Socio-Technical Energy Systems: Configurations That Work Better for Some

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Abstract: The political character of the energy transition requires a fine-grained perspective on the power games occurring to bring it about. There are approaches specifically geared towards calling out the identity-based inequalities in such social processes termed as grand challenges, and then there are those specialised in studying the role of technology in the energy system and how actors in that system interact with these technologies. Feminist social scientists have highlighted the entanglements of intersectionality with technology in general and energy more specifically. At the same time, the literature on Science and Technology Studies (STS) emphasizes a social dimension, e.g., how technology is co-constructed by societal actors or how large technical systems structure our daily lives. Of relevance for feminist social scientists, STS approaches are well-positioned to analyse how technology creates, re-enacts, or mirrors power asymmetries. STS approaches understand technologies as socio-technical systems that inadvertently incorporate societal realities in production and consumption which allows an analysis of the covert seats of power in socio-technical systems. Similarly, energy systems have been a popular research object in STS due to their large-scale, often high-tech character, especially when considering modern energy technologies. Regardless of the common scope of intersectionality and STS regarding power asymmetries, there is still significant room for "hybridization" of these approaches. Although the energy domain has seen efforts being made with the development of notions such as energy poverty, energy justice, or energy democracy, the hybridization effort with STS has not been taken further significantly. This paper, we contributes to the hybridization of the STS and intersectionality lenses.

Keywords: Gender, Energy, STS, Power, Users

1. Introduction

The energy transition towards a low-carbon society is one of the grand societal challenges the world is facing. It is an economic and political process involving the production and use of new forms of knowledge and technology by different groups in different social contexts. However, we will show that such grand challenges are at the same time normative processes with asymmetries of power in the design of energy technologies and their use, especially visible in the meanings ascribed to gender roles. We use the term 'energy technology' as an encompassing term to describe an artifact that provides an energy service, such as a stove which cooks food and, in some cases, provides space heating, or as a technology which generates a useful energy source such as electricity. Technology can be viewed from a gendered perspective on the energy transition that justifies a more fine-grained conceptual treatment.

Putting literatures from science and technology studies (STS) as well as feminist sociology to the test, we intend to elaborate the entanglements of energy technologies with intersectionality. A review of STS theories describes links between justice theories, and relevant STS theories (Sovacool and Hess, 2017). While theories such as the Social Construction of Technology (see section 2.1) are seen as 'descriptive-explanatory', social justice have a normative outlook: they aim to identify inequalities/problems and improve empirical reality (at least more than those theories characterised as descriptive-explanatory). Furthermore, the goals of these theories, generally, also differ. Whereas social justice theories aim to critique and guide transformation, descriptive-explanatory theories are more interested in describing to understand and search for patterns. We concur with Sovacool and Hess (2017) about the different characteristics of justice theories versus other STS-related theories. STS theories are more observant of empirical realities, attempt to understand how they come about and which factors are at play; critical, justice and feminist theories are much more action-oriented. Although the energy domain has seen efforts being made with the development of notions such as energy poverty, energy justice, or energy democracy (Bouzarovski et al, 2021, Jenkins et al, 2016, Szulecki and Overland, 2020), integration with STS has not been taken further significantly. Hence, there are opportunities for further "hybridization" of these perspectives (Hess and Sovacool, 2020).

As a gender and energy researcher and an environmental STS researcher, we see merit in mapping the meeting points between our particular approaches, thereby promoting interdisciplinary learning and deeper understanding of the complex problem at hand. This paper can be understood as a work in progress towards

an integrated, gendered STS perspective on the energy transition. This reflective piece of conceptual thinking based on purposefully selected, existing literature might initiate empirical work at a later stage. Thus, the questions guiding our thinking are "How do feminist sociological theories and STS theories relate to each other, and what is their combined potential to inform a more fine-grained perspective on the energy transition?"

2. STS, Energy, and Intersectionality

2.1 Science and Technology Studies

Science & Technology Studies (STS) treat 'technology' and highly technological domains such as the energy domain as a core empirical phenomenon. For example, the energy system has figured in studies relating to the material and social infrastructures of the technologies constituting the system, (see for example Hughes, 1983). This interest in the socio-technical nature of technology has resulted in a multi-dimensional understanding of the notion of 'technology'. In this paper we adhere to a definition of technology as a "configuration that works" (Rip and Kemp, 1998). This definition sees technology as a configuration of physical resources, knowledge and people, which Rip and Kemp (1998) classify as hardware, software, orgware, and socioware. For example, photovoltaics panels installed on a rooftop can be seen as a system of hardware. However, rooftop photovoltaics do not simply work autonomously: at some point human beings are involved who need knowledge and skills of differing types and degrees. For example, a user needs the skills to operate the involved transformers, displays, etc. (software). Technicians require the skills to assemble the panels and material infrastructure (software). Training systems need to be set up for these technicians (orgware). All of this occurs within a legal and cultural framework in a specific societal context, e.g., the energy transition (socioware). These four '-wares' are not only elements constituting what a technology 'is' but are also systemically related: each '-ware' shapes the other three to some extent.

This definition of technology opens up avenues for the study of social influences in all processes involved with technology and falls within the perspective of the 'social construction of technology' (SCOT) (Bijker et al, 2012). Technological development has often been depicted as a linear, deterministic process, however, SCOT contends that it is actually a 'messy' process that involves interpretative flexibility at each stage within a development process. When developing a technological artifact, 'social groups' or actors engage in a meaning-making struggle over what constitutes 'the problem' and which technological artifact constitutes a 'solution' to that problem (Pinch and Bijker, 2012). At a certain point, the interpretive struggle over the meaning of a technological artifact leads to a stabilised form and 'accepted facts' emerge (Becker, 2017). Viewing technology development in this way reveals the fact that there are choices to be made along the way. Which choice is made at each junction, specifically, is the result of an interaction between involved actors, their meanings, and wider contexts. These interactions are not necessarily between equals. Although SCOT speaks of the 'social groups' involved in the construction of technology, Pinch and Bijker (2012) are neither too explicit about how the struggles over meaning between actors play out, nor how technologies constrain its users. This original overview of SCOT also omits to differentiate between actors. Such studies can be found in the STS field of 'Technology in use'. One of the findings in this field – and an outcome of the struggle over technology development between different actors – is the fact that technologies become 'scripted' by their developers. Scripting is a common notion in the field of design, denoting a designer's process to 'fit' an artifact-to-be to the envisioned user. According to Van Oost (2003) a gender script can be defined as "the representations an artifact's designers have or construct of gender relations and gender identities – representations that they then inscribe into the materiality of that artifact".

Van Oost (2003) applies this notion of gender scripting to the imaginative example of electric shavers. She shows that shavers intended for male usage assumed a higher technological competence than those designed for females; a link that has re-emerged in recent studies of renewable or smart energy technologies (Breukers, 2022). As literature on the in- and exclusion of women from the design and use of technology has shown (Oudshoorn et al, 2016), it matters who is involved in the scripting processes. Consistently, STS scholars have developed methods such as 'Constructive Technology Assessment'/'Constructive Innovation Assessment' that prescribe an explicitly stronger involvement of all relevant stakeholders – both usual suspects and ones not often thought of – in the development of technology and innovation (Aukes et al, 2022).

2.2 Energy

The energy transition is a complex socio-technical problem based around an energy system which consists of a number of chains starting with a particular resource (e.g. coal, oil, sun, wind, biomass), which is extracted,

converted, transported, further refined to a form suitable for distribution to a consumer who will use the energy to provide a range of desired applications or services (e.g. light, cooking, transport, music). However, viewing the energy system from an STS perspective we see that the system consists not only of resources, hardware and equipment and the knowledge to use them, but also of actors (e.g. people acting individually or within social groups, such as firms or other organizations) with their own interests, values and behaviour, and institutions with societal and technical norms, regulations, or standards of good practice (Geels, 2004). In other words, there are multiple social actors with multiple perspectives and decision-making paths, which, in turn, are dependent on situation and context to determine the nature of the transition. There are actors on the supply side (e.g. policy makers, industrial strategists, regulators, technology developers, and investors) and on the demand side (e.g. users). Decisions about the form of the energy transition will result from the interaction between actors in processes of adjustments, modifications and negotiations which, in turn, depends on their awareness, attitudes, risk perception and behaviour. However, these interactions are not always between equals since social groups can have different enabling, mediating, and aggregating functions which affect other actors in meaningful ways.

Despite these very clear social dimensions to the energy transition, social scientists have been slow to engage with the energy system. An obvious intervention that social scientists could make relates to the characteristics of actors, and the social groups they represent, in the energy transition asking questions about whether the equality in participation and benefits; for example, in terms of energy services enjoyed, participation in any employment/income-generating opportunities, and capacity to influence the form of the energy transition. Most of the research to date tends to focus on women as a homogeneous group, with little differentiation across other social categories.

The initial interest from a social science perspective focused on the Global South; in response to the lack of attention to 'the fuelwood crisis' at the Fourth World Conference on Women (Beijing, 1995) which was defined as a woman's problem since they were considered to be the primary gathers of a fuel increasingly in short supply. The resulting research has tended to focus on documenting what has been done to improve women's access to household energy sources particularly in the Global South, and making the case that there is a gender perspective in the energy sector particularly in the Global North. In terms of benefiting from employment/income-generating opportunities, the emphasis in the Global South has been on women's empowerment as small-scale entrepreneurs either using energy to run a business or selling energy technologies. The nature of this empowerment is undefined and unmeasured. In the Global North, attention has focused on increasing women's participation in the commercial energy sector including identifying why more women do not study STEM subjects. There is little attention to the values and norms of actors in energy sector institutions. There has been some gender analysis of energy policies which to date, globally, appear to be gender blind – neglecting gender-based differences in perception, socialization and values, assuming that women and men have the same values, experiences and aspirations towards energy production and use.

2.3 Intersectionality

Feminist and social scientist researchers have long argued that gender is not a binary condition but that individuals are differentiated by a range of social and economic characteristics. In the 1990s, black feminist researchers in the US argued that there is an interconnectedness and interdependence between social categories such as race, gender, ethnicity, socioeconomic status, sexual orientation, and other social identities or positions which shape social experiences (Valentine, 2007) or are affected by economic or political projects (Yuval-Davis, 2016). In response to this point about social categories, the concept of 'intersectionality' was introduced to highlight the different experiences by social categories of the same phenomena and policies (Valentine, 2007).

Intersectionality use has evolved. First, as a lens to focus on how different social categories interact in a specific context (e.g. gender, class and race in employment), without prioritising one facet or category of social difference, that influence outcomes (Yuval-Davis, 2016). It is used to analyse social stratification revealing positions that are marginal in some ways but dominant in others, for example migrant men or white women. Intersectionality provides an understanding of how invisible power relations shape inequality. Researchers in the Global South have warned against a simplistic assumption of homogeneity in the way identity operates in communities: collective identity in some cultures is stronger than individual identity (Hirtenfelder, 2015). Other researchers have warned about an overreliance of a rather Eurocentric definition of gender which draws on a particular biological construction that presupposes sexual dimorphism and heterosexuality (Lugones, 2016). In some cultures, gender is not constructed around anatomical distinctions (Walsh, 2016).

Second, as theory and methodology: how intersectionality has been developed, adopted, and adapted within different disciplines; application within policy implementation, particularly in the more technical sectors, has helped point to the need for data collection and analysis methods which reflect differentiation. Projects promoting energy access in the Global South have been criticised for the use of undifferentiated terms such as "people," "community," or "consumers" (Cecelski, 2004). However, concerns have been raised about a lack of clear definition of the concept which then creates uncertainty about the categories to use and where to draw the boundaries (Davis, 2008).

Third, to interrogate political interventions through an intersectional lens. Social movements of the Global South have used this approach to raise awareness about how colonialism installed institutions rooted in a patriarchal system in the mould of the coloniser negating the legitimacy of alternatives visions (Lugones, 2016). This helps draw attention to the nature of institutions intended to ensure delivery of services to groups who have been identified as excluded. It acts as a warning not to underestimate the power relations which have shaped the differentiation which results in exclusion (Hospes and Clancy, 2011). It also prompts us to examine the diversity of the people who work in those institutions and their understanding of the lived experiences of those who are identified as excluded. On the other hand, groups or individuals who are targeted for inclusion may reject, for their own reasons, inclusion. While practical measures can be taken to reduce the impacts of exclusion, it is not a given that the causes and institutional mechanisms of social exclusion are addressed (Kabeer, 2000).

3. Meeting Points

In this section we discuss three points at which thinking about intersectionality/gender, energy, and STS meet, describing the role of social constructs, power, users, and scale as central elements. Where appropriate, we point out similarities and opportunities for further elaboration.

3.1 Social Constructs

Social constructs play a prominent role in the previously described STS field known as the Social Construction of Technology (SCOT). It helped challenge the notion that the technology design process is open-ended resulting in different designs depending on the social context. The design of technology can be considered as a social process in which groups negotiate about the form of an artifact to a point at which some of the groups are satisfied that the artifact meets their requirements after which no further changes to the artifact's hardware take place. Within the SCOT literature, attention has focused on which social groups are involved (or not) in the design process. A social group in respect of technological design of a specific artifact's hardware is delineated by members sharing the same set of meanings in relation to that artifact. Several questions then arise in respect of these groups, beyond their social characteristics, including which groups should be included or excluded in relation to a particular artefact. In terms of the excluded, on what terms are they excluded and who defines these terms? Structural factors, such as a lack of organisation by actors who would identify as part of a social group, can also act as a barrier to participation (Klein and Kleinman, 2002).

The manner in which a design process is organised has also been an item of interest including the nature of interaction both between and within groups. The interaction is governed by "rules of play" which can be formal or informal, explicit or implicit (Klein and Kleinman, 2002). These rules can give some actors advantages over other actors since the rules influence resource distribution which in turn influences capacities and enables opportunities for some actors and creates constraints for others. These rules reflect asymmetries of power found in all social contexts. Exclusion from the design process results in an inability to influence the incorporation of a group's cultural meaning into an artifact which in turn may mean that group rejects the artifact. Cultural meaning is part of a cognitive framework that group members share about an artifact. Such a framework tacitly or explicitly shapes the reaction to an artefact. This issue is illustrated by the decade-long substantial efforts to promote the switch from wood fuels for cooking to cleaner fuels in the Global South. In a study of household wood fuel use in rural South Africa, women were found to be reluctant to give up the wood pile outside of their houses, since the size of the pile was culturally taken as a measure of their capabilities as a "good mother" (Matinga, 2010).

Researchers have examined how gender roles influencing technology design. For example, historical studies revealed how the gendered social norms about what was appropriate behaviour for women and men shaped the design of the early bicycles in 19th-century United Kingdom (Klein and Kleinman, 2002). Kline and Pinch (1996) showed how women were excluded from the design process of automobiles since this was considered the realm of the technical experts who were all men. Little appears to have changed. A recent review of the

transport planning system in Sweden found that decisions in respect of transport policies tend to be taken by men with a background in engineering (Kronsell et al, 2016).

3.2 Power of Words and Acts

Power has always been a central phenomenon in STS literature. The role of power in the production of energy (technology) can be divided into (a) the way we talk about energy and related technologies, and (b) the way energy and its technologies come about. The 'words'-side of power relates to the notion of 'discourses' which "ritualise[…] power into a truth regime" (Sovacool and Hess, 2017). This indicates that among social groups certain truths have been established that categorise empirical reality in a certain way resulting in them having more or less rigidly entrenched ways of talking about (a) technology, (b) energy, (c) roles of its members and outsiders, etc. That notion also corroborates the idea that those truths are actually 'accepted facts', generated through negotiations and debates within the group. However, discourses provide a more or less stable speech structure in which its elements are put into dependent relationships with each other. That means that technologies, actors, and processes all obtain a certain normative connotation. Changing these relationships is hard. Hence, how these discourses and, by extension, the knowledge enshrined in them, come about in everyday life, scientific life, and political life, must be objects of study. The definitions of technology and their social construction above provide useful heuristics to uncover these discourses.

Several 'acts' of power can be distinguished. These include 'power over' and 'power to' (Haugaard, 2010). The former relates to the relational ability of some actors to influence the words and acts of others. This is a structural characteristic that occurs within social groups. Some (kinds of) individuals have the implicit or explicit ability to determine how others behave. They may do so by virtue of their role of 'discourse leader' (e.g. politicians wielding social media), by hierarchical rules (e.g. hierarchical superiors in a company), or in elected capacities (e.g. elected politicians in legislative functions). The latter 'power to' describes the agential capacities of individuals or organisations of acting according to their volition. Such capacity exists either because structures provide individuals with this room to manoeuvre (e.g. anything that is within the bounds of existing laws), because individuals or organisations act in spite of existing rules frameworks (e.g. laws, norms, values), or because they have self-confidence, self-awareness and assertiveness. The feminist movement calls these latter features 'power within. The movement also recognises 'power with' which means organising with other people or groups who share a common purpose (Clancy, 2003).

The fact that design processes can define 'power over' and 'power to' makes for the necessity to involve users in many more phases of technology development. As Lindsay (2003) asserts that "users are [also] designed along with the technology", it becomes crucial to involve them – or rather potential users for the early stages – along the whole life history of a technological artifact. The overlap between the notions of 'power' and 'users' is, thus, quite apparent.

3.3 Users

Users of technology can be analysed from two perspectives, by identifying who they are and how they interact with technology. Identifying users can be on the basis of socio-economic categories, such as gender, age, ethnicity, sexual identify, economic class. Recognising that users are not a homogeneous group has implications for their routes of (non-)adoption of technologies. Users will make decisions about which technology to adopt at a particular moment in time, for which Cowan introduced the notion of the 'consumption junction' (Cowan, 2012). Cowan's intervention was to encourage social scientists who were interested in a network analysis of technology to shift their focus from the scientists and engineers who designed the technology to its users. Researchers who took a gender perspective to analyse users, established another change in the perception of the nature of users: from passive recipients, particularly women, to active participants (Trescott, 1979).

A differentiation of users brings to light their different positions towards influencing which problems are prioritised for development of a technological solution, the form of that technology and their capacity to adopt it. In other words, power relations enter the picture. Feminist sociologists introduced a categorisation of users based on their capacity to influence the design process. End-users, who can be individuals or groups, are at the end of the chain who are affected by new technology although they may not be the direct operator. Within end-users there are those referred to as 'lay end users' or 'implicated actors' (Oudshoorn and Pinch, 2003) who are excluded from the development process by being silenced, ignored or made invisible by those with power within the process. Within households, there are competing demands over resources including decisions about whether to acquire a particular technology. The power to decide does not always reside with

the person who will be the direct user of the technology. For example, in the case of domestic stoves it can be a man, based on cultural norms and practice, who will decide on purchasing the equipment even though he probably does not use the stove.

4. Conclusion

What are the 'take homes' produced by bringing together STS and gender/intersectionality in the energy transition? For one, there is a need for more empirical evidence regarding the energy transition from the gender perspective to assist in policy formulation. Second, STS draws attention to the design process of an artifact, including which groups are involved and excluded in the process and the role of struggles over meaning in them. The exclusion of women as a group from the design process is not a common focus in the energy transition and could be an explanatory factor in the uptake or not of stoves in the Global South. However, women are not a homogeneous group and adopting intersectionality as a group descriptor could benefit STS analysis. Third, early research into the history of technology design for the Global North has shown how existing gender norms have played a role in the design of artifacts which can be summarised as men designing for (idealised) women. This is another area for further investigation in the energy transition in the Global South. Fourth, the notion of meaning assigned to an artifact is an aspect to be further explored in terms of energy technologies, particularly when the artifact is designed in a cultural context which differs from the one where it will be used. The designer will ascribe to a set of gendered/socially-constructed set of norms particularly in respect of behaviour.

Research in engendering the energy transition has tended to look at the user in relation to adoption and use of an artifact or on the gender awareness of energy policy. However, STS draws attention to the structures within which problems are prioritised into policies which are then translated into processes. Within these structures groups interact and power operates in asymmetric ways. Klein and Kleinmann (2002) make an important point that the social world is made up of historically established structures which can be difficult for new groups to penetrate and influence processes. Here intersectionality could be better used within STS, to understand which groups dominate and decide using social 'variables', such as race, gender, ethnicity, socioeconomic status, sexual orientation, that were formerly often positioned as 'explanators' on their own or in smaller subsets. Acknowledging the complexity of individual identity from a sociological perspective can nuance the image of societal struggles over knowledge, technology, and even everyday life in general. While, a more fine-grained perspective on the nature and role of technology should prompt gender and intersectionality researchers to generate empirical evidence of social tensions.

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