupants spending less time at home, flexibility windows were also wider. The reduced availability of flexibility-providing technology in lower-income households is therefore a limiting factor and pushes the affected groups to the margins or outside of participation opportunities offered by flexibility services. Based on these results the authors underline the importance of finding inclusion opportunities for consumers of socioeconomically disadvantaged consumer groups for a just energy transition and to avoid designing incentivization strategies that only reach high-income, high flexibility consumers.

These results underline as well that the core barrier for low-income consumers is the legitimacy barrier, the need to ensure their ability to participate at all, enabling them to benefit from DSM. The most salient hurdle here is access.

### Age, flexibility and income

In the literature we reviewed, the elderly were identified as a vulnerable group when it comes to DSM (Barnicoat & Danson, 2015; White & Sintov, 2020). Households composed of elderly peoples disproportionately occupy the high flexibility low-income quadrant of Fell and Powell's (2019) grid that illustrates the interactions between flexibility capital and financial resources. On the one hand, asset rich, income-poor retirees have the time and motivation to pursue DSM opportunities. On the other hand, they have reservations about using demand management technologies to optimize their efficiency and relieve pressure on the grid. For example, Yilmaz et al. (2019) shows that the willingness to shift electricity consumption to the middle of the day (11 am to 3 pm) is higher in households with a responsible person aged over 65. Another study finds four distinct groups of people with regards to their interest in DR schemes, with increasing age being a significant predictor for higher interest. Ecological and social motives (e.g., strong sense of community) for participating in DR were found to exceed financial motivation (Schöne et al., 2022). Another study from Sweden finds that individuals who prioritize cost considerations and regularly review their bills demonstrate a better ability to

comprehend the signal. Furthermore, it's not particularly surprising that those who frequently read their bills tend to be male, older, and residing in villas (El Gohary et al., 2023).

With regards to elderly consumers, overcoming the legitimacy barrier might therefore require highlighting other benefits than financial advantages more strongly while the credibility barrier seems to pose a specific challenge with regards to reaching and building trusted communication with this consumer group.

*The 'young and flexible' narrative*

Younger respondents had a high interest and willingness to manage electricity demand at home, but with limited flexibility even if higher savings could be achieved. Students and young people are not typically perceived as vulnerable to energy poverty (Ferreira et al., 2018). However, Bouzarovski et al (2013) discovered that students who engaged in flat-sharing and rented accommodations often experienced temperatures as low as 15.8°C, below what is considered an acceptable standard. This study highlights that this group does indeed encounter fuel poverty due to the high cost of heating. At the same time the student narrative revolves around the idea of being free and flexible to pursue individual choices (Kousis et al., 2020). This narrative aligns with discussions about flexibility. A student's freedom at the individual level is contrasted by the constraints they face in their daily activities, which are interconnected with their communal living arrangements. Here, societal temporal rhythms and material factors impose inflexibility and when there are strong economic incentives for flexibility, the student may paradoxically be confronted with reduced flexibility, giving rise to a phenomenon termed "flexibility poverty" (Fjellså et al., 2021a, 2021b; Fjellså et al., 2021a, 2021b).

Building a social license with younger consumers might therefore, similarly to low-income groups, may fail to cross the legitimacy barrier if there is no access to DSM technology and there is insufficient temporal flexibility.

## Discussion: How can the social license to automat address DSM barriers by using intersectionality?

The social license to automate concept highlights three key boundaries: legitimacy for acceptance, credibility for approval, and trust for psychological identification with the DSM (Adams et al., 2021). Adding insight from intersectionality brings the context around these three key barriers into better focus, and we see that questions around legitimacy, credibility and trust may be more effectively addressed by research that sees DSM entangled with household dynamics and power (who carries out domestic tasks and who surveils them), and complex social identities as they concern both privilege and disadvantage. In other words, the social license to automate is not just about one individual's legitimacy but rather about gaining credibility and trust more widely from the entire household and wider society with its diverse groups of users.

Our methodology in this review has been driven by a commitment to broaden the understanding of the domain of DSM and to map out the extent to which marginalized voices have been taken into consideration in developing solutions that do not reinforce existing social inequalities. As a result, we initially employed multiple categories to identify relevant literature on DSM. However, our findings indicate that existing DSM literature predominantly focuses on certain demographic groups, such as men, high-income households, and middle-aged individuals in addition to the more restricted number of counter studies that concern gender, age and economic status that are mentioned above. We will use the next section to discuss how the SLA 2.0 with the help of intersectionality can aid us in lifting other imaginaries and values than the ones that have traditionally dominated DSM technology development. Some examples of this include values that address collaboration, diversity and equality in the everyday domestic energy lives of people (Pink et al., 2023). Such values can be helpful for designers to actively use to open up their own biases concerning how they frame the user and what role automation has in the DSM project (Verkade & Hoffken, 2018).

### DSM barrier #1: Gender inequalities within the household

We have explored how flexible energy consumption is affected by disparities within households concerning the gendered nature of household work. As the literature review shows, men's experiences and perspectives are overrepresented while women's experiences have been underrepresented in the field of DSM. We wonder in addition: are there other domestic experiences and perspectives that have not been adequately taken into consideration? By using SLA and the lens of intersectionality, we acknowledge that our western knowledge production, when it comes DSM, shows that the industry is still gender biased, and that when male consumers are taken as the unmarked, neutral subject, we miss the opportunity to gain the approval of and build legitimacy within the household as a whole.

### DSM barrier #2: Power dynamics in DSM technology development

Economic situation, technical affinity, gender and age all influence who can participate in DSM adoption and how flexibility work is distributed. Ethical considerations also emerge when DSM technology risks being used as a tool for control of household resources. In extreme cases, it may be used to support abusive situations within the home (Bowles, 2018; Nicholls et al., 2020), highlighting the need for third-party oversight. This underscores the importance of examining these technologies through the social license to automate concept in order to understand their broader social impacts and ensure equitable access.

### DSM barrier #3: Marginalized groups

Social license to automate is ideally about gaining credibility and trust from the entire household and wider society, including members of groups who are marginalized with respect to the procuration and use of DSM technology. As we saw in our literature review, there exists a distinct gap in the published research on flexibility technology, particularly concerning marginalized groups. These groups often encounter barriers related to accessibility, including language, sight, hearing, and finger sensitivity, as well as affordability.

The inclusion of a diverse social landscape—where class, race, age, ability, marital status, religion, ethnicity, and global location are potentially included – is missing in the DSM literature. Only with consideration of a broader social landscape will benefits be created and legitimacy built for the widest span of potential users. Further, the assurance of accessibility is key to creating credibility and further trust. Without paths of communication there is no flow of information, no proof of accountability, no dialogue that can establish collaboration.

## Conclusions: social license to automate

This review uncovers a scarcity of studies addressing DSM in relation to social factors and the ways in which household social dynamics influence consumer energy behaviour and its potential for adaptability. We also show that, although many studies point out that gender, income, and age have an impact on the flexibility of energy consumption by impacting daily practices and material design such as DSM equipment, only a small number have approached this in a theory-based, in-depth, qualitative manner that goes beyond simply differentiating results according to demographics and "genuinely give voice to lived experiences".

We enhance this line of research by scrutinizing published studies on automated energy systems and the ways in which end-users interact with them. Additionally, we propose moving beyond mere critical reflection and advocate for employing intersectionality to expand and practically apply the concept of social license to automate. While the social license to automate has been focused on understanding the (mis)alignments between the expectations of actors with the energy system on one hand and the everyday life of households on the other (Adams et al., 2021), our review takes this concept a step further by focusing on who we bring together in pilot testing and research on flexibility, and how we do it. Putting intersectionality into dialogue with social license to automate shows the need for automated DSM program designers to acknowledge power relations and context. This means designing in such a way as to

acknowledge the ways in which material and non-material resources (e.g. digital alienation, everyday life routines, gender inequality not as single variables but interconnected) work to form systematic differences in access and knowledge to DSM solutions.

To build legitimacy with all user groups, designers need to take a closer look at consumers' varying motivations and the lived realities in households: who carries which loads, who can access which type of flexibility under which conditions and which of their needs DSM can meet. Only with such an expansion of perspective can consumers beyond the typical, male, technology-afficionado and well-to do user group be reached and included. To achieve credibility, accessibility needs to be considered much more carefully, in medium, in language, in framing, and with the involvement of middle actors that can support the flow of communication to groups that are harder to reach. Finally, to establish trust, these communication pathways need to be solidified, the true involvement of diverse user groups needs to be made possible and inviting, ensuring that marginalized voices are heard and given weight. The concept of the social license to automate can therefore be applied by developers of DSM by reflecting critically upon question like:

- What kind of end-user do we include in pilots? Do we have variety across end-users from different socioeconomical backgrounds, social classes, gender, ages, etc.?
- What other kinds of business models or incentivization are possible or needed, beyond the economic rationale aimed at the resource man, to motivate a broad group of people to sign up for (automated) DSM products? What kind of imaginaries are at play when making the product? Who are we making the product for? What is their age and gender? What kind of education and interests do they have? What does everyday life including both chores and leisure activities look like? How can we broaden our imaginaries of end-users? Can technology be imagined as a disrupter of social inequality? For example, serving two potential purposes, load shifting and reducing burden?
- Which conditions do we assume as given for users to be able to use this technology? Who is excluded and what can be done to enable them access? Which needs can technology fulfill in these currently excluded user groups and what does this mean for the solutions to be developed that enable their inclusion?
- Which pathways and frames of communication are we currently using when we reach out to end-users? How do they hold up if we are considering different barriers related to gender, age, income, class, able-bodiedness, language, etc. What needs to be done and whose help do we need to bridge the communication gaps to user groups outside of the communication used today?
- And finally: Are we not just communicating to but listening to everyone? Are we aligning the transition we are supporting with the transition these different groups of consumers need? Are we ensuring continuous involvement and interaction in order to encourage identification and an experience of ownership?

Including social inequality, class, and gender in R&D projects for DSM will not only give project proponents a competitive advantage, but we argue it to be absolutely necessary to scale DSM beyond the scattering of pilots and technology-specific programs to the centerpiece of energy policy. This inclusion cannot be an afterthought. Users, rather than the grid, must be the starting point of DSM solution design. Such a shift and the associated changes of design and framing of solutions have the potential to open up access for less technology-savvy users and enable user-level connection with solutions through personal tasks and experiences. This opening of access would allow for greater transparency regarding personal impact and a conversation on equal footing. The results further show that to enable participation of the energy-poor, their needs and limitations should be integrated from the beginning into program design, finding ways to avoid disadvantaging and enabling benefits for users with little flexibility to offer and little to invest on their own.

## Future research and limitations

More research is needed that acknowledges the complex social inequalities potentially involved in the conception and implementation of design-side management. By incorporating intersectionality into research design, knowledge production can build on the experiences of typically underrepresented groups such as ethnic minorities, indigenous communities,

the elderly, and individuals with disabilities – to name a few. More research is needed on the entanglements and intersections of vulnerable groups. By acknowledging certain marginalized groups, and going beyond single-category analysis alone, the SLA concept – supporting the active building of legitimacy, credibility and trust – can further extend the social justice aim of intersectionality, supporting not only a sustainable but also a socially just energy transition.

We also note that this literature search may have limitations related to the limited number of databases used (Web of Science and Scopus), the number of search terms, and the language of these terms. For example, we limited our search to English language keywords, which favors research literature emerging from an Anglo-American context. We will undoubtedly have missed a number of local studies written in languages other than English.

Energy policy recommendations

The cutting-edge concept of social license to automate, applied with an intersectional lens, provides a more comprehensive understanding of energy consumption conditions for end-users. By recognizing the deep integration of energy consumption flexibility into societal structures and culture, and using the concept from the outset when developing DSM programs, it becomes possible to unlock the full potential of consumer flexibility. We do draw the following policy recommendations from the review, the concept of SLA and the acknowledgment that intersectionality has much to contribute to the field of DSM.

Researchers, businesses, and governmental bodies must understand that their technologies are not socially neutral. Therefore, they must integrate strategies to address the injustices.

- By considering the constraints and requirements of the energy-poor population early in the design phase, energy programs need to develop participation options than are available to low-income households that can enable participation of a wider range of consumers, increasing their effectiveness and ensuring that benefits reach also reach vulnerable consumers with limited resources.
- Accessibility is a key element of scaling. More effort needs to be put into ensuring that both the concept of demand side management and the benefits it can provide are successfully communicated in accessible framings and channels to different user groups, involving middle actors and rooting the communication in everyday experiences of end users in order to facilitate the involvement of hard-to-reach groups and allow for low-threshold access.
- Collaborative frameworks should be established that allow for the continued involvement of diverse users including members of marginalized communities, ensuring that their voices are heard, and decisions can be reached collaboratively, and trust is built.
- All these above should be supported by long-term policies that ensure continuity and provide a reliable base for implemented measures that ensure longevity of built trust in the ongoing energy transition

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**Declarations**

**Conflict of interest** No conflict of interest.

## Appendix

**Table 1** Further analysis of relevant articles based on geographic context of the study conducted, methodology, perspectives covered, and the analytical complexity of intersectionality:

| Citation | Context | Methodology | Perspectives covered | Analysis Level |
|---|---|---|---|---|
| Aagaard & Madsen, 2022 | Denmark | Interviews & Home visits | Gender, Technological affinity | Level 3 |
| Barnicoat & Danson, 2015 | UK | Interviews | Age (older users), Income, Location (rural) | Level 3 |
| Crawley et al., 2021 | UK | Secondary analysis of data from trials | Income (low) | Level 3 |
| Elnakat & Gomez, 2015 | USA | Survey | Gender, Income, Education | Level 3 |
| Fjellså et al, 2021 | Norway | Interviews | Age | Level 3 |
| Grünewald & Diakonova, 2020 | UK | Activity tracking, Survey | Gender | Level 3 |
| Håkansson et al., 2022 | Sweden | Interviews | Gender, Income | Level 3 |
| Johnson, 2020 | UK | Pilot | Gender | Level 3 |
| Khalid & Razem, 2022 | Pakistan, Jordan | Interviews | Gender, Income (middle) | Level 3 |
| Mechlenborg & Gram-Hanssen, 2022 | Denmark | interviews | Gender | Level 3 |
| Organo et al., 2013 | Australia | Mixed method household study | Gender, Class | Level 3 |
| Scharnigg & Martin, 2024 | Portugal | Texts, Observation, Interviews | Gender, Income | Level 3 |
| Shirani et al., 2022 | UK | Interviews | Gender, Age | Level 3 |
| Standal et al., 2020 | Norway & UK | Interviews | Age, Income, Gender, Location (urban/rural) | Level 3 |
| Strengers et al., 2019 | Australia | Digital ethnography | Gender, Early adopters | Level 3 |
| Tjørring et al., 2018 | Denmark | Pilot | Gender, age | Level 3 |
| White & Sintov, 2020 | US | Survey | Disability, Ethnicity, Income | Level 3 |
| Brell et al., 2019 | Germany | Survey | Gender, Education, Area of living, Dwelling type | Level 2 |
| Sen & Qiu, 2022 | USA | Survey | Housing tenure, Income, Household composition, Education, Gender | Level 2 |
| Strengers et al., 2022 | Australia | Mixed method household study | Gender | Level 2 |
| Von Platten, 2022 | Sweden | Survey | Gender, Age, Income | Level 2 |
| Anker-Nilssen, 2003 | Norway | Survey | Income, Gender, Age, Education, Dwelling type, Ownership (car, holiday home) | Level 1 |
| Balta-Ozkan et al. 2014 | UK, Germany, Italy | Workshop | Age, Income | Level 1 |
| Bouzarovski, 2013 | UK | Survey & interviews | Income, Age, | Level 1 |
| Broberg & Persson, 2015 | Sweden | Survey (WTP) | Gender, Age, Income, Dwelling type, Family composition | Level 1 |
| Bugden & Stedman, 2019 | USA | Survey | Age, Education, Gender, Income | Level 1 |
| Bwalya Umar et al., 2022 | Zambia | Survey | Income, Location | Level 1 |
| Curtis et al., 2020 | Ireland | Survey | Gender, Age, Income, Education, Employment status, Household composition | Level 1 |
| El Gohary et al., 2023 | Sweden | Survey | Age, Gender, Education | Level 1 |

**Table 1** (continued)

| | | | | |
|---|---|---|---|---|
| Faruqui et al., 2013 | USA | Pilot | Income (low) | Level 1 |
| Ferreira et al., 2018 | Portugal | Survey | Gender, Age, Education, Household composition | Level 1 |
| Jang et al., 2021 | South Korea | Interview & Survey | Income | level 1 |
| Jang et al., 2022 | South Korea | Survey | Household composition, Income, Education, Age, Gender | Level 1 |
| Jin & Zhang, 2013 | China | Survey | Income | Level 1 |
| Khalid et al., 2019 | Denmark, Pakistan | Interviews | National culture, Income (middle) | Level 1 |
| Kousis et al., 2020 | Europe | Survey | Age, Income (low) | Level 1 |
| Nicholls & Strengers, 2015 | Australia | Interviews & Survey | Age, Income, Gender | Level 1 |
| Ohler et al., 2022 | USA | Survey | Income | Level 1 |
| Parag & Butbul, 2017 | Israel | Survey | Gender, Income | Level 1 |
| Pesantez et al., 2023 | USA | Survey | Household composition, Income, Education, Age | Level 1 |
| Ponce de Leon Barido et al., 2018 | Nicaragua | Survey, Interviews, Interventions in households | Income (low, low-middle), Age, Education, Gender, Ownership | Level 1 |
| Ribo-Perez et al., 2021 | Spain | Survey | Income, Household composition, Location | Level 1 |
| Schöne et al., 2022 | Mayotte (France) | Survey | Age, Gender, Employment status, Location, Household composition, Income, Dwelling type | Level 1 |
| Sovacool et al., 2021 | UK | Survey, Focus groups | Income, Age, Gender | Level 1 |
| Sridhar et al., 2023 | Finland | Survey (DCE) | Gender, Age, Education, Dwelling type, Household composition, Income | Level 1 |
| Srivastava et al., 2020 | Belgium | Survey (DCE) | Age, Gender, Income, Education, Dwelling type, Household composition, Housing tenure | Level 1 |
| Srivastava et al., 2021 | India | Survey (DCE) | Age, Gender, Income, Education, Dwelling type, Household composition, Housing tenure | Level 1 |
| Strielkowski et al., 2022 | Russia, Czechia, Germany, Poland, Slovakia | Survey | Age, Gender, Income, Education, Dwelling size | Level 1 |
| Trotta et al., 2020 | Denmark | Register data | Household composition (single), Age (older), Income (low), Dwelling type (detached housing) | Level 1 |
| Vassileva et al., 2013 | Sweden | Survey, Pilot | Income (low and high) | Level 1 |
| Xu & Chen, 2019 | US | Secondary data analysis | Income (low) | Level 1 |
| Yilmaz et al., 2019 | Switzerland | Field experiment | Housing tenure, Age, Education, Household composition | Level 1 |
| Yilmaz et al., 2020 | Switzerland | Survey | Housing tenure, Age, Gender, Employment, Education, Household composition | Level 1 |
| Yilmaz et al., 2022 | Switzerland | Survey | Age, Gender, Employment status, Household composition, Income, Dwelling type, Housing tenure | Level 1 |
| Yoo et al., 2020 | South Korea | Survey | Income, Gender, Age, Education, Household composition | Level 1 |

Level 1: Articles that primarily described the socio-demographic factors of informants

Level 2: Articles where marginalization and social inequality were theory-based but referenced only in the background literature

Level 3: Articles where the analysis of marginalized groups was theory-based and formed the central focus of the paper's analysis

References marked in blue indicate articles that were analyzed but not referred to in the main body of the paper and hence do not appear in the reference list. These references are consolidated in the list below

Anker-Nilssen, P. (2003). Household energy use and the environment—a conflicting issue. Applied Energy, 76(1–3), 189–196. 10.1016/S0306-2619(03)00056–4

Balta-Ozkan, N., B. Boteler, and O. Amerighi. "European Smart Home Market Development: Public Views on Technical and Economic Aspects across the United Kingdom, Germany and Italy." *Energy Research and Social Science* 3, no. C (2014): 65–77. 10.1016/j.erss.2014.07.007

Brell, T., Biermann, H., Philipsen, R., & Ziefle, M. (2019). Trust in Autonomous Technologies. In A. Moallem (Ed.), HCI for Cybersecurity, Privacy and Trust (pp. 371–384). Springer International Publishing. 10.1007/978–3–030–22351-9_25

Broberg, T., and L. Persson. "Is Our Everyday Comfort for Sale? Preferences for Demand Management on the Electricity Market." Energy Economics 54 (2016): 24–32. 10.1016/j.eneco.2015.11.005

Bugden, D., and R. Stedman. "A Synthetic View of Acceptance and Engagement with Smart Meters in the United States." *Energy Research and Social Science* 47 (2019): 137–45. 10.1016/j.erss.2018.08.025

Bwalya Umar, B., M.N. Chisola, B.M. Mushili, C.F. Kunda-Wamuwi, D. Kafwamba, G. Membele, and E.N.S. Imasiku. "Load-Shedding in Kitwe, Zambia: Effects and Implications on Household and Local Economies." Development Southern Africa 39, no. 3 (2022): 354–71. 10.1080/0376835X.2020.1870934

Curtis, J., G. Grilli, W. Brazil, and J. Harold. "Why Do Preferences for Electricity Services Differ? Domestic Appliance Curtailment Contracts in Ireland." *Energy Research and Social Science* 69 (2020). 10.1016/j.erss.2020.101705

Faruqui, A, S Sergici, and L Akaba. "Dynamic Pricing of Electricity for Residential Customers: The Evidence from Michigan." Energy Efficiency 6, no. 3 (August 2013): 571–84. 10.1007/s12053-013–9192-z

Jang, M., Jeong, H. C., Kim, T., Chun, H. M., & Joo, S. K. (2022). Analysis of residential consumers' attitudes toward electricity tariff and preferences for time-of-use tariff in Korea. *IEEE Access*, *10*, 26,965–26,973

Jang, M., Jeong, H. C., Kim, T., Suh, D. H., & Joo, S. K. (2021). Empirical analysis of the impact of COVID-19 social distancing on residential electricity consumption based on demographic characteristics and load shape. *Energies*, *14*(22), 7523. 10.3390/en14227523

Jin, Y., & Zhang, S. (2013). Elasticity estimates of urban resident demand for electricity: a case study in Beijing. *Energy & environment*, *24*(7–8), 1229–1248. 10.1260/0958-305X.24.7–8.122

Khalid, R., Christensen, T. H., Gram-Hanssen, K., & Friis, F. (2019). Time-shifting laundry practices in a smart grid perspective: a cross-cultural analysis of Pakistani and Danish middle-class households. *Energy Efficiency*, *12*(7), 1691–1706

Parag, Y., & Butbul, G. (2018). Flexiwatts and seamless technology: Public perceptions of demand flexibility through smart home technology. *Energy Research & Social Science*, *39*, 177–191. 10.1016/j.erss.2017.10.012

Pesantez, J. E., Wackerman, G. E., & Stillwell, A. S. (2023). Analysis of single-and multi-family residential electricity consumption in a large urban environment: Evidence from Chicago, IL. *Sustainable Cities and Society*, *88*, 104,250. 10.1016/j.scs.2022.104250

Sen, A., & Qiu, Y. (2020). Aggregate Household Behavior in Heating and Cooling Control Strategy and Energy-Efficient Appliance Adoption. IEEE Transactions on Engineering Management, 69(3), 682–696. 10.1109/TEM.2020.2974377

Sridhar, A., S. Honkapuro, F. Ruiz, J. Stoklasa, S. Annala, A. Wolff, and A. Rautiainen. "Residential Consumer Preferences to Demand Response: Analysis of Different Motivators to Enroll in Direct Load Control Demand Response." *Energy Policy* 173 (2023). 10.1016/j.enpol.2023.113420

Srivastava, A, S Van Passel, R Kessels, P Valkering, and E Laes. "Reducing Winter Peaks in Electricity Consumption: A Choice Experiment to Structure Demand Response Programs." Energy Policy 137 (February 2020). 10.1016/j.enpol.2019.111183

Strielkowski, W., Kovaleva, O., & Efimtseva, T. (2022). Impacts of digital technologies for the provision of energy market services on the safety of residents and consumers. *Sustainability*, *14*(5), 2934. 10.3390/su14052934

Yilmaz, S, C Chanez, P Cuony, and MK Patel. "Analysing Utility-Based Direct Load Control Programmes for Heat Pumps and Electric Vehicles Considering Customer Segmentation." *Energy Policy* 164 (May 2022). 10.1016/j.enpol.2022.112900

Trotta, G., Gram-Hanssen, K., & Lykke Jørgensen, P. (2020). Heterogeneity of electricity consumption patterns in vulnerable households. *Energies*, *13*(18), 4713. 10.3390/en13184713

Yoo, S., Eom, J., & Han, I. (2020). Factors driving consumer involvement in energy consumption and energy-efficient purchasing behavior: evidence from Korean residential buildings. *Sustainability*, *12*(14), 5573. 10.3390/su12145573

Vassileva, I., Dahlquist, E., Wallin, F., & Campillo, J. (2013). Energy consumption feedback devices' impact evaluation on domestic energy use. *Applied energy*, *106*, 314–320. 10.1016/j.apenergy.2013.01.059

## References

Aagaard, L. K., & Madsen, L. V. (2022). Technological fascination and reluctance: Gendered practices in the smart home. *Buildings and Cities, 3*(1), 677. https://doi.org/10.5334/bc.205

Adams, S., Kuch, D., Diamond, L., Fröhlich, P., Henriksen, I. M., Katzeff, C., Ryghaug, M., & Yilmaz, S. (2021). Social license to automate: A critical review of emerging approaches to electricity demand management. *Energy Research & Social Science, 80*, 102210. https://doi.org/10.1016/j.erss.2021.102210

Atewologun, D. (2018). Intersectionality theory and practice. *Oxford research encyclopedia of business and management*, 1–20.

Ballo, I. F. (2015). Imagining energy futures: Sociotechnical imaginaries of the future Smart Grid in Norway. *Energy Research & Social Science, 9*, 9–20. https://doi.org/10.1016/j.erss.2015.08.015

Barnicoat, G., & Danson, M. (2015). The ageing population and smart metering: A field study of householders' attitudes and behaviours towards energy use in Scotland. *Energy Research & Social Science, 9*, 107–115.

Bell, S. E., Daggett, C., & Labuski, C. (2020). Toward feminist energy systems: Why adding women and solar panels is not enough☆. *Energy Research & Social Science, 68*, 101557. https://doi.org/10.1016/j.erss.2020.101557

Berg, A.-J. (1992). *The smart house as a gendered socio-technical construction*. Centre for Technology and Society, University of Trondheim.

Boutilier, R. (2011). *G & Thompson, I.* Fruits of a dialogue between theory and practice. Shinglespit Consultants Inc.

Bouzarovski, S., Petrova, S., Kitching, M., & Baldwick, J. (2013). Precarious domesticities: energy vulnerability among urban young adults. *Energy justice in a changing climate: Social equity and low-carbon energy*, 30–45.

Calver, P., & Simcock, N. (2021). Demand response and energy justice: A critical overview of ethical risks and opportunities within digital, decentralised, and decarbonised futures. *Energy Policy, 151*, 112198. https://doi.org/10.1016/j.enpol.2021.112198

Clancy, J., & Roehr, U. (2003). Gender and energy: Is there a Northern perspective? *Energy for Sustainable Development, 7*(3), 44–49.

Collins, P. H. (2019). *Intersectionality as critical social theory*. Duke University Press.

Crawley, J., Johnson, C., Calver, P., & Fell, M. (2021). Demand response beyond the numbers: A critical reappraisal of flexibility in two United Kingdom field trials. *Energy Research & Social Science, 75*, 102032. https://doi.org/10.1016/j.erss.2021.102032

Crenshaw, K. (1989). *Demarginalizing the Intersection of Race and Sex: A Black Feminist Critique of Antidiscrimination Doctrine, Feminist Theory and Antiracist Politics, 1989 U* (p. 139). Legal F: Chi.

El Gohary, F., Nordin, M., Juslin, P., & Bartusch, C. (2023). Getting the signal–Do electricity users meet the preconditions for making informed decisions on demand response? *Energy Research & Social Science, 100*, 103119. https://doi.org/10.1016/j.erss.2023.103119

Elnakat, A., & Gomez, J. D. (2015). Energy engenderment: An industrialized perspective assessing the importance of engaging women in residential energy consumption management. *Energy Policy, 82*, 166–177. https://doi.org/10.1016/j.enpol.2015.03.014

Fell, M. J., Shipworth, D., Huebner, G. M., & Elwell, C. A. (2014). Exploring perceived control in domestic electricity demand-side response. *Technology Analysis & Strategic Management, 26*(10), 1118–1130. https://doi.org/10.1080/09537325.2014.974530

Ferreira, P., Rocha, A., & Araújo, M. (2018). Awareness and attitudes towards demand response programs–a pilot study. In *2018 International Conference on Smart Energy Systems and Technologies* (SEST) (pp. 1–6). IEEE. https://doi.org/10.1109/SEST.2018.8495804

Fjellså, I. F., Ryghaug, M., & Skjølsvold, T. M. (2021a). Flexibility poverty: 'locked-in' flexibility practices and electricity use among students. *Energy Sources, Part b: Economics, Planning, and Policy, 16*(11–12), 1076–1093. https://doi.org/10.1080/15567249.2021.1937403

Fjellså, I. F., Silvast, A., & Skjølsvold, T. M. (2021b). Justice aspects of flexible household electricity consumption in future smart energy systems. *Environmental Innovation and Societal Transitions, 38*, 98–109. https://doi.org/10.1016/j.eist.2020.11.002

Forlano, L. (2017). Posthumanism and design. *She Ji: The Journal of Design, Economics, and Innovation, 3*(1), 16–29. https://doi.org/10.1016/j.sheji.2017.08.001

Gelazanskas, L., & Gamage, K. A. (2014). Demand side management in smart grid: A review and proposals for future direction. *Sustainable Cities and Society, 11*, 22–30. https://doi.org/10.1016/j.scs.2013.11.001

Grünewald, P., & Diakonova, M. (2020). Societal differences, activities, and performance: Examining the role of gender in electricity demand in the United Kingdom. *Energy Research & Social Science, 69*, 101719. https://doi.org/10.1016/j.erss.2020.101719

Haraway, D. (1988). Situated Knowledes: The science question in feminism and the privilege of partial perspectiv. *Feminist Studies, 14*(3), 575–599.

Hargreaves, T., & Middlemiss, L. (2020). The importance of social relations in shaping energy demand. *Nature Energy, 5*(3), 195–201.

Håkansson, M., Renström, S., Lööf, J., Sall Vesselényi, L., & Jonasson Tolv, J. (2022). " Do they pass the woman test?" Navigating and negotiating the gendering of residential solar panels. Nordic Human-Computer Interaction Conference. https://doi.org/10.1145/3546155.354664

Hyysalo, S., & Juntunen, J. K. (2024). Series of configurational movements: User activities in technology generalization. *Technological Forecasting and Social Change, 200*, 123158.

Jenkins, K., McCauley, D., Heffron, R., Stephan, H., & Rehner, R. (2016). Energy justice: A conceptual review. *Energy Research & Social Science, 11*, 174–182. https://doi.org/10.1016/j.erss.2015.10.004

Johnson, C. (2020). Is demand side response a woman's work? Domestic labour and electricity shifting in low income homes in the United Kingdom. *Energy Research & Social Science, 68*, 101558. https://doi.org/10.1016/j.erss.2020.101558

Khalid, R., & Razem, M. (2022). The nexus of gendered practices, energy, and space use: A comparative study of middleclass housing in Pakistan and Jordan. *Energy Research & Social Science, 83*, 102340. https://doi.org/10.1016/j.erss.2021.102340

Kousis, I., Laskari, M., Ntouros, V., Assimakopoulos, M.-N., & Romanowicz, J. (2020). An analysis of the determining factors of fuel poverty among students living in the private-rented sector in Europe and its impact on their well-being. *Energy Sources, Part b: Economics, Planning, and Policy, 15*(2), 113–135. https://doi.org/10.1080/15567249.2020.1773579

Maranta, A., Guggenheim, M., Gisler, P., & Pohl, C. (2003). The reality of experts and the imagined lay person. *Acta Sociologica, 46*(2), 150–165. https://doi.org/10.1177/0001699303046002005

Mechlenborg, M., & Gram-Hanssen, K. (2022). Masculine roles and practices in homes with photovoltaic systems. *Buildings and Cities, 3*(1), 638–652.

Moser, I. (2006). Sociotechnical practices and difference: On the interferences between disability, gender, and class. *Science, Technology, & Human Values, 31*(5), 537–564.

Nicholls, L., Strengers, Y., & Sadowski, J. (2020). Social impacts and control in the smart home. *Nature Energy, 5*(3), 180–182.

Nicholls, L., & Strengers, Y. (2015). Peak demand and the 'family peak'period in Australia: Understanding practice (in) flexibility in households with children. *Energy Research & Social Science, 9*, 116–124. https://doi.org/10.1016/j.erss.2015.08.018

Organo, V., Head, L., & Waitt, G. (2013). Who does the work in sustainable households? A time and gender analysis in New South Wales, Australia. *Gender, Place & Culture, 20*(5), 559–577. https://doi.org/10.1080/0966369X.2012.716401

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., & Brennan, S. E. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *International Journal of Surgery, 88*, 105906.

Pink, S., Strengers, Y., Martin, R., & Dahlgren, K. (2022). Smart Home Masculinities. *Australian Feminist Studies, 37*(112), 117–133. https://doi.org/10.1080/08164649.2023.2197155

Ponche de Leon Barido, D., Suffian, S., Kammen, D. M., & Callaway, D. (2018). Opportunities for behavioral energy efficiency and flexible demand in data-limited low-carbon resource constrained environments. *Applied Energy, 228*, 512–523. https://doi.org/10.1016/j.apenergy.2018.06.115

Powells, G., & Fell, M. J. (2019). Flexibility capital and flexibility justice in smart energy systems. *Energy Research & Social Science, 54*, 56–59. https://doi.org/10.1016/j.erss.2019.03.015

Ribó-Pérez, D., Heleno, M., & Álvarez-Bel, C. (2021). The flexibility gap: Socioeconomic and geographical factors driving residential flexibility. *Energy Policy, 153*, 112282. https://doi.org/10.1016/j.enpol.2021.112282

Scharnigg, R., & Martin, A. (2024). Gendered sociotechnical imaginaries: Understanding the role of masculinities in Portugal's pursuit of multi-scalar solar energy transitions. *Energy Research & Social Science, 108*, 103372. https://doi.org/10.1016/j.erss.2023.103372

Schiebinger, L., Klinge, I., Paik, H. Y., Sánchez de Madariaga, I., Schraudner, M., & Stefanick, M. (2011–2020). *Gendered Innovations in Science, Health & Medicine, Engineering, and Environment*. https://www.jst.go.jp/pdf/event_diversity160316.pdf

Schöne, N., Greilmeier, K., & Heinz, B. (2022). Survey-based assessment of the preferences in residential demand response on the island of Mayotte. *Energies, 15*(4), 1338. https://doi.org/10.3390/en15041338

Shirani, F., O'Sullivan, K., Henwood, K., Hale, R., & Pidgeon, N. (2022). Living in an Active Home: Household dynamics and unintended consequences. *Buildings and Cities, 3*(1), 589–604. https://doi.org/10.5334/bc.216

Silvast, A., Williams, R., Hyysalo, S., Rommetveit, K., & Raab, C. (2018). Who 'uses' smart grids? The evolving nature of user representations in layered infrastructures. *Sustainability, 10*(10), 3738. https://doi.org/10.3390/su10103738

Skjølsvold, T. M., Jørgensen, S., & Ryghaug, M. (2017). Users, design and the role of feedback technologies in the Norwegian energy transition: An empirical study and some radical challenges. *Energy Research & Social Science, 25*, 1–8. https://doi.org/10.1016/j.erss.2016.11.005

Standal, K., Talevi, M., & Westskog, H. (2020). Engaging men and women in energy production in Norway and the United Kingdom: The significance of social practices and gender relations. *Energy Research & Social Science, 60*, 101338.

Strengers, Y., Dahlgren, K., & Nicholls, L. (2022). Emerging technologies' impacts on 'man caves' and their energy demand. *Buildings and Cities, 3*(1), 503. https://doi.org/10.5334/bc.222

Strengers, Y., & Kennedy, J. (2021). *The smart wife: Why Siri, Alexa, and other smart home devices need a feminist reboot*. Mit Press.

Strengers, Y., Kennedy, J., Arcari, P., Nicholls, L., & Gregg, M. (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* (pp. 1–13). Paper No.: 645. https://doi.org/10.1145/3290605.3300875

Strengers, Y. (2014). Smart energy in everyday life: Are you designing for resource man? *Interactions, 21*(4), 24–31. https://doi.org/10.1145/2621931

Sovacool, B. K., Martiskainen, M., & Del Rio, D. D. F. (2021). Knowledge, energy sustainability, and vulnerability in the demographics of smart home technology diffusion. *Energy Policy, 153*, 112196.

Sovacool, B. K., Axsen, J., & Sorrell, S. (2018). Promoting novelty, rigor, and style in energy social science: Towards codes of practice for appropriate methods and research design. *Energy Research & Social Science, 45*, 12–42. https://doi.org/10.1016/j.erss.2018.07.007

Srivastava, A., Van Passel, S., Kessels, R., Valkering, P., & Laes, E. (2020). Reducing winter peaks in electricity consumption: A choice experiment to structure demand response programs. *Energy Policy, 137*, 111183. https://doi.org/10.1016/j.enpol.2019.111183

Throndsen, W. (2017). What do experts talk about when they talk about users? Expectations and imagined users in the smart grid. *Energy Efficiency, 10*, 283–297. https://doi.org/10.1007/s12053-016-9456-5

Tjørring, L., Jensen, C. L., Hansen, L. G., & Andersen, L. M. (2018). Increasing the flexibility of electricity consumption in private households: Does gender matter? *Energy Policy, 118*, 9–18. https://doi.org/10.1016/j.enpol.2018.03.006

Tolmie, P., Crabtree, A., Rodden, T., Greenhalgh, C., & Benford, S. (2007). Making the home network at home: Digital housekeeping. In *ECSCW 2007: Proceedings of the 10th European Conference on Computer-Supported Cooperative Work, Limerick, Ireland, 24–28 September 2007* (pp. 331-350). Springer London. https://doi.org/10.1007/978-1-84800-031-5_18

Xu, X., & Chen, C.-F. (2019). Energy efficiency and energy justice for US low-income households: An analysis of multifaceted challenges and potential. *Energy Policy, 128*, 763–774. https://doi.org/10.1016/j.enpol.2019.01.020

Yilmaz, S., Weber, S., & Patel, M. (2019). Who is sensitive to DSM? Understanding the determinants of the shape of electricity load curves and demand shifting: Socio-demographic characteristics, appliance use and attitudes. *Energy Policy, 133*, 110909. https://doi.org/10.1016/j.enpol.2019.110909

Yilmaz, S., Xu, X., Cabrera, D., Chanez, C., Cuony, P., & Patel, M. K. (2020). Analysis of demand-side response preferences regarding electricity tariffs and direct load control: Key findings from a Swiss survey. *Energy, 212*, 118712. https://doi.org/10.1016/j.energy.2020.118712

Verkade, N., & Höffken, J. (2018). The design and development of domestic smart grid interventions: Insights from the Netherlands. *Journal of Cleaner Production, 202*, 799–805.

White, L. V., & Sintov, N. D. (2020). Health and financial impacts of demand-side response measures differ across sociodemographic groups. *Nature Energy, 5*(1), 50–60.

Winther, T., & Sundet, Ø. (2023). Flexibility for whom? Householder and stakeholder perspectives on justice regarding the introduction of dynamic grid tariffs in Norway. *Energy Efficiency, 16*(7), 75. https://doi.org/10.1007/s12053-023-10153-1

von Platten, J. (2022). Energy poverty in Sweden: Using flexibility capital to describe household vulnerability to rising energy prices. *Energy Research & Social Science, 91*, 102746. https://doi.org/10.1016/j.erss.2022.102746