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# The water–energy–food nexus at home: New opportunities for policy interventions in household sustainability

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The nexus of water–energy–food (WEF) is as apparent at the household scale as it is anywhere else. We introduce the “Nexus at Home” as a starting point for exploring the dynamics of WEF resource use and household sustainability. Drawing on two research projects we focus specifically on domestic kitchens as a site where practices of cooking, eating, cleaning and disposing of waste come together. While these practices have long been targets for policy intervention, existing approaches draw on a limited range of perspectives from the social sciences. Reflecting on our work with four non-academic partners (Defra, BEIS, FSA, Waterwise), we consider how social practice and geographies of household sustainability research might be combined with the dictum of “nexus thinking” to re-imagine the framing of policy and intervention to reduce the resource intensity of everyday life. Synthesising existing “home practices” literature in the context of the “live” policy problems raised by our partners, we seek to provide clear guidance for intervening in kitchen practices. We draw on one topic which has not yet been the subject of social practices research: fats, oils and grease (FOG) going down the kitchen plughole and contributing to widespread sewer blockages. In doing so we document the sequence of interrelated food provisioning activities through which WEF is put to use in domestic kitchens and contributes to FOG blockages in sewers. We reflect upon the multiple ways these practices are shaped by the rhythms of daily life, dynamics within the home, wider cultural conventions, and infrastructures. This paper contributes to the nascent transdisciplinary research agenda of translating home practices research into wider conceptualisations of “intervention”, with a specific orientation towards academic and non-academic stakeholders who are interested in influencing systems of sustainable consumption and production within, and across, the WEF sectors.

## KEYWORDS

domestic practices, everyday practice, fats–oils–grease, household sustainability, policy interventions, water–energy–food nexus

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## 1 | INTRODUCTION

“Nexus Thinking” promises a new way of approaching water–energy–food (WEF) crises (see Scott & Larkin, forthcoming). Initial responses have focused on macro-scale, city-to-national-to-international interdependencies of WEF supply systems. What happens when we transfer nexus thinking to resource consumption, and to the much more intimate scale of the home? In particular, what understandings can be gained if nexus thinking is combined with recent insights into home resource consumption arising from research on social practices and the geographies of household sustainability? Aimed at an interdisciplinary and policy audience, this paper explores these questions and what they mean for interventions in WEF resource production and consumption. It does so through an account of WEF consumption in the domestic kitchen, focusing on reducing disposal of fats, oils and grease (FOG) to sewers.

Prompted by mutual interests in understanding the constitution of domestic demand across the “nexus” of water, energy and food, the authors undertook two research projects which underpin the argument of this paper (see Acknowledgements). The first involved a series of facilitated multi-stakeholder workshops taking stock of the existing state-of-the-art in home practices research. These events highlighted how policy-makers and researchers alike work in resource-specific silos concerned with water, food, waste or energy. Moreover, though interested in how previous research sheds light on the details of different WEF-demanding home practices, workshop participants were unsure how such insights could shape programmes to influence these practices and their socio-material circumstances.

These insights informed our second research project in which we focused on the kitchen as a site of WEF resource transformation to examine how social practice theory could reframe key WEF nexus policy challenges. To these ends we worked with four UK policy and delivery partners, with each identifying one “live” policy issue that crossed two or more domains of the WEF nexus. Around each issue, we synthesised existing evidence, focusing on generating new ideas about interventions relevant to their identified policy goal. The partners and issues identified were:

1. Department for Business, Energy and Industrial Strategy (BEIS): energy use, flexibility and domestic food practices;
2. Department for Environment, Food and Rural Affairs (Defra): household food waste and kitchen practices;
3. Food Standards Agency: food waste, food safety and kitchen practices;
4. Waterwise: fats, oils, grease (FOG) and kitchen practices.

In this paper we describe and reflect on the findings of this project, illustrated through the example of FOG disposal. FOG – released from food during cooking and disposed of via the kitchen sink – combines with other products like wet wipes, solidifying as “fatbergs” within the sewer system. As emphasised by a number of recent high-profile incidents (Ratcliffe, 2015; Taylor, 2017), “fatbergs” can lead to sewer blockages and flooding, causing ongoing problems for UK water companies. FOG represents a meaningful focus for nexus inquiry: it is an outcome of food practices, it involves the mixing of waste food with water and other disposed products, and requires substantial water and energy to deal with once in the sewer. While FOG problems originate with food, they are predominantly tackled within the water industry. Potential alternative interventions lie in engagement with the waste disposal and energy sectors (e.g., converting waste fats to biofuel). Unlike the policy problems our other research partners identified, FOG has yet to be subject to sustained social scientific engagement (see Marvin & Medd, 2006; Ibáñez Martín & de Laet, 2017 for notable exceptions). Thus it afforded the opportunity to illustrate “from scratch” how a nexus lens on household sustainability can generate new policy insights. An auxiliary aim of this paper is therefore to contribute to the development of nascent social scientific perspectives on FOG.

Our research reflects novelty in relation to three areas. First, the domestic focus offers an original angle on nexus thinking. While most nexus-oriented work investigates large-scale systems of supply, resource interdependencies also occur at other sites and scales. For example, it is unusual to prepare food without making significant use of water and energy (either in the supply chain or in the home). By looking at the domestic scale, this paper pioneers a very different form of nexus research focused on interdependencies of demand, not just of supply.

Second, focusing on the nexus of resources provides a new way to explore the sustainability of home practices. We acknowledge that dominant features of “nexus thinking” – attending to connections, interdependencies, alignments, trade-offs (Leck et al., 2015) – is nothing new to human geography (Schwanen, 2017) or to theorists of social practice (cf. Hui et al., 2016). Nevertheless, we note that despite many investigations of household consumption, this research remains largely within water, energy or food silos (e.g., Browne, 2015; Evans, 2014; Kuijer & Watson, 2017; Sharp et al., 2011; Watson & Meah, 2013). Taking a cue from suggestions that “the nexus” can potentially mobilise activity across disciplinary silos (cf. Stirling, 2014) we suggest that it also represents an opportunity for those interested in the resource intensity of

everyday life and the sustainability of domestic practices to work together. Taking domestic kitchens as our starting point highlights the many and frequently occurring interdependencies of WEF resource use.

Finally, our approach helps present home practice research in a way that is more “policy ready”. Theories of practice and the geographies of household sustainability literature have the potential to redefine sustainability interventions significantly (Head et al., 2013; Keller et al., 2015; Strengers & Maller, 2012). Policy actors and change agents appear to recognise this potential, as evidenced by their commissioning of reports (e.g., Southerton et al., 2011) and co-funding action-based research projects to implement findings from social practices research (e.g., Defra using findings from Pullinger et al., [2013]; see also Eppel et al., [2013]). However, as became clear early in our research, policy stakeholders still question what “the offer” is, and how this body of work moves beyond current ways of framing policy problems to generate new approaches. Our research team hence sought to meet this call for stimulating a policy-focused, “useful” translation of home practices research.

In the next section we briefly introduce home practices in the domestic kitchen as a site of transformation for WEF resources, and demonstrate how the “nexus at home” invites new research and policy questions. We then describe our methods, before presenting the FOG case study and the insights towards intervention which developed from it. To conclude, we consider the implications of this case study for understanding the “nexus at home”, and for reframing interventions in household sustainability.

## 2 | HOME PRACTICES AND THE KITCHEN AS A KEY SITE OF WEF TRANSFORMATION

Domestic use of WEF has become an important topic for policy intervention and research. Dominant approaches seek to moderate demand through price signals or appeals to individual environmental consciousness. As Shove’s influential “ABC” critique (2010) demonstrates, these models of intervention utilise a limited range of social science perspectives, drawn principally from mainstream economics and social psychology, in which individuals – and their attitudes, behaviour and choices (ABC) – are positioned as the locus of social change. These approaches have been criticised widely for, *inter alia*, being overly optimistic about the power of individuals to make choices and to influence other household members, blind to the specific constraints and needs of households, and lacking awareness of the wider infrastructural and societal contexts shaping habitual resource consumption (Shove, 2010).

Alternative perspectives on “the domestic” have been generated from recent research on social practices and geographies of household sustainability (see Gibson et al., 2013; Lane & Gorman-Murray, 2011). We term these complementary bodies of work “home practices” research; literatures which explore the constitution of household members’ routines and the diverse socio-material dynamics shaping and constraining patterns of domestic resource consumption (Allon & Sofoulis, 2006; Fam & Lopes, 2015; Head et al., 2016). These studies emphasise that people do not consume WEF resources *per se*; rather they consume the services that resources provide (cooking, laundering, thermal comfort; cf. Bouzarovski & Petrova, 2015; Shove & Walker, 2014). This body of research has been particularly useful in undoing assumptions about the consumer across various resource sectors, and suggesting different lenses to view how change occurs within systems of consumption and production (Browne, 2015; Evans et al., 2017; Geels et al., 2015).

Insights about home practices have advanced disciplinary and interdisciplinary debates about household sustainability, and are beginning to gain some traction in policy, but have not yet been brought into dialogue with perspectives on “the WEF nexus”. This appears an odd omission given that the social practices that form the empirical focus of many recent studies involve the consumption of more than one resource. Laundry, for example, draws on water and energy while cooking uses all three. If, as the home practices literature argues, better understanding of social practices is a prerequisite for designing effective interventions, then attending to the WEF nexus might be a real advantage in further understanding the interconnected socio-material dynamics of household resource consumption.

In order to examine the potential for the home practices literature to inform WEF debates, we focus briefly on the kitchen as a site of WEF transformation. It is perhaps most readily imagined as a designated site of food preparation in which one might find technologies and spaces for cold storage, heating food and drink, cleaning, and waste collection. Some variation exists historically and contextually (Freeman, 2004); for example, British kitchens are often equipped with a washing machine; and kitchens are increasingly sites of food consumption, as well as preparation (cf. Munro, 2013).

The very routines that constitute the kitchen as a site of social reproduction – gendered labour, creativity, care, love (DeVault, 1991; Meah, 2014, 2016) – are also those that account for the consumption and disposal of WEF resources by the work of food provisioning. We stress that the kitchen can be conceptualised as “part of, and a product of, a network of

connections” (Head et al., 2013, p. 352) and that the flow of resources through domestic kitchens needs to be understood in relation to wider systems and infrastructures of provision. We note that the domestic kitchen has long been a target for policies relating to public health concerns (nutrition, food safety) and, more recently, sustainability agendas (energy/water efficiency, waste reduction).

Recent studies of kitchen practices and waste (Evans, 2014; Waitt & Phillips, 2016; Watson & Meah, 2013) clearly signal the limitations of approaches that frame food waste as a problem of consumer behaviour. Indeed, they demonstrate that waste is the fallout of people negotiating the complex and contradictory demands of everyday life and that kitchen technologies are complicit in the processes through which “food” becomes “waste”. Other studies, concerned with how kitchen practices help constitute domestic demand for energy and water, largely mirror these findings (Nicholls & Strengers, 2015; Powells et al., 2014; Pullinger et al., 2013). In light of the available research on home practices and kitchen lives it might seem that a ready-made set of insights can simply be mined and transferred to advance research and policy discussions around the domestic WEF nexus. As we demonstrate below, this is only partly true.

### 3 | METHODS

The goal of producing useful recommendations for four policy and delivery organisations during a 10-month project concentrated our efforts into a tightly timetabled programme of literature synthesis, partner meetings, interviews and report writing. We adopted a four-step research process that began by meeting with our non-academic research partners to agree on a “live” policy concern that brought together a focus on “the nexus at home” to generate new evidence and recommendations. In the second step, the research team collated information about current approaches for each of the issues identified. This involved a grey literature review and interviews with relevant experts. In relation to FOG we consulted over 30 documents (including research, strategy and campaign literatures) and spoke to five stakeholders across three regional water companies in the UK.

The third step involved synthesising insights from the “home practices” literature with a view to understanding better the connections and interdependencies between water, energy and food. As all four challenges identified by our partners (food waste, food safety, FOG, energy use in food preparation) pertained to the processes of food provisioning, we worked towards a single understanding of kitchen practices that could be transferred across the different policy issues under consideration. Once this understanding was in place, we considered its modification and application to each of the issues at hand.

In the final step we compared existing approaches to intervention with the potential alternative options opened up by our model of kitchen practices. This formed the basis of a draft report in which we provided each partner with a set of tentative recommendations on the implications of our findings for reframing policy approaches. Each partner was then interviewed to discuss our approach, identify remaining gaps in knowledge, and reflect upon the translation of our recommendations into policy. During the course of the project a total of eight partner meetings were held, involving more than 30 policy and related actors.

## 4 | EXEMPLIFYING THE NEXUS AT HOME: FATS, OILS, GREASE AND KITCHEN PRACTICES

Fats, oils and grease (FOG) is instructive for thinking about the domestic WEF nexus. Much of the fatty matter that ends up in sewers begins its life as food. The application of energy to food in cooking helps generate FOG, often as liquids released from fat-rich foods. Frequently disposed of via the kitchen drain, this matter congeals in sewers as it mixes with water and other waste products. In this section we discuss how the application of our approach to this issue of FOG (drawing on Foden et al., 2017) not only opens up the complexities of emergent policy problems but also enables the identification of different intervention options.

### 4.1 | Understanding FOG

Debates about sewer systems and their susceptibility to blockage from inappropriate waste disposal arose in the 1840s (Hamlin, 1992). Specific concerns about FOG date back at least half a century (Wallace et al., 2017). In recent years, FOG in sewers has been increasingly recognised as a significant wastewater management issue in the UK and internationally (cf. Marvin & Medd, 2006). FOG coalesces with other food residues and with discarded sanitary products in iconic subterranean

“fatbergs” that become expensive problems for sewerage utilities (Ratcliffe, 2015). FOG-related blockages restrict flows in drains and sewers, which can lead to flooding, property damage and pollution. In 2012–2013 approximately 366,000 blockages were dealt with by water and sewerage companies across the UK, at a cost of £88 million, with up to 80% estimated to be caused by FOG and/or other items inappropriately flushed down drains (Dyson, 2016).

Fats, oils and grease is generated from industrial, commercial or domestic sources, but tight regulation means industrial FOG is not a significant part of the problem. Commercial sources (including restaurants and takeaways) are a key target for current interventions due to high levels of FOG generation from a relatively small number of often clustered premises. Domestic sources are currently of lower priority. However, recent water industry research estimates that domestic properties account for approximately 70–80 % of FOG in UK sewers (Gelder & Grist, 2015). Other estimates suggest that in 2012, UK households disposed of 55,000 tonnes of oil and fat via sinks and drains (2 kg/household), not including the fat content of over 1.5 million tonnes of other food and drink disposed of through the drain, including large quantities of milk and meat juices (WRAP, 2013). Focus on the domestic kitchen as one significant site through which FOG flows (Marvin & Medd, 2006) is therefore well justified.

## 4.2 | Current FOG interventions

Existing responses to FOG can be divided into three categories (Hoolohan & Browne, 2016): ensuring continued service provision, appealing to individual decision-making, and harnessing social norms and networks. While *service provision* involves a traditional engineering focus on making the infrastructure work, both *individual decision making* and *social norms and networks* seek to engage consumers to modify how they dispose of waste, and hence to reduce the quantity of FOG at source (Table 1).

*Service provision* approaches involve implementing technical measures to ensure that normal service is maintained in an invisible and uninterrupted way (Hoolohan & Browne, 2016; see also Spurling et al., 2013). In principle, sewers could be designed to better facilitate the movement of fat (Mattsson et al., 2015). In reality, the prohibitive expense of sewer redesign and reconstruction means that in the UK, as in many countries, FOG *service provision* requires the periodic removal of fat, usually reactively in response to a reported blockage (Arthur & Blanc, 2013; Gelder & Grist, 2015). As well as being expensive and resource intensive, it casts the water sector as responsible for managing FOG, something that the water industry disputes (Water UK, 2016).

Reflecting these concerns, appealing to *individual decision making* has emerged as the preferred approach to FOG prevention (Hoolohan & Browne, 2016; Water UK, 2016). Initiatives of this type see water companies seeking to influence consumers’ attitudes, behaviours and choices, by drawing attention to the problem of FOG and/or offering tips for appropriate disposal, disseminated through online media, letters or leaflets delivered to homes. These communications focus on “sewer misuse”, covering food waste alongside discussion of the disposal of other troublesome items such as wet wipes, nappies and women’s sanitary products. There is limited evidence as to the success of these campaigns (Arthur & Blanc, 2013).

While still focused on behavioural change, some recent interventions have targeted FOG “hotspot” areas, seeking to take advantage of disruptions in existing routines – for example, a local sewer blockage affecting particular households – as an opportunity to question habits and try to shape new ones.<sup>1</sup> Other programmes provide simple tools – such as plastic plate scrapers and “gunk pots” for collecting and disposing of fat – to encourage households to try different means of disposal.<sup>2</sup> Although they remain focused on the decisions made by individuals, these recent initiatives are part of a broader recognition of the need to provide a working alternative to FOG disposal via the sink, backed up by appropriate infrastructure.

**TABLE 1** Three existing approaches to intervening in FOG in the UK

Style of intervention	Characteristics of FOG intervention	Status
Service provision	Aims to maintain services without noticeable disruption to customers through infrastructure improvement and maintenance; given a non-ideal sewer network, this is largely achieved through identifying, clearing and repairing where blockages arise.	The current default response to FOG problems
Individual decision-making	Aims to persuade householders to stop disposing of FOG in sewers, using websites, social media, letters and leaflets to draw fresh attention to the problem of FOG and/or suggest tips for disposing of fats in other ways.	The emerging focus of the water industry
Social norms and networks	Aims to communicate and normalise desirable behaviours often through identifying key actors and influential groups within a community.	A few initiatives evident

In a similar way, behavioural change initiatives have begun to harness *social norms and networks*, seeking to mobilise perceived public opinion and community influence to achieve changes (Hoolohan & Browne, 2016). However, FOG interventions that actively utilise social norms and networks are rare. One approach is to present certain desirable attitudes and behaviours as “normal”, supported by relevant statistical evidence. For example, promotion of Anglian Water’s (n.d.) *Keep it Clear* campaign claims that in areas where the campaign has been implemented, “most people are already putting their waste in bins and recycling their used cooking oil. And it’s working – sewer blockages have gone down by an average of 52%”. Another feature is to recognise diversity and identify key actors and groups judged to hold influence within a given community. This has been central to Yorkshire Water’s community cooking oil collection scheme in Bradford,<sup>3</sup> working with volunteers from a local community centre and university accommodation services (Holland, 2016).

A home practices perspective immediately raises questions about the emphasis of these three existing types of intervention. From a wastewater management perspective the issues of kitchen FOG and bathroom non-flushables are inseparable, as these products come together in sewers to cause blockages. However, from a householder perspective the two issues arise during different activities in separate parts of the home. Although the broad message is the same, the practical responses to dealing with non-biodegradable wet wipes, feminine hygiene products, and other products flushed down the toilet are considerably different from dealing with messy and formless substances like fats and cooking oils in kitchens.

Moreover, these three existing types of intervention carry particular understandings about responsibility and problem ownership. Though removal of FOG deposits remains the predominant intervention, water industry disquiet with the disposal of inappropriate materials is exemplified by their term “sewer misuse” (Water UK, 2016). Such language is potentially problematic, blaming certain types of (in)actions of consumers (cf. Sofoulis, 2005; Evans et al., 2017; Ibáñez Martín & de Laet, 2017), and hence has the potential to generate counterproductive responses such as denial or anger. Further, it focuses intervention almost exclusively on the moment of disposal.

### 4.3 | Identifying new moments of intervention for FOG

From the vantage point of home practices research, the disposal of FOG via the kitchen plughole is concomitant with the broader routines and rhythms that comprise kitchen life. In the course of acquiring, using and disposing of food, the people responsible for household labour engage in a series of different tasks: shopping, storing and managing food, food preparation, cooking, eating, dealing with leftovers, and clearing up. Together this sequence of practices makes up the domestic food provisioning process (Evans, 2014; Warde, 2016). Also important are the interdependencies between each of these stages. For example, what is bought in the supermarket helps define which techniques are used in preparation and cooking, while concerns about shelf life, storage and disposal impact on the shopping trip (Munro, 1995). These interconnected stages of food provisioning are well established within social science (e.g., Marshall, 1995). The novelty lies in explicating their application to policy problems – including FOG and other food disposal – where attention has traditionally been directed to end-of-pipe processes.<sup>4</sup>

From a WEF-nexus perspective, we can see food – and its movement through the kitchen – at the centre of this process and identify where water and energy are also used in all stages of preserving or transforming food. Importantly, waste is produced, directly or indirectly, through different stages of the domestic provisioning process and not just at the point of disposal. Each stage represents a moment where numerous courses of action could plausibly be pursued, and hence represent sites, for intervention in kitchen practices. Different courses of action have different implications for what ends up in liquid and solid waste streams, as well as for other policy concerns relating to food (e.g., healthy eating, food safety) and the conservation of water and energy. We now (hypothetically) trace these intersecting concerns through six such moments,<sup>5</sup> as the basis for later considering how peoples’ actions at these moments are shaped and what this means for intervention.

First, decisions made when *buying* food can ultimately affect how much FOG and other waste matter enters the sewerage network (cf. Evans, 2014 on solid food disposal). For example, some types of food release large amounts of fat during cooking (e.g., meat), while others release much less or none at all (e.g., leaner varieties of meat, vegetables).<sup>6</sup> Some foods are more likely than others to be cooked in oil or other fats, reflecting cultural conventions, tastes and the material properties of the food. Although problematic to operationalise, as it would require drastic intervention into embedded cultural dietary practices, reducing the purchase of foods that require or release more fat could reduce the quantity of FOG entering sewers.

Second, food solids enter the liquid waste stream through methods of *food preparation*: rinsing, scrubbing, peeling, trimming or otherwise removing matter that is considered unpleasant or unhealthy to eat. Here, in making food materially and meaningfully edible (Roe, 2006), liquid and solid wastes are directly produced and sorted: wastewater in washing food, solid waste in separating out unwanted detritus.<sup>7</sup> In practice, solids are commonly mixed up with the wastewater, at least in small quantities. This wastewater might then be disposed of via the drain, or saved and put to some further use, for

example watering plants, thus reducing overall demand on both water provision and sewerage services (Chappells & Medd, 2008). Washing and/or peeling are recommended from a food safety perspective, particularly for fruit and vegetables eaten raw (FSA, 2017). Choosing between washing and peeling, however, can involve a trade-off between creating food waste and using other WEF resources: washing might have nutritional benefits over peeling, and may reduce solid waste, but it is likely to use more water and energy.

Third, many items can be *cooked* in multiple ways, with different methods of cooking producing different amounts of leftover fat, as well as carrying vastly different energy requirements (Hoolohan et al., 2016). Choosing between methods can result in different quantities, and qualities, of FOG to be managed. Here, then, there are potential synergies as well as trade-offs between efforts to conserve energy and those to reduce FOG generation.

The fourth moment is *eating* itself. Most directly, the format and location of a meal can result in different quantities and forms of residual food waste (Evans, 2014), including FOG. Eating is also consequential insofar as expectations of what constitutes “proper” food shape what is bought, how it is prepared and cooked, and so what is left to be disposed of (see below – leftover fat).

Fifth, cooking often produces *leftover* fat. These fats are liquid when hot, but may solidify when cooled, complicating the distinction between solid and liquid waste (Water UK, n.d.). Again, there are multiple possibilities as to what can be done with these leftover fats. Some people might pour them down the drain, others dispose of them via solid waste collections, but they might also be reused in cooking. Meat fats can be used, for example, in making gravy or roasting vegetables; however, promoting their ingestion might conflict with healthy eating agendas. FOG can also be collected and recycled for non-food use, from making soap (Ibáñez Martín & de Laet, 2017) to generating energy (Gelder & Grist, 2015).

Finally, liquid and solid wastes are produced in *cleaning up* after food: washing dishes, wiping surfaces and rinsing packaging for recycling. In the process, clean water mixes with residual food and grease to become dirty dishwater. The extent of fats and solid waste consigned to the sewer can be minimised by placing scraps of food in the kitchen bin or food waste caddy and by wiping plates and pans to remove residual grease before washing (Water UK, n.d.). Reducing the burden on wastewater management in this way might, however, increase the burden on solid waste streams, a further intersection between distinct policy domains.

The moments outlined above are all part of the processes which might lead to FOG disposal down the kitchen plughole, and so represent potential focal points for intervention, with multiple courses of action possible at each stage. Drawing on our synthesis of the home practices literature, we turn now to the question of what shapes food practices and why particular ways of performing them prevail and, at times, resist change. This reveals a number of opportunities and challenges for intervening in practices to reduce FOG production.

#### 4.4 | Opportunities and challenges for intervening in kitchen practices

Research inspired by theories of practice stress that environmentally problematic patterns of resource consumption and wastage are very often inconspicuous and undertaken without much conscious reflection, becoming routinised and normalised via the integration and alignment of heterogeneous elements over time. Chief among these are the infrastructures that ensure consistency and reliability in both the supply of resources and the disposal of waste (Shove & Chappells, 2001; Strengers, 2011). Notwithstanding the moments when these are interrupted in some way, the impacts of providing information and advice or appealing to people’s attitudes about drains and sewers are likely to be limited (Allon & Sofoulis, 2006; Browne & Foden, 2017).<sup>8</sup>

The specific ways that people carry out domestic tasks – including preparing and eating food in the kitchen – are carefully coordinated to fit alongside any number of other ongoing time commitments, including employment and caring responsibilities (Nicholls & Strengers, 2015; Southerton, 2003; Wills et al., 2013). It follows that any attempt to change how people carry out specific tasks needs to consider the wider rhythms of daily life. For example, asking householders to take their used cooking oil to a municipal household waste recycling centre might be a poor fit with existing routines (Dyson, 2016).

Another consideration is the emphasis placed on diversity within and between households in the geographies of household sustainability (cf. Gibson et al., 2013). Applying these insights to FOG, it seems credible that while some household members may be willing to reuse cooking fat or wastewater, others might find this unsanitary (cf. Metcalfe et al. [2013] on use of food waste caddies). Certain households – perhaps differentiated by age, lifestyle or ethnicity – may produce and dispose of more FOG than others.<sup>9</sup> Both are empirical questions; future interventions need to understand these challenges and opportunities better, and what can be learnt from them.



Similarly, care must be taken to acknowledge the labour involved in managing kitchens differently. Evidence suggests that the burden of consumption and waste work falls disproportionately on women (Wheeler & Glucksmann, 2015). It is therefore vital to be attuned to the unintended consequences of pursuing “good” environmental outcomes (Evans, 2017).

In considering the diversity of households it becomes apparent that how people go about domestic activities is not merely a matter of personal preferences or individual habits. Instead, kitchen practices are shaped by shared understandings about what is and is not food, what it means to cook and eat “properly”, hygiene and cleanliness conventions, prudent use of resources and environmental responsibility (e.g., Lucas, 2002; Murcott, 1995; Roe, 2006). These conventions change over time, vary geographically and culturally, and can be difficult to intervene in, at least in predictable and controllable ways.

Building on the modes of intervention discussed earlier (Table 1), there is significant potential for use of “social norms and networks” to achieve change in this area (e.g., WRAP, 2012). Sustained campaigning on multiple fronts – from enlisting high-profile intermediaries (e.g., celebrity chefs) to community groups and NGOs – may potentially start to change what is normal, appropriate and desirable conduct related to FOG waste (cf. Hards, 2011; Piper, 2015). Potential synergy across and beyond WEF areas should also be noted; for example, low-fat and vegetable-oriented meals may minimise fat use with beneficial impacts on FOG and population health.

Disposal of FOG via the kitchen sink recalls recent geographical thinking on the performativity of materials in transformative states (Evans, 2017; Gregson et al., 2010). Fats are troublesome materials. The fact that they are often liquid at cooking and room temperatures makes them simpler to dispose of as liquid rather than as solid waste, and yet their tendency to solidify and accumulate in the specific physical and chemical conditions of drains and sewers (Williams et al., 2012) makes this disposal highly problematic. FOG is also difficult to deal with insofar as it is likely to elicit visceral “disgust” responses or at the very least reify cultural categories of what is clean and what is dirty (Ibáñez Martín, 2014; Waitt & Phillips, 2016; Watson & Meah, 2013). The riskiness of these materials – smells, appearances and associations – most likely calls forth the requirement for it to be sealed off and ejected from the home with minimal human contact (cf. Evans, 2014). If this is indeed the case, then successful interventions to divert FOG from sewers will mean providing an alternative, yet similarly effective, option for quick and hassle-free disposal beyond the kitchen sink.

Finally, domestic kitchen practices are shaped by wider systems of provision and disposal. When people buy, prepare and cook food these activities are part of a wider complex of interdependent practices together making up the “food provisioning system”, including farming, retail and so on. Changing the ways food is supplied will impact on how people eat, and vice versa. Notably, Fine and Leopold’s approach to systems of provision (1993) stresses that patterns of food consumption have less to do with consumer choices than the historical evolution of the food system, and alignments between agricultural policies and the interests of food corporations.

Similarly, how people dispose of food waste (including FOG) is part of a complex of practices making up the “food disposal system”, including waste, energy and water management practices, governance and the operation of all associated infrastructures (Ibáñez Martín & de Laet, 2017). A crucial part of intervening in the problem of FOG in sewers is the provision of alternative waste disposal infrastructures that – from a user perspective – are effective and reliable at ejecting unwanted materials from the home, without significantly adding to competing demands on time and resources (cf. Metcalfe et al., 2013).

In summary, our analysis highlights how kitchen-focused interventions in relation to FOG are challenging to design, partly because they seek to disrupt highly routinised but closely programmed kitchen procedures, but also because the very diversity and complexity of everyday lives means that different initiatives will work in different circumstances. FOG’s troubling materiality also requires new disposal arrangements that are effective at sealing and ejecting it from the household.

Notwithstanding these challenges, our analysis points to a variety of potential approaches to intervention (Foden et al., 2017; Hoolohan & Browne, 2016; Spurling et al., 2013). As outlined in Table 2, these complement and extend the three current dominant approaches to intervention (recall Table 1). Specific applications of these approaches might include taking opportunities to make infrastructure more visible to the public; collaborating with waste infrastructure providers to design routine-friendly waste fat collection processes suitable for diverse household types; and supporting food product innovation to minimise leftover fat. Overall, the analysis offers a unique systematic consideration of different moments for intervening to address the sources of domestic FOG in sewers.

## 5 | CONCLUSIONS: BEYOND FOG TO LESSONS FOR THE WEF NEXUS

This paper opened with the assertion that challenges related to the interdependencies of water, energy and food arise not only in the supply of these resources, but also in their consumption within the home. Taking and applying insights from a well established literature on home practices and how they create demand for resources, we have worked through a case

**TABLE 2** Three emerging opportunities for intervening in FOG in the UK

Style of intervention	Characteristics of FOG intervention	Status
Changing <i>practices</i> in the kitchen	Aims to influence the social practices within the kitchen directly. This involves taking opportunities to make water and food disposal infrastructures more “visible”, developing understandings of where FOG is produced through household routines, recognising the rhythms of daily life, appreciating diversity within and between households, and working with cultural conventions.	Recognised within the WEF sectors as a useful approach but implementation still rare or partial (e.g., innovative aspects of some water companies’ consumer-focused campaigns <sup>10</sup> ; cf. also WRAP, 2012)
Changing <i>systems</i> to shift practices	Aims to make changes in wider systems in order to influence and reconfigure practices within the home and kitchen, for example, innovation within the food supply and food disposal systems. System design considers flexibility, convenience and reliability of provision; takes seriously how the messy nature of decomposing food impacts on disposal.	Few examples, opportunity to develop approach (cf. Holland, 2016; Ibáñez Martín & de Laet, 2017; Metcalfe et al., 2013)
Distributing responsibility	Designing and implementing interventions that consider multiple infrastructural and resource implications, requiring collaborative working across policy domains and public/private/voluntary sectors; e.g., waste governance, energy-water companies collaborating for waste resource recovery for biofuel. Reconfigures systems of practices.	Few examples, opportunity to develop approach (cf. Brockett, 2016; Evans & Welch, 2015)

Source: Based on Foden et al. (2017).

study example of fats, oils and grease entering and disrupting the wastewater management system to explore the interdependencies of WEF resources in the home. Specifically, our contribution has been to explore the heterogeneous associations (across processes of food provisioning and involving the material agency of WEF resources) that underscore FOG production and the forms of governance that these call forth. To conclude, we focus on broader insights arising from considering kitchen practices through a nexus lens. We consider insights for the nexus and home practices literatures in turn.

Our analysis joins existing WEF nexus debates by stressing the importance of attending to the numerous intersections between water, energy and food flows. We contribute to these debates, first through highlighting that concern about *demand* for WEF resources can be part of addressing crises of resource supply. Second, from this basis we bring to bear burgeoning evidence and understanding of the constitution of that demand, in the practices of everyday life. Third, we build on insights from that research to articulate an approach informing policy interventions to tackle that demand.

Extending nexus thinking into the kitchen underscores the unavoidability of cross-agency collaborative working in addressing the trade-offs and potential synergies between resource-focused interventions. For example, tackling FOG in sewers primarily presents a problem for water companies, but effective prevention is likely to require coordination with authorities and providers responsible for management of solid food waste, energy companies and even collaboration with designers, manufacturers and retailers of food products. Responsibilities for intervention are then defined much more widely than current strategies that focus on maintenance of infrastructure or behaviour change campaigns (cf. Browne et al., 2014; Evans et al., 2017).

Our focus on kitchen practices also prompts further critical engagement with the nexus concept. While taking seriously the trade-offs and synergies between mutually implicated resource challenges, we stress the importance of not reducing debate to a narrow, technical, quantitative appraisal of which “home practices” use the least water, energy and food (in different combinations). Defining efficiency and determining the appropriate prioritisation of particular resources over others are always political matters (Williams et al., 2014), open to contestation and with consequences for those who stand to gain or lose out from these decisions. Consensus should not be assumed.

The home practices literature also highlights the often good reasons for “bad” behaviour, and the economic and social injustices that can be embedded in “good” environmental behaviours (for example, the gendered labour burden of sustainable consumption). WEF resource efficiency should not be assumed to be a self-evident priority that eclipses all other concerns within the home. Moreover, a narrow focus on improving WEF efficiency at the household scale might obscure more radical reappraisals of the status quo, for instance the prevailing organisation of food retail, or formation of new coalitions across WEF stakeholders to re-imagine interventions of resource supply and waste disposal.

We nevertheless suggest that the dictum of “nexus thinking” is generative of new understandings of home practices. Our research team brought together specific expertise in water, energy and food, and we note that where research in each

domain engages similar theoretical and substantive concerns, certain themes are better developed than others in each “silo”. For example, research on water has a more developed account of infrastructure than research on food, which has a more developed account of gender relations and ethics of care than energy research, which has a more developed account of service provision than water research. Combining these strengths affords more comprehensive analysis of the practices and infrastructures through which households meet their needs.

Beyond simply combining these disparate strands of resource-relevant research, we suggest that taking seriously the invocation to consider water and energy and food simultaneously forces home practices research to engage more thoroughly with questions of resource use and environmental impacts. In stressing the interdependencies of resource flows through households and connecting these to wider infrastructures of provision and disposal, we also invite a focus on the causes of environmentally damaging consumption and the locations in which it arises. In turn, this calls for renewed attention on the *distribution of responsibilities* for sustainability outcomes and processes of change (cf. Evans et al., 2017).

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## ENDNOTES

- <sup>1</sup> Interview no. 3: water company representative, February 2017.
- <sup>2</sup> Interview no. 1: water company representative, February 2017; and interview no. 3.
- <sup>3</sup> Interview no. 2: water company representative, February 2017.
- <sup>4</sup> Partner meetings, especially nos. 5, 7 and 8, June 2017.
- <sup>5</sup> Our intention is not to catalogue the WEF resource implications of different courses of action at these various stages of food provisioning exhaustively; it is merely to illustrate that material transformations occur at each stage and that these vary according to precisely how each stage is carried out. For more detailed discussion, see Foden et al. (2017).
- <sup>6</sup> Interview no. 5: water company representative, May 2017.
- <sup>7</sup> WRAP (2013) distinguishes between “avoidable” and “unavoidable” food waste on the basis of how commonly such matter is discarded as non-food detritus. See Evans (2014) and Coles and Hallett (2013) on the cultural contingency of these classifications.
- <sup>8</sup> For example, in 2018 a piece of the Whitechapel Fatberg was shown in an exhibition in the Museum of London. This is an interesting way of raising public awareness of a previously relatively unknown problem. However, the attention that such exhibitions bring may possibly be transitory and wider considerations need to be given to intervention approaches that attempt to reconfigure systems of waste disposal (Foden et al., 2017; Moss, 2018).
- <sup>9</sup> Partner meeting no. 1: November 2016; and interview no. 2.
- <sup>10</sup> Interviews, especially nos. 1, 2 and 3.

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