

Modelling Energy-Consuming Social Practices as Agents

Tina Balke, Thomas Roberts, Maria Xenitidou, Nigel Gilbert

University of Surrey

Centre of Research in Social Simulation

Guildford, Surrey GU2 7XH, UK

Email: {t.balke,n.gilbert,t.m.roberts,m.xenitidou}@surrey.ac.uk

I. INTRODUCTION

Household energy use and personal transport account for a considerable proportion of total energy use and of greenhouse gas emissions. For example, in Europe about 35% of all primary energy use and 40% of all greenhouse gas emissions come from private households [1]. Given the vital importance of reducing greenhouse gas emissions from energy use, the dynamics of household energy demand and consumption have become a matter of considerable interest.

Following [2], the discussion of energy consumption and efficiency in the domestic sector usually takes the form of highlighting either practice-related behaviour or the potential of technological innovation. Although it touches on aspects of the latter, this paper has its main focus on the former, which according to [3] has so far has been underrepresented despite being able to make a significant difference with respect to energy consumption [4].

The paper presents some initial ideas about an agent-based model for simulating practice-related aspects related to household energy consumption. For this purpose it draws upon the vast body of social science literature discussing determinants of human lifestyles and how lifestyle changes could be promoted (see [5]–[7] for examples). It adopts a *Social Practice Theory* (SPT) approach, which in recent years has received increasing attention by researchers and policy makers, because—instead of placing individual trait driven behaviour and decision making at the centre of analysis—it puts the spotlight on how, at given points of time, broader collectives of practices establish and achieve everyday objectives.

In the next section this approach and its relevance for the study of domestic energy consumption are presented. One of the conclusions drawn is that so far no simulation model accounting for the different aspects of social practices exists, which is why we aim to close this gap and present our idea of a social practice agent-based model (ABM) in Section III. The paper closes with a short summary and proposals for future work.

II. SOCIAL PRACTICE THEORY

Over the last 40 years there have been numerous attempts to identify the determinants of human behaviour in order to direct it into more pro-environmental channels (see e.g. [4], [8] for reviews). This work has attempted to identify individual's

beliefs, attitudes and values and use them as predictors of behaviour, so that they can be modified to promote behaviour change. Fundamental to this work is the assumption that behaviour is the outcome of a rational process undertaken by rational individuals.

The most widely cited of these approaches is the *Theory of Planned Behaviour* [9] which argues that behavioural intention, which precedes actual behaviour, results from interactions between an individual's attitude towards the behaviour in question, their beliefs about what others think about the behaviour—the subjective norm—and their perceived level of control over the behaviour, or perceived behavioural control. However, in recent years this approach, which indirectly suggests that, provided that the necessary cognitive components can be identified and modified, a desired behaviour change will follow, has been subject to substantial criticism. One of the main reasons is its lack of consideration of habitual behaviours and the social and material contexts in which people perform their actions [4].

In contrast to these behavioural models, which focus solely on individual agency, SPT adopts Giddens's [10] theory of structuration which seeks to find a balance between structure and agency. Giddens concludes that human agency and social structures are shaped recursively. As activities emerge and are enabled by structures of rules and meanings, these structures are constantly re-enforced and legitimised in the flow of human action. Consequently, it is the practices themselves, featuring both structures and agents, not two independently given sets of phenomena, that form the basis of our social arrangements. As Giddens [10, p. 2] argues:

The basic domain of study of the social sciences... is neither the experience of the individual actor, nor the existence of any form of societal totality, but social practices ordered across space and time.

Attention is therefore no longer focused on individual decision making, but on 'the doing' of various social practices and the inconspicuous consumption that forms an integral part of many practices [11]. As a result, the individuals become the 'carriers' of social practices rather than the centre of attention [12]. Central to practice theory is the idea that it is through these engagements with practice that individuals come to understand the world around them and develop a more or

less coherent sense of self [13].

Despite this focus on 'Practical Consciousness' [10], practice theory does not suggest that individuals are completely passive. Instead it argues that they are skilled agents who actively negotiate and perform practices in the course of their daily lives. In terms of reducing the environmental impact of consumption, practice theory suggests that transforming practices to make them more sustainable is a far more effective approach than simply persuading individuals to make different decisions. As Warde [13] notes, "the principal implication of practice theory is that the sources of changed behaviour lie in the development of practices themselves".

Although these basic principles can be applied to almost all theories of practice, there is 'no unified practice approach' [12]. Nevertheless, there are a number of common features that are becoming established as 'core' components. It is universally agreed that practices are made up of a number of different *elements*, which are linked together. While there is some debate regarding precisely what constitutes an element and what the key elements which make up a practice are, there is a growing consensus around Shove's [14] understanding of practices as being made up of three core elements. The first of these: *materials*, encompasses objects, infrastructures, tools, hardware and the human body itself. The second element: *competence*, is drawn from what Giddens [10] describes as practical consciousness, deliberately cultivated skill and shared understandings of good or appropriate performance in terms of which specific enactments are judged. The final element: *meaning*, is a combination of what Reckwitz [12] describes as mental activities, emotion and motivational knowledge [14]. It also includes social norms, shared beliefs that dictate how members should behave in a particular context [15]. Essentially the meaning element refers to the social and symbolic significance of participation at any one moment.

A simple example often used to explain how practices evolve is 'showering'. Showering is a relatively recent method of cleaning oneself that has rapidly evolved in many western countries over the last fifty years. Previously, it was considered the norm to take a bath once or twice a week. However, over the past 50 years bathroom infrastructure has changed to incorporate showers (*materials*). There have also been corresponding changes associated with 'normal' levels of personal hygiene (*meanings*) along with conventions related to the way in which people prepare themselves for the day ahead (*competence*) [16]. As these elements have come together and been regularly repeated by skilled actors one aspect of everyday life has been transformed, evolving into the new and now standard practice of showering.

Showering has become a routinized part of daily life for billions of people living in western society and deeply integrated into everyday life. Furthermore, as the practice is performed by more people and new associated products become available (such as shower gels) the practice continues to evolve.

In summary, SPT de-emphasises the idea of studying human behaviour in favour of exploring how social practices are ordered across space and time. Social practices emerge, evolve

and eventually die out as a result of the reconfiguring of their component elements and their reproduction by skilled practitioners.

In this paper we put particular emphasis on this two-way dynamic and the self-perpetuating nature of practices by describing an approach to modelling the practices and their dynamics as an ABM.

In the next section we present this social practice ABM and introduce the idea that because of their self-perpetuating nature and their active role in the downward causation, practices can be modelled as agents.

III. CONCEPTUALISING A SOCIAL PRACTICE ABM

Although there is some published work mentioning (and even outlining the idea of) social practices (e.g. [17]), most papers either focus on the learning of the individual agents about the actions of their neighbours (and then their utility considerations about what they have learnt), or demonstrate the propagation of habits within an agent society using different social network structures and neighbourhood typologies.

What is however missing in all current models is the consideration of the role these practices have themselves in shaping a system, not only by promoting more agents to carry out practices and repeating them, but also by encouraging industry to develop products that support these practices, which in turn makes it 'easier'¹ for the actants² to carry out the practice. Thus, although sometimes claiming differently, most papers aiming at analysing social practices fail to address and explain this feedback loop and the dynamics of practices, such as how practices are emerge, evolve over time, influence other practices and possibly die out.

In this paper we look into exactly this issue and focus on the micro-macro dynamics present in the above described setting. Phrasing it in the classical micro-macro terminology used in ABM research, social practices emerge as a result of the interaction between elements at the micro and macro levels. Micro level acts affect (strengthen/weaken) macro level elements (e.g. following a shared rules reinforces that rule). In the other direction, macro level elements constrain/encourage micro level acts (a shared rule is more likely to be followed). Thus, there is a two-way link between the micro and macro levels (both up- and down- ward causalities are present).

We identify four main processes which need to be considered when designing a social practice ABM:

- households performing practices,
- the spread of these practices to other households,
- the development of products for practices by households, and
- the adoption of products for their practice performances by households.

¹The term 'easier' can have several meanings in this context ranging from more convenient, less difficult and cheaper to less time consuming or more in accordance with social conventions, more encouraged, and less sanctioned.

²We use the term 'actant' to refer to anything that does things. This could be a person, but also a machine such as a washing machine.

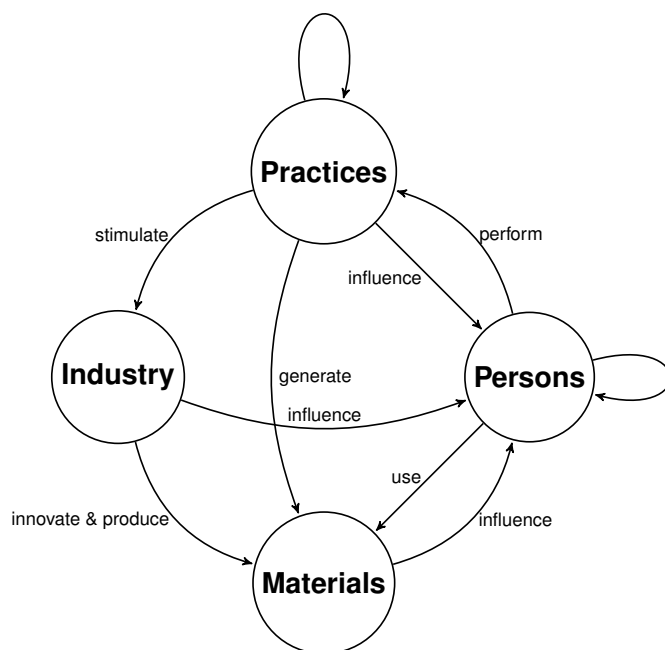


Fig. 1. Components of the Social Practice ABM

To make these points more specific, recall the following points of the showering example:

- Showering is a social practice that is regularly performed by households.
- The regular performance of the showering practice by households has resulted in a general change of understanding of cleanliness in the population, which in turn had an influence on people's perception of what the right amount of cleaning/washing is, which in turn resulted in a change of household cleanliness practices towards more showering.
- The spread of the showering practice furthermore resulted in it becoming of interest to industry, which developed new products for the practice in the hope of making profits.
- These new products had an influence on the perceived 'easiness' of the performance of showering by households, which thereby influence the showering practice.

Figure 1 summarizes these dynamics by means of arrows. It also shows the four components the links affect: (i) households (ii) social practices (iii) industry (iv) materials.

In our ABM, of these four components, the first three are conceptualized as agents, whereas the last one is represented as 'features' or 'artefacts' of the environment. For our definition of agency we follow the ideas of Macy and Willner [18] who proposed four criteria for agency in ABMs:

- 1) **Autonomous Behaviour:** Systemic patterns emerge not as a result of central planning, authorities or institutions, but as a result of the interactions between the individual actants in the system.
- 2) **Interdependence:** The different agents in a system influ-

ence each other.

- 3) **Agents follow simple rules.**
- 4) **Adaptive and backward-looking behaviour:** Agents adapt by imitation, replication, and so on, but not by calculating the most efficient action.

While defining households and industry as agents is not unusual, we also apply this definition to the practices and hence model them as agents in the system. Thus, different social practices can show individual autonomous influences on the system in the sense that their system influences are not centrally planned and coordinated, but result from the individual characteristics of the social practices and the environment they are situated in. Similarly, social practices not only influence other practices (e.g. the showering practice might for example influence the laundry practice in terms of more towels being used and therefore requiring washing). We only use a simple behavioural rule for practices, in which it tries to increase the number of its performances by households. Practices can change, for example as a result of changes in the elements the households use when performing the instances of practices (e.g. adopting power showers). New practices can be 'born' (e.g. the showering) if new elements appear and are being used (e.g. the shower as product) or if old practices are being recombined in a new way.

Having outlined the elements of the ABM, how does it work in detail? In the ABM the household agents are represented as decision trees, which have certain competences and meanings as part of their properties. The nodes in the decision tree are either conditions referencing elements (a combination of competences, meaning and materials from the environment) or they are acts that can be performed (if the node is a leaf node). At each time step of the simulation, the agents work through the decision tree nodes to reach a leaf node, which yields a decision to perform an action. If the action is regularly repeated, this generates a social practice (or alters an existing one). After performing an act (using an evaluation function specific to the domain) the household agent evaluates it by obtaining a score of 'easiness'. This easiness measure is used in a learning algorithm that enhances the decision tree to consolidate the agent's competence and the meaning it associates with different (combinations of) acts.

On the macro level, the social practice agents have the ability to influence the know-how and meanings of household agents. The strength of their influence depends on the frequency of their performance by households, i.e. the more a practice is performed, the stronger its influence on the household agents.

In addition (and again in relative relation to their influencing strength) the social practice agents can foster the generation of material elements for the practices and trigger the consideration of innovations by industry agents. These industry agents are set up similarly to the household agents, i.e. they are represented as decision trees. When triggered by a social practice agent, an industry agent will work through to its leaf nodes, where it has to make the decision about whether to create a new material for a practice or whether to create more

material for an existing practice (possibly using economies of scale for the latter). The materials created (together with a description of its intended use) are placed as an artefact in the environment, where it can be used by the household agents. The household agents will use a new material if it makes the performance of practices easier for them³. The more a product is being used, the more positive feedback the industry agent receives, which it can account for in its learning about the ‘market’ for new materials. The adoption of new materials by household agents (in combination with their competences and meanings properties) can result in them changing their performances, which in turn can affect the social practice agents, to close the micro-macro loop.

IV. SUMMARY AND FUTURE WORK

In this paper we have outlined an initial idea for an energy-consuming social practices ABM. The novelty of our approach is that, because of their important role in their own spreading, we model the practices themselves as agents and link them both to the performances of households and to industrial product development.

At the current stage, the model has been conceptualized and is currently being implemented as a first version using a single practice only. In the future we aim to advance our model to account for several practices and the relations between them. For this purpose we have identified five specific social practices and we are currently collecting qualitative empirical data on them by means of walking interviews:

(i) heating, (ii) laundry, (iii) television watching, (iv) cooking, and (v) electronic communication.

The reasons for choosing these five practices are that not only are they often mentioned when household energy efficiency is being discussed, but they are also interlinked, both on a practice level (e.g. electronic communication has resulted in more home-office work, which in turn has resulted in the home being heated during the day), and on an elements level (e.g. cooking and heating both require water). Our aim is to combine our qualitative interview data with quantitative individual energy consumption data collected in households to get a better picture of the relationship between actual and perceived energy consumption in households.

We aim to provide our models to policy makers to help their understanding of practice issues. We have recently discussed these ideas with staff of the UK Department of Energy and Climate Change and will integrate their input into a first prototype of our model.

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³Household agents do not necessarily need to use materials in the way they were intended by industry.

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