Low Carbon London project: Data from the dynamic time-of-use electricity pricing trial, 2013

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Abstract

This document describes the public data release from the UK's first residential sector, dynamic time-of-use electricity pricing trial, which took place as part of the Low Carbon London project. The trial involved 5,567 households in the London area, of which 1,122 received an experimental dynamic time-of-use tariff, which was in effect for the duration of 2013. The data collection consists of smart-meter energy consumption measurements and consumer survey responses. The first two sections explain the context of the trial and summarise the salient features of the trial design. The next section introduces the trial's data sources and describes the data tables that comprise the data collection. The steps taken to ensure the validity and anonymity of the data are also listed.

Details

Data citation:	J. Schofield, R. Carmichael, S. Tindemans, M. Bilton, M. Woolf and G. Strbac, "Low Carbon London project: Data from the dynamic time-of-use electricity pricing trial, 2013", UK Data Service, SN: 7857, 2015. Available: `https://discover.ukdataservice.ac.uk/doi?sn=7857-1`
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Project citations (for this trial):	For consumer attitudes and engagement see: R. Carmichael, J. Schofield, M. Woolf, M. Bilton, R. Ozaki, G. Strbac, "Residential consumer attitudes to time-varying pricing", Report A2 for the "Low Carbon London" LCNF project: Imperial College London, 2014. For experimental design and quantitative analysis see: J. Schofield, R. Carmichael, S. Tindemans, M. Woolf, M. Bilton, G. Strbac, "Residential consumer responsiveness to time-varying pricing", Report A3 for the "Low Carbon London" LCNF project: Imperial College London, 2014.

1 Introduction

Dynamic time-of-use (dToU) tariffs may be used to incentivise increase or decrease in electricity consumption over time. This change in consumption is known as demand response (DR). DR may be able to provide benefits [1] to the electricity system, including the more efficient integration of renewable energy generators (system balancing) and more efficient management of networks. In turn, such benefits may help to reduce electricity bills and increase the quality of service for the consumer.

The Low Carbon London (LCL) project was a £28m research programme that ran from the beginning of 2011 to the end of 2014 and was funded by energy consumers via Ofgem's Low Carbon Network Fund. The programme was designed to investigate the impact of a wide range of low carbon technologies on London's electricity distribution network. It was in this context that the UK's first residential sector, dynamic electricity-pricing trial took place. This trial involved 5,567 households in the London area, of which 1,122 received an experimental dToU tariff that was in effect for the duration of 2013. The trial was carried out by a partnership of organisations:

- UK Power Networks: the London DNO and the lead programme partner;
- Imperial College London: trial design and results analysis;
- EDF Energy: retail energy supplier and implementer of the dToU tariff;
- Siemens: database and communications implementation;
- Logica (now CGI): smart meter head-end.

The learning objectives of the dToU trial were twofold: to understand the potential value of dynamic pricing to the electricity system, and to understand its social impact on residential consumers. The first objective was achieved by designing the experimental dToU tariff to inform on the feasibility of using DR to assist in two key use cases: system balancing and network constraint management. The second objective was achieved though use of surveys to obtain data on the physical characteristics of consumer's homes and the appliances within, and their experiences and attitudes towards the experimental dToU tariff at the end of the trial year.

2 Trial design

This section provides a brief summary of the trial design. Further details may be obtained from the LCL project reports [2, 3], or [4] for more technical detail and deeper analysis.

2.1 Groups and sampling

Initially, 5,567 households that were EDF Energy customers were opt-in recruited onto the trial. From these households, 1,122 were then opt-in recruited into the experimental group—group D—which received the dToU tariff. The remaining 4,545 households—group N—remained on their existing non-dynamic tariffs. Due to the necessity of opt-in recruitment, group N was not a true control in that it was not sampled from the same population as group D. However, CACI Acorn [5] socio-economic classification data was used to ensure, via targeted and iterative recruitment drives, that groups D and N were approximately representative of London (by this measure).

All households had smart-meters installed and consumption measurements were taken at half-hour intervals for the duration of 2013. As the process of activating smart-meteres was necessarily completed before trial commencement, measurements outside of the trial year are available for many households—approximately 6 months before and 2 months after.

2.2 dToU tariff

The dToU tariff comprised three rates: "default" at £0.1176/kWh, "high" at £0.6720/kWh and "low" at £0.0390/kWh. Trial days were used as the base *experimental unit* in the time dimension and were defined as beginning at 5am (wall clock time), chosen to approximately corresponded with the minimum demand point of the day according to Elexon's Profile Class 1 [6]. Customers were informed of upcoming price changes one day ahead of delivery via notifications that appeared on their smart-meter linked in-home-display and also, if requested, via SMS messages to their mobile phones. Price events were designed to inform the use cases of system balancing (SB) and distribution network constraint management (CM).

It was assumed that SB events could occur at any time of day and year and that they could last from a few hours to a day in duration. As such, both high and low rate SB events consisted of the durations 3, 6, 12 and 24 (low price only) hours and were assigned start times so as to completely subtend the day. Each unique price-rate, duration and start-time combination was implemented on three separate trial days during the trial year to give a total of 93 SB events. These events were scattered randomly throughout the 365 days of the trial year.

For CM events it was assumed that network constraints were most likely to occur during the periods of highest annual demand and on sections of network where capacity is reduced due to a fault. In order to incentivise the greatest possible reduction/shift in demand during the peak period, events were designed with a high rate covering the peak period and a low rate on both sides so as to give a low–high–low sequence over the trial day. The times of highest demand were informed by Elexon's Profile Class 1 [6] with the result that CM events targeted the regular weekday morning (7am–10am) and evening (5pm–11pm) peaks, and weekend afternoon (10am–2pm) peaks, during predominantly winter months. The persistence of CM events (number of consecutive days over which they must act) was informed by an analysis of 4,233 network fault-resolution durations (supplied by UK Power Networks), which showed that approximately 80% of all faults were resolved in greater than 10 days. However, as the social and business constraints of the trial permitted a maximum of three consecutive CM event days, events of each type—designated by peak-time and whether they act on a weekday or weekend—were designed to act over either 1, 2 or 3 consecutive days.

3 Data

3.1 Sources

This data release includes data from the following sources:

- Smart-meters: Electricity consumption (kWh) measured over 30 minute intervals for each household in the trial. A largely complete set of measurement exists for all households during the trial year of 2013, with an additional 6 months before and 2 months after the trial for a significant fraction of households. It should be noted that the dToU tariff was only in effect during 2013.
- Appliance survey: Issued at the beginning of the trial, this consisted of appliance ownership numbers, physical parameters of the premises (e.g. insulation, number of rooms etc.) and basic details of its occupants (e.g. number of occupants, age categories etc.). 1,870 submissions were received from group N and 990 from group D.
- Attitudes survey: Only issued to households in group D, it was designed to assess attitudes and behaviour change related to dynamic electricity pricing. Additional focus was given to the factors that enabled and hindered responsiveness. 714 submissions were received in total.

This data collection does not constitute all of the data that was collected during the dToU trial. Necessary omissions have been made in order to preserve the privacy of those on the trial and where the validity of the data was in question.

3.2 Access and permissions

This data collection is hosted by the UK Data Service [7]. Access is provided via their Safeguarded Access regime, which is appropriate for data that does not contain personally identifying information, though may pose a residual disclosure risk. The data collection is made available for download to any registered or authorized user.

Users are not permitted to share this data collection with third parties. All users must register and download the data via the UK Data Service in accordance with their terms.

3.3 Structure

All data tables are provided in CSV format in the below described files, which are located in folder `./data_tables/`. In addition, PDF format samples of the relevant survey forms are provided in folder `./survey_forms/`, and copies of key project references are provided for convenience in folder `./references/`.

Columns in the CSV data file schema tables provide the following details:

- Column: The column header in the CSV file
- Type: The type of data contained in the column (useful for parsing)
- Unique: Whether the data in that column can be used as a unique identifier (key)
- Description: A brief description of the data contained in the column

consumption_d.csv Energy consumed in each half-hour measurement period for all households in group D.

Column	Type	Unique	Description
GMT	time-stamp	yes	Time-stamp at the end of each half-hour measurement period in the GMT time-zone.
{D0,D1,D2,···}	float	no	Consumption measurement in units of kWh. Column headings map to the Household_id key.

consumption_n.csv Energy consumed in each half-hour measurement period for all households in group N.

Column	Type	Unique	Description
GMT	time-stamp	yes	Time-stamp at the end of each half-hour measurement period in the GMT time-zone.
{N0,N1,N2,···}	float	no	Consumption measurement in units of kWh. Column headings map to the Household_id key.

tariff_d.csv The dToU tariff received by group D households. Tariff rate is presented for each half-hour measurement period during the trial year of 2013.

Column	Type	Unique	Description
GMT	time-stamp	yes	Time-stamp at the end of each half-hour measurement period in the GMT time-zone.
Price	float	no	Tariff rate for each half-hour measurement period in units of £/kWh.
Event_tags	string	no	Tags that identify the type of price event (for convenience). "Hnn" for high and "Lnn" for low price supply balancing events, where nn is the duration of the event in hours. "CM" for constraint management events.

survey_questions.csv Survey questions.

Column	Type	Unique	Description
Question_id	string	yes	Unique identifier for each survey question.
Survey	string	no	The name of the survey in which the question appeared.
Question	string	no	The text of the question asked. This may be truncated as it is a direct extract from the project database. Users should refer to the relevant survey form for context.

survey_answers.csv Survey answers.

Column	Type	Unique	Description
Household_id	string	yes	Unique identifier for each household in the trial.
{Q0,Q1,Q2,···}	string	no	Answers to the survey questions for each household. Column headings map to the Question_id key.

3.4 Validity and omissions

Consumption data. Consumption measurements were believed to be accurate with no more than 3.4% of measurements missing in any half-hour measurement period and an average missing measurements per period of just 0.17%, during the trial year of 2013. After data validation and cleansing, the number of households in this data release stood at 1,025 in group D and 4,173 in group N. Households were removed from the data collection if they had inside knowledge of the trial (e.g. working in one of the partner companies), were found to have been on a non-standard tariff before the trial commenced (e.g. Economy 7), had a fault with their smart meter that necessitated its replacement, or specifically asked to be withdrawn from the trial.

Survey data. The curators of this data release (Imperial College London) designed the questionnaire items but did not perform or oversee the data collection, which was managed by EDF Energy and UK Power Networks. Some additional questionnaire items relating to customer satisfaction, designed by EDF Energy, have been omitted from this data release.

Some households had multiple entries (rows) in the survey results table. This was believed to arise when a transcriber created a new row for a household with already existing survey results—perhaps for the responses to another survey. That multiple response rows did not contain overlapping survey responses supports this view. Households with multiple response rows were therefore combined into single rows without loss of information.

Data validity was believed to be unaffected by this. With this one exception, survey results are herein presented in the condition in which they were received from the data collectors (EDF Energy and UK Power Networks).

While there is a question in the appliance survey regarding the ownership status of the premises (question 3 in the attached appliance survey form), answers to this have been omitted due to concerns over the validity of the response data. After obtaining unusual ownership correlation results, spot checking of ownership responses was performed for several households where the status was known from information gathered in consumer interviews [3]. This check revealed errors. To investigate whether the errors were localised to only this survey question or were a more general issue with all survey responses, spot checking of other (but not all) survey responses was performed. No additional errors were found. Furthermore, correlation results [4, Ch. 9] were not observed to be counter-intuitive.

3.5 Anonymity

The identity of those on the trial has been protected through the following measures:

- All obvious identifying information (e.g. names, addresses, locations, etc.) has been omitted.
- Household_id keys were randomly generated so as not link to any external data sources, including internal LCL programme references.
- All free-text questions included in the survey answers have been checked for the inadvertent inclusion of personally identifying information.

References

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[2] J. Schofield, R. Carmichael, S. Tindemans, M. Woolf, M. Bilton, and G. Strbac, "Residential consumer responsiveness to time-varying pricing," Report A3 for the "Low Carbon London" LCNF project: Imperial College London, Tech. Rep., 2014.

[3] R. Carmichael, J. Schofield, M. Woolf, M. Bilton, R. Ozaki, and G. Strbac, "Residential consumer attitudes to time-varying pricing," Report A2 for the "Low Carbon London" LCNF project: Imperial College London, Tech. Rep., 2014.

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[6] Elexon, "Load Profiles and their use in Electricity Settlement," 2013. [Online]. Available: http://www.elexon.co.uk/wp-content/uploads/2013/11/load_profiles_v2.0_cgi.pdf

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