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Original research article

Engaging men and women in energy production in Norway and the United Kingdom: The significance of social practices and gender relations

Karina Standal^{a,*}, Marta Talevi^b, Hege Westskog^a

^a CICERO - Center for International Climate Research, Oslo, Norway

^b Department of Geography and Environment, London School of Economics and Political Science, UK



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ABSTRACT

To achieve an energy transition favouring renewable energy in the face of climate change, several countries in the EU region have pursued different economic incentives to encourage citizens to invest in household solar systems. This enables citizens to become 'prosumers' who produce electricity for their own consumption and sell excess produced electricity to the central grid supply. Influencing people's energy consumption in this way can potentially reach EU's renewable energy targets, as prosumers add to the stock of renewable energy nationally. Through in-depth interviews with men and women from 28 households in Norway and the United Kingdom, this article explores the process of becoming a prosumer and the energy practices in prosuming households. Drawing on theories of social practice and domestication, the article pays particular attention to how the phases of appropriation, objectification, incorporation and conversion of household solar systems are gendered in the sense that women and men have different economic, social and cultural capital, and to how this influences their interaction with technology in the transition from consumers to prosumers. Viewing prosuming through the gender lens reveals how policies need to be designed to promote new practices that are attractive for a more diverse group than today's standard subsidies and feed-in tariffs if the aim is to increase the number of residential prosumers and transition to a more sustainable and equitable low-carbon energy system.

1. Introduction

To achieve an energy transition favouring renewable energy in the face of climate change, several countries in the EU region have pursued different economic incentives to encourage citizens to invest in household solar systems. These incentives enable citizens to become 'prosumers' who produce electricity for their own consumption and sell any excess electricity they produce to the central grid supply [1]. They also offer the potential to reach EU's renewable energy targets, as prosumers add to the stock of renewable energy nationally (European [2]). This article aims to explain the adoption, use, acceptance and diffusion or rejection of residential prosuming (e.g. [3]: 704) focusing on the role of social practices and gender relations. Understanding these aspects of the energy transition requires insight into the social and cultural factors underlying people's decisions to make such investments and take on such roles [4].

Previous literature on prosuming has focused on factors that motivate people's decisions to become prosumers, such as regulatory approaches [1,5,6] and economic factors [7]. These studies have often focused on financial incentives (e.g. [1]) and better information to

households to induce desired changes in behaviour (e.g. [8]). Literature has also pointed to the role of new technological innovations such as micro-generation, smart metering and energy management systems in engaging consumers in energy production and reduced energy consumption (e.g. [9–11]). Partly as a critique of the dominant role of economic and psychological theories in explaining consumer behaviour and the potential for influencing change (e.g. [8,12]), a body of literature has explored how energy consumption and adoption of new carbon-friendly energy technologies could be understood as dynamic social practices [4,13,14,15]. Some studies of prosuming have also followed this path ([16,17];). Another neglected aspect in the literature is the gendered and socio-cultural dimensions of energy technologies in the home [4,13]. With some exceptions ([4,13,14,18,19,20,21,45]), gender has generally been given little focus in the energy scholarship in the global North, as energy technologies are presented as gender neutral and one-size-fits-all solutions, superfluous to social differentiation. A few studies have highlighted the importance gender plays in decision-making, ownership and interaction with renewable energy production in households (e.g. [22,23]). Lack of consideration of how gender ideologies frame social differentiation and practices, even in egalitarian

* Corresponding author at: CICERO P.B. 1129 Blindern, 0318 Oslo, Norway.

E-mail address: karina.standal@cicero.oslo.no (K. Standal).

countries, may explain why the literature on gender and energy practices in the global North is scarce [24].

In this article, we analyse the process of becoming a prosumer and of prosumers' energy practices in 28 households in Norway and the United Kingdom (UK). Prosuming is a new phenomenon in Norway, and the number of prosumers is small (700 in 2016) [1]. Regulations concerning residential prosumers have been in place since 2010. A national subsidy scheme and a few municipal schemes provide economic support for the up-front costs, and the number of prosumers is growing. At present there is one member-based civil society organisation, the Norwegian Solar association, which work to promote solar energy in Norwegian society. They represent both the industry and consumers. In the UK, a country-wide feed-in tariff scheme was implemented between April 2010 and March 2019, enabling a rapid growth of domestic solar photovoltaic (PV) prosumers, especially between 2010 and 2015 [1]. As of March 2019, the UK has 966,082 installed systems with a capacity below 10 kW (according to the solar photovoltaics deployment tables published by the Department for Business, Energy and Industrial Strategy, June 2019). The feed-in tariff rates for new entrants have been reduced and discussed several times, and the scheme was closed to new applicants from April 2019. At the time of writing, a Smart Export Guarantee is under discussion to ensure that new prosumers will be remunerated for the surplus electricity they export to the grid. The UK has several civil society and trade organisations that promote solar energy nationally and at the local level, such as the Solar Trade Association and the Renewable Energy Association, which see themselves as the voice of the UK solar industry, and the UK Solar Energy Society, which represents both industry and the general public.

Drawing on theories of social practice and domestication, this article pays particular attention to how the phases of appropriation, objectification, incorporation and conversion of household solar systems are gendered in the sense that women and men have different economic, social and cultural capitals. This influences how they interact with technology in the transition from consumers to prosumers. Viewing prosuming through the gender lens reveals a need for policies to be designed to promote new practices that are inclusive and that appeal to a more diverse group if the aim is to transition to a more sustainable and equitable low-carbon energy system.

2. Theoretical approach: social practice and domestication perspective

Social practice theory is a well-established approach to exploring socio-technical change and consumption [3], as it aims to provide a comprehensive understanding of 'why people do what they do' ([25]; Warde 2005; Reckwitz 2002). Social practice as a theoretical approach is often informed by (Pierre Bourdieu [42]) and starts with the idea of practice as something that transcends earlier notions of agency vs structure. Instead, practices are understood to result 'from relations between one's dispositions (*habitus*) and one's position in the field (capital) within the current state of play of that social arena (field)' (Maton [44]: 50). The concept of *habitus* includes an understanding of a predisposition, tendency, propensity or inclination ([42]: 214), which are also structured by material conditions, while the concept of capital addresses structures and functions of the social world such as cultural and symbolic capitals that create lasting social differentiations [26]. Bourdieu's work on capital and social practice explains social mechanisms that create social inequality, and this work has also been influential in feminist scholarship because it highlights how both class and gender distinction are produced through *habitus* and cultural capital. The gendered division of labour in households and society has tended to assign women primary responsibility for unpaid domestic duties and low-paid or part-time jobs that limit their access to economic and cultural capitals [27,28]. Further, Bourdieu (2001) has expanded his work to include symbolic capital, which aims to explain why unequal gender relations entail hidden structures of masculine domination

once the gendered division of labour and attributed gender roles become naturalised and unquestioned in society.

Westskog et al. [29] have further developed the idea of social practice in relation to energy behaviour. Here, social practice is understood in terms of different fields of rationality encompassing skills and knowledge; attitudes and norms; and beliefs, values and identities which are also influenced by material conditions. Without a holistic perspective of how these are related and interdependent, it will not be possible to overcome barriers (e.g. in policymaking) to changing social practices that are unsustainable. Gender is important here, as household members' financial agency is often unequally distributed between men and women, and unpaid domestic work is connected to a household's energy consumption [13,18,20]. Norway and the UK are countries with a high level of gender equality, and the social practices of men and women are often immersed in symbolic capital. This applies for the policy sector, which implements incentives for prosuming based on the household unit, and for the men and women interviewed in this study, who see gendered differences as individual characteristics rather than practices of social differentiation in society.

This article also employs domestication theory to emphasise how prosuming and the related technology (i.e. solar PV systems) become integrated into families and their everyday routines and lifestyle, and the symbolic meaning prosuming acquires in this process (see also [30]). Domestication theory explicitly scrutinises four phases of this process; appropriation, objectification, incorporation and conversion [31]. An object is brought into a household with its dynamics, everyday practices and relations to the outer world. Introduced to a new world of communication and information technologies in the 80s, Silverstone et al. [31] developed their thinking on domestication using the metaphor of taming wild animals [32] for the process of bringing technologies into a home, in which technologies are redefined and used according to the households' own interests and values.

When an object is purchased by a household, it leaves the general market economy and becomes an object with meaning and significance. This first phase in the domestication process is termed appropriation. Silverstone et al. [31] emphasise that the moment the object leaves the market, the meaning of the object may change and differ from that in the public sphere. The placement of the object and its integration in the household denote the objectification phase of the process. The dynamics of the objectification process is as in [31]: a process of fitting the object into an already established geography of the home, involving negotiations between family members. Next, the technology is incorporated into daily routines and practices articulating gender, age differentiation and status. Finally, conversion defines the relationship between the household and the outer world with the potential to signal its own values and attitudes and, hence, identity. Silverstone et al. [31] framework has been used in many different contexts and has expanded towards looking at domestication processes of technologies per se, also in studies of prosuming. One example is the work by Juntunen [33] studying households with different types of renewable energy technologies such as wood pellet stoves, heat pumps, solar-thermal collectors, wind turbines and PV systems. The study sheds light on how multiple domestication processes are linked and lead to increased use of renewable technologies. Juntunen refers to these processes as domestication pathways, emphasising that domestication processes are evolutionary. New technology exists alongside other supporting technologies. Another example is the study by Winther et al. [17] on different prosumer groups in Norway who followed distinct paths of domestication of PV technology. All groups, however, use the technology to signal their identity as technological enthusiasts (e.g. Stengers 2013), environmentally engaged, or as households emphasising the modern and convenient aspects of life.

Bourdieu's concept of social and cultural capitals has been used in other domestication studies; for example, (Hynes and Rommes [43]). In the present article, we go further and create a dialogue between domestication theory and social practice theory. We apply domestication

theory to understand the phases of becoming a prosumer and the role social practices play in them. This sheds light on the complicated dynamics and mediation between men and women within households who adopt, modify and use a technology.

3. Methodology

3.1. Recruitment and informants

As this study explores qualitative issues of intra-household decision-making and gender roles, we recruited and interviewed members of 28 prosumer households in Norway and the UK in the months of January, February and March 2018. The members of all but three of the households were couples, the exceptions being two where the interviewee was single and one where only the woman in the household was interviewed. In the UK, the informants were recruited from a national household survey. In Norway, the number of prosumers is too small to recruit through surveys, so informants were recruited through information on relevant online sources such as solar company websites and Facebook groups. We obtained a diverse sample in terms of geographical coverage and urban–rural areas in both countries. All our informants were owner-occupiers living in semi-detached, detached or terraced houses installed with rooftop solar plants connected to a central grid to allow excess electricity to be fed into it. Most of the informants had middle-class socioeconomic status, were over 40 years old, had secondary or higher education and lived in a family setting. As discussed in the analysis, seven of the informants in Norway worked in the energy sector, mostly in the solar industry. In addition, several of the men had technical training and occupations outside the energy sector. Still, the sample of informants is diverse in terms of age, occupation, household type and location, as illustrated in the overview in the table below:

Household	Gender	Approx. age	Occupation	Location
H1	F	40	Homemaker	Urban
	M	45	Energy sector	Norway
H2	F	50	Care sector	Urban
	M	50	Consultancy/energy sector	Norway
H3	F	45	Educational sector	Rural
	M	45	Energy sector	Norway
H4	F	55	Artist	Rural
	M	55	Farmer	Norway
H5	F	60	Farmer/educational sector	Rural
	M	60	Farmer	Norway
H6	M	40	Environmental NGO	Urban
				Norway
H7	F	35	Educational sector	Urban
	M	40	Educational sector	Norway
H8	F	50	Energy sector	Urban
				Norway
H9	F	60	Retired (prev. educational sector)	Urban
	M	60	Energy sector	Norway
H10	F	50	Nature conservation	Rural
	M	50	Energy sector	Norway
H11	F	50	Energy sector	Urban
				Norway
H12	M	25	Energy sector	Rural
				Norway
H13	F	60	Retired (prev. librarian)	Urban
	M	60	Retired (prev. educational sector)	Norway
H14	F	40	Health sector	Urban
	M	35	Sales	Norway
H15	F	65	Retired (prev. educational sector)	Rural UK
	M	65	Retired (prev. engineer)	
H16	F	40	Police force	Urban UK
	M	40	Construction industry	
H17	F	70	Retired	Urban UK
	M	45	Entertainer	
H18	F	80	Retired (prev. educational sector)	Urban UK
	M	80	Retired (prev. health sector)	

H19	F	50	Educational sector	Urban UK
	M	70	Retired (prev. finance and sales)	
H20	F	65	Retired (prev. educational sector)	Rural UK
	M	75	Retired (prev. health sector)	
H21	F	70	Retired (prev. civil servant)	Urban UK
	M	55	Financial analyst	
H22	F	80	Retired (prev. manufacturing industry)	Urban UK
	M	70	Retired (prev. manufacturing and electronics)	
H23	F	65	Retired (prev. health sector)	Rural UK
	M	65	Retired (prev. removal services and car repairs)	
H24	F	55	Homemaker	Rural UK
	M	75	Retired (prev. fire service)	
H25	F	65	Retired (prev. accounting)	Urban UK
	M	65	Police force	
H26	F	60	Admin/management	Rural UK
	M	60	Banking	
H27	F	45	Homemaker (prev. banking)	Rural UK
	M	45	Food industry (quality control)	
H28	F	55	Retired (prev. educational sector)	Urban UK
	M	55	ICT	

All informants were provided information on the interview process, their rights as research participants, and on data management plans during the recruitment process and interviews to ensure ethical conduct.

3.2. Interviews and diary notes

The interviews were mainly conducted in the prosumers' homes. In brief, a household photovoltaic system converts energy from sunlight into electricity. The major components of such a system are solar panels placed on the rooftop to absorb sunlight, an inverter, and a smart meter installed inside the home. The inverter ensures that the current and voltage are correct for household use and for feeding into the main grid. Conducting interviews in the prosumer households allowed us to see how they checked energy production information on inverters, computers or mobile apps. It was also a good way to explore who in the household monitored this information and where the inverters were placed. Five households in Norway were interviewed over the phone to avoid excessive travel. To elicit information concerning gendered aspects and intra-household decision-making, we asked to interview men and women separately, which we had pointed out in the information shared in the recruitment phase. The interviews were semi-structured to allow informants to raise issues and concerns relevant to them. The interview guide listed several dimensions that allowed for a comparative analysis: 1) motivations for becoming a prosumer; 2) process of becoming a prosumer, including the decision-making phase; 3) household division of energy-related domestic work; 4) the PV system's effect on energy-related domestic work and energy use; and 5) perceptions of prosumers in society and gendered implications.

In addition to semi-structured interviews, all informants were asked to complete a daily diary form and make notes during the week before the interview. The diary form and notes focused on energy practices related to monitoring production and consumption, and on domestic work and division of labour within the household. In Norway, nine of the households recorded the information. In the UK, 11 of the households recorded the information, though some described a 'typical' week rather than the actual seven days prior to the interview. The diary notes were discussed during the interviews and provided a good overview of the allocation of energy-related tasks in the households as perceived by the informants, though the findings cannot be generalised to the general populations in Norway and the UK.

4. Results

4.1. Prosumer motivations and household negotiations

In domestication theory, the appropriation phase focuses on the process by which an item leaves the market and on the meaning it acquires as it enters the home [31]. The informants' motivations for investing in a rooftop solar system reveal the meaning they attach to the technology and provide insights into the negotiation processes between different household members. In both Norway and the UK, environmental or climate aspects were stated across age and gender to be an important motivation. Domestic production of renewable energy was perceived as a future-oriented and environmentally friendly lifestyle. Several of the informants in Norway argued that by becoming prosumers they were actively participating in developing the Norwegian solar market and thereby enabling a low-carbon energy transition.

A second important motivation shared across gender and age was the economic benefits of prosuming. In the UK the financial incentives were highlighted in every interview, often over environmental motivations, and both men and women perceived the household solar system as a smart investment financially. One of the prosumers stated:

My focus, really, was equally spread between earning the money and having the technology that gave us free electricity ... If we can do anything that would help the environment it was a plus, but I wouldn't say it was a decision maker (Man prosumer, UK).

Subsidy schemes available in Norway are more limited than the feed-in tariffs in the UK and the upfront costs are higher, meaning that the return on investment in a solar household system in Norway takes 10–15 years. In the UK, the estimated annual return on investment in a solar PV system for an average household is approximately 10 per cent, and the savings and revenues generated would recoup the costs in around 5–15 years, depending on the energy use pattern of the household, type of PV system, and the feed-in tariffs and costs at the time of installation.¹ Therefore, the financial gains were downplayed when talking to Norwegian prosumers, though several pointed to public perception in Norway that electricity prices would rise in the future.²

The above-mentioned motivations were generally shared by the informants. However, a third important motivation for several informants was a strong technological interest. The prosumers motivated by technology were most often men, and several of them had skills and social networks related to solar technology or technology in general. In Norway, six male and two female prosumers worked in the energy sector, mostly in the solar industry, and thus had both an interest and technological skills in solar energy production. This is equivalent to almost one person in every other household interviewed. In the UK, six of the male prosumers had technical training and/or a technical professional background. Several of the other male prosumers in Norway and the UK also mentioned technological interest as a motivating factor. Apart from the two Norwegian women working in the energy sector, most of the women in Norway and the UK showed a notable lack of interest in – and sometimes even reluctance towards – implementing new energy technologies such as the household PV system, as illustrated below:

¹ In Norway the national subsidy scheme provides economic support proportionate to the capacity installed, up to a maximum amount of EUR 3,060. Some municipalities have also offered similar subsidy schemes. In the UK, the feed-in tariff system pays prosumers for 20 years for the electricity they produce, according to the rate in force at the time the system was registered, adjusted for inflation. The rate for small-scale solar was initially set at 41.3p/kWh and was progressively reduced until the scheme was closed at the end of March 2019.

² The Norwegian government has signalled that a capacity-based tariff-model will be introduced, with increased electricity tariffs during peak hours. In 2018, Norway joined the EU's third energy package, which will align Norwegian electricity tariffs more closely with those of EU member states.

It was my husband; he was mad keen to try them. I was a bit worried, what if we have a bad storm? We've got 16 on this side of the roof, it's full. Which is what he wanted in the first place... I'm going, no, no, no, I said, just let's have five, and he says, five, no, no. He always gets his way. I was frightened that they might fall off (Woman prosumer, UK).

Our finding is consistent with Bell et al.'s (2015: 101–102) analysis of household dynamics on everyday energy consumption, which showed how women and men downplay or highlight their technological expertise in specific domains (such as laundry) to assert their gender identity.

The perception of solar energy technology as the male partner's domain was echoed in a broader view of prosuming as a male domain in the way the informants described their idea of the typical prosumer. The majority, including the two women working in the energy sector, described the typical prosumer as a man with technological skills, an environmental interest, aged over 40 and with economic means to make the investment. The reason for stating 'he' was, according to several informants, that women often lacked the necessary interest or expertise in technology to make such a decision. This is illustrated in the quote below:

Men are always going to be interested in technology, so you get some men together and they're like, oh, you know, I've got micro inverters and I've got this brand of solar panels, because that's what men do. And I think women would probably more likely, you know, I'm doing my little bit for the planet and maybe enjoy being able to put the washing machine on without using any electricity (Man prosumer, UK).

Still, most informants also stated that women could manage the process of becoming prosumers if they wanted to, as they considered women to be just as competent as men. All emphasised the need for financial capital in the form of one's own house (with the right roof type and orientation) and money to invest. Several women also stated that they would have been more engaged in implementing new technology in the household had they been single. However, some also saw the gendered stereotypes of the prosumer as a result of cultural ideas formed in childhood. As one of the women prosumers working in the energy sector in Norway put it: 'It has nothing to do with knowledge or ability, if you ask me. It's about culture and how we are raised and taught what we should be interested in'. Like her, Brian et al. [34] assert that gender stereotypes about intellectual ability emerge in childhood and influence children's interests.

The perception of PV technology as a male domain was also reflected in the ways the men and women in the prosumer households participated in the process to become prosumers, and in the way they interacted with the technology. An important driver for many of the prosumers was what ([35], p. 89) refer to as 'trigger events', which take place after individuals are exposed to a new practice. Several of the informants had been invited to demo houses showing household solar systems or had met people who had knowledge about or experience of solar PV systems. Five of the informants working in the renewable energy sector in Norway had purchased their systems with a discount subsidized by their employer. As the Norwegian solar market for household prosumers is small, the availability of information and suppliers can be problematic, especially outside the major cities. However, the trigger events also reveal the importance of social networks. Men with technological interests or people working in the energy sector benefitted from their understanding of prosuming and from the availability of information and suppliers.

With the exception of the two women working in the energy sector in Norway and one woman in the UK who installed the solar system while single, it was largely the men in both Norway and the UK who took the initiative and put prosuming on the agenda in their home. This was illustrated by a woman prosumer:

In terms of gender, just basing it on how we are, if I hadn't been with him would I have gone and driven that project and done it on my own? I'd like to say yes, because it was important to me, but it was really

helpful having that driver as well, so I imagine that it's probably male driven rather than female driven (Woman prosumer, UK).

Despite men generally being the active party in becoming prosumers, the informants emphasised that the decision was taken jointly: 'It was a joint decision. There is no boss in the house if you know what I mean.' (Female prosumer, UK). Despite it being a joint decision, the gender difference in skills, social networks and financial capital resulted in reduced agency for some women. As an example, women with fewer financial resources felt obliged to consent: '[It took] not very long, actually, because once he decides on something, and he has the money to do it. [The money for the panels] came out of his account.' (Female prosumer, UK). This was also echoed by some of the men interviewed in the UK: 'I was the one who was going to win by having the panels, she had a vested interest in not being interested in it because she wasn't paying for anything.' (Male prosumer, UK). On the other hand, two women in the UK were sole owners of their house and played a more active role in the process and decision-making.

The appropriation phase also involved finding information on household solar systems, dealing with bureaucracy concerning buildings and utility companies, and deciding on which company to choose. Valid documentation is required before being allowed to sell excess electricity to the grid. Here too, social networks and skills played a role. In Norway this process was mainly driven by the men (except for the two women working in the energy sector). In four of the households, men had not only taken care of practicalities, but had also installed the solar panels themselves, reducing costs and giving them time to get acquainted with the technology. In Norway, a certified electrician must connect the PV system with the inverter, but homeowners may install the panels on the roof themselves. Among the couples in the UK households, appropriation of the panels (seeking information, contacting installers and utility companies) was more of a joint effort, though the men more often carried out the technical research. Men with technical backgrounds tended to investigate panel specifications and technical details, while men and women with financial backgrounds investigated subsidies, savings and costs. The reason the women often gave for not getting equally involved was because their partners had the interest and motivation to drive the process, so their contribution was not needed. This is illustrated by the interviewee statements below:

We very much have made joint decisions and discussed what we want to do together. ... When it came to the solar panels, my husband did most of the research, and then discussed his findings with me, so I did feel fully a part of the process. I'm not a very scientific sort of person, so I'm quite happy to leave the research to my husband. (Woman prosumer, UK).

Because I was the one who fronted [the solar PV system] and the one who got involved in it, so I'm in the way of anyone else who might want to be in on it. They think they're not good enough, in a way (Man prosumer, Norway)

Again, this illustrates the importance of skills, networks and sense of self-efficacy, which makes it difficult for a partner with no experience in technology to be equally engaged. The two women working in the energy sector bear out this argument because their skills and social networks enabled them to drive the process, not their partners. When asked, the informants stated that all the installers were men, and in several cases the women did not engage that much in the process. But some vendors made a point of having both spouses/partners present to make sure that both were included:

We call it the 'wife acceptance factor'. It's important to get everyone on board in the process, because if only one person in the family is a strong driving force it might halt the whole project. I try to make the weak one strong in these cases. The competition isn't really between companies [selling household solar systems], but between the priorities of the family members. If one wants a solar system, the other might be afraid that the holiday will be cancelled.' (Prosumer and solar company owner, Norway).

However, in a few cases the women felt deliberately ignored in the

process, as expressed by one of the interviewed women prosumers:

'It's a little bit like, if a woman goes to buy a car, sometimes you just get that very patronising attitude. You know; [When they explain, they are] not sure you'd really understand, or they tend to speak to you slightly differently. (woman prosumer, UK).

4.2. When the solar system enters the home: negotiating gendered spaces

In domestication theory, the objectification phase addresses how technologies are spatially located and integrated into the home. As discussed in (Henning's 2005) analysis of households' adoption of pellet stoves and solar systems and (Bell et al.'s 2015) analysis of household dynamics of energy consumption, certain zones of the house are perceived as more male or female than others, even though the residents see their home as gender neutral. The gendered spaces of the household come especially to light when the new technology is negotiated and installed in the household. In some families this entailed negotiating priorities and household space:

The move [from previous house] was painful [for him]. He had to make [this place] his, do you know what I mean? One of the ways of making it his was putting that [solar panels] up there without even consulting me. Absolutely his idea. They are grotesque and I loathe them. It was just him claiming the house as his own. (woman prosumer, UK).

Yes, it was the practical issues, I had objections. The whole wardrobe closet was taken over by these boxes [inverter]. And it was a good deal of money after all. But he's very committed, more than average, about this and environmental protection. [I thought] are we going to have a kitchen in a few years? We've lived here since 2003 and can you see it's beginning to get worn. Or a new bathroom? I guess I was a little more inclined towards that direction.' (woman prosumer, Norway)

These women's statements show that their priorities clashed with their partners' plans to become prosumers. Several of the women prosumers had been reluctant to invest in the solar system because they understood it would come at the expense of something else, and some had successfully delayed the investment for the same reasons. For the women cited above, the solar system broke with the aesthetics and practicalities of the house, whereas their partners saw it as a symbol of a modern forward-looking energy-savvy household.

However, some men also found it challenging having to have a visible artefact on the roof. The prosumers in both countries worried about their neighbours' reactions. Prosumers living in residential areas that were densely populated or that had a uniform design were particularly concerned that the solar panels should not be conspicuous

As shown above, the negotiations over becoming a prosumer and where the solar PV system is physically and symbolically placed in the home (see [32]) reveal how energy production and consumption are part of socio-cultural processes that produce and reproduce social differentiation through practices that may be considered 'masculine' or 'feminine', 'skilled' or 'unskilled', and so on (see [36]). As will be discussed below, the gendered spaces of the household, together with the gendered division of labour within it, influence how women and men interact with the technology adopted.

4.3. Incorporating solar PVs in everyday life: reproducing gendered divisions of labour

In domestication theory, the incorporation phase denotes the stage when the technology is integrated and used in everyday life. This relates to the importance of prosumers in the low-carbon energy transition. Prosuming adds to the national mix of renewable energy supply and has the potential to enable more sustainable energy practices such as reduced peak-hour demand (peak clipping) and energy conservation in the home. As environmental concerns and financial reasons were the most cited motivational factors for becoming a prosumer, most of the informants had high awareness of their energy consumption. Several

had internalised routines and values for using as little electricity as possible, whereas others felt that reducing their electricity consumption would be difficult since they already used only what they needed. The first group attributed their reasons for energy conservation to their upbringing and/or concern for the environment. A few families had even turned energy conservation into a kind of hobby.

Neither group had changed their values concerning electricity consumption since adopting the solar systems, though some stated that becoming prosumers was part of a process to assert themselves as environmentally friendly or energy savvy. Being a prosumer was thus integrated with other practices such as using public transport, recycling, eating more vegetarian food and so on. As expressed by a family interviewed in Oslo:

Interviewer: Speaking of environmental interest, what's that like in practice, in addition to being prosumers?

Woman prosumer: We enjoy and love using nature, and we see that we need to do more than just recycle our trash. Among other things we've chosen not to have a car, and that's been almost a year now. We cycle and walk, and think that works just fine (Woman prosumer, Norway).

Though the informants had not changed their views or values concerning electricity consumption (being a prosumer was an integrated part of an environmental value or a financial investment), several had rescheduled their electricity consumption to fit with the periods that were optimal for the solar system to produce electricity (see also [17]). In the UK, some informants mentioned that because there was no net metering (i.e. in the UK the feed-in-tariff payment mostly depends on how much electricity is generated rather than on how much of it is exported to the grid), there was an incentive to shift electricity use to periods when the panels generated energy (i.e. to use 'free' electricity), but no incentive to reduce electricity consumption overall. The main source of household energy, especially in Norway, is heating, but the need for heating usually does not coincide with the energy production of the PV solar systems (since the weather is generally milder when the sun is shining). Moreover, in Norway the rooftop solar panels are often covered with snow during the coldest winter months. However, several households attempted to reschedule their domestic tasks such as using the washing machine and dishwasher, vacuuming, and charging laptops and mobiles to periods when their solar PV system was producing energy:

I would describe it as a bit of juggling going on, in that I do try to do my washing during the day and be charging the laptop during the day. There are times though when life gets busy, when that doesn't happen, and it gets to the point where it's after dark and I'm switching the washing machine on. When that happens, I'm not very happy about it, because I know that's going to cost us money (Woman prosumer, UK).

We've got into a habit of charging mobile phones, electric toothbrushes, putting on washing machine, the dishwasher, only during the day. And, if it's a sunny day, we will try and have everything going, as much as possible. So, yes, we've completely changed our lifestyle, and we frown at my daughter when she arrives in the evening, and plugs in her mobile phone, and I'll just say, 'What are you doing?' (Man prosumer, UK).

To better understand the division of labour concerning energy-related domestic work in the households, we asked the men and women to keep separate diary notes (see methods section) on the number of times they did laundry and cooked dinner during a week.³ As the above quotation shows, there may also be inter-generational differences in energy consumption in households (e.g. [13,20]), although this is

³ We limited the inquiry to laundry, tumble drying and cooking dinner in order to maximise the likelihood of the informants taking the time to keep the diary notes. A broader time-use survey would have given a more detailed account to understand how prosuming can enable sustainable energy practices in the home.

outside the scope of the present study. However, as shown in the tables below, there is a gendered division of labour within the households interviewed. Women do the lion's share of laundry, which requires electricity for the washing machine and tumble drier. Because use of the tumble drier was much less frequent (only by two informants in the UK), and was only used women informants it is not included in the tables. Cooking dinner was more gender balanced. The sample of interviews is small, so the information cannot be generalised, but it provides a useful background when informants discussed division of labour in the households. The trends are illustrated in the table below:

Laundry activities per week				
	# done by women	% done by women	# done by men	% done by men
Norway (n=9)	30	86	5	14
UK (n11)	16	80	4	20
Cooking dinner per week				
	# done by women	% done by women	# done by men	% done by men
Norway (n=9)	34	62	21	38
UK (n11)	41	58	30	42

Our findings are broadly supported by other studies showing that women do most of the domestic work, which is intrinsically linked to energy provision and practices [13,18,20,37]. Women are thus positively affected if energy technology reduces time and labour spent on domestic work, but are negatively affected if new energy practices, such as energy conservation, lead to heavier workloads. Interestingly, previous studies have also shown that modern technology such as washing machines might make certain domestic tasks easier, but it also influences perceptions of cleanliness and modernity that result in women doing laundry more often than before [25,38].

Rescheduling energy-related domestic work and consumption also relates to other dimensions such as occupation, age, and family situation. As Bell et al. [13] show, a family's lifecycle (whether they have young children, teenagers or adult children) plays an important part in a household's capacity to change energy practices. Several of the informants were retired and stated that they had fewer problems in changing their energy-related housework schedule and habits compared to prosumers with young children and/or were working. Women who were homemakers or who had stopped working for health reasons also stated that it was easier for them to do housework during the day. We did not find that younger families had a more equal division of labour, nor major differences between urban and rural locations or between Norway and UK, though we assume that a time-use survey of the general population would reveal significant differences, especially in the age dimension.

Gendered division of labour in households was also reflected in the ways in which men and women prosumers generally interacted with solar PV technology. The women coordinate and make decisions on housework-related matters, while the men were more active in implementing and monitoring the solar PV system and more physical refurbishment work. This is illustrated in the following statement by a woman prosumer:

My domain is definitely cooking, what are we going to eat, what are we not going to eat, that kind of thing really. Peter very much looks after the cars for us, that kind of thing. He looks after DIY, maintenance, that kind of thing. We are quite gender stereotypical in that kind of area. It's one of those things where I know that if I was on my own, I would learn how to do it, but because I don't have to – luckily – I don't (Woman prosumer, UK).

The idea of technology as the men's domain and responsibility was also reflected in how the couples dealt with electricity production and consumption in the home. In most households it was the men who paid the electricity bills and tracked consumption. They also monitored the production of electricity from the solar PV system more closely, as illustrated in the table below:

Checked solar production per week				
	# Women	% Women	# Men	% Men
Norway (n9)	18	33	37	67
UK (n11)	4	25	12	75

The gendered division of labour with regard to electricity production and consumption in the household echoes the gendered domains of technology mentioned earlier. Several of the informants expressed how men would stress the importance of rescheduling electricity consumption and how women felt obliged to change their practices. Several women mentioned how they actively used weather forecasts or checked the inverter display to see when the best time would be to do laundry or similar tasks:

When I want to put the washing machine on, I check [electricity production] and if we're not producing enough then I think OK, I'll wait a bit and see if it's sunny later. Or I generally know if it will be good weather because I check the weather forecast. (Woman prosumer, Norway).

Though several tried to reschedule their electricity consumption, some households took a more passive role:

I can't say I've noticed it has reduced a lot. So I mean I just don't have the energy or the willingness to sort of sit down and compare figures, and it seems meaningless in a way because there's nothing you can do about, at least as far as I can see. I'm certainly not going to go around turning things off, you know, just because we're using too much electricity (Man prosumer, UK).

4.4. Prosuming and household identity

Once integration of the solar system in the household has moved from 'a process of transformation that goes from seeing an artefact as radical, exciting, unfamiliar or possibly even dangerous, to seeing it as routine, mundane and an ordinary part of life' [3], the conversion phase starts. An important dimension of this phase is how the members of the prosumer households portray themselves as prosumers to the outside world (see [31]).

The decision to invest in solar household systems rather than other technologies that might facilitate a low-carbon energy future deserves particular attention. The roof panels are a visible testimony of the residents' belief in a low-carbon energy future. As one of the informants, who also worked in an environmental NGO, put it:

Yes, it's visible! Like, [if we] insulated [the house] or fitted a new [veranda] door, that would have been really smart, right? But that's extremely boring. So, then we went for solar [system] instead (Man prosumer, Norway).

I really like the fact that our panels are on the front of our house, the way they come out ... to me, more than anything else, it's a visual sign, a signifier to anybody who sees it, saving our planet is important. That's what it says (Woman prosumer, UK).

For her and others sharing this view, public display of the solar panels would 'normalise' residential prosuming, which they saw as an important and relevant measure. Several also reported feeling responsible for decreasing their energy consumption in order to live more environmentally sustainable lives, seeing prosuming as their personal contribution to a nationwide or global effort to mitigate climate change. This view was expressed as follows:

It was the right thing to do, because it means I'm generating renewable energy, so you've got the ethical point of view. We need to not burn all the coal, we need to not burn all the oil, so the sooner we get solar panels installed to more or less cover the entire energy needs for the nation, when the sun is shining, the better. That's the position as a country we need to get to, and so I feel like I'm doing my bit. (Man prosumer, UK)

In some cases, the phase where the technology becomes part of the routine is also the phase when women get on board. Whereas men are often first-movers in bringing the technology into the home, women tend to take on the identity of prosumers in their engagement with the outside world. Some of the informants would only bring up prosuming when directly asked, reluctant to come across as moralistic environmentalists. In the UK interviews, this was also associated with aesthetic concerns, especially among the women, who, favoured installations that were less visible from the outside. Nevertheless, most were eager to share their experiences and the benefits of prosuming with others. As illustrated by the statements below from women prosumers in the UK, women were just as engaged as their partners in this respect:

Woman prosumer: We are the leaders of the pack, you might say. Because, we're very into neighbours, we've got a close knit [relationship].

Interviewer: So, after you installed the panels, did you discuss them with your neighbours?

Woman prosumer: Yes, and I think, now, I think J. has got some on, and I think C. and L. have, on the other side of the road.

Interviewer: Do you think that that's because of you telling them about them?

Woman prosumer: Yes.

Even though women were more on board in projecting themselves as prosumers than in the appropriation and integration phase, some still experienced that the gendered stereotype of technology as a male domain excluded them from being consulted, especially regarding the financial and technical specifications:

There probably is a slight tendency, it tends to be more a sort of thing that men would get into rather than women. So, you'd probably find, if a conversation is likely to start up about it with friends, it would be more likely they'd ask my husband questions about it than me, in terms of what return, how many have you got, what are they (Woman prosumer, UK).

Discussion: Energy practices and gendered domains of technology

The presented results reveal two important barriers to women becoming fully engaged in the different phases of domestication of the solar panels, both in Norway and in the UK. Women and men share the environmental and financial motivation for becoming prosumers, but as shown through the analysis of the appropriation phase, it was the men who put prosuming on the agenda and who to a greater extent attended to the practicalities of the process, such as researching the technical and bureaucratic aspects. Furthermore, for several men (and two of the women in Norway) their technological interest and skills and their social networks played a decisive role in motivating them to become prosumers. This type of relevant cultural, social and symbolic capitals, acquired by working with technology and in the energy sector, was distributed unevenly between the men and the women interviewed in this study.

In the objectification phase, the gendered negotiations over the installation and integration of the solar PV system reveal that men and women attach different social meanings to solar PV technology in the first phases. Still, the decision was almost always referred to as joint and equal one in the couples. However, some women felt they lacked the relevant economic or cultural capitals and thus 'gave in' to their partner's wishes. Conversely, when the woman was the legal owner of the house and contributed to purchasing the panels, she was also more actively engaged in the early phases.

In the incorporation phase, the gendered division of labour becomes

clear; men take care of the process of becoming prosumers, communicating with the installers or installing themselves, keeping the documentation, and monitoring production. The tendency by men to monitor energy consumption and pay electricity bills has also been noted in other studies [24,39]. Women, on the other hand, do most of the energy-related domestic work and bear the brunt of the cost of moving towards more sustainable energy practices, such as doing housework during the (sunny) daytime. In the conversion phase, the technology becomes 'normalised' and the novelty fades. For most of the informants, being a prosumer was an important part of their identity, and 'conversion, like appropriation, defines the relationship between the household and the outside world' [31]. Women take a more active part in the conversion phase, but are still rarely consulted on the technical aspects.

Women and men thus (partly because of the historical gender gap in science and technology occupations) operate in different social fields (workplace, family, community group, neighbourhood) resulting in different dispositions (*habitus*) and different social positions (capital) that can affect their success as prosumers. Women tend to have less of the economic, cultural and social capitals needed to become prosumers, whereas men are more often associated with the cultural and symbolic capitals which frames technology as largely a male domain [13,36]. Gendered divisions of labour, whereby women have historically managed responsibilities with less status, such as unpaid domestic work, strengthen perceptions of certain domains as masculine and others as feminine [27,28]. It is tempting to compare the found division of labour with [4] term 'Resource Man' to describe the vision of the smart energy consumer. The Resource Man is in control of his energy practices and interested in his energy data, and actively uses new technology to optimise his energy use in rational ways:

I refer to Resource Man as a male not because he is always directly identified as one, but because he is cast in the image of the male-dominated industries of engineering, economics and computer science, and because visions of him exclude most household labour, which is still predominantly carried out by women. ([4]:37)

However, women (and men) are not merely isolated individual agents who act out of financial or environmental concerns; they are, as Bourdieu states, framed by social differentiation (2001; 1986). Solar panels are not merely physical artefacts; they configure into a network of meanings and social practices. If prosuming is socially perceived as an exclusively male domain, it creates barriers to an inclusive decarbonised energy future. Other dimensions that have not been addressed in this study, such as age, class, ownership type, ethnicity and language, further thwart the realisation of a scenario where citizens are empowered to become managers of their energy consumption and contributors to the sustainable supply of energy, according to the desired objectives of the EU's energy policy (see European [2]⁴).

Conclusion

In this article, the experiences of prosumer households on their path towards domesticating residential solar systems have been investigated through a gender lens. As the findings show, implementation of energy technology in the home is far from a matter of one-size-fits-all. Drawing on social practice theory from the respective points of view of women and men, we have unveiled the dynamics and negotiation processes at play in each phase of the domestication process of the technology. In this process we find that the economic, cultural, social and symbolic capitals to which individuals have access, as well as the different social fields they move in and their internalised *habitus*, are important enablers and barriers to becoming a prosumer and interacting with the technology. Here, solar PV systems stand out from other energy

technologies in the home since, according to the informants, it is a sophisticated and still unfamiliar technology, loaded with several symbolic meanings and requiring special interest or skills. Several of the women we interviewed are interested in prosuming because of the environmental and future-oriented implications or the financial benefits it can carry. Nevertheless, the existing social differentiation along gender lines, where 'modern' technology continues to be perceived as a masculine domain, constitutes a barrier to most women becoming fully engaged prosumers. Unsurprisingly, 'old' technology related to activities such as cooking and laundry are perceived as feminine domains, further reproducing gendered divisions of labour between couples, where men deal with much of the prosumer-related issues while women perform the traditional energy-consuming tasks.

These findings are relevant for our need to move towards a more sustainable and equitable low-carbon economy. So far, aspects of gender and social differentiation have been largely neglected in policies concerning energy production in the home, which may hamper fulfilling European and global renewable energy targets. Viewing prosuming through the gender lens reveals a need for new policies to be designed to promote new practices that are inclusive and that appeal to a more diverse group, and that complement today's one-size-fits-all subsidies and feed-in tariffs. This is crucial if the aim is to increase the number of residential prosumers and transition to a low-carbon energy system. Providing financial benefits for prosuming will remain an important incentive in the future, but significant gender barriers that remain to be addressed are the ideas of solar technology as a male domain and of women's (perceived or real) lack of skills and social networks. An important contribution to reducing these barriers is the recruitment of women into science, technology, engineering and mathematics education and occupations (see [40]), which is needed to achieve an equitable and sustainable energy transition [41]. Measures to enhance energy literacy and general awareness in the general population are also highly relevant to ensure that people be informed about and realise the importance of energy transition and energy efficiency. Social capital and peers who move in the same social fields have also emerged as important catalysts for success in prosuming, suggesting that community initiatives and local social networks could be leveraged to this end. While this research provides qualitative insights on the dynamics and mechanisms at play, more qualitative and quantitative research on the topic is advisable to probe the generalisability of our findings and expand their scope.

By paying attention to gender aspects and social differentiation in general when designing support schemes for PV systems, information material and campaigns, marketing activities for home solar systems, policymakers, associations and companies can frame prosuming in ways that appeal both to those who are tech-savvy and to those who are not. Moreover, advertising and information material can be presented in ways that challenge the idea of prosuming and energy technology as male domains and thereby appeal more to women.

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⁴ <http://www.europarl.europa.eu/factsheets/en/sheet/68/energy-policy-general-principles>

Supplementary materials

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