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Understanding the timing of energy demand through time use data: Time of the day dependence of social practices



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ABSTRACT

The time dependence of social practices at specific points of the day shapes the timing of energy demand. This paper aims to assess how dependent energy-related social practices in the household are in relation to the time of the day. It analyses the 2005 UK Office for National Statistics National Time Use Survey making use of statistically-derived time dependence metrics for six social practice: preparing food, washing, cleaning, washing clothes, watching TV and using a computer. The focus is on social practices over temporal scales of different days of the week and months of the year. The main findings show that: washing has the highest value for the time dependence metric; using computers is the least time-dependent practice; Tuesdays, Wednesdays and Thursdays have the highest time dependence for all practices; and certain energy-related practices have higher seasonal dependence than others.

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1. Introduction: time dependence, social practices and the timing of energy demand

Years of research in energy demand have seen the predominance of technical factors (including weather, building characteristics, appliance design, appliance control, interdependencies between energy services, etc.), which have partly explained variations in volumes of energy demand, but have inevitably failed to describe any intra-day variation in patterns (e.g. residential electricity load profiles). Peak energy demand emerges as a phenomenon which epitomises the relevance of practices as a unit of analysis in this context. At the heart of the approach which places social practices at the centre of our understanding of the dynamics of energy demand is the position that the timing of energy demand is determined by the way practices are ordered in time [1]. A simple example which can illustrate how the timing of energy demand and, hence, peaks are a reflection of people's practices derives from the substantial difference between residential electricity load curves for weekdays and weekends. During the same season the weather can be equal at the weekend compared with the weekday. Building type, appliances, fuel substitution, price of energy and appliance control, and the moment of the day in which sunlight is present or absent may be the same between weekday

and weekend. The only substantial change between weekday and weekend is in terms of people's activities.

Previous attempts to describe the social phenomenon of peak energy demand have focused on issues of synchronicity of practices [2], sequencing [3] and (lack of) flexibility [4]. Peaks are also triggered by an infrastructure that simultaneously services those multiple 'doings'. Social practices have characteristics which define the way energy demand comes about. They are habitual, synchronised, varied, sequenced and contingent [2].

The issue of time dependence of social practices has been debated for some time at different conceptual levels, but seldom operationalised in empirical research. This relates to the general argument that issues of timing in energy and the social sciences are seldom supported by evidence [5]. The starting point of this work is that the time dependence of social practices at specific points of the day shapes energy demand in households. This is in an effort to operationalise the realisation that a social order underlies regular patterns relating to the fundamental temporal characteristics of social events (e.g. duration and sequence) [6].

This paper aims to assess how dependent energy-related social practices are in relation to the time of the day. It addresses specific questions regarding the variation of time-dependence throughout the working days of the week and the relationship between time dependence and seasonality. The purpose of this paper aligns with how people make decisions about energy [7].

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The analysis of the 2005 UK Office for National Statistics National Time Use Survey makes use of time dependence calculations for six activity codes: preparing food, washing, cleaning, washing clothes, watching TV and using a computer. Activity codes are used here in order to establish a quantitative link with social practices. The focus is on social practices over temporal scales of different days of the week and months of the year.

Time dependence is defined as high occurrence of the same practice over the same periods of the day. Practices which repeatedly take place at the same time of the day are said to be time dependent. Two simple observations underpin the concept of time dependence of social practices. First, social practices have rhythms [8]. Rhythms introduce the possibility of rigidity of the daily temporal structures [9] and time dependence in social practice ordering. Rhythms and routines co-exist and are interdependent, not rival [10]. This is not to say that time follows exogenous forces or that practices have independent rhythms [11]. Quite the opposite, time can be a quantitative measure of the ordering of practices, notwithstanding the temporal dynamics within and across practices. Second, empirical evidence shows the time dependence of the peak energy demand phenomenon [12]: with different intensities, depending on the season, every morning and evening of any weekday there are the same peaks in electricity demand. Peaks are seemingly time-bound and are a signal of societal synchronisation.

After this introduction, Section 2 briefly reviews the literature on social practices, time and energy demand. Section 3 describes the dataset on which the analysis is based and the statistical methods used for measuring time dependence. Section 4 analyses which practices are more or less time dependent. Section 5 examines how time-dependence varies throughout days of the week. Section 6 explores whether time dependence changes depending on seasons. Section 7 discusses the implications of this paper and concludes.

2. Time, social practices and energy demand

The theoretical foundations of this paper are based on four basic propositions. This section explains the concepts underpinning each of these four propositions and reviews elements of practice theory which are relevant to work on time, social practices and energy demand.

First, the starting conceptual proposition put forward by this paper is that in order to understand the timing of energy demand, the social ordering of practices needs to be analysed. The timing of energy demand is arranged to accomplish social practices, such as watching TV, working, cooking or washing up [13]. By placing the social ordering of people's activities at the centre of the study of social life, social practice theory offers a consistent ground to investigate the dynamics between people, time and energy demand. Social practice theory considers the relation between time and consumption in relation to the fact that human activities are ordered recursively across space and time [14]. From social practice theory, the timing of energy demand can be defined as the result of the socio-temporal organisation of daily practices [15]. Having made this link between time, social practices and energy demand, it is suggested that understanding the timing of energy demand involves studying social practices in terms of their ordering and time dependence.

Second, practices do not occur in isolation, but tend to cluster together over time and space. The temporal and social ordering of practices shapes material arrangements. Material arrangements, as defined by Schatzki [15], are the relatively stable relationships between people and materials and natural objects and infrastructure, which set the frameworks within which practices take place. Arrangements are critical in understanding energy because 'the arrangements amidst which practices are enacted are not only

social: arrangements include substances of all kinds, including natural phenomena along with man-made fabrications' [16,p. 23]). Arrangements and social practices are connected as the latter are determinative of and dependent on the former. Social practices happen (for instance at different times of the day), whereas material arrangements 'exist' [15]. Arrangements last longer than any instance or moment enactment. The context in which social practices are enacted depends on the specific practices that are contextualised [16]. Arrangements -including energy- only have meaning within, and in relation to, the practices in which they are enfolded, and through which they are reproduced [17]. Understanding the dynamics of energy demand and the variation which occurs with peak phenomena is a matter of studying the ordering of social practices.

Third, turning to peak energy demand specifically, very few studies of peak demand have used a social practice framework for analysing domestic energy consumption in empirical terms. For instance, Nicholls and Strengers [4] analyse the inflexibility to certain bundles of practices in Australian households with children. Anderson [18] investigates the temporal changes of a single practice (i.e. laundry) over 20 years. More widely, examples of the changing temporal and spatial rhythms of social practices (i.e. 'timespace') abound in the literature: the move from lower frequency and higher duration bathing to higher frequency lower duration showering [19], the change in patterns of consumption in Turkey associated with the import of teabags [20], and the diverse eating timings and durations in different countries [21]. However, the work on the measurement of rhythms in terms of time dependence is not very developed. Both conceptual and methodological challenges explain why time dependence of social practices has seldom been operationalised in empirical research. An exception consists of the qualitative analysis presented by Southerton [22], in which the temporal rhythm of the day is characterised by practices which hold a fixed position in time.

Fourth, a practice approach could make a novel contribution to approaches to managing load shifting. From a research perspective, any household energy demand model seeking to represent and then manipulate electricity demand under different scenarios needs to take account of the timing of energy-related practices. Representations of the time and timing of practices play a vital role in describing the timing of demand and its consequences for time-related scenarios, such as manual Demand Side Response, electric vehicle charging or automated demand control. Understanding where routines are most strongly embedded in everyday lives may provide crucial insights into the predictability of activities and their associated loads.

In addition to the four propositions, two critical clarifications on the definition of time in this paper are that: (i) time is socially constructed, meaning that the distinction, for instance, between weekday and weekend is entirely attributable to the framework of time as designed by the society in which we are living in; and (ii) the resolution of time in this paper is generally intra-day (in tune with the discussion on peak demand, loads profiles and timing of energy demand). For this reason, the concept of time dependence needs to be critically linked to material arrangements. Social practices vary not only from one location to the next, but also in time. The existence of material arrangements and the presence of space dependence (i.e. the fact that practices vary depending on locations, countries, etc.) allows for scope conditions, including time dependence. The existence of scope conditions does not imply that all social processes typically have standard causal configurations from which deviations can be gauged. This work acknowledges the role of time in ordering practices when measuring rhythms and the potential for creating dependence according to the measurements of time, which are processed by the space and time in which practices are performed.

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