

Gender Relations in Sociotechnical Energy Transition: Heating System Change Motivations and Negotiations among Couples in Single Homes

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Abstract. The energy transition as one of the most challenging sociotechnical transformations processes of our time is lacking gender sensitive reflection and shaping. In a qualitative pilot study about the reasons behind the decision to install renewable energy systems in the home and the impact on household-related practices of homeowners, the couple dynamics and positioning strategies towards renewable technologies are analysed. The study shows that, on the one hand, positioning strategies enable 'doing gender' and, on the other hand, that these strategies differ according to the different technology-related action resources and competence attributions among homeowner couples. The results are reflected in the theoretical framework of an actor-centred sociotechnical transformation. The article concludes with considerations for the resulting implications for practice and for further research informed by gender theory.

1. Introduction

The future energy supply has become a key issue of the 21st century. There is a broad consensus, at least in large parts of Europe, that it is impossible to maintain a fossil fuel-based energy supply due to the already advanced stage of climate change. In many respects, the conversion of the energy system to regenerative and climate-neutral technologies has moved from the political agenda to regulation through legislation, into the investment strategies of industries and business, and finally into the everyday lives of citizens. (cf. Kaufmann-Hayoz et al. 2011: 130ff). The German and European energy transition is therefore one of the most challenging sociotechnical transformation processes of our time. The fundamental and especially social changes associated with it involve all areas of life. However, in technology and innovation research, the focus is often on the technical and economic components of the energy transition. From the STS

perspective, in contrast, the social side of the energy transition takes centre stage. Linked to this is the question of how society deals with economic, technical and ecological changes. Nonetheless, mainstream STS research is (once again) largely blind to gender-relevant effects (cf. Walk 2024, Wolfram & Kienesberger 2023).

It is to the credit of STS research to show that technology is always embedded in social contexts as expressed, for example, in the concept of the seamless web (Hughes, 1986) and that transformations - especially major ones - will not succeed if the social conditions in which the technical transformations are embedded are ignored. Especially with such a perspective on technology and innovation, the relevance of gender and diversity relations in technology research is often obvious and offers a variety of methodological approaches for social science analysis.

I would like to illustrate this using the example of the use of renewable energy systems in existing private buildings. This involves considerable investment decisions about when energy-saving technologies or renewable energy technologies are to be purchased and installed. A closer look at how these decisions are made and implemented suggests, on the one hand, traditional gender orders. On the other hand, a research design, that takes into account other relevant social categories in the context of these decisions, such as professional background, socio-economic status, socio-cultural orientation, introduces a more complex and well-founded analysis.

2. Problem Background

The relevance of owners of private buildings for supporting the energy transition can be illustrated by looking at CO₂ emissions of the private building sector. The building sector is the area in which the most CO₂ emissions are produced in Germany. The building sector takes up about 40% of total emissions if not only the energy consumption for hot water and heating but also the so-called grey emissions for construction and possible dismantling are taken into account. (dena 2021) In 2018, 30% of the 41.4 million households in Germany were single-family homes. Around two-thirds of the energy required by houses is used for space heating. And here, single-family homes account for the largest share of energy consumption for space heating by far at 47.5 % (ebd.). Moreover, this number is especially high considering that only 30% of households live in single-family homes.

One lever in the building sector for reducing greenhouse gases is the integration of renewable energies for heat supply, i.e. for heating and hot water. This can be achieved, for example, by installing heat pumps and photovoltaics as well as solar thermal systems. As owners of owner-occupied single-family homes have autonomy of decision and action here, it can be concluded that they have a relevant influence on the design of energy emissions in the building sector and thus also on the energy transition.

The available statistics (Statistisches Bundesamt 2019: 30) differentiate between the following household types: single people living alone, differentiated by gender, single parents, couples differentiated by "without child" or "with child(ren)" and other households. As expected, single-family homes are predominantly occupied by couples (46.7 %) with children (52,7 %) and without children (43,7 %). However, the largest group among single-family homeowners is the "other households" group at 53.6%. These include households with children over the age of 18, multi-generational households, shared living arrangements, etc. However, no further information is available on how these other familial and non-familial household constellations. Decisions regarding larger investments, such as those required for energy-efficient building renovations and measures, are likely to be far more complex in these cases.

3. Literature Overview: Gender and Technology in Energy Transition

Research into the social dimensions of the energy transition that specifically takes gender perspectives into account is still in its infancy, as Kannig and colleagues explain in their literature review. (Kannig et al. 2016) International gender research focussing on climate and energy issues primarily concentrates on ecological problems in the Global South. (ibid.) In the European context, there are a few studies that address spatial and planning science issues and, among other things, analyse space in its socially relevant dimensions (Mölders et al. 2025). There are also studies that include questions of gender equality in the transformation process of the energy system (Bauriedl/Wichterich 2014, Fraune 2015) and studies that focus on the consumers of energy (Weller 2013, Offenburger 2016). However, especially from a feminist STS-informed perspective, there is still a lack of work focussing on the sociotechnical transformation of the energy sector. Feminist STS (Faulkner 2001, Wajcman 2003, Suchman 2007) understands gender and technology equally as socially constructed and therefore does not take either for granted, but rather emphasises their mutual co-construction. This means that transformation processes such as the energy transition can only be adequately understood and at best governed as socio-technical transformation processes. In these processes, everyday power and domination relationships also come into play, and these are structured by the category of gender and other effective social categories which can also have complex interdependencies. This pilot study addresses this research gap and builds on some few

studies who deal with the question in recent years, how visions, relationships, and practices with emerging energy technologies are gendered in the context of home relations. (Strengers et al. 2022, Mechlenborg & Gram-Hanssen 2022) Especially Ursula Offenburger (2016) investigates how the emergence of a 'home' is created through the gender-differentiated division of labour around housing. Part of this ongoing process is the establishment and maintenance of living space and therefore also the processes of construction and renovation. The supply and consumption of thermal energy is of central importance in this respect. Offenburger's concern is to make clear how these aspects of creating a home are integrated into overarching, historically developed standards that structure the practices of creating a home. The fully automated heating system, developed after the Second World War, has represented an unquestioned expectation that has been taken for granted for decades¹, and this is carried over to the installation of heating systems with renewable energy sources. Interaction with the heating system is reduced to the actuation of thermostats during unobstructed operation. While the focus of the analysis is on individual fireplaces and stoves in living rooms and central heating systems in functional rooms that are operated with biomass (logs, woodchips or pellets), my focus is on solar and solar thermal systems, with the latter becoming increasingly relevant and strong in the market, especially in combination with heavily subsidized heat pumps in private homes. With regard to the individual fireplaces, Offenburger finds that the location of the individual fireplace and the associated specific design suggest strongly gender-differentiated meanings and typical patterns of family division of labour. (ibid.: 99) Under the concept of knowledge orders, Offenburger also focuses her attention on the interactions of central actors in connection with the acquisition and use of heating technologies and the associated negotiation content. She shows that "technical knowledge" and "technical competence" are both negotiated in these interactions. Gender acts here as a resource for the creation of analogies and the drawing of boundaries and channels technical expertise and knowledge to the actors involved. (ibid.: 101)

These findings refer to another instructive study by Elisabeth K. Kelan (2007), who works out how gendered positions are discursively produced in the context of technologies. Based on a social constructivist understanding of gender, in which gender is the result of a continual and perpetual performance. Kelan argues that the tendency of women to distance themselves from technology while men's tendency to appropriate technology as subject positioning fulfil the function of 'doing gender'. (Kelan 2007: 359) She investigates how far these relative positions regarding technology are enacted in ICT work and identifies four strategies of positioning through which a hegemonic gender order is

¹ These expectations are comparable with the automotive based individual mobility as Katrin Manderscheid has worked out and called these expectations as "Automobility in the Head" (Manderscheid 2019)

reproduced either in a conformist or in a non-conformist way. While her study examines the positioning strategies of professionals in the ICT sector, decision-makers in single-family homes generally have no relevant technical expertise, if any at all. In this respect, it can be asked how men and women with different levels of technical competence position themselves in retrospect regarding the decision process to install renewable energy systems. What strategies do they use and how do these strategies relate to the subject positioning of their partners? What are expectable and what are not expectable strategies and how are these positioning strategies communicated?

4. Research Design of the Pilot Study, Methodological Approach, Data Collection and Sample

In the pilot study "Gender arrangements of sustainable energy behaviour in everyday life" the focus was on the question of how the energy transition is implemented in everyday life. What are the (sustainable) energy practices in households and in people's everyday lives? What gender and diversity-relevant insights can be generated with regard to positioning strategies in relation to technology? What conclusions can be drawn from this with regard to the question of how sustainable energy practices can find a broader entrance into society and thus serve the implementation of the energy transition?

The aim of the pilot study was therefore to explore initial starting points as to how the energy transition can be implemented starting from the actor level and how actor behaviour is embedded in and interacts with the socio-technical energy system and interacts. I pursued these questions in a qualitative and therefore explorative research design. In the pilot study, seven interviews with homeowners were conducted, in detail three couple interviews, four individual interviews because the partner was unable or unwilling to participate at the time of the interview and one written interview because the interviewee requested this. The interviewees differed as much as possible in terms of their socio-demographic characteristics, i.e. in particular in terms of social class, lifestyles, gender, age, city/country, mobility needs, technical affinity and occupations. The interviews followed a structured guideline but were nevertheless open to support the narrative flow and the interviewees' own logic. The guidelines covered the above-mentioned questions. It was also focussed on the social negotiation and implementation processes involved in the installation of photovoltaic or solar thermal systems, including in combination with e-mobility as given, among the residents of single-family homes. And finally, it was also looked at their sustainability-related attitudes and behaviour.

Data collection took place between December 2020 and August 2021. Due to the COVID-19-pandemic, the interviews had to be conducted online, which meant that no personal impression of the homes could be gained and that observation of the interactions between the couples was also limited. The interviews lasted between 60 and 90 minutes. The data collection was carried out in the form of theoretical sampling, which aimed to cover the descriptive diversity contrasts in order to be able to analyse the various meaning structures of the respective motivations, resources and energy practices in terms of their origins and effects. All interviews were recorded and fully transcribed.²

To analyse the data material, thematic content analyses and discourse analyses were carried out. The qualitative data analysis used the data software MaxQDA. I relied on Braun & Clarke's (2006) approach to thematic analysis with multiple rounds of coding using an inductive approach. I began using an open coding process generating initial codes on a semantic level, coding based on common words or phrases in the comments. The data were then recoded for similarities in attitudes, beliefs, and ideas surrounding experiences (Braun & Clarke 2006). Furthermore, I relied on the Davies and Harré (1990) approach to discourse analysis. Different positions are created through discourse, but these are negotiated in interactions. By adopting and asserting certain positions for themselves, people establish themselves as certain subjects. Of interest here is how gender is performed through adopting or rejecting subject positions and thereby communicating and doing gender. (West & Zimmerman 1987)

These approaches opened the view for the individual case typology and for typical and generalisable characteristics across cases, as well as for the production practices of gender in the context of renewable energy technologies. During the analysis, no theoretical saturation became apparent in the present sample, meaning that the scope of the results has not yet been fully explored. In this respect, the results presented below only allow for the formulation of hypotheses that need to be examined and expanded in further interviews.

² I would like to take this opportunity to thank my student assistant at the time, Julia Neidhardt, for her collaboration on the interview study. In particular, she supported me in conducting the interviews, transcribing them using speech recognition software and helping with the thematic content analyses.

5. Findings

The interviewees are largely located in middle-class milieus, mostly with modernised attitudes towards an egalitarian gender order. But even in these milieus, gender-differentiating technical relationships are still predominantly handed down. This means that women tend to downplay their own technical competence and knowledge and leave responsibility for technology-based installations firmly in male hands. In focussing their responsibilities and sustainable behaviour largely on household management, men and women enact masculinity and femininity in suitable ways. Gender arrangements that deviated from this pattern also deviated from the ones of traditional couple relationships.³

Within the heteronormative couple relationships, the wives supported the cost-intensive projects of converting or upgrading the energy supply with PV systems and, in some cases, the associated automotive e-mobility, although they had to adapt their everyday organisation considerably in some cases. For example, hot water may not be available all day, or the reduced capacity of the PV system may be supplemented in winter by using a wood-burning stove that must be filled and lit in the morning. However, they also expressed their pride in switching to an alternative energy supply. The *motivation* of these couples was largely driven by climate protection. If, on the other hand, the motivation was of an economic nature, the installations and conversions were perceived more as a burden.⁴

In contrast to these patterns of behaviour and attitudes between women and men, which have been selected here as examples and are generally quite predictable, the further analysis of different masculinities and their positioning strategies towards (regenerative) technologies is of more in-depth interest, as it allows us to explore very different resources and patterns for these strategies and therefore of justification for the (non-)use of sustainable energy in housing and mobility.

³ In my sample, two study participants fall outside the heteronormative couple constellation. One is a female homeowner who lives in a same-sex marriage and the other is a middle-aged owner of a three-family house who lives in a weekend-only long-distance relationship. For both of these interviewees, the motivation for retrofitting or building a zero-emission home was primarily an ecologically conscious attitude with a corresponding lifestyle.

⁴ It makes an important difference whether the renewable energy is fed into the electricity grid or is predominantly used by the homeowner. Feeding energy into the grid involves only minor adjustments to everyday organisation, while not feeding energy into the grid in conjunction with a lifestyle that is as energy self-sufficient as possible requires a major adjustment or change in the use of appliances and therefore energy consumption in the home. The degree of self-consumption of the energy generated varied considerably in some cases, but most couples endeavoured to consume as much of the energy generated as they possibly could.

The resources of homeowners can be derived, among other things, from their localisation in specific types of masculinity, which in turn are rooted in different lifestyles and ways of life. In my sample, there is the technology-informed, ecologically committed academic; the craftsman specialising in renewable energies; the economically motivated, conservative pensioner supported by a son; or the family man - who makes use of comprehensive advice - who is concerned about a viable future for his children.

Offenberger (2016) points out in her study that specialised knowledge relating to construction and renovation is not a monopoly of professionals. Rather, homeowners are able to acquire a considerable amount of their own knowledge and skills, which leads to an increase in 'consumer sovereignty' (Offenberger 2016: 106), especially when their own (technical) professional expertise can be activated (ibid.: 105). Offenberger uses this finding to explain the low consumer sovereignty of women:

“Since technical professions are still numerically dominated by men, the statistical chance that male household members will assert their own professional expertise and involvement in professional networks is significantly higher than the chance that women will make their professions relevant in order to interact with experts in construction professions on an equal footing.” (ibid.: 106)

Even the women with technical professional expertise in her sample would not use their professional knowledge for the transfer or acquisition of skills for construction and renovation matters. This finding points to Kelan's assumption that “positioning towards technology can be seen as doing - and indeed communicating - gender” (Kelan 2007:364) i.e. that technology-related subject positions are not equally accessible to all.

Based on these assumptions and findings, I would like to draw on the concept of consumer sovereignty to explore the resources for technology-related positioning strategies that may result from this, from which a differentiation of “energy technology-related masculinities” can be derived. I would like to do this by comparing two of the four types of masculinity initially defined above.

Mr. Green, a 58-year-old mechanical engineer, set up his own business in the field of renewable energy systems 25 years ago and used his circle of friends in the field of ecological construction to renovate the farmhouse he bought with his wife six years ago from the ground up in an ecological manner. With his relevant self-employment experience, he is at the upper level of a continuum of the concept of consumer sovereignty, insofar as he possesses comprehensive expert knowledge. At the same time, this leads to a partner-backed positioning as the sole expert for technology-based ecological construction. However, Ms. Green also presents herself as technically informed and therefore also interested.

“... and I originally had no idea about all this stuff (meaning solar technology in particular and ecological building in general). (...) Yes, and I was actually always interested in nature and animal protection (...) and waste avoidance, that was always my focus, but that suits Gerd quite well. Ecological building and these energy-related things, I'm also learning about them now.”

In contrast, 65-year-old Mr. White, also a mechanical engineer, also presents himself as interested in technology, but his interest in and commitment to an ecologically sustainable lifestyle must also be economically justifiable. After the 15-year-old heating system in the detached house had to be replaced in 2015, Mr. and Ms. White opted for gas heating with condensing boiler technology and had a PV system installed at the same time. However, the electricity produced is fed into the grid in its entirety due to what they consider to be the high feed-in tariff. Mr. White cites his technical interest as the main motivation for installing the PV system.

“That's perhaps a little disappointing. The motivation was not necessarily to do something good for the environment, but simply an interest in technology and the idea that the investment would pay for the system when we retire and, of course, to use renewable forms of energy.”

He informs himself about PV systems, but also makes use of advisory services, which he considers to be consistently competent. With a view to consumer sovereignty, he confidently positions himself as technically competent and on a par with solar technology experts.

“Of course, I did my research before making the decision to put a system on the roof. But the advice was competent, not just from the company we chose, but in general. I didn't start studying the technical literature even a year beforehand.”

Mr. White positions himself as willing to take risks and open to new technologies. He does this in particular in contrast to his wife, who supports the decision after her concerns about the PV system had been allayed:

“My wife was more concerned about electromagnetic fields and whatnot, and fire safety and things like that. She tends to be anxious. Of course we talked about it, but she didn't push for it (the installation of the PV system).”

In both cases, the men claim technological expertise for themselves alone, and this is accepted by their female partners. Nevertheless, women also succeed in positioning themselves as technically interested or informed by either increasingly acquiring technical knowledge in the process of use, as in the case studies presented, or by reflecting on and scrutinising the possible risks of new technologies.

6. Discussion and Theoretical Framing of the Results

The interview analyses have so far shown that in the context of the installation of renewable energy systems in private homes, these technologies are used to express masculinity in heteronormative gender arrangements in particular. In contrast, female subject positions are expressed in the form of a gradual orientation towards technology or in the form of a more negative attitude in the sense of risk reflections. In addition, the women in these gender arrangements are considerably affected by the negative implications of the new energy systems, such as the change in everyday routines or noise and dust nuisance when renovating their own home. (cf. also Fischer 2011)

Two case studies were used to illustrate how the homeowners indirectly communicate gender by communicating a certain relationship to technology. These still preliminary findings are less indicative of the fact that gender differences are actively produced via technology. Rather, they show how the genders and their unequal relationship to each other is achieved through communication.⁵ It is also interesting to note the rejection of women's lack of interest in technology and their lack of technical expertise in traditional gender arrangements, which is reflected in their own approaches to renewable energy systems. This reveals new female subject positions that express new ways of dealing with new technologies.

In the following, I would like to discuss the results within the theoretical framework of an actor-centred sociotechnical transformation. Transformation research has long been working on analysing the interactions between socio-economic and technical aspects in systemic transformations (Geels and Schot 2007; Araújo 2022). Here, for example, new governance mechanisms or changing power structures associated with the transformation are analysed (Avelino and Rotmans 2009; Loorbach and Rotmans 2010).

With regard to the role of actors in socio-technical transitions, the conceptualisation and analysis at the actor level in socio-technical transitions has also become increasingly elaborate. In their literature analysis, Fischer and Newig (2016) provide a comprehensive overview of the different conceptualisations of actors. At the same time, they show that gender-theoretical perspectives are largely lacking here.

In order to situate agency of actors within the transformation process of the socio-technical energy system, I draw on the conceptualisation of Grin et al (2011). Here, the actor levels "government," "market," "science and technology," and "civil society" are differentiated. In addition, Fischer and Newig (2016) categorise "civil society" as "NGO/s,"

⁵ This pattern is also identified by Kelan (2007) in her study, which analyses the subject positions of women and men in the ICT sector and thus among equally qualified people.

“trade union/s,” “political party/ies,” “environmental group/s,” “interest group/s,” and “household/s.” According to her literature review, if the research is strongly underrepresented in the area of “civil society” compared to the other actor levels, this applies even more to the subgroup of households. However, it is precisely in the subgroup of households that women in particular come into focus while existing power structures marginalise women in particular in all the other areas mentioned that can be assigned to the public sphere. Judy Wajcman (2003), among others, has already pointed this out when she emphasised that women in particular come into the focus of gender-technology relations when the lens is widened. Then the actors in STS analyses are not just the male heroes, the big projects, and important organisations, but the work of women as production workers, marketing and sales staff, and as end users of technologies comes into focus. Here, regarding the use of new renewable energy systems, it is clear that these once again have ambivalent implications for women.

If the perspective is directed to the household level in the context of sociotechnical transformations, however, the focus is not only on women as users of household technologies, but also on gender relations. The more traditional the gender relations are, the more consumer sovereignty shifts to the male side of the relationship, through which ‘doing masculinity’ is effectively (re-)produced. In contrast, justified questioning of new technologies, e.g. with regard to their risks or usefulness, is devalued as a lack of technical expertise and as female emotionality. At the same time, however, this denies women relevant agency as actors in the energy-related socio-technical transformation.

7. Research Perspective

This article has set itself the goal of expanding energy-related sociotechnical transformation research to include perspectives informed by gender theory that have been largely lacking to date. This was done on the basis of a pilot study that investigates the motivations behind the installation of renewable energy systems in owner-occupied homes and the subject-related positioning strategies in relation to these technologies of homeowners in their respective gender arrangements.

With the qualitative design of maximum contrasts, the initial aim was to identify and make sense of the gender-differentiated motivations and resources that transform owner-occupiers into change agents in the energy transition. An important finding that emerged was that women are relegated to marginal subject positions in this process, especially when they are living in heteronormative relationships, which at the same time deny them appropriate agency. Of course, the pilot study does not exhaustively capture this. In the future, further qualitative case studies will be needed to identify the full range of subject positions and the motivations and resources associated with them. It will be particularly

instructive here to identify those subject positions that are produced outside of heteronormative life contexts. In addition, the interweaving of these positionings with other categories of social inequality must be substantiated by making a decidedly intersectional-theoretical approach fruitful for this purpose. Subsequently, a quantitative design can build on a sound knowledge of the motivations and resources of sustainable energy practices in order to be able to make statements about the relevance of motivations and resource correlations.

In contrast to the expected patterns of behaviour and attitudes between women and men in heteronormative gender arrangements, the further analysis of further subject positions in terms of masculinities and femininities in connection with a intersectional approach is of particular interest here, as this can also be used to explore very different patterns of justification for the use and non-use of sustainable energy in the area of housing and mobility.

With regard to an actors-centered understanding of the energy transformation, a gender-sensitive framework is required and very useful. On the one hand, this must take into account the constitution of gender-differentiated actor behaviour, i.e. the different factors influencing actor behaviour, such as individual practices, goals, perception and learning processes. And secondly, the embedding of this diversified actor behaviour and interactions or lack of interactions with the sociotechnical system must be taken into account, insofar as questions of power also become relevant here.

The article therefore locates itself in the field of multi- and transdisciplinary energy research and expands it to include gender perspectives, which were previously in their infancy. The study builds on the ground-breaking work of Ursula Offenberger, whose work expands current behaviourist-oriented theoretical approaches to include practice and action-theoretical approaches. Regenerative energy supply and sustainable energy use can thus be examined beyond individual attitudes and behaviours and can instead highlight collective patterns and dynamics of sociotechnical transformations without losing sight of interaction-based, situational negotiation processes. (Offenberger 2016: 5) Combined with a critical feminist perspective, the structures and results of current knowledge production - here in the context of the sociotechnical energy transformation - can also be questioned and criticised with regard to their epistemic premises or (natural) scientific models of objectivity, universality and neutrality and their interweaving with a positivist understanding of science. (Hofmeister et al. 2013: 348f). How such an understanding is reflected in the practices and attitudes of homeowners who will be confronted with the installation of renewable energy systems in the near future due to current European and national legislation and how this reconfigures or reconfigures gender orders will be of great interest.

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