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Energy housekeeping: intersections of gender, domestic labour and technologies

SPECIAL COLLECTION: ENERGY, EMERGING TECHNOLOGIES AND GENDER IN HOMES

RESEARCH

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ABSTRACT

Emerging energy technologies and tools aim to enhance peoples' understanding and control over household energy. Yet, important questions are emerging about precisely whose understanding and control such technologies benefit, and how increasingly commonplace tools may shape the gendered division of domestic labour. This article explores how smart energy technologies, and in particular energy feedback, may reproduce or further entrench the unequal distribution of household labour between men and women. Theories of social practice are used to frame ethnographic research (semi-structured interviews, card game prompts and home tours) conducted with 24 Australian households using solar photovoltaics and batteries. Evidence is provided of men interpreting energy feedback for other household members, policing other householders' energy-using practices and more broadly orchestrating patterns of energy consumption. Building on the concept of 'digital housekeeping', which refers to the gendered way in which domestic technologies are used and maintained, the paper suggests these practices constitute gendered forms of 'energy housekeeping'. The energy housekeeping concept provides a means of understanding how emerging energy technologies and tools intersect with issues of gender and domestic labour.

PRACTICE RELEVANCE

It is well established that domestic labour is largely performed by women. Research also shows that the use of smart technologies and energy feedback are gendered. Evidence from Australian households with solar photovoltaics and batteries shows that energy feedback and associated technologies may reinforce gender asymmetries in the home and enable men to control the domestic labour undertaken by others in the home. These outcomes are undesirable, even if they advance sector aims of aligning domestic energy consumption with patterns of renewable generation. Current energy management and feedback approaches need to engage with and be tailored for a wider, more diverse group of domestic energy users. This will better reflect the different ways that people engage with and think about energy.

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The present research considers an expanded form of digital housekeeping, which in the first instance includes more energy-oriented housework including washing solar panels, rebooting inverters, checking batteries and engaging with ICTs. This article also considers whether, and if so how, energy-oriented digital housekeeping can shape the way that conventional kinds of domestic labour are performed. This might involve digital housekeepers personally engaging in housework, or, more significantly, their monitoring, policing and orchestrating of how *others* undertake domestic labour. Through developing the concept of energy housekeeping, the present research examines the confluence of smart technologies, energy feedback and domestic labour to understand how the gendered use of energy feedback and technologies can shape the performance of traditional forms of housework.

A growing body of research already illustrates the gendered ways in which (energy) technologies are largely designed, installed, maintained and used by men. For example, scholars have observed a tendency for the person who introduces, manages and mediates technology to be a man (Rode *et al.* 2005; Takayama *et al.* 2012; Verkade & Höffken 2017). Women are also underrepresented in the energy and technology sectors (Baskett 2020; IRENA 2019). Scholars have argued that the male dominance of these industries shapes their visions and interests, including in relation to perceptions of home (Strengers & Kennedy 2020; Strengers & Nicholls 2017). Strengers (2014) points out, for example, that the resource management approach to energy—which in essence aims to manage consumption through quantification—is partly a reflection of the male-dominated industries such as engineering and economics that underpin the sector. Here Strengers notes that the focus is on transferring demand management skills and technologies from the energy sector to consumers, who through access to smart technologies become 'micro-resource manager[s]' (26). Meanwhile, much of the productive domestic labour carried out by women is obscured by the focus on energy as a resource (kilowatt-hour, kWh), commodity (cost) or impact (greenhouse gas emissions).

The term 'energy policing' and related concepts have been used as ways of understanding such management. For example, Grønhøj & Thøgersen (2011) describe the use of feedback to observe and control other family members' behaviour as 'energy surveillance'. Snow *et al.* (2015) discuss examples of fathers monitoring and policing their children's use of air-conditioning. Alongside illustrating a gendered dimension to fathers engaging in energy policing, Snow *et al.* also argue that the design of energy feedback is potentially conducive to 'police-style monitoring relationship[s]' between family members (939). Wider research likewise suggests that energy feedback can be used to 'police' wasteful consumption among children or induce accountability (Hargreaves *et al.* 2015), and that managing energy consumption is often also a cause of family disagreement (Barreto *et al.* 2013; Jensen *et al.* 2018). The capacity for monitoring and surveillance enabled by smart energy technologies, whether performed by utilities, potential criminals or other members of the household, has also been depicted as 'Orwellian' or 'Big Brother-like' by academics, research participants and in the media (Goulden *et al.* 2014; Myers & Beck 2013).

Another way of understanding energy management and technologies is through social practice theories. Practice scholars are concerned with the 'meanings' underlying practices (*i.e. Why* do people perform a given practice?). This question encourages one to understand why people engage in activities such as energy policing, which can be interpreted as an expression of care. For example, Richardson *et al.*'s (2017) exploration of smart technologies' role in human-animal relations frames surveillance as an extension of care. Closer to the subjects of energy monitoring and gender, Strengers *et al.* (2019: 6) see surveillance as a potential expression of:

> care-full masculinity, in which technology (a traditionally masculinized domain) was applied to practices of care (traditionally feminized).

Financial and environmental motivations for using energy feedback are well documented, and can also be understood as enacting care for the environment or the household (Foulds *et al.* 2017; Halloran *et al.* 2021).

The concept of orchestration is another way of exploring how people, practices and energy consumption are coordinated across time and space. Skjølsvold *et al.* (2018) note that in energy

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research the orchestra metaphor has been used as a means of understanding the coordination of different actors in complex systems. Wider scholarship has shown that energy demand at a system level has historically been created and organised around the needs of generators, including electrifying transport such as trams to increase daytime energy consumption (Chappells & Shove 2004). The orchestration of energy demand around supply is relevant at a household level, as efforts to increase energy self-sufficiency in homes with solar and batteries have been widely recognised in the literature (Kloppenburg *et al.* 2019; Martin 2020b). Researchers have further examined the energy implications of orienting practices such as bathing children around which other practices are arranged (Nicholls & Strengers 2015), or the rhythms of activity associated with different times of the day, week or year (Jalas & Rinkinen 2016).

The concept of energy housekeeping is employed here to examine instances of women managing household energy consumption and how they differ from men. However, it is argued that tools such as energy feedback designed for household energy management may enable and even encourage their mostly male users to control the domestic labour and wider practices performed by others in the home.

3. RESEARCH CONTEXT: FIELD SITES AND RESEARCH METHODS

The findings presented in this paper were collected as part of a wider ethnographic research project exploring how weather impacts everyday practices in households with solar photovoltaic (PV) and batteries. A total of 50 people from 30 households participated in the larger study. Research was conducted over 2019 and 2020 at three sites around south-eastern Australia (Yackandandah, Victoria; Sydney, New South Wales; and Canberra, Australian Capital Territory—ACT). However, because the Sydney participants were living in a student housing cooperative (in units of up to six individuals), significant differences existed in the way domestic labour was organised and undertaken that made comparisons with the other sites challenging. The material presented here is therefore drawn only from the more comparable sites of Yackandandah and Canberra.

With the aim of generating 100% of the town's electricity from renewable sources by 2022, the Yackandandah community established a number of mini-grids from 2017. The mini-grids connect households with rooftop solar, batteries and energy management systems such that they can collectively trade energy. When it was established in 2016, the ACT (in which Canberra is the major city) became the site of the world's largest virtual power plant trial. At present 1500 systems have been installed. The virtual power plant links together household batteries across the ACT so that they can be drawn on during peak events such as summer heatwaves. The systems are linked by energy management systems developed by different companies, and which along with communicating energy feedback offer various features including remote appliance control and automated energy trading. Participants' solar installations ranged in size from 3 to 27kW, with battery capacities between 5 and 24 kWh.[1]

Observations were collected from a total of 24 households and 34 participants. A total of 10 of these research visits were conducted with two participants, and 14 with a single participant (though only two of this latter group were single-person households). A total of 14 females, 19 males and one person of undisclosed gender took part in the research. The average age was 62 years. 17 participants from 12 households were recruited in both Yackandandah and Canberra. Participants were recruited using a combination of advertisements (a local newsletter), attending community meetings and snowballing. Research visits ranged between 57 and 140 min, with the average lasting 94 min.

The project employed both innovative and established ethnographic research methods. In Yackandandah, research visits were based around semi-structured interviews, which Hitchings & Latham (2020) and Hitchings (2012) note are both commonplace and capable of facilitating insights into people's practices. Additional material came from home tours, photography and captioned photo diaries (16 households), the latter involving an open-ended task where participants shared their experiences of weather and energy in the week following the research visit (for a similar example, see Hitchings & Day 2011).

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A novel card game method was also developed to explore participants' lay and embodied knowledge of weather and energy (Martin & Strengers, 2022). The game involved participants sorting cards with weather phenomena (rain, sunny), embodied experiences (sticky, uncomfortable) and associated descriptors (consistent, unpredictable) into broad seasonal categories, and talking through their placements.

These complementary methods were chosen to draw out the tacit dimensions of everyday practices and lay knowledge about weather and energy. With the onset of the Covid-19 pandemic and resulting travel restrictions, however, these research visits were adapted to a virtual format for Canberra. Virtual research was conducted via Zoom, and as the last of three field sites was designed to resemble the in-person visits as far as possible. For example, the home tour was conducted via video call. While virtual research presented unique challenges, including around building rapport and gathering information through personal observation, the online research did not deviate significantly from the in-person fieldwork. Interviews were transcribed and all research data was coded abductively using NVivo software, after which the materials were thematically analysed.

The research was framed using social practice theories (Higginson *et al.* 2014) with a focus on 'routinized type[s] of behaviour' (Reckwitz 2002: 249). Examples of practices include cleaning, entertaining and cooking. A widely employed definition from Shove *et al.* (2012) identifies three practice elements: materials (tools, physical things), meanings (aims, emotional dimensions) and competences (skills, knowledge). In contrast to the emphasis on individuals and rational behaviour evident in much energy research, practice theories emphasise the shared, contextual and sometimes unexamined nature of human action. By backgrounding energy and instead focusing on the services that energy provides, social practice theories enable valuable insights into the ways energy is used and understood (Shove & Walker 2014). In this research, social practice theories are used to illuminate the shared and inconspicuous dimensions of human action, and to show how changes in the material element of various domestic practices—specifically the introduction of energy data and feedback tools—effected changes in their performance. The major themes regarding energy housekeeping that emerged from this analysis are presented below and explored in detail through vignettes. The three major themes are energy interpreting, energy policy and energy orchestration.

4. ENERGY HOUSEKEEPING

Three dimensions to energy housekeeping were observed among research participants: energy interpreting, energy policing and energy orchestrating. Before outlining these concepts, however, one household—that of Jane and Simon—is briefly introduced. Though the findings of this research are supported by a wider evidentiary base, Jane and Simon are presented as an illustrative case that represents many of the ideas this article explores. The use of ethnographic vignettes from Jane and Simon (among others) is also intended to foreground everyday life and the empirical material in the analysis. Emphasising the everyday through these vignettes is vital because the complexities of daily life, including as they relate to energy, technology use and gender, reveal unanticipated yet important household dynamics.

As recent retirees, Canberrans Jane and Simon were happily adjusting to a more considered pace of life in their renovated and suddenly spacious house. Like other retirees, the couple's long-established habits and household dynamics were slowly shifting after years of repetition. Former public servant Simon had taken over much of the housework once performed by Jane, who was now busy managing a full social calendar when not impeded by Covid-19 restrictions: 'She'd be out most mornings and I'd be washing,' commented Simon, wryly.

Along with performing more of the conventional housework, since installing a solar and battery system in 2017 Simon was also assuming responsibility for the digital housekeeping associated with these new energy technologies. In Simon's case, digital housekeeping involved, among other tasks, accessing energy feedback via a smart phone app three to four times a day. But accessing energy feedback was more than a matter of curiosity; for Simon, it was also about using energy data to make the best use of his home's solar resources:

> it's not just looking at the energy that's being used in the house but being efficient about it I suppose.

For Simon, this efficiency took several forms. As he was now performing a greater share of the housework, in the first instance he would typically coordinate his own activities around the availability of energy, whether generated from their solar panels or stored in the home battery:

> I usually keep [using energy when the solar panels are] generating around 2 kilowatts, and or if there's something in the battery as well, and that will be the determinate.

Jane, on the other hand, was decidedly less interested in energy feedback. When the couple were asked whether or not they found terms such as 'kilowatt'—the energy unit commonly used to communicate energy feedback—meaningful, Jane simply replied:

> For me it is [still opaque]. I'm not even, I don't even want it [laughs].

These brief quotations raise important issues around the gendered use of energy technologies in the home.

4.1 ENERGY INTERPRETING

Compared with Simon, Jane found energy feedback less meaningful and interesting. Consequently, in his efforts to manage household energy consumption, Simon began explaining their energy data to Jane. Importantly, though, Simon did not simply repeat what the energy monitor communicated, but instead *translated* the data in an effort to make it more relevant.

> Jane: [...] I don't like to be restricted to a particular time to do the washing. [...] So I tend to ask 'When can I put the washing on?'
> Simon: Well any time after about 10:30 to 11 in wintertime.

Similar examples of energy interpreting were observed in other participants' homes. Lewis, a former academic and do-it-yourself (DIY) enthusiast living with his wife Miranda, also had access to detailed energy feedback from his solar and battery system. Checking the previous day's energy feedback over breakfast was a regular part of the couple's morning routine: 'You develop an inherent interest in it,' Lewis explained. Like Simon, Lewis was the person in his household most interested in engaging with energy feedback. According to Lewis (Miranda was not present for the research), while energy units such as kilowatts were 'certainly meaningful to me', he thought that Miranda 'would understand in relative terms what's happening'. As with Jane and Simon, Miranda would often go to Lewis with questions about their energy system or energy feedback, rather than engage with the system directly herself: 'She doesn't follow the technology quite the same, she'll say "why is this happening?"'

These vignettes illustrate two features of energy interpreting. First, a member of the household who acts as the primary point of connection between the technologies that communicate energy feedback, and other people in the home. Second, the act of interpretation itself, whereby energy feedback data is translated, contextualised or made actionable by a translator.

Broader research supports the observations of this study that energy interpreting is a gendered phenomenon. On the whole men appear more interested in using technologies to monitor, manage and analyse their energy consumption data (Accenture 2011; Hargreaves *et al.* 2010). As one of the male participants explained: 'No one else looks at [the energy monitor ...] I'm the big looker' (Rakin). Women, meanwhile, appear more concerned with—or perhaps due to the gendered division of domestic labour, occupied with—the *implications* of energy data for household routines, including those based around housework (Ellegård & Palm 2011). For example, in Johnson's (2020) empirical research on demand-side management programmes such as time-of-use tariffs, she develops the construct of 'flexibility woman' as a direct counterpoint to Strengers' (2013) 'resource man', the latter personifying an idealised vision of a smart energy consumer envisaged by the sector. Where resource man is portrayed as a 'gendered, technologically-minded, information-oriented and economically rational consumer' (Strengers 2013: 36), flexibility woman's responses to demand-side management incorporate deep understandings about:

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> her family's consumption habits, the loads in [her] home and the schedules of life that shaped her household's electricity demand profile.
>
> (Johnson 2020: 6)

Flexibility woman melds the energy system's needs for households to shift or shed their energy demand with an intimate knowledge of the domestic realities of her own home. Without seeking to valorise flexibility woman, Johnson (2020) notes that demand-side management approaches which overlook chore-doing routines, as well as the unequal burden borne by women in undertaking domestic labour, risk furthering disadvantage by turning demand-side management into women's work. The implication is not that only men are interested in or able to use energy technologies and feedback. Rather, a fairly narrow approach is pursued to the understanding and use of energy feedback in the home. This gives rise to circumstances where men become energy interpreters.

A further issue regarding energy interpreters concerns their potential absence: What is the effect of energy feedback when energy interpreters disappear, or do not exist? The experiences of Betty, a retiree living alone in Canberra, provide some insight (Figure 1). Although enthusiastic, in contrast to Simon and Lewis, Betty was a less frequent user of energy feedback:

> At the most, I suppose I look at it about twice a week. And it's usually just a casual look, I don't live by it, but it's just to check, 'yeah it's still working, it's still charging, it's okay'.

For Betty, the main benefit of monitoring was not that she could access data about her system, but rather that the companies who installed and operated the technology could check that everything was functioning normally: '[…] I found [it] a delight to think that somebody else is monitoring it.' When it came to using energy feedback to manage her own energy use, however, Betty faced some challenges. Without an understanding of the feedback, and lacking an energy interpreter of her own, Betty felt compelled to physically visit the technology developer's office to find someone who could explain the system and its data to her.

Energy feedback systems do not necessarily communicate energy data directly or equitably to all members of the household. Betty's experiences, along with those of Simon, Jane, Lewis and Miranda, highlight how human energy interpreters—whether in the form of certain members of the household (*i.e.* men) or technology installers and experts outside the home—play an important but under-recognised role in communicating energy feedback in the context of everyday life. By representing a gendered use of energy tools and data, the concept of energy interpreting underpins the wider issue of energy housekeeping explored in this article. The next sections draw out the implications of this differentiated use of, and access to, energy feedback among the participants.

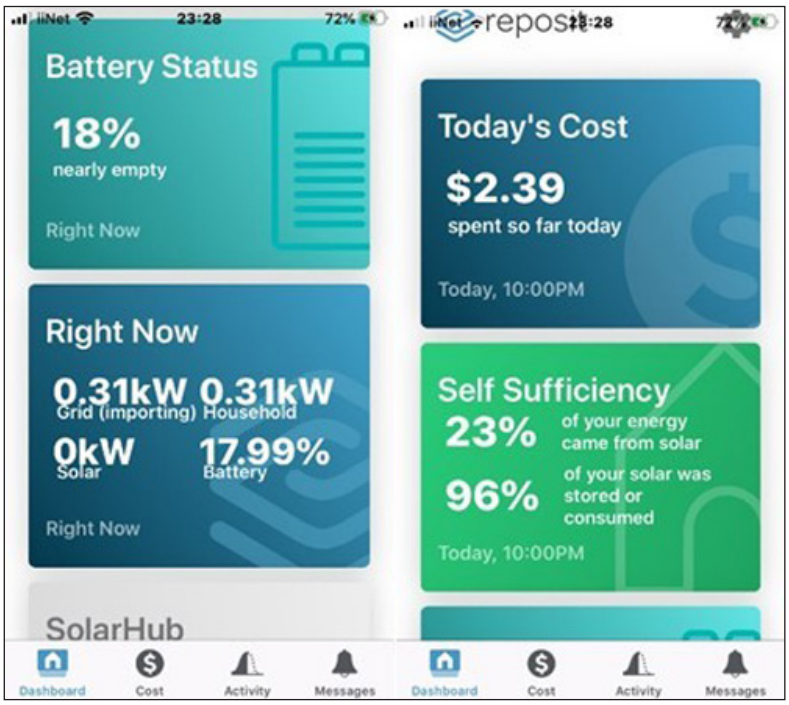

Figure 1: Excerpt from Betty's captioned photo diary illustrating her use of feedback to check the system was operational: 'I was out most of the day so the house just ticked over until I came home at 21.40 [p.m.].'

4.2 ENERGY POLICING

With the introduction of energy feedback Simon changed when and how he performed cleaning and laundry practices at home. Simon also used insights from his energy feedback to monitor, surveil and subsequently regulate the energy-using practices of the member of his household. These acts of monitoring, surveillance and enforcement could be usefully considered forms of energy policing. Like energy interpreting, the observations collected here indicate that energy policing also appears to be gendered and performed largely by men.

The term 'policing' is proposed for two reasons: first, because policing reflects the instances of monitoring, surveillance and rule enforcement observed in participants' homes; and second, because just as policing in the community is underpinned by a statutory authority to enforce laws, so too is energy policing based on a sense of authority which arguably derives in part from the use of technology-mediated and data-driven energy feedback.

According to Foulds *et al.* (2017), energy monitoring is defined by routinised attempts to measure and identify energy use patterns and drivers. Engaging with energy feedback appears to appeal to men. Like many participants in this project, Simon used energy feedback to measure his household's energy use, and to identify consumption he deemed unusual, wasteful or inefficient:

> [...] I also use it to get a sense of how we're tracking if you like. But I still use it even after a number of years, I still keep a fairly close eye on it.

Simon also engaged in a particular kind of monitoring that could be labelled 'energy surveillance'. In contrast to broader (if regular) engagement with energy feedback, energy surveillance as used here describes a more targeted monitoring of specific practices, appliances or people. Other research suggests that the primary user of energy feedback in a household may engage in surveillance of others in the home (Hargreaves *et al.* 2010; Schwartz *et al.* 2013), and energy surveillance was commonplace among male participants in this research. Participants used energy feedback to track specific (and generally high-consumption) practices such as bathing, baking, heating, cooling and boiling the kettle, to watch specific energy-hungry devices such as pool pumps, and to observe other members of the household they suspected were wasting energy. Acts of energy surveillance were also characterised by the precision with which energy data were used to identify an offending practice, appliance or individual, as evident in this exchange between Jane and Simon:

> Jane: [...] when you get into bed at night you look at the app and see what we've used in the day.
> Simon: Or even when I'm overseas I can see who's having a bath here.
> Jane: He used to say 'Who's in the bathtub?' He'll be on a work thing and asking who's in the bath.

In another household, the participant Margaret explained a similar situation with her husband Clive, a self-described 'energy Nazi', calling her up to enquire about high energy usage:

> Like he [was on holiday] in Victoria and obviously looked at [his app], and rang me up and said 'What were you doing?' [...] Give me a break!'

Rakin, the self-described 'big looker' and sole participant in his household to use energy feedback, similarly quipped (Figure 2):

> No one else looks at [the energy monitor ...] I'll have a look at it and see oh geez, drawing bloody 200, 2000 watts, who's got stuff on? Turn that bloody line off! You know? [laughs].

The final dimension of energy policing evident among participants, that of enforcement, marks the transition from observation to action. As energy feedback is neither uniformly accessed nor engaging, using feedback data to change behaviours frequently involves some form of enforcement whereby the person(s) with access to energy feedback regulate the energy-using actions of others.

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Several instances of (at least attempted) enforcement were discussed during the virtual research visit with Jane and Simon. For example, through his use of energy feedback Simon knew that heating hot water for bathing was a large consumer of energy in their household. When the couple's adult children were visiting over the Christmas break, Simon recognised through energy feedback that their demand for hot water increased. In order to save money and energy, Simon had proposed to talk with the children about limiting the use of the bath. But because it was only a temporary situation, Jane convinced Simon to stay quiet on the subject. Jane explained:

> If [the kids] lived here permanently I would have this discussion but when they only visit it's not worth it, just let them be happy.

Ultimately, this instance of energy enforcement was never followed through. But Simon's use of energy feedback to identify what were from his perspective wasteful practices (bathing) and people (his adult children) nonetheless illustrates how energy policing can occur, as people use energy data to monitor and surveil their household's energy consumption and, where necessary, to regulate offending practices, appliances or people.

Figure 2: The tablet used by Rakin to monitor energy feedback and police household consumption.

Non-digital forms of energy monitoring, surveillance and enforcement have existed for a long time. By way of example, many participants recalled childhood memories of being told to turn off lights in vacant rooms. These represent instances where energy monitoring and regulation occurred without the involvement of digital energy feedback. But because of the ways that digital energy feedback both *extends* and *deepens* the ability to observe and control people and their energy consumption in the home, these earlier instances of household energy management arguably differ in important ways from energy policing as outlined here. Children can now be scolded retrospectively for leaving on lights (as potentially evident from historical consumption data), partners contacted in real time from interstate or overseas about bathing habits, and appliances turned off remotely as a way of controlling another's energy-using practices. Though the latter was not observed in this project, recent research shows such forms of coercive control do occur (Henry *et al*. 2020; Strengers & Kennedy 2020). Thus, energy policing is a more pervasive means of observation and control that harnesses powerful digital tools such as energy feedback to build on existing forms of energy monitoring, surveillance and enforcement.

It should also be acknowledged that among the participants there were instances of women rather than men engaging in aspects of energy policing. For example, Annette confessed to shadowing her husband Scott through their home as he left a trail of lights behind him: 'Though I turn lights off, Scott leaves lights on all over the house. So I'm the policewoman!' However, these instances tended to reflect the non-digital rather than digital forms of energy management.

A final dimension of energy policing to consider is how feedback technologies can give their users a sense of objectivity and authority that potentially encourages their management of both energy and other people. Research has highlighted the overwhelming dominance of energy research by positivist perspectives and methods. As Strengers *et al*. (2017: 177) note:

> Within this epistemology, countable or measurable knowledge is viewed as more rigorous and valid (hard) than non-countable or immeasurable (soft) knowledge.

Put simply, 'quantification reigns supreme' (179). The issue here is not the use of data in itself; the potential problem is that because 'hard' data may be seen as inherently objective, it can create an impression that those who use it are automatically making incontrovertible observations. In other words, the very idea that energy data is objective can bestow a kind of authority on its users to police how energy is consumed in the home. This sense of authority underpins energy policing.

In summary, it can be seen that energy policing is a gendered phenomenon consisting of energy monitoring, surveillance and enforcement, and is underpinned by a (perception of) authority to manage energy arising in part from the nature of energy feedback itself. Energy policing thereby constitutes an important dimension of energy housekeeping that draws attention to issues of control arising from the design and use of energy feedback.

4.3 ENERGY ORCHESTRATING

The last dimension of energy housekeeping explored here is energy orchestrating. For example, along with monitoring and policing the use of energy in his home, Simon also sought to coordinate his household's energy consumption around generation from their rooftop solar, or the availability of energy stored in the household battery. This self-sufficiency approach was summed up by Simon's comment (referenced above) about timing the use of appliances (*e.g.* the dishwasher) when solar generation matched consumption.

Orchestrating and enforcing energy rules are closely connected. Both involve their performers using ICTs and digital energy feedback to change how others in the home use energy. The distinction is that while energy enforcement concerns *reducing or avoiding* energy consumption, such as through suggestions to 'switch off lights', energy orchestrating is instead about *shifting the timing and the quantity* of energy consumption in order to promote individuals' goals such as energy self-sufficiency or meeting network demands. Expressed differently, enforcing energy rules is about avoiding practices/consumption perceived as unnecessary or wasteful, while energy orchestrating is concerned with aligning (often non-negotiable) practices with more favourable generation or price conditions. Energy orchestration can be used to understand how an actor (human or technological) coordinates energy consumption across a system in a way that aligns with the needs of the energy network. Energy shifting and shedding in response to time-of-use tariffs are examples of energy orchestrating. The crucial point is that system needs are commonly communicated via energy data and ICTs. The research found that orchestrating appears to be a gendered activity.

The focus of orchestration on making the 'best' use of one's energy resources rather than regulating wasteful consumption was summarised by one participant:

> [...] it's not a case of 'Hey the battery only lets us run the air conditioning for 1 hour 10 minutes so I'm sorry family it's 1 hour 10 minutes.' It's more 'You know what, if we can hold off putting on the washing machine for half an hour, we won't have to import energy from the grid.'
>
> (Richard)

Examples of energy orchestrating from participants included shifting laundry, dishwashing, bread-making, cooking and vacuuming to coincide with periods of high solar generation. Changes in the performance of these practice can be attributed (at least in part) to the presence of new materials, such as ICTs, solar panels or battery systems. Interestingly, several participants noted that before installing solar and batteries, practices such as bread-baking and laundering were performed overnight to align with off-peak energy tariffs; these are examples of how networks and energy generation can orchestrate everyday practices.

For Jane and Simon, instances of energy orchestrating revolved primarily around Simon using energy data to provide what he described as 'informed advice' about when they should perform laundry, use the dishwasher or vacuum: 'in terms of energy use, I usually give the green light or

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the orange light', he explained. Jane expressed a different approach to undertaking housework, explaining that:

> Simon will tell me when I'm allowed to put the dishwasher on. I would just put the dishwasher on at whatever time if it was full, whereas Simon tends to put it on when the sun [is generating electricity].

By Jane's account Simon was not questioning her use of energy nor trying to change practices he viewed as wasteful (as might occur with energy policing); Simon was instead seeking to coordinate Jane's use of the dishwasher so that her energy use aligned with his goals for energy self-sufficiency.

This interview excerpt raises another interesting point: female participants in this research also managed household energy consumption, but in ways that were different to the instances of energy housekeeping performed by their male counterparts. In one example, Annette explained she cleaned and vacuumed:

> [...] when the weather's reasonable. But I do try and do it in the middle of the day, I put the dishwasher on and the washing machine on when I know that we're making some energy.

When Annette was asked if she used energy feedback to determine this, she replied:

> No I'm not that careful [...] I just try to do it in the middle of the day when I know that there's something going on.

Similarly, Georgia wrote in her captioned photo diary (Figure 3) about using the sun to know when energy was plentiful:

> Dishwasher is on during the day as the sun is shining, so powering the dishwasher with solar.

Although she acknowledged that as a retiree living alone she was more flexible than other households might be, another participant, Louisa, explained the same concept more succinctly: 'You work around the weather. I can afford to do that.'

Figure 3: Example of energy orchestrating from Georgia's captioned photo diary. The entry reads: 'Dishwasher is on during the day as the sun is shining, so powering the dishwasher with solar.'

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These examples reflect that men and women appear to have different approaches to managing housework and energy consumption. Where men seem more interested in monitoring feedback and managing energy as a resource, women seem to draw on wider sources of information to inform their practices and use energy. These include weather-based feedback about energy generation (Martin 2020b), or sensory feedback about cleanliness or cosiness (Strengers 2011). Scholars have therefore argued that energy feedback could be made more accessible or effective if communicated intuitively via smart lights (Martin 2020a), or by more explicitly connecting energy with practices and everyday life (Strengers 2011; Verkade & Höffken 2017). This is not to suggest that gendered approaches to housework and energy are necessarily fixed or binary, but simply that people relate to and engage with household practices and energy in ways that appear to be shaped by gender.

5. CONCLUSIONS

Drawing on research conducted with 24 Australian households using solar and batteries, and using selected contributions from participants as illustrative cases, this article has elaborated the concept of energy housekeeping. Building on the concept of digital housekeeping, energy housekeeping represents the gendered use of digital energy data and tools (largely by men) to control the performance of domestic labour and other everyday practices by others. Energy housekeeping is comprised of (at least) three parts:

- Energy interpreting: energy feedback is translated for other members of the household
- Energy policing: the regulation of others' energy-using practices
- Energy orchestrating: the coordination of broader patterns of consumption to make 'best' use of the available energy resources

Like the use of energy feedback in Jane and Simon's home, the implications of increased energy feedback data and technologies will vary between individuals and households. If framed as part of efficient resource management, the use of energy feedback may result in more men participating in housework. For example, Simon's digital housekeeping practices contributed to his increased participation in housework (although considerations including retirement should not be discounted). However, the impetus that energy feedback creates to measure and manage consumption may also lead to men controlling (rather than participating in) domestic labour. For example, Simon expanded his control over when and how Jane performed practices such as cleaning. Such outcomes are hardly desirable, even if at face value they represent men investing more time in domestic labour, or advancing sector aims to align domestic energy consumption with intermittent renewable generation.

There are limitations to this research. Though unintended, the research on which this article is based was confined to primarily heterosexual, white and middle-class households. As noted by other scholars, these limitations are commonplace in energy and technology research, but do not reflect the diversity of households or people, whether in Australia or abroad (Fathallah & Pyakurel 2020; Søraa *et al.* 2020). In focusing on two-gendered households, it should also be stated that the aim has not been to reinforce heteronormative views of gender as binary. Notions of gender as fixed and existing within a male–female binary have been extensively critiqued (Hyde *et al.* 2019), and also considered in relation to energy and social practice theories (Mechlenborg & Gram-Hanssen 2020). The aim here, however, has been to understand how power disparities and gender differences concerning technology use, energy and domestic labour were (re)produced among participants. The research presented in this article is therefore not comprehensive, but should instead serve as a starting point for further enquiry. Future research drawing on the energy housekeeping concept could look at more diverse kinds of people, household configurations and contexts to explore if and how energy data and tools shape household labour dynamics.