Providing electricity in the future

Tamsin E. Lee
Mathematical Institute, University of Oxford
tamsin.lee@maths.ox.ac.uk

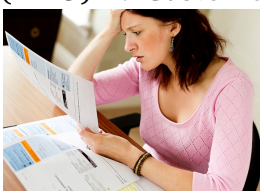
IX Modelling Week
Universidad Complutense de Madrid
15th to 19th June 2015

Introduction

Electricity demand is rapidly evolving, but the infrastructure delivering our electricity is not. The infrastructure is maintained by Distribution Network Operators (DNOs), who ensure that electricity is delivered reliably and safely.

Supplier → Distribution network operator (DNO) → Customer





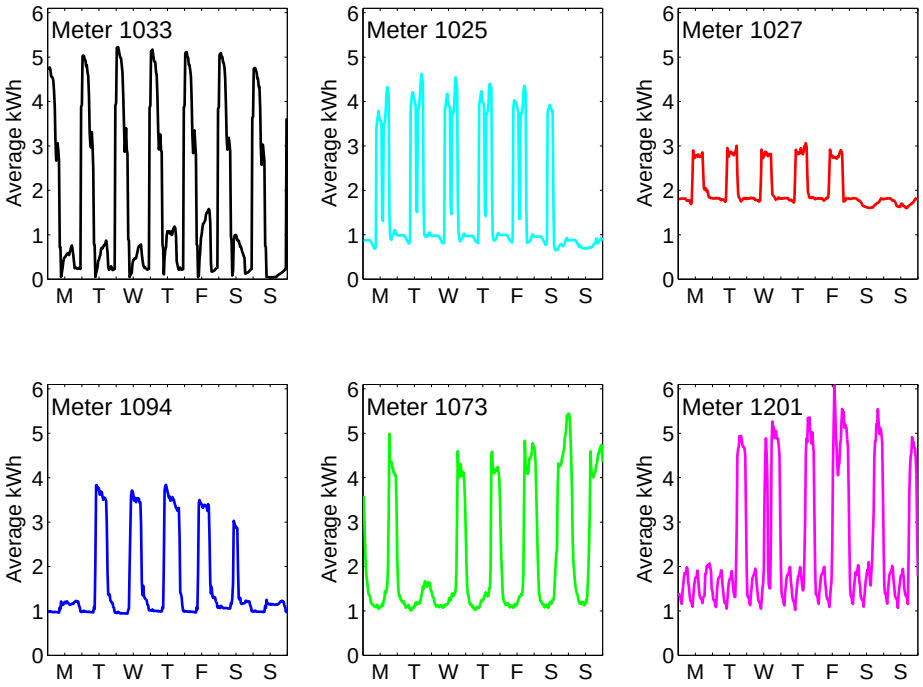
Traditionally their focus has been on large consumers, such as warehouses. However, it is electricity use on the low voltage (LV) network (domestic and small-to-medium enterprises (SMEs), such as the corner shop) that is changing the most as more and more of our devices require electricity in some way. As we move into a low carbon future there will be further uptake of electric vehicles, fast charging electric vehicles, solar panels and heat pumps. These all contribute to stresses upon an infrastructure which is decades behind the technology it supplies.

In particular, SMEs have

- fairly high use - considerably higher than domestic customers.
- very regular behaviour.
- little research into their electricity use.

Data gathering

The advent of smart meters will provide much needed insight into electricity consumption on the LV network. For example, here are electricity profiles from smart meters in SMEs over an average week:



From these profiles a DNO could predict the electricity profile for these SMEs, including the time and size of peaks. This would enable planning and management decisions, such as when to encourage charging of electric vehicles.

The problem

However smart meter data is frequently unavailable/expensive for DNOs. As such, what can we infer from the limited smart meter data?

The task

Using data from smart meters for 196 SMEs, you'll need to predict the electricity profile for SMEs without a smart meter.

For the majority of the 196 SMEs you'll have information from survey responses, such as "How many employees" and "Age of building". It is safe to assume that you can gain this information for SMEs without a smart meter. You would also have access to quarterly readings (electricity consumed ev-

ery three months) for SMEs without smart meters.

A rough prediction capturing the general behaviour is good, however peak behaviour is what causes the most stresses to the network. As such, DNOs are particularly interested in predicting the time and size of peak electricity use.

Modelling plan

Usually industry partners provide data with lots of faulty entries, such as missing data. In these cases decisions need to be made - for example, interpolate to fill the missing data or remove the customer? All decisions, with reasons, would be reported to the industry partner. However, to make efficient use of our week, the data set provided will be cleaned.

Working with big data sets means that you must be competent at programming. You will need to be able to efficiently identify key features of different SMEs.

Possible strategy

- Identify the open and closed hours for each SME from their electricity profile.
- Find the quarterly meter reading (essentially the daily average use) for each SME.
- Find relationships between average use during open/closed half hours and information available without a smart meter, i.e. survey responses and/or quarterly meter readings. Do buildings of the same age and size have similar electricity profiles?
- Using the discovered relationships, create an approximate profile for an SME. The simplest would take on one value for open half hours and another for closed half hours.
- Focus on peak behaviour - can you provide the time and size of peaks? Perhaps a probability distribution for each half hour?
- What is a suitable way to compare the predicted profile with the actual profile?

Possible techniques

- Clustering. K-means or finite mixture modelling.
- Probability distributions.