



Energy, emerging technologies and gender in homes

YOLANDE STRENGERS

KIRSTEN GRAM-HANSEN

KARI DAHLGREN

LINE KRYGER AAGAARD

*Author affiliations can be found in the back matter of this article

SPECIAL COLLECTION:
ENERGY, EMERGING
TECHNOLOGIES AND
GENDER IN HOMES

EDITORIAL

]u[ubiquity press

HIGHLIGHTS

This special issue explores a key question in the energy transition: how are visions, relationships and practices with emerging technologies gendered, and what does this mean for home relations and energy outcomes? Homes are deeply gendered spaces where labour, care, technology management and household responsibilities are unequally distributed. Yet, as the papers in this special issue reveal, policy and industry visions tend to overlook gendered dynamics associated with these technologies, reflecting a perceived technology neutrality. This oversight puts the energy transition at risk. This special issue reveals how understanding the gender impacts of emerging technologies is crucial for realising energy policy, regulatory and building efficiency aspirations. The collection identifies how technology use, energy consumption and everyday practices in homes reflect gendered differences. Studies from diverse empirical and geographical contexts explore questions of gender in relation to emerging technologies such as energy feedback portals, smart home systems, home efficiency improvements, electric vehicles, solar photovoltaic panels and home batteries. Recommendations are provided for policymakers, and house, technology and program designers, to achieve an equitable energy transition. The collection demonstrates the need for concerted policy and industry attention to gendered dynamics in order to ensure inclusive energy policy and technology development.

CORRESPONDING AUTHOR:

Yolande Strengers

Emerging Technologies Research
Lab, Monash University, Caulfield
East, VIC, AU

yolande.strengers@monash.edu

KEYWORDS:

care, digital housekeeping;
emerging technologies; energy;
everyday life; gender; homes;
housing; smart home; social
practices

TO CITE THIS ARTICLE:

Strengers, Y., Gram-Hanssen, K.,
Dahlgren, K., & Aagaard, L.
K. (2022). Energy, emerging
technologies and gender in
homes. *Buildings and Cities*,
3(1), pp. 842–853. DOI: <https://doi.org/10.5334/bc.273>

1. INTRODUCTION

It is now widely recognised that the energy transition towards renewable energy and net zero emissions requires considerable involvement and participation from people who live in homes and communities and use emerging technologies such as home automation (Takayama *et al.* 2012; Richardson 2008; Hargreaves *et al.* 2018). Homes are deeply gendered spaces in which labour, care and household responsibilities are more likely to be led and carried out by women (Sullivan 2018). This means that in recent iterations of the energy (smart) home—featuring home automation and load control, solar and battery charging integration, real-time feedback, demand response and/or improved efficiency—questions of gender are inescapable (Allison *et al.* 2019). Recognising the importance of household involvement in realising energy ambitions, a growing number of social scientists are turning their attention towards gender and homes (Johnson 2020; Furszyfer Del Rio *et al.* 2021; Mechlenborg & Gram-Hanssen 2020; Pink *et al.* 2017; Strengers 2013; Tjørring 2016; Tjørring *et al.* 2018). Importantly, these scholars are demonstrating that attention to gender is critical for achieving household engagement in the energy transition, and for ensuring that the outcomes of this transition are equitable.

The energy sector has traditionally been—and remains—a male-dominated field (Carlsson-Kanyama *et al.* 2010), led by the disciplines of engineering and economics which provide technological and market-based solutions. While the renewable energy sector is more gender diverse than the fossil fuel sector, women remain underrepresented, particularly in technical positions (Allison *et al.* 2019). In addition, the increasing focus on emerging technologies—such as solar photovoltaic (PV) systems, battery storage, electric vehicles and home automation—has seen growing involvement from another masculine field: computer science and artificial intelligence (West *et al.* 2019). This has led to biased visions and technology designs intended for energy consumers, which are commonly imbued with masculine and rationalist assumptions about how people will act in their homes (Hargreaves & Wilson 2017; Strengers 2013). Yet, too often questions about whose futures are being enabled and imagined, or who is doing the work to enable them, are left unanswered (Aagaard 2021; Dahlgren *et al.* 2021; Strengers *et al.* 2022).

This special issue advances this research agenda with 11 articles that bring gendered perspectives to the fore in relation to the growing energy policy and industry focus on emerging technologies in homes. The collection of papers came into being as a collaboration between Aalborg and Monash universities, and more specifically between the eCAPE and Digital Energy Futures projects. An international call for papers yielded 21 abstracts. The selected contributors to this special issue then participated in an online symposium to develop papers in collaboration with a community of scholars working in this field of research. The manuscripts then underwent the journal's double-blind peer-review process and revisions leading to the acceptance of 11 articles. Each paper reveals important insights into the gendered dynamics involved in imagining and establishing future energy and technology visions, and people's experiences of emerging technologies across different countries and contexts. The collection also advances understanding of the impact of gender for realising energy policy, regulatory and building efficiency aspirations. This editorial highlights the existing literature on energy, emerging technologies and gender in homes before introducing the papers in relation to a set of key themes. It concludes by identifying the key policy and practice recommendations this special issue offers, and opportunities for future research.

2. BACKGROUND

There has been considerable attention paid to the social and household dynamics involved in engaging with emerging and smart technologies and their impacts on energy outcomes (Darby 2018; Gram-Hanssen & Darby 2018; Hargreaves & Wilson 2017; Hargreaves *et al.* 2018; Nicholls & Strengers 2019; Ransan-Cooper *et al.* 2020). However, less attention has been given to gender in such analyses. Past literature on emerging technologies, energy and gender in homes has made several crucial contributions. First, this research has highlighted the biased and masculine visions that permeate energy industry imaginaries (Strengers & Nicholls 2017). These include visions for

energy consumers as rational, tech-savvy and independent operators of the home (Hargreaves & Wilson 2013), which Strengers (2013) characterised as the caricature consumer, Resource Man, and which subsequent research has explored and challenged (Groves *et al.* 2016; Johnson 2020; Verkade & Höffken 2017). Additionally, past research has critiqued technology visions as prioritising masculine or highly technical interests and pursuits (Wilson *et al.* 2014; Strengers & Kennedy 2020), such as targeting smart home technologies towards freeing up men's leisure time (Strengers & Nicholls 2018), or appealing to masculine techno-hedonist tendencies in consumers (Dahlgren *et al.* 2021).

A second area of focus has been on the gendered designs of emerging technologies, and how this affects usability, uptake and interactions. This research has explored how smart technologies are gendered by design or ergonomics (Perez 2019; Strengers & Kennedy 2020). This body of work builds on a broader field of feminist technoscience, which has demonstrated how engineers and technologists have traditionally undervalued feminine knowledge and housework as a design resource for domestic technologies (Berg 1994; Cockburn 1997), whilst simultaneously prioritising masculine fantasies of technology as an ideal 'housewife' that can take care of domestic labour and responsibilities (Spigel 2005; Strengers & Kennedy 2020).

Third, research on technology in the home has highlighted the gendered labour dynamics associated with its introduction, such as the rise of digital housekeeping (Tolmie *et al.* 2007). This research has identified that men are more likely to do the work involved in setting up, maintaining, using or responding to technologies in the home, which can take them away from other, more traditional, household tasks (Aagaard 2022; Kennedy *et al.* 2015; Rode & Poole 2018; Strengers & Nicholls 2018). Relatedly, a smaller body of research is exploring the gendered effects of increasing automation, Internet of Things and smart devices in the home, such as the increasing surveillance and manipulation (Sadowski *et al.* 2021) and the potential inclusion of these technologies in digital abuse and domestic violence (Lopez-Neira *et al.* 2019; Sovacool *et al.* 2021; Strengers *et al.* 2019; Strengers & Kennedy 2020; Tanczer *et al.* 2021). In the context of energy ambitions for smart technology, several studies have noted men's heightened interest; however, few studies have explored the gendered labour involved in achieving energy flexibility. Johnson (2020) identified that women may be crucial to realising demand-response ambitions, coining the term 'Flexibility Women' to understand the work in which women engage for this purpose. Similarly, Tjørring *et al.* (2018) highlighted the importance of women in achieving flexible electricity consumption in homes. Several studies demonstrate that women are crucial to realising the energy transition through their interest and uptake of some emerging technologies such as solar PV (Allison *et al.* 2019). More broadly, Bell *et al.* (2020) demonstrate how feminist perspectives can broaden our understanding of the systems of power that underpin renewable energy systems, and contribute to a more just energy transition.

Finally, a fourth area of research includes perspectives from the Global South. Questions of gender and energy have a long tradition in developing countries, though these mainly deal with either energy poverty or gendered entrepreneurship (McDade & Clancy 2003; Listo 2018), with a less explicit focus on emerging technologies and gender. Nonetheless, an emerging body of work is exploring the role of technology and gender in demand management, everyday practices and energy flexibility in this region (Khalid & Sunikka-Blank 2017; Khalid & Razem 2022). Other scholars are exploring how underrepresented Indigenous perspectives can help reconnect the energy transition with local gendered realities and community dynamics (Lieu *et al.* 2020).

This special issue builds on these contributions as outlined below.

3. OVERVIEW OF THE PAPERS AND THEIR CONTRIBUTIONS

An overview of the papers in this special issue is provided in Table 1, whereas Table 2 identifies each paper's themes and approaches. This section discusses how the papers contribute to three key themes: expert and design visions; everyday life and practices; and the emerging importance of care.

AUTHORS	TITLE	DOI
Y. Strengers, K. Gram-Hanssen, K. Dahlgren & L. K. Aagaard	Energy, emerging technologies and gender in homes [editorial]	http://doi.org/10.5334/bc.237
L. K. Aagard & L. V. Madsen	Technological fascination and reluctance: gendered practices in the smart home	http://doi.org/10.5334/bc.205
M. Mechlenborg & K. Gram-Hanssen	Masculine roles and practices in homes with photovoltaic systems	http://doi.org/10.5334/bc.211
S. Pink	The gender of smart charging	http://doi.org/10.5334/bc.212
F. Shirani, K. O'Sullivan, K. Henwood, R. Hale & N. Pidgeon	Living in an Active Home: household dynamics and unintended consequences	http://doi.org/10.5334/bc.216
R. Martin	Energy housekeeping: intersections of gender, domestic labour and technologies	http://doi.org/10.5334/bc.218
K. Lucas-Healey, H. Ransan-Cooper, H. Temby & A. W. Russell	Who cares? How care practices uphold the decentralised energy order	http://doi.org/10.5334/bc.219
D. Chambers	Attuning smart home scripts to household and energy care	http://doi.org/10.5334/bc.220
Y. Strengers, K. Dahlgren & L. Nicholls	Emerging technologies' impacts on 'man caves' and their energy demand	http://doi.org/10.5334/bc.222
A. Schiffer, M. Greene, R. Khalid, C. Foulds, C. A. Vidal, M. Chatterjee, S. Dhar-Bhattacharjee, N. Edomah, O. Sule, D. Palit & A. N. Yesutanbul	Brokering gender empowerment in energy access in the Global South	http://doi.org/10.5334/bc.236
A. Aggeli, T. H. Christensen & S. P. A. K. Larsen	The gendering of energy household labour	http://doi.org/10.5334/bc.224
F. Bartiaux	Gender roles and domestic power in energy-saving home improvements	http://doi.org/10.5334/bc.232

Table 1: Overview of the papers in this special issue.

AUTHOR	EVERYDAY PRACTICES	EXPERT VISIONS AND DESIGN	EQUITY, LABOUR DIVISION, POWER	TYPE OF TECHNOLOGY	COUNTRY AND GEOGRAPHICAL CONTEXT	METHODOLOGY
L. K. Aagard & L. V. Madsen	×		×	Smart home technology	DK	Qualitative with households
M. Mechlenborg & K. Gram-Hanssen	×		×	Photovoltaic (PV) prosumption and feedback	DK	Qualitative with households
S. Pink	×	×		Batteries	AU	Ethnographic with households
F. Shirani, K. O'Sullivan, K. Henwood, R. Hale & N. Pidgeon	×	×		Smart heating, batteries and PV	UK	Qualitative with households and developers
R. Martin	×		×	Energy feedback and PV prosumption	AU	Ethnographic with households
K. Lucas-Healey, H. Ransan-Cooper, H. Temby & A. W. Russell	×	×		Energy systems	AU	Qualitative with households and developers
D. Chambers		×		Smart home technology	UK	Marketing content analysis
Y. Strengers, K. Dahlgren & L. Nicholls	×			Smart home technology	AU	Ethnographic with households

(Contd.)

AUTHOR	EVERYDAY PRACTICES	EXPERT VISIONS AND DESIGN	EQUITY, LABOUR DIVISION, POWER	TYPE OF TECHNOLOGY	COUNTRY AND GEOGRAPHICAL CONTEXT	METHODOLOGY
A. Schiffer, M. Greene, R. Khalid, C. Foulds, C. A. Vidal, M. Chatterjee, S. Dhar-Bhattacharjee, N. Edomah, O. Sule, D. Palit & A. N. Yesutanbul		×	×	Local energy provision in the Global South	GH, IN, NG, PK	Qualitative with energy professionals
A. Aggeli, T. H. Christensen, S. P. A. K. Larsen	×			Smart home technology	IT, NL	Qualitative with households
F. Bartiaux	×		×	Energy retrofitting and saving	BE	Quantitative and qualitative with households

3.1 CHALLENGING GENDERED EXPERT, INDUSTRY AND DESIGN VISIONS

Mainstream and expert visions of the energy and technology sectors often overlook the importance of gender to the uptake, domestication and operation of emerging technologies. Chambers' content analysis of marketing materials reveals that marketing continues to represent a lack of household diversity, representing able-bodied affluent households and emphasising hedonist values of pleasure and comfort over energy efficiency. Despite women being present in technology brochures, marketing materials still maintain a masculine emphasis on control and surveillance rather than feminine practices of care such as housework. Chambers argues that smart home technologies should be designed as agents of care, making them more fitting to diverse households such as single parents, or older adults, as well as better incorporating energy and sustainability goals. Pink similarly contrasts a content analysis of industry reports from the energy and technology sectors with ethnographic research with Australian households to reveal an incompatibility between the industry vision of electric vehicle charging, based on a 'rational masculine commuter', against the reality of everyday life contingencies. Pink shows that charging is a gendered practice and its temporalities and spatialities are interwoven with women's everyday ways of knowing. The contrast between a masculine industry vision and feminine everyday charging practices, Pink argues, is a significant flaw in future plans for ubiquitous electric vehicles.

Chambers and Pink use content analyses of industry reports and materials, whereas Schiffer *et al.* focus their research on the intermediary role between high-level policy and local communities, interviewing energy brokers from Ghana, Nigeria, India and Pakistan. They describe how male-dominated energy brokerage can place an excess burden on women by encouraging female entrepreneurship in the formal economy. They also emphasise that brokers often have a gender blindness that ignores how energy access is significantly gendered within households and communities, and demonstrate how this blindness can undermine empowerment goals. Though in a significantly different context, in a study of Active Buildings in the UK, which generate, store and distribute renewable energy, Shirani *et al.* show a similar pattern of gender blindness. Through interviews with designers and developers, they identify that developers rarely mention gender, even as their visions hold strongly gendered implications. Further, their visions represent 'technology as a masculine-coded artefact' best operated by experts outside the home. Despite this, Shirani *et al.* found that women actively try to participate in the management of their active homes, even as this is sometimes limited by the insufficiency in the home's design for everyday priorities. Bartiaux similarly reveals the danger of simple assumptions about gender in the uptake of energy-saving home improvements. Through a significant set of mixed-methods research with Belgian households, she reveals that although home retrofits are generally considered to be a male domain, this differs and is often contested in relation to the power dynamics within marriage itself. Her research reveals that power contestation within marriages, represented through differential education levels between husbands and wives, affects the interest, uptake and negotiations around household energy upgrades and do-it-yourself (DIY) retrofitting.

Table 2: Themes and approaches explored in the papers in this special issue.

3.2 TAKING A PRACTICE–THEORETICAL APPROACH TO GENDER AND EVERYDAY LIFE

In order to move beyond the common gender oversight in industry visions and policy, some articles draw from theory that illuminates the complex gendered practices and values inherent in everyday life. Social practice theory informs the research in Mechlenborg and Gram-Hanssen's paper, which discusses findings from qualitative interviews with Danish households that have solar PV. It shows how masculinity is part of the process of buying and getting the PV installed, as well as part of the process of tracking the electricity produced. Both aspects are often part of male hobbies and relate to the informants' masculine identity. Getting the most out of the produced electricity includes time-shifting and -adjusting. Masculinity can here play out in different ways, though the paper argues that in the adjusting of production and consumption, masculine domesticities may work best if aligned with feminine domesticities.

Martin similarly employs practice theory in his ethnographic project with Australian households that have solar PV, though his focus is on how men use the energy feedback from their appliances to follow or control different household members and their practices in what he terms 'energy housekeeping'. Different forms of this energy housekeeping are identified, including energy interpreting, energy policing and energy orchestrating. Martin points out how energy housekeeping is performed in differently gendered ways, and thus how emerging technologies may take part in reinforcing gender asymmetries in homes and in domestic labour.

Building on Martin's concept of energy housekeeping, and also drawing on theories of social practice in relation to qualitative research pilots from Italy and the Netherlands, Aggeli *et al.* analyse how domestic labour related to energy housekeeping includes both bodily and mental aspects, arguing that the mental aspect of energy housekeeping is understudied. The paper details and discusses how mental aspects of energy housekeeping, together with physical aspects, are shaped by emotions including enjoyment, fear, curiosity and frustration. Following from this insight, the paper reflects on how mental aspects of energy housekeeping—such as controlling and monitoring, paying for consumption, maintaining devices, and coordinating, anticipating and planning—are all gendered in different ways.

Where Aggeli *et al.* identify a new space for analysis in the mental and emotional aspects of household practices, Strengers *et al.* draw attention to new physical sites and relational spaces of consumption and emerging technology by moving out of the house to the garages and sheds on the periphery of the home. With a specific focus on the masculinity of these edges, which have been termed 'man caves', the analysis draws on ethnographic research with Australian households to focus on how the practices in these sites are changing with the introduction of emerging technologies. As well as becoming charging sites for home batteries and power tools, and an experimental space for emerging smart technologies, sheds and garages are also starting to become a more gender-inclusive second centre and living space in their own right, all with significant energy implications.

All papers in this special issue take a non-essentialist approach to gender and include how femininity and masculinity correspond in different ways to the sex or gender of research participants. Aagaard and Madsen focus more specifically on how everyday practices related to smart home technologies can be gendered in different ways, depending on how competences and interest related to technologies vary among household members. Drawing on qualitative research with Danish households, these authors identify how the frontrunners are often male, and this has implications for the gendering of household practices in these homes. However, not all males are tech-savvy, and Aagaard and Madsen show how gender roles and labour divisions related to emerging technologies depend on how interest and competences are distributed.

3.3 CARE AS AN EMERGING CONCEPT IN ENERGY AND EVERYDAY LIFE

In recent years, feminist concepts of care and ethics of care have been brought into energy studies (Damgaard *et al.* 2022), often in combinations with different approaches of science and technology studies and specifically feminist STS. In this special issue the concept of care is explicitly applied

in two papers. As already mentioned, Chambers, based on media content analyses, proposes that households should be viewed as caregivers and smart home technologies as co-performers of this caregiving.

The other paper that includes a care perspective broadens the view to include not only smart technologies but also the (decentralised) energy system. Lucas-Healy *et al.* build their analysis on interviews and focus groups with both Australian householders and energy professionals. Their perspective brings forward conceptualisations of how matters of care (e.g. in relation to householders, the energy system, society or the environment) imply different aspects and different acts of taking care. Different human and non-human actors can both be caregivers and care-receivers and the analysis points towards gaps within relations between actors and how these gaps impact both gender and the energy system. The paper calls for further exploration of what caring for people and others within a decentralised energy system could look like, as well as for what caring for the energy system itself could look like.

4. POLICY, DESIGN, AND RESEARCH IMPLICATIONS AND RECOMMENDATIONS

This section highlights three important contributions made by the special issue to advance knowledge and recommendations for energy policymakers and regulators, technology, program and house designers, and researchers.

4.1 POLICY AND REGULATORY RECOMMENDATIONS

All contributors to this special issue highlight the policy risks associated with ignoring gendered dynamics, including the risk of increased household energy surveillance and ‘policing’ by men (Martin), disempowerment and lack of energy access for women (Schiffer *et al.*), exacerbated power struggles within marriages (Bartiaux), exclusion and inaccessible technologies and opportunities (Pink), and ineffective or underused capacity for engaging and involving people in the energy transition (Lucas-Healy *et al.*). In addition, the authors in this special issue propose a variety of policy and regulatory recommendations from their research to advance gender equity and energy outcomes in homes. Schiffer *et al.* focus their attention on the role of energy professionals in brokering energy access in the Global South. Their recommendations include recognising the need for differentiated energy brokerage across the grassroots–policy spectrum, moving away from ‘gender neutral’ brokerage by recognising that women’s empowerment is essential to realising energy system change, and creating networks and programs to empower women across the energy system, including in the supply chain and energy governance.

Strengers *et al.* recommend more policy and regulatory attention be paid to the ‘edges’ of the home, such as sheds as garages, through energy- and building-efficiency standards and consideration in demand–response programs. They argue that this is particularly important as the traditional ‘man cave’ takes on new roles as electrified charging hubs and more gender-inclusive living spaces. Lucas-Healy *et al.* provide a convincing framework for prioritising care in emerging energy policy visions within the Australian context. As they outline, this could involve sharing solar power with neighbours via a community battery, as is already part of the moral imperative for household interest in emerging energy technologies. Martin recommends that energy feedback needs to be understood and potentially redesigned to account for the gendered dynamics of household practices if it is to be a meaningful policy approach for encouraging consumer and household participation in the energy transition.

More broadly, the special issue has relevance to public policy, particularly labour, social and equality agendas. For instance, several papers reveal that when emerging technologies do not account for the complex power dynamics in households, they are likely to reproduce power asymmetries in the home through increasing mental load for women (Aggeli *et al.*), perpetuating male-dominated energy housekeeping (Martin) and related masculine forms of control (Chambers), associated with particular competences and meanings in the performance of practices (Aagaard and Madsen). Left

unattended, these dynamics may further entrench gender inequities with regard to the household division of labour, and women's opportunities to participate in paid employment. This special issue therefore collectively reveals that policy must be informed by a greater understanding and attention to gender at all levels to facilitate an energy transition that responds to households' everyday realities, priorities and values.

4.2 REGENERATING TECHNOLOGY, HOUSE AND PROGRAM DESIGN

In addition to policy and regulatory recommendations, the authors provide ideas and inspiration for how housing and technology design can incorporate gendered understandings and perspectives. Shirani *et al.* call for a simplified approach in the context of the UK's Active Homes, which is grounded in people's everyday lives with the provision of clear and relevant information. For instance, they recommend housing designs with adequate space for flexible energy practices (e.g. a ventilated room suitable for drying laundry), and simplified systems for controlling heating and hot water. Mechlenborg and Gram-Hanssen argue that feminine practices associated with running the home need to be (re)linked to the masculine practices involved in operating and running energy systems to achieve demand-response outcomes. In line with this, Agaard and Madsen point to the need for designing for variation in technology competences and interests. Chambers recommends that the smart home industry adopt ethical principles to guide design and to repurpose smart home technologies as *care technologies*, which cater for diverse household types and varied expressions of femininity. She argues that this is crucial to realising energy sustainability outcomes, and begins with gathering comprehensive care knowledge to inform design decisions. Pink calls for greater attention to the gendered experiences and uses of batteries and charging by those who design them to develop more inclusive systems that are grounded in existing everyday routines rather than structuring routines in their own right. As her research demonstrates, this involves designing charging infrastructures with women to address inaccessibility and exclusion.

Further, the authors of this special issue demonstrate that gender-blind discourses common in development and design (Shirani *et al.*), household retrofitting and DIY (Bartiaux) or in the brokerage and intermediaries between policy and households (Schiffer *et al.*) fail to recognise the gendered reality of household life and thus energy and emerging technology access, use and energy flexibility. The papers in this special issue therefore highlight that ignoring gender is likely to limit the energy transition, as many of the envisioned, planned and trialled technologies fail to sufficiently account for and align domestic masculinities and femininities, around solar PV and energy flexibility (Mechlenborg and Gram-Hanssen), smart charging (Pink), or the spatiality of the home and its edges (Strengers *et al.*).

4.3 FUTURE RESEARCH OPPORTUNITIES

In contributing new conceptual resources to understandings of digital housekeeping, both Martin and Aggeli *et al.* call for further research into their contributions of energy housekeeping (Martin) and the mental load associated with it (Aggeli *et al.*). In particular, and alongside other authors in this special issue, they call for further research with a diverse range of household configurations and contexts. Likewise, all authors point towards opportunities for future research that would build more inclusive perspectives for policy and technology design. These include research with same-sex couples and people from the LGBTIQ+ community who are absent from this special issue and current research on this topic. There are further opportunities for research that adopts an intersectional lens to explore the relationship between gender and age or disability, which is especially relevant in a future where technologies are expected to advance human care, but also in relation to race and/or sexuality. In addition, while the special issue includes a paper focused on the Global South (Schiffer *et al.*), more research could be undertaken in this context that faces unique gendered issues. Likewise, research with people living in shared housing or alternative living arrangements are likely to reveal important gendered insights for the energy transition that deserve further attention.

5. CONCLUSIONS

From technology visions through to use and sometimes rejection, emerging technologies are deeply gendered with important implications for the energy transition. Spanning different contexts and countries, the special issue highlights why gender matters for energy policy and practice, and why energy policy and practice matters for gender.

The papers in this special issue provide new evidence that policy and industry visions within various fields, such as energy brokerage, smart home technology, electric vehicles and Active Homes, which often neglect the importance of gender in the implementation of technologies into everyday life. A gender ‘blindness’ is detected and uncovered, which allows authors to highlight the inequities that characterise technology use, energy consumption and access in Global North and South contexts. This insight forms a key contribution of this special issue: to challenge gender-blind tendencies and advance more inclusive visions within policy and industry whilst acknowledging, regulating with and designing for the lived experiences, gendered dynamics and everyday practices of people. In this regard, the special issue calls for more inclusive technologies designed for different competences, flexible practices and routines.

Another key contribution is to reveal the gendering of the edges of energy consumption, including physical edges (e.g. in home peripheries such as sheds), the role of intermediaries and other third parties (e.g. energy brokers) and cognitive edges (e.g. mental loads of housekeeping). These often-overlooked spaces provide important ground for the achievement of an equitable and inclusive energy transition. Finally, the papers advance feminist understandings of care in relation to energy and emerging technologies in homes, which holds great potential in developing more inclusive technologies and advancing equity in the energy transition.

With an increasing array of emerging technology ‘solutions’ coming into the market and people’s homes, policymakers, technologists and researchers need to carefully consider and attune to these dynamics, and engage in further ongoing research. Above all, maintaining an intersectional gender lens will be critical to realising energy policy ambitions, and ensuring that the energy transition delivers equitable and inclusive outcomes.

ACKNOWLEDGEMENTS

The authors of this editorial acknowledge and thank journal Editor-in-Chief Richard Lorch, who provided substantial support and input from the conception of this special issue and throughout the whole process, specifically finding peer reviewers and providing feedback for all authors. They also acknowledge and thank all authors, peer reviewers and a broader set of contributors for their engagement in the online symposium convened as part of the process of forming this issue, and for their contributions to this process.

AUTHOR AFFILIATIONS

Yolande Strengers  orcid.org/0000-0002-5664-621X
Emerging Technologies Research Lab, Monash University, Caulfield East, VIC, AU

Kirsten Gram-Hanssen  orcid.org/0000-0002-8543-2501
Department of the Built Environment, Aalborg University, Copenhagen, DK

Kari Dahlgren  orcid.org/0000-0002-3111-8891
Emerging Technologies Research Lab, Monash University, Caulfield East, VIC, AU

Line Kryger Aagaard  orcid.org/0000-0003-2701-1335
Department of the Built Environment, Aalborg University, Copenhagen, DK

COMPETING INTERESTS

The authors have no competing interests to declare.

This editorial work was co-financed by the project eCAPE, a European Research Council (ERC) Advanced Grant under the European Union's Horizon 2020 Research and Innovation programme (grant agreement number 786643); and the Australian Research Council's Linkage Projects funding Scheme ('Digital Energy Futures'; project number LP180100203) in partnership with Monash University, Ausgrid, AusNet Services and Energy Consumers Australia.

REFERENCES

- Aagaard, L. K.** (2021). The meaning of convenience in smart home imaginaries: Tech industry insights. *Buildings & Cities*, 2(1), 568–582. DOI: <https://doi.org/10.5334/bc.93>
- Aagaard, L. K.** (2022). When smart technologies enter household practices: The gendered implications of digital housekeeping. *Housing, Theory and Society*. DOI: <https://doi.org/10.1080/14036096.2022.2094460>
- Allison, J. E., McCrory, K., & Oxnevad, I.** (2019). Closing the renewable energy gender gap in the United States and Canada: The role of women's professional networking. *Energy Research & Social Science*, 55(September), 35–45. DOI: <https://doi.org/10.1016/j.erss.2019.03.011>
- 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, 1–13. DOI: <https://doi.org/10.1016/j.erss.2020.101557>
- Berg, A. J.** (1994). A gendered socio-technical construction: The smart house. In C. Cockburn & R. Furst Dilic (Eds.), *Bringing technology home: Gender and technology in changing Europe* (pp. 165–180). Open University Press.
- Carlsson-Kanyama, A., Ripa Juliá, I., & Röhr, U.** (2010). Unequal representation of women and men in energy company boards and management groups: Are there implications for mitigation? *Energy Policy*, 38(8). DOI: <https://doi.org/10.1016/j.enpol.2010.03.072>
- Cockburn, C.** (1997). Domestic technologies: Cinderella and the engineers. *Women's Studies International Forum*, 20(3), 361–371. DOI: [https://doi.org/10.1016/S0277-5395\(97\)00020-4](https://doi.org/10.1016/S0277-5395(97)00020-4)
- Dahlgren, K., Pink, S., Strengers, Y., Nicholls, L., & Sadowski, J.** (2021). Personalization and the Smart Home: Questioning techno-hedonist imaginaries. *Convergence*, 27(5), 1155–1168. DOI: <https://doi.org/10.1177/13548565211036801>
- Damgaard, C. S., McCauley, D., & Reid, L.** (2022). Towards energy care ethics: Exploring ethical implications of relationality within energy systems in transition. *Energy Research & Social Science*, 84. DOI: <https://doi.org/10.1016/j.erss.2021.102356>
- Darby, S. J.** (2018). Smart technology in the home: Time for more clarity. *Building Research & Information*, 46(1), 140–147. DOI: <https://doi.org/10.1080/09613218.2017.1301707>
- Furszyfer Del Rio, D. D., Sovacool, B. K., & Martiskainen, M.** (2021). Controllable, frightening, or fun? Exploring the gendered dynamics of smart home technology preferences in the United Kingdom. *Energy Research & Social Science*, 77, 1–18. DOI: <https://doi.org/10.1016/j.erss.2021.102105>
- Gram-Hanssen, K., & Darby, S. J.** (2018). 'Home is where the smart is'? Evaluating smart home research and approaches against the concept of home. *Energy Research & Social Science*, 37 (Suppl. C), 94–101. DOI: <https://doi.org/10.1016/j.erss.2017.09.037>
- Groves, C., Henwood, K., Shirani, F., Butler, C., Parkhill, K., & Pidgeon, N.** (2016). The grit in the oyster: Using energy biographies to question socio-technical imaginaries of 'smartness'. *Journal of Responsible Innovation*, 3(1), 4–25. DOI: <https://doi.org/10.1080/23299460.2016.1178897>
- Hargreaves, T., & Wilson, C.** (2013). Who uses smart home technologies? Representations of users by the smart home industry. *ECEEE Summer Study Proceedings*, 6, 1769–1780. https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2013/6-appliances-product-policy-and-ict/who-uses-smart-home-technologies-representations-of-users-by-the-smart-home-industry/
- Hargreaves, T., & Wilson, C.** (2017). *Smart homes and their users*. Springer. DOI: <https://doi.org/10.1007/978-3-319-68018-7>
- Hargreaves, T., Wilson, C., & Hauxwell-Baldwin, R.** (2018). Learning to live in a smart home. *Building Research & Information*, 46(1), 127–139. DOI: <https://doi.org/10.1080/09613218.2017.1286882>
- 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. DOI: <https://doi.org/10.1016/j.erss.2020.101558>

- Kennedy, J., Nansen, B., Arnold, M., Wilken, R., & Gibbs, M.** (2015). Digital housekeepers and domestic expertise in the networked home. *Convergence*, 21(4), 408–422. DOI: <https://doi.org/10.1016/j.erss.2018.11.019>
- 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, 1–11. DOI: <https://doi.org/10.1016/j.erss.2021.102340>
- Khalid, R., & Sunikka-Blank, M.** (2017). Homely social practices, uncanny electricity demands: Class, culture and material dynamics in Pakistan. *Energy Research & Social Science*, 34, 122–131. DOI: <https://doi.org/10.1016/j.erss.2017.06.038>
- Lieu, J., Sorman, A. H., Johnson, O. W., Virla, L. D., & Resurrección, B. P.** (2020). Three sides to every story: Gender perspectives in energy transition pathways in Canada, Kenya and Spain. *Energy Research & Social Science*, 68, 1–13. DOI: <https://doi.org/10.1016/j.erss.2020.101550>
- Listo, R.** (2018). Gender myths in energy poverty literature: A critical discourse analysis. *Energy Research & Social Science*, 38, 9–18. DOI: <https://doi.org/10.1016/j.erss.2018.01.010>
- Lopez-Neira, I., Patel, T., Parkin, S., Danezis, G., & Tanczer, L.** (2019). ‘Internet of Things’: How abuse is getting smarter. *Safe—The Domestic Abuse Quarterly*, 63, 22–26. DOI: <https://doi.org/10.2139/ssrn.3350615>
- McDade, S., & Clancy, J.** (2003). Editorial. *Energy for Sustainable Development*, 7(3), 3–7. DOI: [https://doi.org/10.1016/S0973-0826\(08\)60360-9](https://doi.org/10.1016/S0973-0826(08)60360-9)
- Mechlenborg, M., & Gram-Hanssen, K.** (2020). Gendered homes in theories of practice: A framework for research in residential energy consumption. *Energy Research & Social Science*, 67, 1–9. DOI: <https://doi.org/10.1016/j.erss.2020.101538>
- Nicholls, L., & Strengers, Y.** (2019). Robotic vacuum cleaners save energy? Raising cleanliness conventions and energy demand in Australian households with smart home technologies. *Energy Research & Social Science*, 50, 73–81. DOI: <https://doi.org/10.1016/j.erss.2018.11.019>
- Perez, C. C.** (2019). *Invisible women: Exposing data bias in a world designed for men*. Random House.
- Pink, S., Leder Mackley, K., Morosanu, R., Mitchell, V., & Bhamra, T.** (2017). *Making homes: Ethnography and design*. Bloomsbury.
- Ransan-Cooper, H., Lovell, H., Watson, P., Harwood, A., & Hann, V.** (2020). Frustration, confusion and excitement: Mixed emotional responses to new household solar–battery systems in Australia. *Energy Research & Social Science*, 70, 1–10. DOI: <https://doi.org/10.1016/j.erss.2020.101656>
- Richardson, H. J.** (2008). A ‘smart house’ is not a home: The domestication of ICTs. *Information Systems Frontiers*, 11(5), 599–608. DOI: <https://doi.org/10.1007/s10796-008-9137-9>
- Rode, J. A., & Poole, E. S.** (2018). Putting the gender back in digital housekeeping. *Paper presented at the Proceedings of the 4th Conference on Gender & IT*, Heilbronn, Germany. <https://doi-org.ezproxy.lib.monash.edu.au/10.1145/3196839.3196845>. DOI: <https://doi.org/10.1145/3196839.3196845>
- Sadowski, J., Strengers, Y., & Kennedy, J.** (2021). More work for big mother: Revaluing care and control in smart homes. *Environment and Planning A: Economy and Space*, June, 1–16. DOI: <https://doi.org/10.1177/0308518X211022366>
- Sovacool, B. K., Furszyfer Del Rio, D., & Martiskainen, M.** (2021). Can prosuming become perilous? Exploring systems of control and domestic abuse in the smart homes of the future. *Frontiers in Energy Research*, November, 1–18. DOI: <https://doi.org/10.3389/fenrg.2021.765817>
- Spigel, L.** (2005). Designing the smart house: Posthuman domesticity and conspicuous production. *European Journal of Cultural Studies*, 8(4), 403–426. DOI: <https://doi.org/10.1177/1367549405057826>
- Strengers, Y.** (2013). *Smart energy technologies in everyday life: Smart utopia?* Palgrave Macmillan. DOI: <https://doi.org/10.1057/9781137267054>
- Strengers, Y., Dahlgren, K., Pink, S., Sadowski, J., & Nicholls, L.** (2022). Digital technology and energy imaginaries of future home life: Comic-strip scenarios as a method to disrupt energy industry futures. *Energy Research & Social Science*, 84, 1–16. DOI: <https://doi.org/10.1016/j.erss.2021.102366>
- Strengers, Y., & Kennedy, J.** (2020). *The smart wife: Why Siri, Alexa and other smart home devices need a feminist reboot*. MIT Press. DOI: <https://doi.org/10.7551/mitpress/12482.001.0001>
- 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 CHI ’19* (pp. 1–13). Association for Computing Machinery. DOI: <https://doi.org/10.1145/3290605.3300875>
- Strengers, Y., & Nicholls, L.** (2017). Convenience and energy consumption in the smart home of the future: Industry visions from Australia and beyond. *Energy Research & Social Science*, 32, 86–93. DOI: <https://doi.org/10.1016/j.erss.2017.02.008>

- Strengers, Y., & Nicholls, L.** (2018). Aesthetic pleasures and gendered tech-work in the 21st-century smart home. *Media International Australia*, 166(1), 70–80. DOI: <https://doi.org/10.1177/1329878X17737661>
- Sullivan, O.** (2018). The gendered division of household labor. In B. J. Risman, C. M. Froyum & W. J. Scarborough (Eds.), *Handbook of the sociology of gender* (pp. 377–392). Springer. DOI: https://doi.org/10.1007/978-3-319-76333-0_27
- Takayama, L., Pantofaru, C., Robson, D., Soto, B., & Barry, M.** (2012). Making technology homey: Finding sources of satisfaction and meaning in home automation. In *Proceedings of the 2012 ACM Conference on Ubiquitous Computing* (pp. 511–520). ACM. DOI: <https://doi.org/10.1145/2370216.2370292>
- Tanczer, L. M., López-Neira I., & Parkin, S.** (2021). 'I feel like we're really behind the game': Perspectives of the United Kingdom's intimate partner violence support sector on the rise of technology-facilitated abuse. *Journal of Gender-Based Violence*, 5(3), 431–450. DOI: <https://doi.org/10.1332/239868021X16290304343529>
- Tjørring, L.** (2016). 'We forgot half of the population!' The significance of gender in Danish energy renovation projects. *Energy Research & Social Science*, 22, 115–124. DOI: <https://doi.org/10.1016/j.erss.2016.08.008>
- Tjørring, L., Jensen, C., Hansen, L., & Andersen, L.** (2018). Increasing the flexibility of electricity consumption in private households: Does gender matter? *Energy Policy*, 118, 9–18. DOI: <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 L. J. Bannon, I. Wagner, C. Gutwin, R. H. R. Harper, & K. Schmidt (Eds.), *ECSCW 2007* (pp. 331–350). Springer. DOI: https://doi.org/10.1007/978-1-84800-031-5_18
- Verkade, N., & Höffken, J.** (2017). Is the Resource Man coming home? Engaging with an energy monitoring platform to foster flexible energy consumption in the Netherlands. *Energy Research & Social Science*, 27, 36–44. DOI: <https://doi.org/10.1016/j.erss.2017.02.015>
- West, S. M., Whittaker, M., & Crawford, K.** (2019). *Discriminating systems: Gender, race and power in AI*. AI Now Institute. <https://ainowinstitute.org/discriminatingystems.pdf>
- Wilson, C., Hargreaves, T., & Hauxwell-Baldwin, R.** (2014). Smart homes and their users: A systematic analysis and key challenges. *Personal and Ubiquitous Computing*, 19(February), 463–476. DOI: <https://doi.org/10.1007/s00779-014-0813-0>

TO CITE THIS ARTICLE:

Strengers, Y., Gram-Hanssen, K., Dahlgren, K., & Aagaard, L. K. (2022). Energy, emerging technologies and gender in homes. *Buildings and Cities*, 3(1), pp. 842–853. DOI: <https://doi.org/10.5334/bc.273>

Submitted: 30 September 2022

Accepted: 30 September 2022

Published: 27 October 2022

COPYRIGHT:

© 2022 The Author(s). This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC-BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited. See <http://creativecommons.org/licenses/by/4.0/>.

Buildings and Cities is a peer-reviewed open access journal published by Ubiquity Press.