Understanding Hourly Electricity Demand: Implications for Load, Welfare and Emissions

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In this study, using sub-hourly appliance-level data from a representative sample of Swedish households on standard tariffs, we investigate the welfare and emission implications of moving to a mandatory dynamic pricing scheme. Our analysis views the substantial variability in the hourly demand for electricity explicitly as being driven by the demand for the underlying, heterogeneous, demand for services provided by it. A related aspect is the fact that the welfare implications of prices differ across appliances and hours, i.e., that a given price has different welfare implications across different hours. The framework we use explicitly accounts for both aspects by constructing household-specific price indices, exploiting the variation in composition of expenditure within hours. In addition, we explicitly allow for unobserved heterogeneity, whose importance has been stressed in the modern demand estimation literature but has thus far not been accommodated in studies on dynamic electricity pricing

Our contribution to the literature is thus two-fold: first, we provide a consistent framework for understanding the effect of the characteristics of residential electricity demand upon hourly retail pricing, allowing us to evaluate welfare and carbon emission implications of different price profiles. Secondly, the use of more detailed consumption data than hitherto available enables us to use household-specific hourly information to drive the hourly demand model.

Our study uncovers interesting changes in hourly demand patterns consequent to hourly retail pricing: households are likely to reduce peak demand and increase off-peak demand, with a maximum peak reduction of three percent and a maximum off-peak increase of two percent. Overall, changes in load at the daily level are rather small, with only a small amount of substitution across hours (at least on average). A similar finding has been reported in some of the literature using household daily or hourly data. In any case, our findings (of relatively low substitution across hours) call into question (at least for the Swedish context) the commonly made assumption in the literature outlining the benefits of RTP, that households are willing to significantly substitute electricity consumption across hours. Another interesting finding is that welfare, measured by the cost of living (for a constant utility), is reduced for most households, with some heterogeneity (some households experience reduced cost of living). This finding suggests that it is unlikely that many households will voluntarily switch to hourly price contracts. Finally, we find negligible effects on emissions, with a very small overall reduction (less than one percent over the day) for both hourly pricing scenarios.

To summarize, our findings suggest that the scope for hourly pricing in Sweden in the short-run is limited. The effects on load are small, most households face a reduction in welfare, and emission effects are negligible.

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