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ASSESSING FLEXIBILITY IN RESIDENTIAL ELECTRICITY DEMAND: FINDINGS FROM THE ANALYSIS OF UK TIME USE DATA

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Overview

The timing of electricity demand has significant implications for system balancing, utilities' pricing and future grid development. Understanding when electricity demand occurs (i.e. at what time of the day) is inextricably related to questions of where electricity demand takes place (i.e. in the home, at work and on the move) and why (i.e. what activities underpin it). Traditionally, balancing demand and supply occurred via expansion of capacity base to deal with aggregate increases in electricity demand. More recently, higher awareness over the greenhouse effects of fossil fuel generation implied that concerns over demand-supply matching cannot justify grid expansion. As a result, balancing electricity supply and demand could be achieved thanks to demand side management, i.e. price and time-based interventions aimed at reducing the absolute amount and shifting the timing of electricity demand. One of the main reasons why demand side management, at least in most European countries, has been relatively slow to emerge in the residential sector is due to the fact that evidence on the timing of electricity demand and how it varies in relation to practices is currently missing. Smart meters are widely expected to fill this knowledge gap, but they will only provide information on how much electricity is consumed in every home, rather than explain the reasons why electricity is used and which practices could be shifted across the day. If demand side management is to provide innovative ways of balancing supply and demand any intervention on load shifting needs to be informed not only by load profiles, but also by patterns of societal synchronisation. This calls for detailed knowledge of when, and on what occasions several people engage in the same activities at the same time, of how such patterns vary, and of how they might be shaped. In addition, the impact of smart meters and controls partly depends on whether there is, in fact, scope for shifting the timing of what people do, and for changing the rhythm of demand throughout the day. This paper analyses time use data with a view to address questions about practices and variations in peak electricity demand, what activities peak electricity demand is composed of, what differences exist between morning and evening peaks of electricity demand, where electricity demand takes place at specific times of the day and which moments of the day experience high degrees of societal synchronisation in terms of social practices.

Methods

In order to understand what people's practices are and how they vary during periods of peak electricity demand, time use data were analysed as they are designed to disclose what people are doing at different times of the day. The most recent UK time use survey, i.e. the Trajectory dataset, was selected and purchased from private consultants for this analysis. This consists of 500 respondents who had GPS devices on them for 3 days collecting 10 minute interval data on location. In addition, diary and questionnaire information revealed what people were doing at any given time of the day. Basic demographic information about respondent, including age, gender, individual income and household income is included in the dataset and can be weighted. The data presented in this paper refer to a sample of 649 days of data from 244 respondents of the Trajectory dataset. The paper develops methods of capturing the relationship between mobility and electricity demand, hence linking the two normally separate domains of electricity and transport studies. This is implemented through the use of indexes of synchronisation, with a view to understand at what times of the day many people conduct the same electricity-related activities; active occupancy indicators, which enables assessing simultaneous presence in the household as a proxy for electricity demand; and spatial mobility indexes, which explores the dynamics between mobility and electricity demand with particular reference to work from home patterns.

Results

Morning and evening peaks in residential electricity demand are composed of different sequences of activities. Morning peaks are characterised by high levels of synchronisation, whereas in the evening a more diverse set of activities is carried out. Women have more erratic schedules at peak time as they are engaged in a higher number of activities which have shorter duration. Conversely, men are engaged in the same activities for longer (e.g. working on their computer even around evening peak periods). Parents with children have very regimented and synchronised schedules around morning peaks. In general, the level of mobility for early morning peaks is relatively low, whereas during evening peaks there are people (though a minority) who are on the move performing a variety of activities outside the household. Occupancy patterns confirm these findings.

Conclusions

The analysis shows that morning and evening peaks of residential electricity demand are composed of very different sequences of activities. Higher levels of mobility and lower levels of occupancy make evening peaks particularly challenging for demand-shifting programmes. A tentative scheme for assessing flexibility shows that: (i) a higher number of shared activities with others implies that there is higher simultaneity of loads and within-the-household synchronisation, making it more difficult to move shared activities in time (i.e. lower flexibility); (ii) higher spatial mobility at a given time leads and lower active occupancy for an extended period of time imply that there is more time to do things (i.e. higher flexibility); (iii) higher synchronicity index implies higher societal constraints (i.e. lower flexibility); higher working from home index implies longer time to perform household errands (for instance, the Trajectory dataset has several people working from home who go shopping or run laundries and dishwashers in the middle of the day) leading to higher flexibility (excludes HVAC loads). These findings are a preliminary attempt to indicate where flexibility is and could potentially inform pricing strategies for demand side management programmes.