



Customer-Led Network  
Revolution

## Test Cell Report:

## Baseline SME Profiles

## SME Customer sub-group analysis

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## 1. Introduction

The Customer-Led Network Revolution (CLNR) aims to understand current, emerging and possible future customer energy characteristics, to allow for a more optimal planning of the energy system in the context of increasing electrical demand and deployment of low-carbon forms of energy generation.

For this purpose, large numbers of customers were recruited<sup>1</sup> and divided into different samples or test cells (TCs), each with a particular combination of metering type, energy tariff and/or low carbon technologies. These tariffs or technologies, referred to as “interventions”, are designed to modify customers’ energy use characteristics, either directly or through changes in behaviour.

This document details the final analysis of Test Cell 1b, which is the SME baseline dataset and adds to previous work in December 2012 and April 2013, which explored some of the early findings of the CLNR trials. The dataset for this test cell was separately published in August 2014<sup>2</sup>.

Test Cell 1b collected electricity usage statistics from over 1500 SME customers across business sectors and creates an overall picture of current SME electrical consumption in the UK. No interventions were applied to TC1b, allowing this to be used as the control group or baseline against which the impacts of interventions (such as low carbon technology or Time of Use tariffs) applied to other SME test cells, can be compared.

This report describes the dataset used in TC1b, provides baseline energy consumption characteristics for different business sectors and looks at the system peak demand on the days of greatest network stress.

The load profiles presented will be of interest to distribution network engineers and designers, as well as DNO operations as a whole, academic bodies and the wider electricity industry. Specifically, the information presented here will be used to direct further work on developing profiles before and after interventions, with a view to updating network design tools.

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<sup>1</sup> CLNR-L036: Project lessons learned from trial recruitment

<sup>2</sup> CLNR-L073: Test Cell 1b Dataset: Basic profiling of SME customers

## 2. Sample

Test Cell 1b is the basic profiling of regular small and medium enterprises (SME) through the monitoring of customers' overall consumption using British Gas' existing Smart Metering population.

The data provides a baseline of demand profiles across a range of business customers which have been previously defined<sup>3</sup> and are shown in table 1 below.

Test Cell sub-group	Sector
SME 1.1	Agriculture, Hunting and Forestry; Fishing - Single-Site, Single-Rate Tariff (1-9 employees)
SME 1.2	Industrial - Single-Site, Single-Rate Tariff (1-9 employees)
SME 1.3	Commercial/Office - Single-Site, Single-Rate Tariff (1-9 employees)
SME 1.4	Public Sector and Other - Single-Site, Single-Rate Tariff (1-9 employees)
SME 1.5	Agriculture, Hunting and Forestry; Fishing - Single-Site, Single-Rate Tariff (10-49 employees)
SME 1.6	Industrial - Single-Site, Single-Rate Tariff (10-49 employees)
SME 1.7	Commercial/Office - Single-Site, Single-Rate Tariff (10-49 employees)
SME 1.8	Public Sector and Other - Single-Site, Single-Rate Tariff (10-49 employees)
SME 1.9	Agriculture, Hunting and Forestry; Fishing - Single-Site, Single-Rate Tariff (50-249 employees)
SME 1.10	Industrial - Single-Site, Single-Rate Tariff (50-249 employees)
SME 1.11	Commercial/Office - Single-Site, Single-Rate Tariff (50-249 employees)
SME 1.12	Public Sector and Other - Single-Site, Single-Rate Tariff (50-249 employees)
SME 1.13	Agriculture, Hunting and Forestry; Fishing - Single-Site, Multi-Rate Tariff (1-9 employees)
SME 1.14	Industrial - Single-Site, Multi-Rate Tariff (1-9 employees)
SME 1.15	Commercial/Office - Single-Site, Multi-Rate Tariff (1-9 employees)

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<sup>3</sup> CLNR-L107 Test cell protocol: Selection criteria for SME customers

Test Cell sub-group	Sector
SME 1.16	Public Sector and Other - Single-Site, Multi-Rate Tariff (1-9 employees)
SME 1.17	Agriculture, Hunting and Forestry; Fishing - Single-Site, Multi-Rate Tariff (10-49 employees)
SME 1.18	Industrial - Single-Site, Multi-Rate Tariff (10-49 employees)
SME 1.19	Commercial/Office - Single-Site, Multi-Rate Tariff (10-49 employees)
SME 1.20	Public Sector and Other - Single-Site, Multi-Rate Tariff (10-49 employees)
SME 1.21	Agriculture, Hunting and Forestry; Fishing - Single-Site, Multi-Rate Tariff (50-249 employees)
SME 1.22	Industrial - Single-Site, Multi-Rate Tariff (50-249 employees)
SME 1.23	Commercial/Office - Single-Site, Multi-Rate Tariff (50-249 employees)
SME 1.24	Public Sector and Other - Single-Site, Multi-Rate Tariff (50-249 employees)
SME 1.25	Commercial/Office - Multi-Site, Single-Rate Tariff
SME 1.26	Public Sector and Other - Multi-Site, Single-Rate Tariff
SME 1.27	Commercial/Office - Multi-Site, Multi-Rate Tariff
SME 1.28	Public Sector and Other - Multi-Site, Multi-Rate Tariff

**Table 1 – Test cell sub-group SME business sector / categories**

This report is based on a total of 1514 customers, with data taken on a half hourly basis between 1 September 2011 and 30 August 2012. As part of this study, the peak demand day and (potential) peak PV supply day were also identified.

The purpose of this test cell analysis is to allow network operators to understand in more detail energy usage across the day and how this varies with business profile. It will also acts as a control cell for the balance of the other CLNR SME trials, which have been analysed and written up separately<sup>4</sup>. In addition Durham University conducted social science interviews and a survey with SME customers.<sup>56</sup>

<sup>4</sup> CLNR-L099 Insight Report: Small and Medium Enterprises

<sup>5</sup> CLNR-L103 SME customers: Energy practices and flexibility

<sup>6</sup> CLNR-L232 Key social science findings: Domestic and SME customers

## 3. Methodology

### 3.1. Assumptions

The assumptions are that the members of each business group behave in a reasonably similar way in terms of their electrical demand. By computing the standard deviation for each customer group, it is possible to assess the validity of this assumption. It will also be assumed that the sample taken from a single year is reasonably consistent with any other year.

Peak demand was defined as the days containing the highest average half hourly measured demand. Specifically, the maximum half hour demand was identified for each day, and the days with the two greatest peaks were identified. The peak identification was performed on both raw demand data and normalised demand.

Normalisation of demand was based upon a customer's annual consumption. For every customer, the half hourly demand data was divided by the customer's total (annual) consumption. The total consumption was computed by summing the half hourly demand across the year divided by 2 to yield kWh. It was assumed that missing half hourly data would be negligible in this sum.

### 3.2. Trial Method and Parameters

The trial involved collecting data from 1514 SME customers to measure their half hourly electrical demand over the period between 1 September 2011 and 30 August 2012. These customers were assigned to one of 28 groups, as defined in CLNR-DEI-RE007 (details in Appendix).

For the time of year profiles, the full data set was used to compute a daily demand profile for each day of the year. From this set of daily average demand profiles, masks were defined to select the weekdays, weekend, months and seasons. These daily averages were then averaged together to compute the average demand profile for the various profiles required. Each profile was reported along with the number of days from the year selected to generate that profile. It should be noted that due to missing days from the data collection that the year contained 363 measured days.

For the business group profiles, a similar approach was taken. For each customer, the half hourly data across the full year was averaged into a single daily demand profile for that customer. Then, these average daily demand profiles were used to generate the summaries for the various groups, including the full population. Each business group profile was reported along with the number of customers that formed the group.

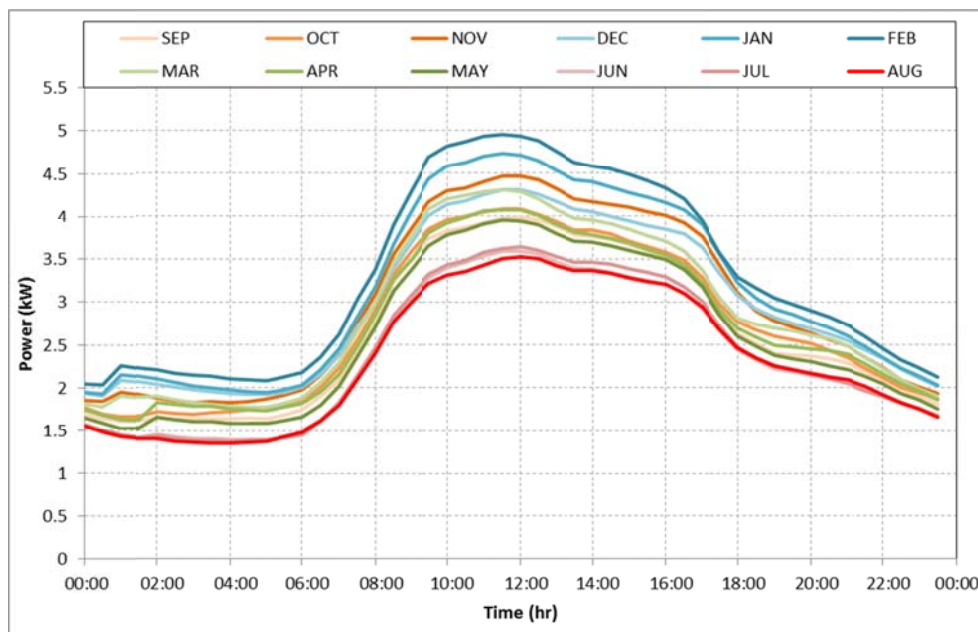
For the peak identification, the daily average demand profile across all customers was used. For each day in the year, the peak half hour demand was identified, followed by then identifying the day with greatest demand (labelled as Peak day 1). Conversely, the second peak (labelled Peak 2) was defined as the day where there is the greatest potential for reverse flow (high PV generation and low network demand). This was identified by focusing on summer days (defined by Elexon seasons) between the hours of 8am and 8pm where the minimum demand was observed. Then for each peak day, the full set of customer meter data for that peak day was extracted and used to generate the relevant statistics (mean, standard deviation, 5th and 95th percentiles). For each statistic, a half hourly profile statistic profile was generated.

Finally, the half hourly demand data for each customer was normalised according to annual consumption. Here, the annual consumption for each customer was computed (ignoring missing data, leading to a slight underestimate where half hourly demand data was missing). This was then used to normalise each customer's demand profile according to this annual total. The statistics were then generated using the same peak days as identified above.

## 4. Results and Analysis

### 4.1. Demand Profiles

Demand profiles were explored on monthly, seasonal and day of the week basis. The following figures represent monthly, seasonal and weekday/weekend demand for customers in TC1b. Figure 1 shows the monthly profiles for the mean demand throughout the analysis period.



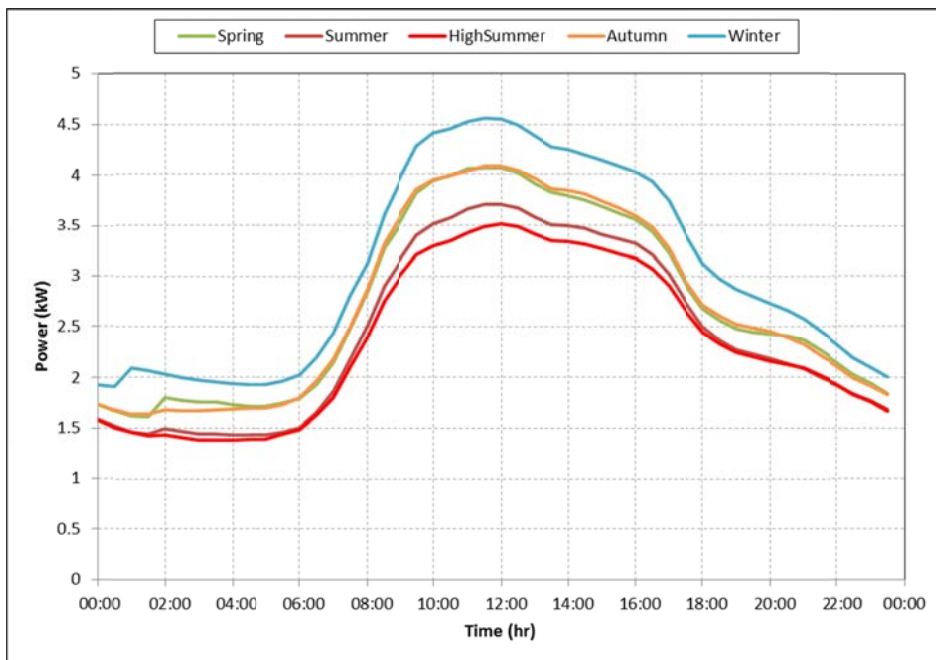
**Figure 1: Monthly Average Demand (1 September 2011 to 30 August 2012)**

It can be seen that the average demand profiles for each month were similar with a distinctive morning rise between 06:00 and 09:00, a peak demand between 09:00 and 17:00 and a more steady decline in load after 17:00. This result was expected as it is the general working hours for most businesses.

As expected, the average daily demand for all SMEs is highest in the winter months of January and February and lowest in the summer months of July and August.



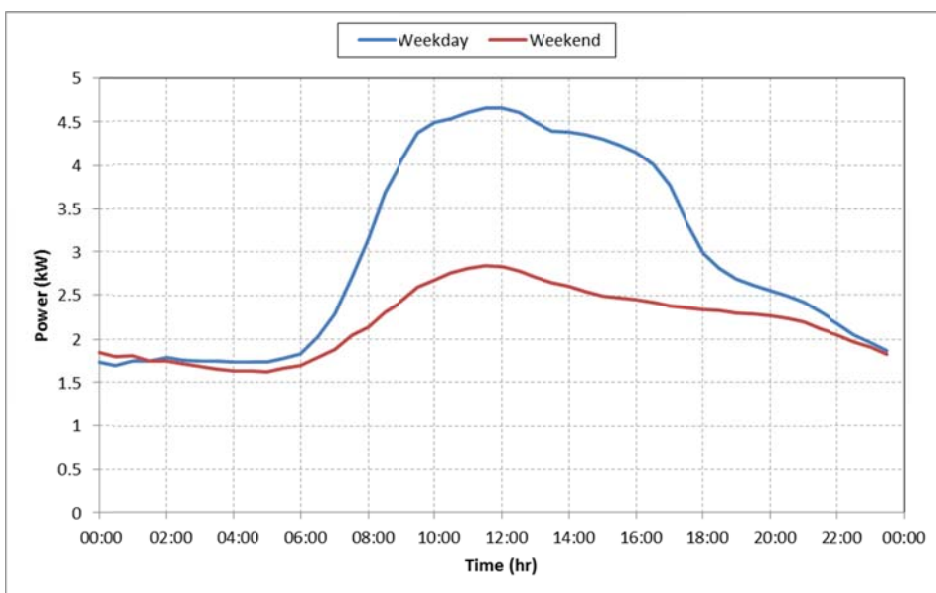
Figure 2 shows the seasonal profiles for mean demand throughout the analysis period.



**Figure 2: Seasonal Average Demand (1 September 2011 to 30 August 2012)**

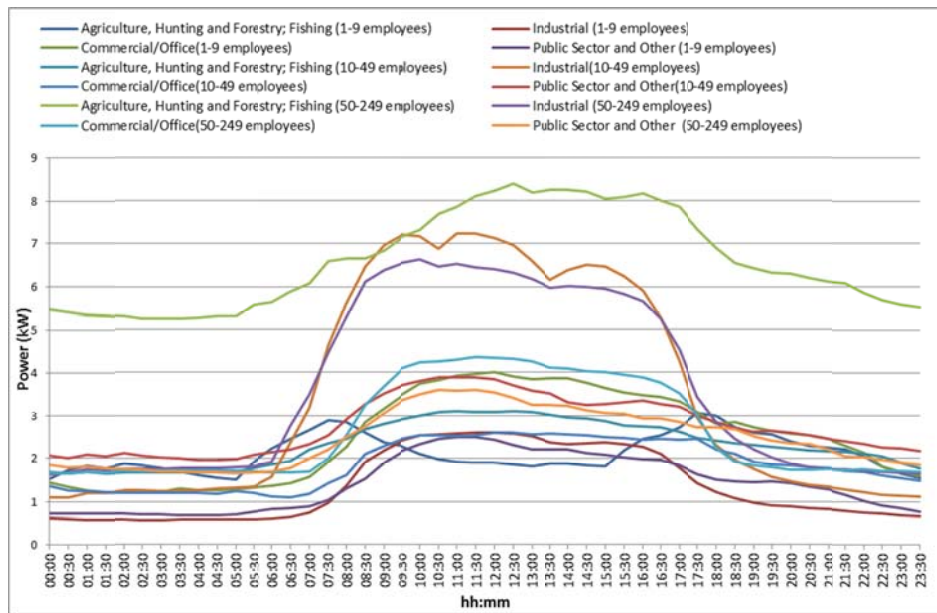
It can be seen that there is no discernable seasonal variation in load shape and as expected the highest demand occurred in the winter and lowest demand occurred in high-summer with demands similar for autumn and spring. The difference between the seasonal average demand for winter and high summer is more than 20%.

Figure 3 shows the weekday/weekend average demand throughout the analysis period.



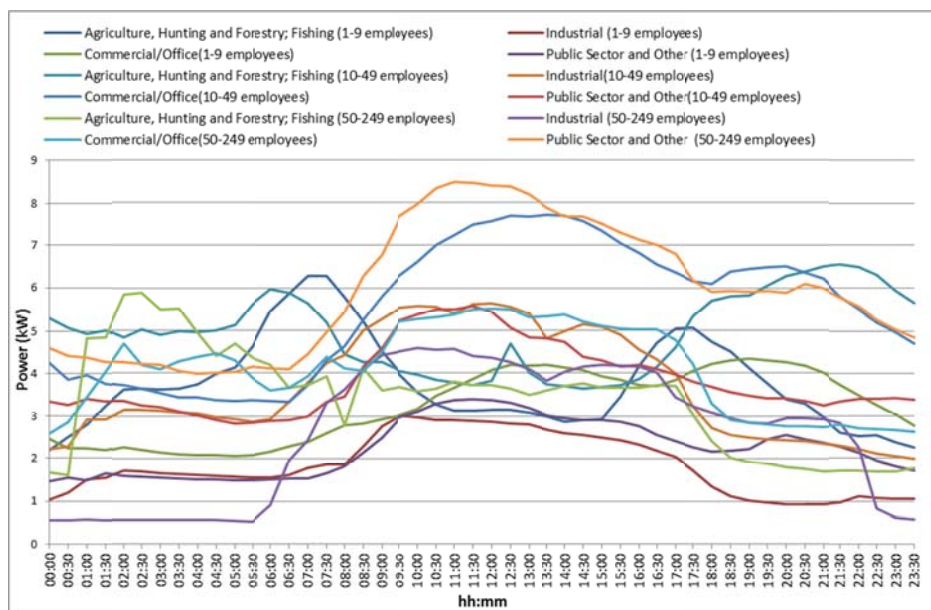
**Figure 3: Weekday/Weekend Average Demand (1 September 2011 to 30 August 2012)**

The curves show the impact of additional load from the increased use of computers and office equipment, lighting, production processes etc. during a workday compared to the weekend. Further analysis was carried out to understand the consumption patterns for different groups of customers (e.g. different sectors, their time of electricity use, etc.). Figure 4 shows the average demand profiles for the different groups of customers in TC1b on a single rate tariff. It can be seen that in general, the average demand of all the customer groups is highest between 09:00 and 17:00.



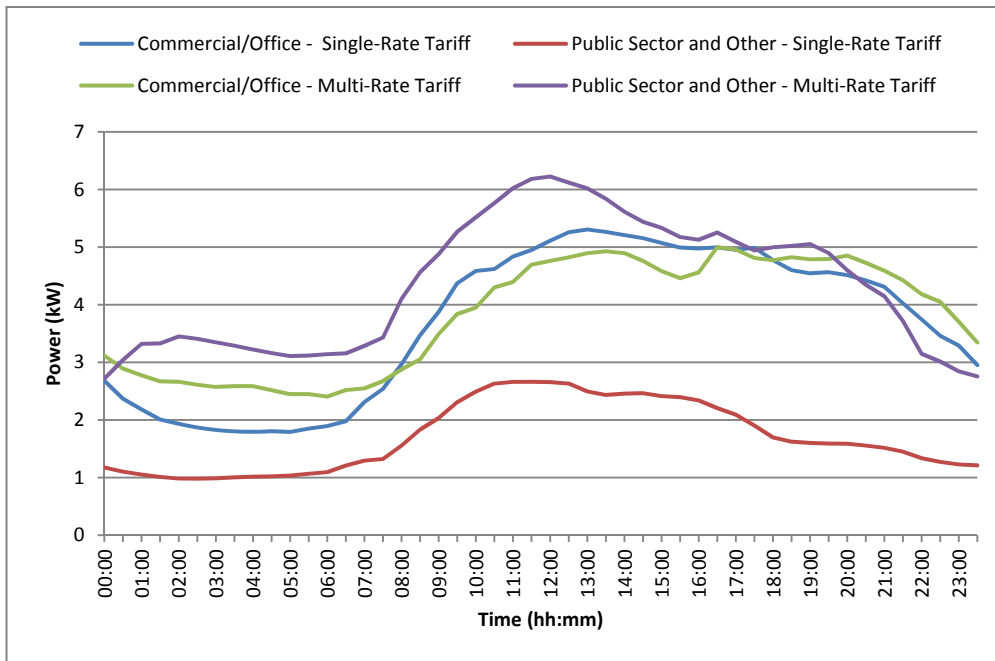
**Figure 4: Average Demand (1 September 2011 to 30 August 2012) for single site, single-rate SME customers**

Figure 5 shows the average demand profiles for the different groups of customers in TC1b on a multi rate tariff. In the case of SME customers on a multi rate tariff, there is a very large variation in the load profiles across the different SME groups.



**Figure 5: Average Demand (1 September 2011 to 30 August 2012) for single site, multi-rate SME customers**

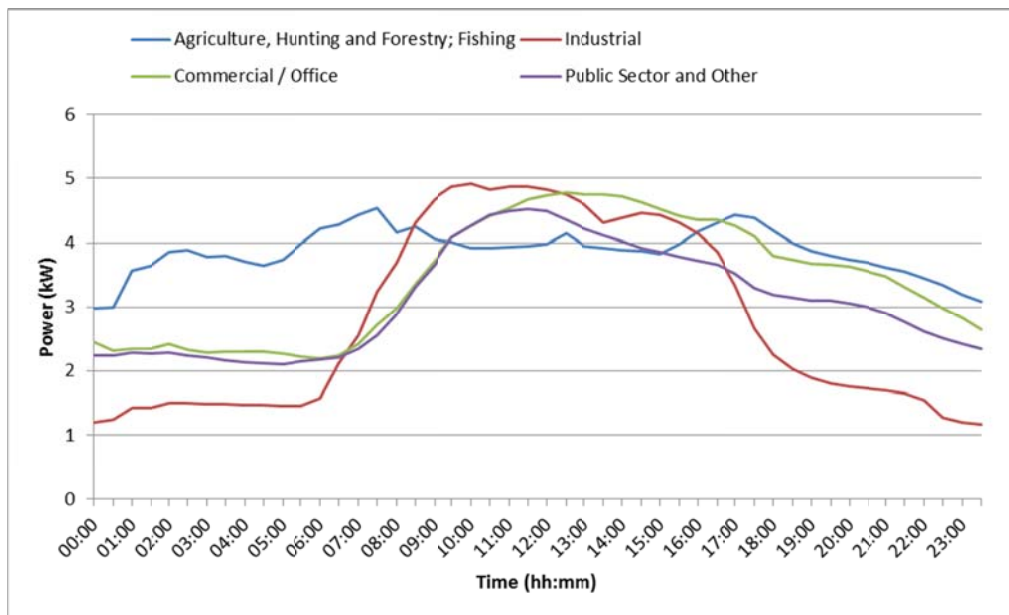
Figure 6 depicts the average demand profiles for multi-site SME customers on both single and multi-rate tariffs



**Figure 6: Average Demand (1 September 2011 to 30 August 2012) for multi-site SME customers**

It can be seen that in the case of the multi-site customers on the single rate tariff, the average demand for both customer types is highest between 09:00 and 17:00. In the case of multi-rate SME customers on a multi rate tariff, there is more of a variation in the load profiles but both customers have their highest demand between 09:00 and 22:00.

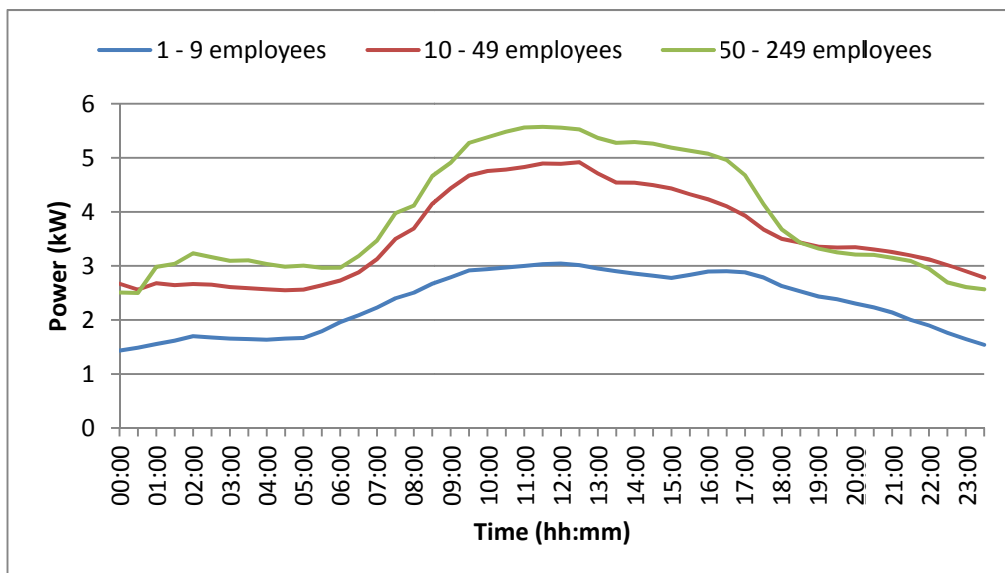
Figure 7 shows the average demand profiles by sector.



**Figure 7: Average Demand (1 September 2011 to 30 August 2012) by Sector**

It can be seen that the proportion of total electricity used varies by sector with industrial businesses average demand highest between 08:30 and 12:30, commercial / office businesses highest between 12:30 and 16:30 and agricultural, hunting, forestry and fishing businesses highest between 16:30 and 08:30.

Figure 8 shows the average demand by size of business.



**Figure 8: Average Demand (1 September 2011 to 30 August 2012) by size of business**

It can be seen that organisations with 50 – 249 employees have the highest average demand, suggesting that the relationship between number of employees and electricity demand is linear.

Figure 9 shows the average demand by tariff type.

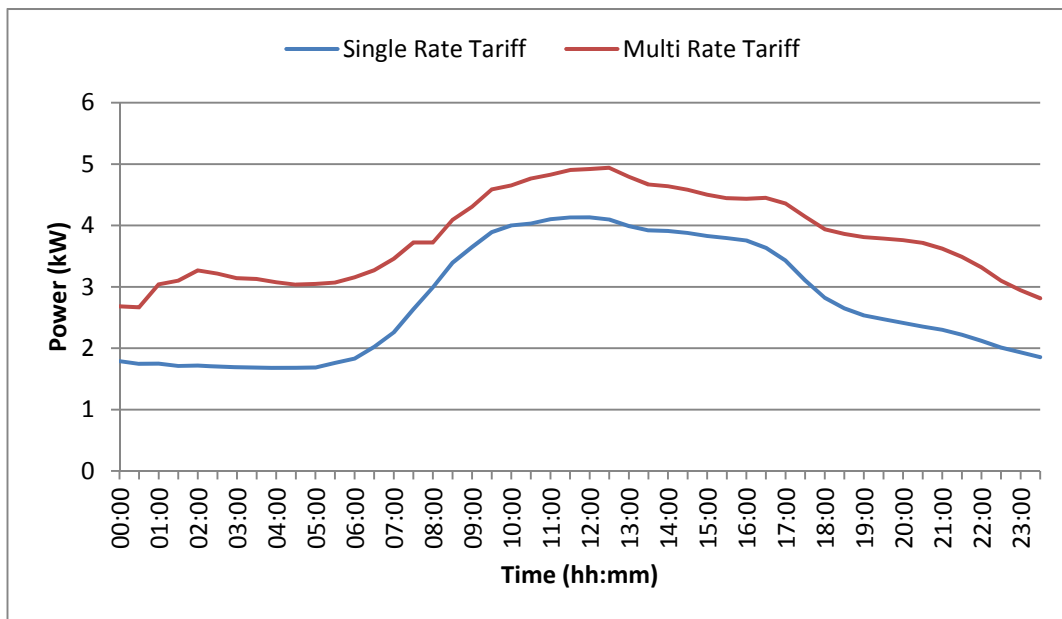


Figure 9: Average Demand (1 September 2011 to 30 August 2012) by Tariff type

It can be seen that customers on a multi rate tariff have a higher average demand than those on a single rate tariff although the peak occurs for both sets of customers between the hours of 09:00 and 17:00.

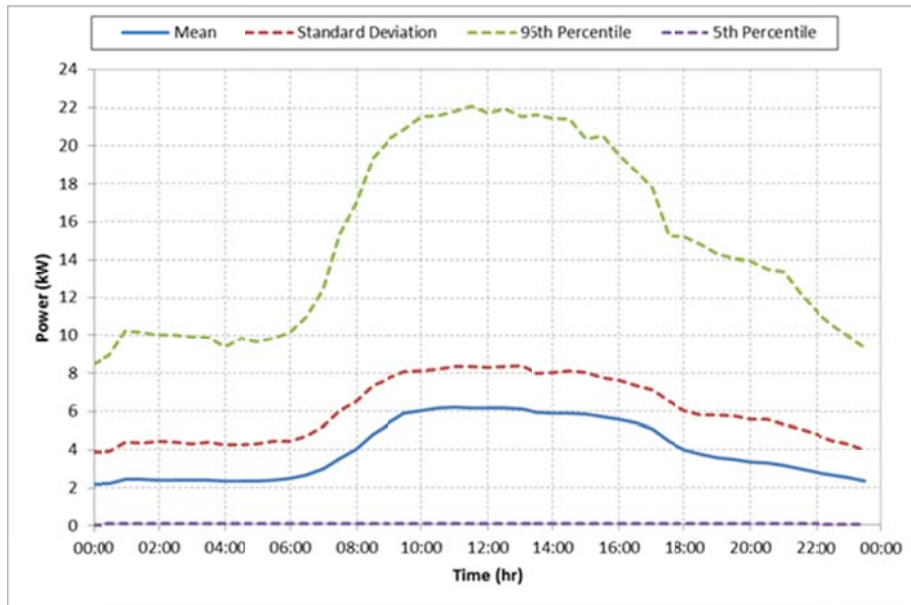
Figure 10 shows the average demand for single and multi sites.



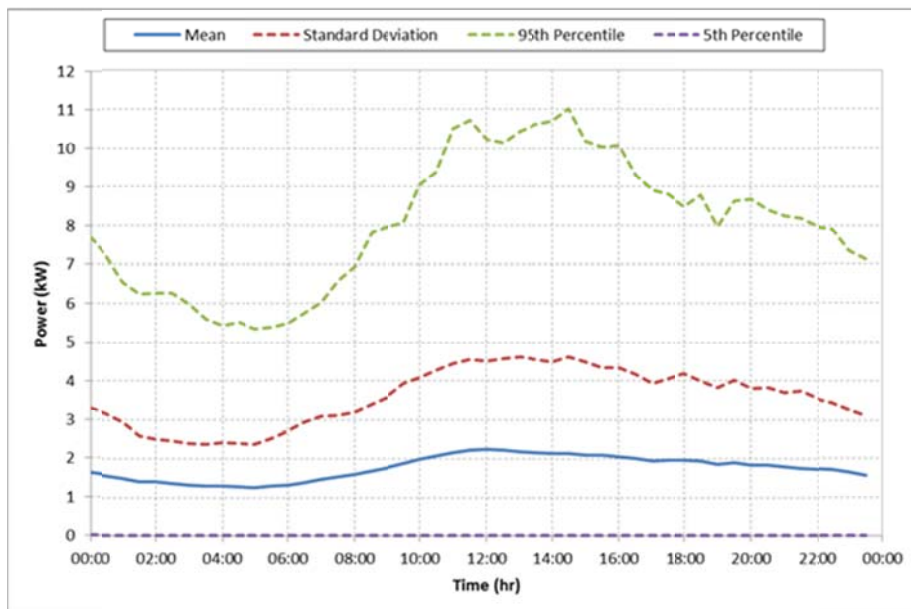
Figure 10: Average Demand (1 September 2011 to 30 August 2012) by type of site

## 4.2. Peak Days

The maximum peak demand day and (potential) peak PV supply day were analysed. The maximum demand day occurred on the 8 February 2012 when the highest half-hour demand averaged across the group occurred. The (potential) peak PV supply day occurred on the 1 July 2012. The results are shown in Figure 11.



(a)



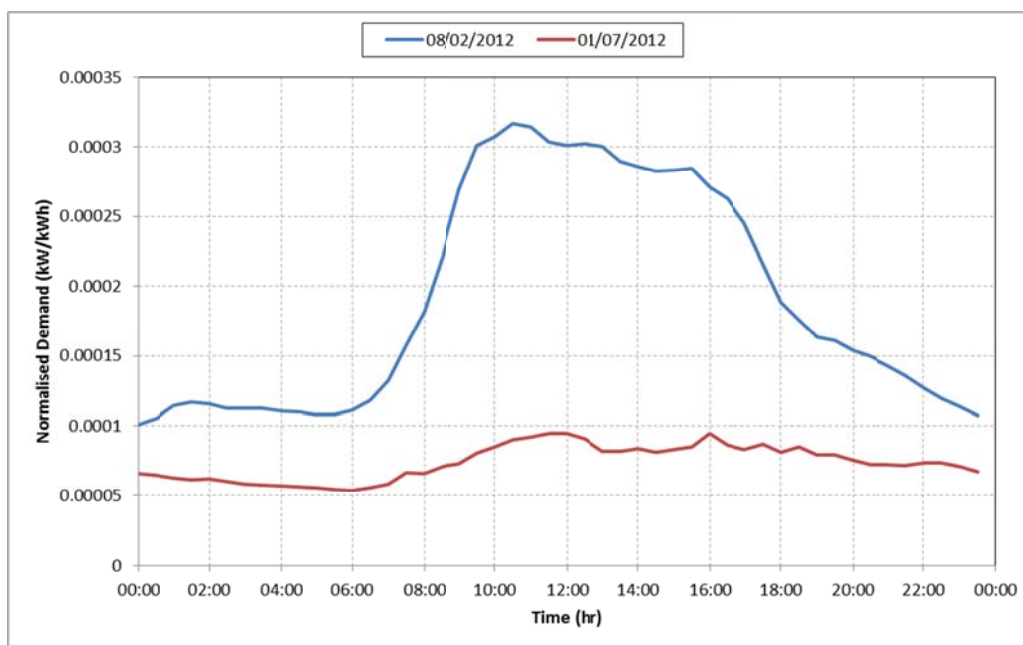
(b)

Figure 11: (a) 8 February 2012, (b) 1 July 2012

Figure 11 shows, the peak days (and half hour stamp) were (a) 8 February 2012 11:00 with mean peak 6.19kW and (b) 1 July 2012 12:00 with mean peak 2.24kW. For the peak demand day, the standard deviation ranges between 3.8 and 8.4kW throughout the day, suggesting a significant spread between customers. This is not surprising given the range of different customer types, and can be seen by the significantly higher 95th percentile demand level (ranging from 8.5 to 22kW).

For the (potential) peak PV generation day, the standard deviation ranges between 2.4 and 4.6kW, however the mean demand remains very stable throughout the day. The 95th percentile demand is much higher in this period, peaking at about 11kW between 11:30 and 14:30, but it is not clear at this point if this would be sufficient to balance out the additional potential PV generation.

Figure 12 shows the normalised peak demand days throughout the analysis period.



**Figure 12: Normalised Peak and Peak Potential PV Generation Days**

One final anecdote based on the minimum peak across the year: the two peak minima were observed on 25 December 2011 and 1 January 2012.

## 5. Conclusions and learning

The key observation from this analysis is that there is a very large variation in the demand profiles of individual SMEs. They are heterogeneous in terms of their business activities, and hence also in terms of their overall demand for power and the timing of that demand during the day. For SMEs the daily demand profile tends to be shaped differently to domestic consumers, with a less pronounced evening peak.

Power demand is driven by the SME's specific business activity, which for many activities, may be relatively more constant throughout the working day. However, in general, the demand profile consists of an 'up' time between 09:00 and 17:00 (weekdays) and 08:00 and 16:00 (weekends), this is particularly pronounced in the working week with more of a gentle ramp up and down on the weekends. As expected, average daily demand is highest for all SMEs in the winter months of January and February.

Overall, there is much less of a pronounced peak demand time than observed with the domestic customers. Throughout the year, the average demand does change as expected with the seasons (more demand during winter, less during summer), but the relative difference between these two extremes is not great. Evidence also showed that peak intensity varies across different sectors.

The proportion of total electricity consumption concentrated in the evening peak is lower for industrial businesses while businesses in Agriculture, Hunting & Forestry, and Fishing sectors consume the most.

## 6. References

- CLNR-L036 Project lessons learned from trial recruitment
- CLNR-L073 Dataset: Basic profiling of SME customers
- CLNR-L099 Insight report: Small and Medium Enterprises
- CLNR-L103 SME customers: Energy practices and flexibility
- CLNR-L107 Test cell protocol: Selection criteria for SME customers
- CLNR-L232 Key social sciences findings: Domestic and SME customers



## 7. Appendix

Test Cell Number	No. within Test Cell	Variables			
		Single vs Multi- site	Time of Use	Size	Sector
SME 1.1	60	Single site	Peak	1 -9 employees	Agriculture, Hunting and Forestry; Fishing
SME 1.2	120				Industrial
SME 1.3	120				Commercial/Office
SME 1.4	120				Public Sector and Other
SME 1.5	60			10-49 employees	Agriculture, Hunting and Forestry; Fishing
SME 1.6	120				Industrial
SME 1.7	120				Commercial/Office
SME 1.8	120				Public Sector and Other
SME 1.9	60			50-249 employees	Agriculture, Hunting and Forestry; Fishing
SME 1.10	120				Industrial
SME 1.11	120				Commercial/Office
SME 1.12	120				Public Sector and Other
SME 1.13	26		Off Peak	1-9 employees	Agriculture, Hunting and Forestry; Fishing
SME 1.14	52				Industrial
SME 1.15	52				Commercial/Office
SME 1.16	52				Public Sector and Other

Test Cell Number	No. within Test Cell	Variables					
		Single vs Multi- site	Time of Use	Size	Sector		
SME 1.17	26			10-49 employees	Agriculture, Hunting and Forestry; Fishing		
SME 1.18	52				Industrial		
SME 1.19	52				Commercial/Office		
SME 1.20	52				Public Sector and Other		
SME 1.21	26			50-249 employees	Agriculture, Hunting and Forestry; Fishing		
SME 1.22	52				Industrial		
SME 1.23	52				Commercial/Office		
SME 1.24	52				Public Sector and Other		
SME 1.25	160			Multi-site	Peak		Commercial/Office
SME 1.26	155						Public Sector and Other
SME 1.27	70	Off Peak			Commercial/Office		
SME 1.28	65				Public Sector and Other		
<b>TOTAL</b>	<b>2256</b>						



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