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Identifying residential consumption patterns using data-mining techniques: A large-scale study of smart meter data in Chengdu, China

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Advanced metering technologies offers the possibility of using fine-grained electricity consumption data to improve our understanding of residential demand. Although there exists a large body of research on demand response in both short-term and long-term forecasting, a comprehensive analysis to identify household consumption behaviour under different scenarios has not been fully carried out. The study's novelty lies in using unsupervised machine learning tools to explore residential customers' demand patterns and response without the assistance of traditional survey tools. In particular, we investigate the following contexts,: 1) Weekly consumption profiles in different seasons; 2) Demand changes for special events/festivals; 3) Behavioural response to extreme weather.

One impediment to carrying out more detailed analysis has been the lack of available high-frequency electricity consumption data. As a result, the easily-accessible Irish smart metering dataset has been a major focus of scholarship. However, in moderate climates such as that of Ireland, the effects of weather would not be expected to be as significant as in more extreme climates. Moreover, the Irish consumer behaviour trial, upon which many studies have been based, lasted only 18 months. Instead, we employ a unique dataset to examine a different location with more extreme weather conditions, Chengdu, the capital of Sichuan in southwestern China. The data we used included smart meter recordings from 2,000 households over a much longer period

of four years, compared to the Irish dataset. By investigating the usage habits from the three perspectives above, we were able to structure and analyse urban households' behaviour patterns on different days and under extreme weather conditions without the assistance of socio-economic data. It is a common dilemma when analysing Chinese residential consumption that few, if any, surveys of detailed electricity consumption behaviour have been carried out. We solve the problem by using clustering methods and providing improved approaches to unravel household behaviour patterns. More generally, smart metering data will increasingly be available without the associated socio-demographic survey and so our approach offers an important methodology to still gain insights into behaviour.

Research into residential demand in China has concentrated on macro-level analysis, that is, how residential electricity consumption is influenced by macroeconomic data, such as GDP, population, income level, etc. Few studies have used household usage data at finer than monthly resolution. Due to limitations on data availability, most micro-level studies have had to use recalled monthly bill data gathered in surveys, which gives rise to concerns over the accuracy of the residential consumption data. The methodology employed here offers a new direction for clustering consumption patterns by comparing fluctuations within a given period. In addition, the innovation of using new indices to cluster the data (reflecting percentage change in demand) produces more robust results than from employing either direct usage data or standardised data based on maximum/minimum usage.

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