University of Reading

Peak demand, price elasticity and intrinsic flexibility from time use activities

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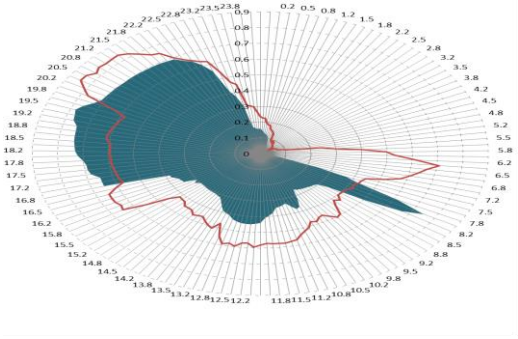
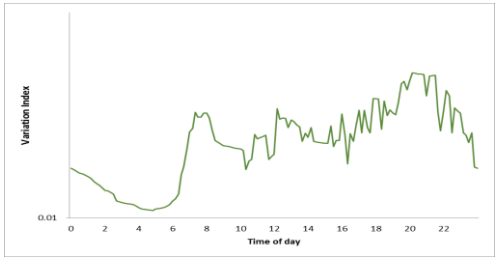
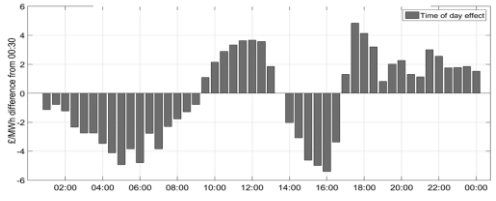
Outline



- What people do and electricity demand

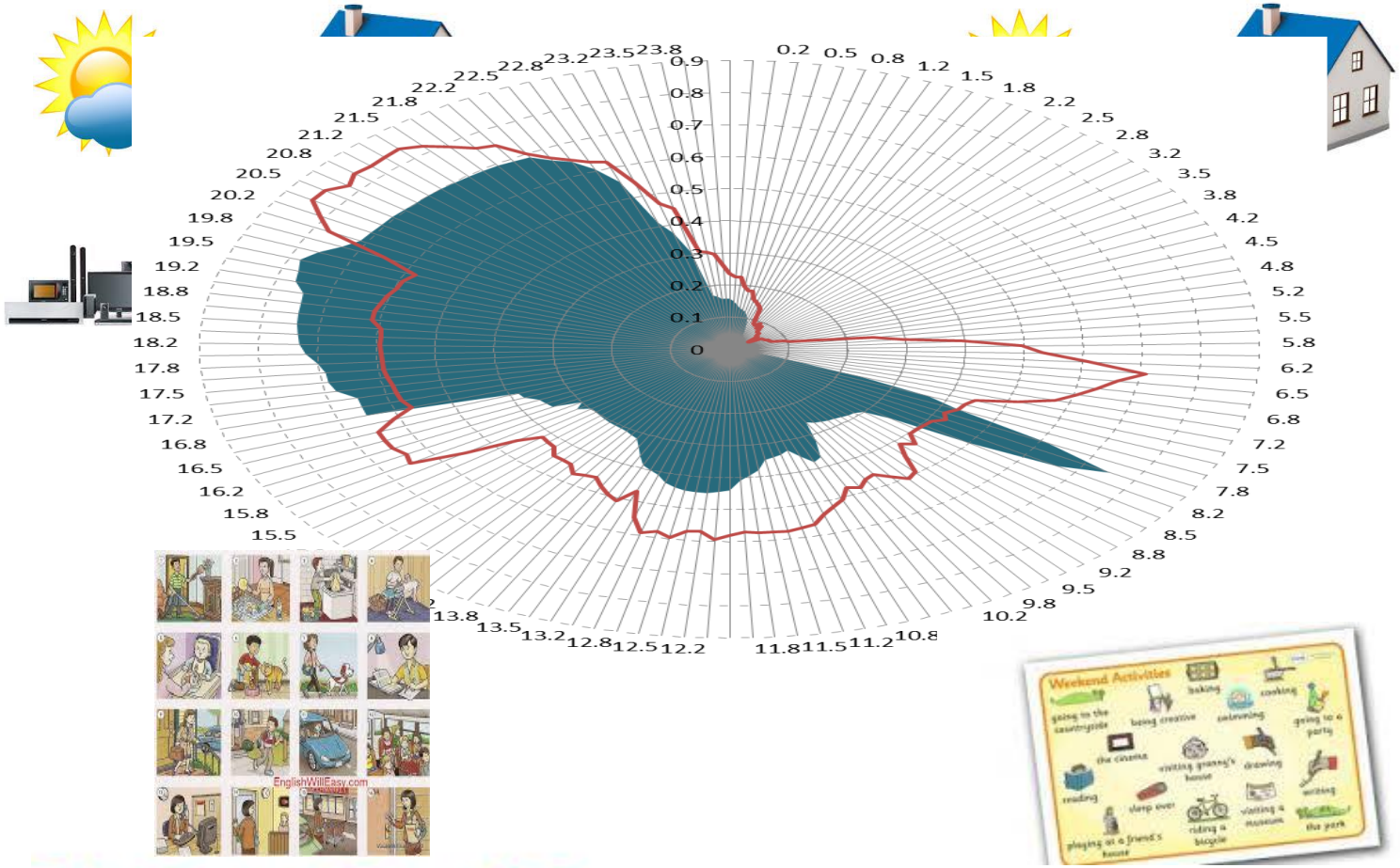


- Intrinsic Flexibility Index
  - Analysis of time use data
  - Time of the day prices in wholesale market



A simple example

- Weekday
- Weekend



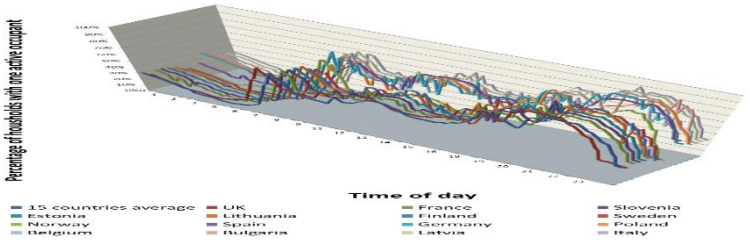
Getting flexibility from price elasticity?

In the energy economics literature, traditionally electricity demand has been seen as relatively inelastic to price changes in the short term

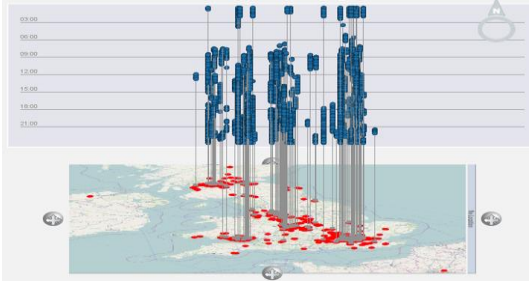
WHY?

Recent work: peak demand, people's activities and price

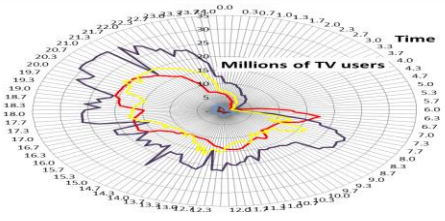
- Active occupancy in 15 European countries



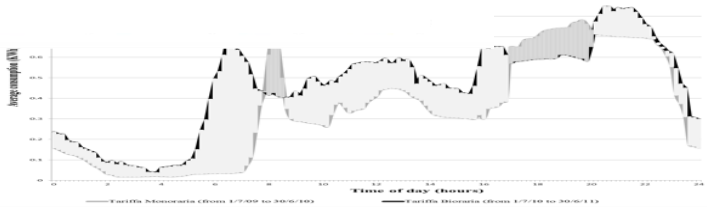
- Computer use in UK



- Modelling TV consumption in Spain



- Effects of Time of Use on Italian end-users



Intrinsic Flexibility Index

(i) how synchronised activities are within the family and with the rest of the country

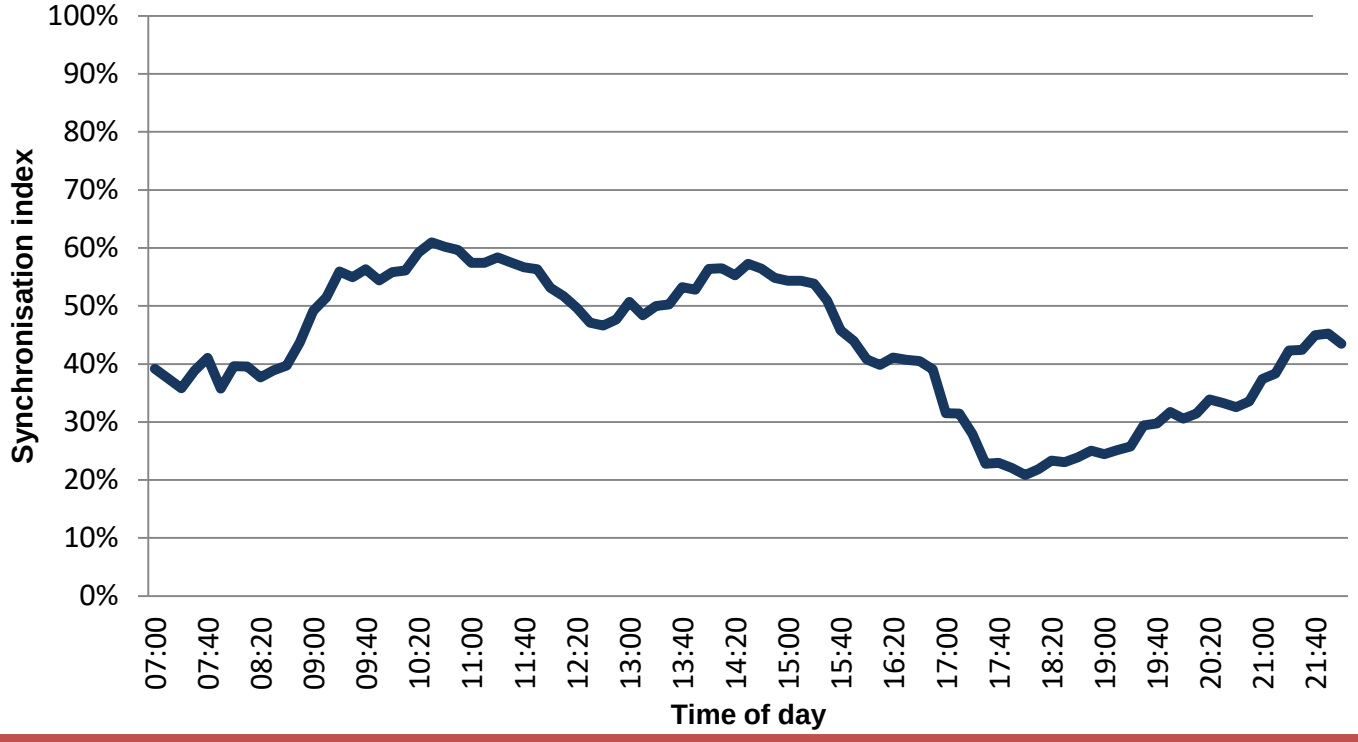
(ii) how many activities requiring electricity are shared with others

(iii) how fragmented days are in terms of number and duration of electricity-related activities.

Overview of Intrinsic Flexibility Index and its components

Index name	Brief explanation of what the index measures	Calculation method (for each demographic, over a given time period)
(1) Societal Synchronisation index	Synchronicity with other people.	Equal to 1 minus the Shannon's H entropy index[24]. SI Is a function of time t per activity i and the number of individuals who are in i at t.
(2) Variation index	Variation of activities, consistency or dispersion of activities over time.	Average number of unique activities for each respondent, divided by the total possible number of activities (i.e. 38 time use codes).
(3))Internal Synchronisation Index	The extent to which respondents were carrying out activities on their own, compared to performing them in the company of others.	Average proportion of respondents who were on their own.

Synchronisation index

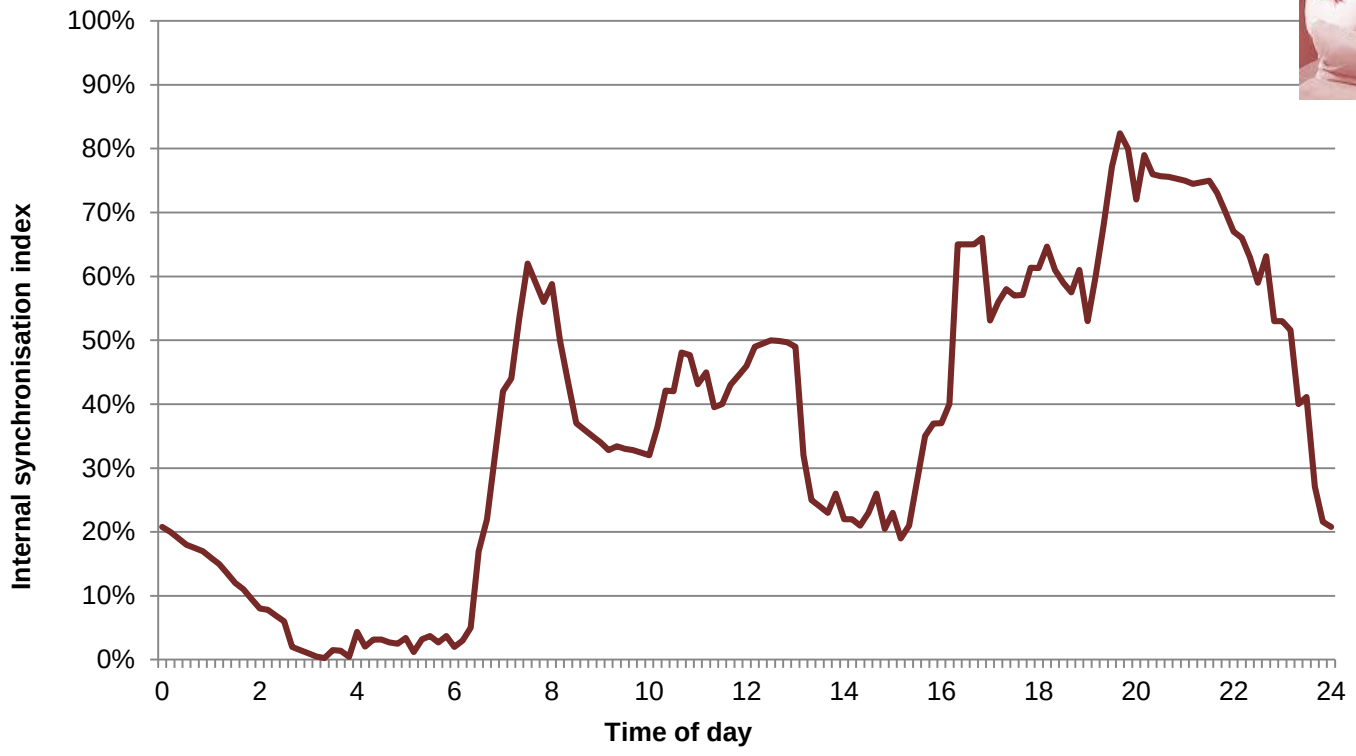


Synchronisation is higher in the morning than in the evening.

During the day synchronisation is relatively high because people work similar hours in the middle of the day.

As work phases out, TV watching ensues, driving synchronization upwards. However, in the evening peak the lowest level of synchronization is reached, meaning that the concept of hotspot is associated with several and diverse activities.

Internal synchronisation

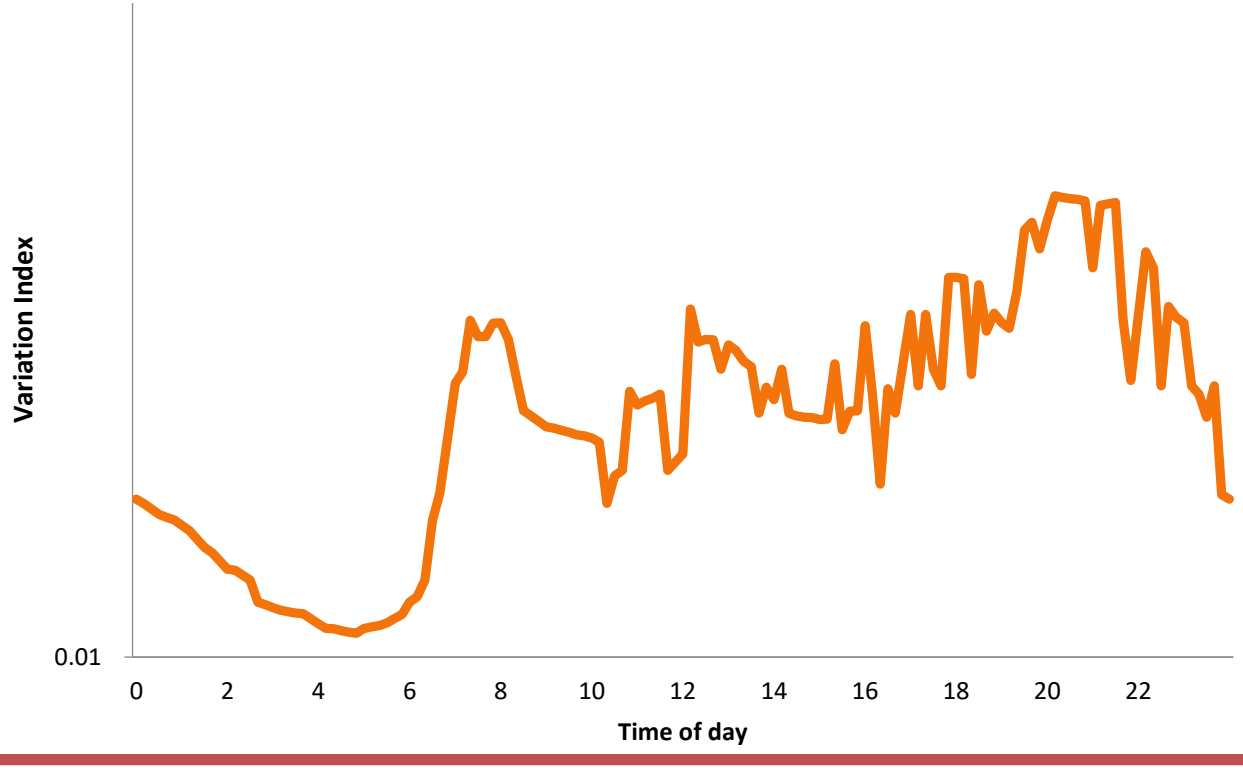


During weekdays, early morning, evening and night time are often spent with partner/spouse and children.

The rest of the day is predominantly spent with work colleagues and/or by oneself.

The shared activities index demonstrates how a substantially great percentage of respondents were on their own throughout the day.

Variation index

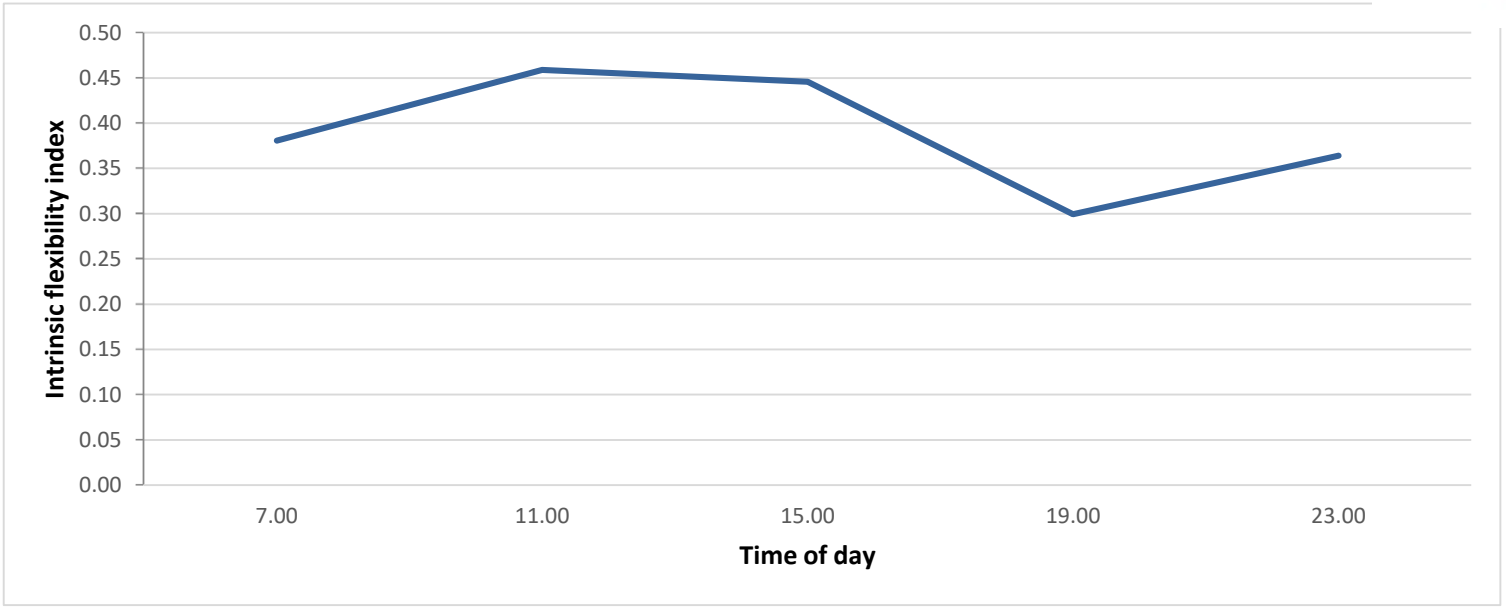


The average number of different activities performed is highest during peaks, and lowest in the middle of the day.

During the central part of the day as activities tend to be prolonged (e.g. working).

Variation index increases again in the evening due to dinner preparation and leisure.

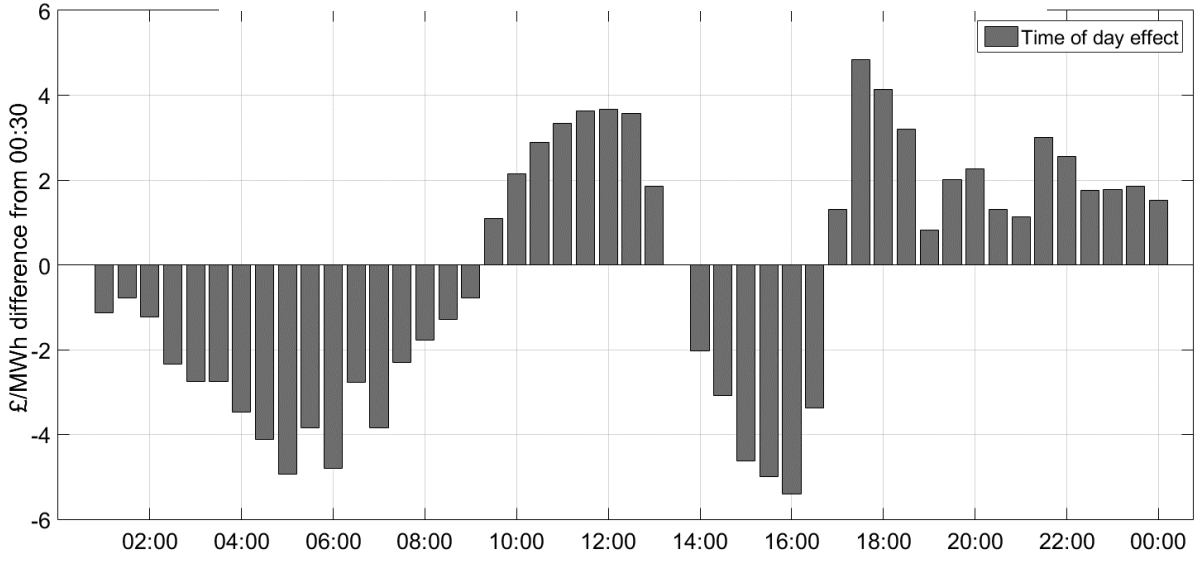
Intrinsic Flexibility Index



Morning: High synchronisation. Occupancy is very high before 8 AM and several activities are shared with others implying a very low level of potential flexibility at this time of day.

Evening: the lowest level of intrinsic flexibility is reached at 7 PM. This time of the day combines high variation of activities and a high internal synchronisation level (possibly due to the fact that people share eating-related practices), despite the fact that overall synchronisation is not very high.

Impact of time of day on APX price



APX prices are likely to reflect to a certain extent demand behaviour.

There is a premium cost of electricity present at peak and morning between 07:00 to 13:00. Conversely the early hours of the morning and early afternoon are periods whereby the impact of time of the day is lower.

ANOVA results for time use data and APX data (indexed)

			Time use data	APX data (indexed)
ANOVA models	Factors		Time of the day	Time of the day
		R^2	0.23*	0.20*
	Additional factors		Day of the week	Day of the week
		R^2	0.21*	0.19*

For time use data time of the day and day of the week have higher ANOVA values than APX data.

Time of the day has higher R^2 values than day of the week.

Conclusions

- Intrinsic flexibility index
  - quantifies the impact of the time of the day and people's activities on the timing of residential electricity demand
  - has significant explanatory power in the analysis of short-term price elasticity for residential electricity demand
- Findings show that spot prices and intrinsic flexibility vary harmoniously throughout the day
- People's activities affect time of the day effects on price

Application of this research to work on price elasticity

- Intrinsic flexibility index may add explanatory power to well-established elasticity estimates and improve the accuracy of tariff setting (for dynamic pricing)
- Study on effect of Time-of-Use tariffs (without flexibility):

usage by household | Fixed-effect | Day of week | TOU band

$$\ln E_{it} = \alpha_i + \mathbf{W}_{it}\boldsymbol{\gamma} + Peak_t \cdot \beta_1 + Day1_t \cdot \beta_2 + Day2_t \cdot \beta_3 +$$

$$+ (Peak_t \times Treat_{it} \times POST_t) \cdot \delta_1 + (Day1_t \times Treat_{it} \times POST_t) \cdot \delta_2 + (Day2_t \times Treat_{it} \times POST_t) \cdot \delta_3 +$$
$$+ (Night_t \times Treat_{it} \times POST_t) \cdot \delta_4 + \varepsilon_{it}$$

Hh receiving TOU | Trial in progress

- Study on effect of Time-of-Use tariffs (with flexibility):

$$\ln E_{it} = \alpha_i + \mathbf{W}_{it}\boldsymbol{\gamma} + Peak_t \cdot \beta_1 + Day1_t \cdot \beta_2 + Day2_t \cdot \beta_3 +$$
$$+ (Peak_t \times Treat_{it} \times POST_t \times Flex_t) \cdot \delta_1 + (Day1_t \times Treat_{it} \times POST_t \times Flex_t) \cdot \delta_2 + (Day2_t \times Treat_{it} \times POST_t \times Flex_t) \cdot \delta_3 +$$
$$+ (Night_t \times Treat_{it} \times POST_t \times Flex_t) \cdot \delta_4 + \varepsilon_{it}$$

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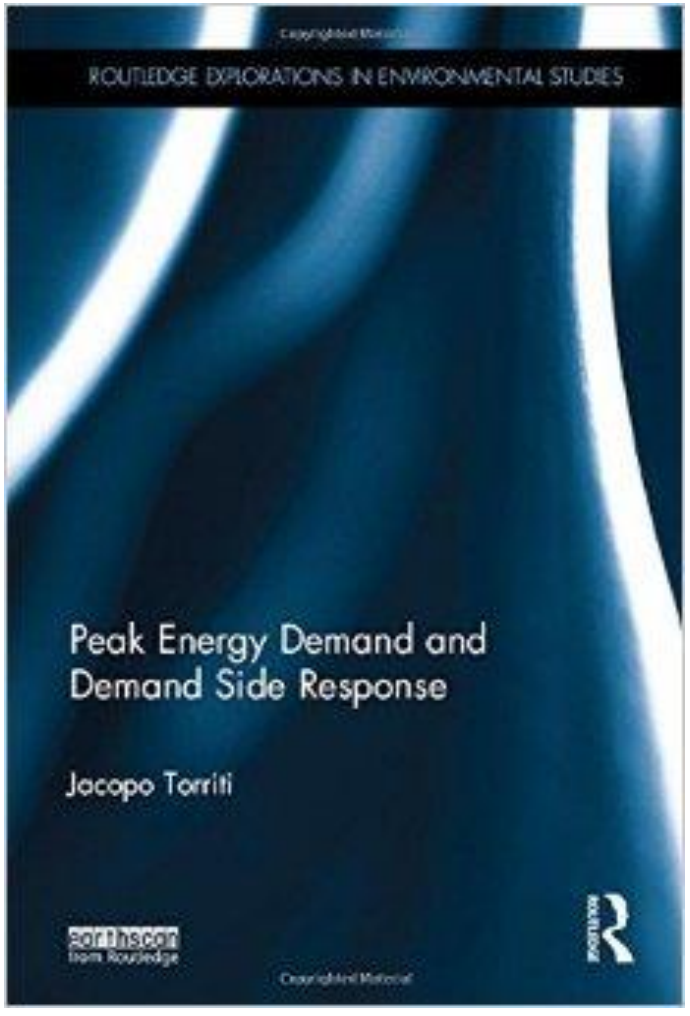

Peak Energy Demand and Demand Side Response (Routledge), pp. 172

https://www.routledge.com/products/9781138016255

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