Customer-Led Network Revolution

Insight Report: Small and Medium Enterprises (SMEs)

Disaggregated Load, Time of Use Tariff and Restricted Hours Trials

DOCUMENT NUMBER
CLNR-L099

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ISSUE DATE
23rd January 2015

Contents

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Date	**Issue**	**Status**
23/01/15	1.0	Published

1 Trial Overview

1.1 Description

This paper reports the findings from three enhanced profiling test cells (2b, 9b, 10b), providing detailed consumption profiles by appliance or circuit for a range of small and medium sized enterprises (SME) customers, as well as providing insights about their potential contribution to Demand Side Response (DSR).

1.2 Purpose

These trials were designed to support Learning Outcomes 1 and 2 from the Customer-Led Network Revolution (CLNR) project. Specifically, they provide the data needed to develop:

- a greater understanding of how future economic, social and technological trends are likely to affect the patterns of the various components of load and generation;
- an improved set of load profiles; and,
- a greater understanding of the degree to which customers who have accepted a proposition for flexibility then respond.

The analysis in the CLNR non-domestic test cells is particularly relevant given the general lack of other empirical evidence regarding GB SME disaggregated load.

1.2.1 Test Cell 2b – Enhanced profiling of regular smart meter customers

TC2b provides detailed consumption data for a range of participating SMEs. This has allowed us to build on the understanding developed by the SME control group (test cell 1b), and more specifically, examine the data from a set of appliances used by SMEs. In doing so, DNOs will be better placed to understand the potential for DSR presented by certain SME business activities. The key aims of this test cell are listed below.

- **Examine the total consumption profiles** for a set of different SMEs – the data enables us to examine the overall load profiles for a small sample of businesses and in particular their contribution to peak demand.
- **Investigate detailed appliance-level consumption profiles** – the granularity of the data available from the test cell enables us to look at the demand profile for different SME appliances.
- **Investigate the potential for different appliances to contribute to DSR** – consideration of the timing of appliance use and the flexibility of different forms of consumption allows for a granular assessment DSR potential.

1.2.2 Test cells 9b, and 10b

These trials investigate the impact of Time of Use (TOU) tariffs on SME daily demand profiles for SMEs. This should provide insight as to the potential for SME TOU tariffs to shift load away from the peak and reduce overall energy consumption. The key aims of these trials are summarised below.

- **Understand the limitations to the take-up of DSR tariffs** – in setting up the test cells insights into the difficulties of attracting interest from SMEs for some types of DSR contract have been gained.
- **Examine potential SME responses to TOU tariffs –** by trialling TOU tariffs the report examines their impact on the shape of daily demand for a particular SME.
- **Examine the impact of TOU with direct control –** the report examines how an SME responds to allowing direct control of their appliances during the peak period.

2 Trial Design

2.1 Test cell 2b

This test cell monitors up to 40 British Gas SME customers all with smart meters. All recruitment was conducted by Optimisa research agency through a telephone campaign. Participating firms were paid £100 on joining the study and £100 at the end of 12 months of monitoring.

The Department for Business Innovation & Skills (BIS) and the Office for National Statistics (ONS) use an employment-based definition for SMEs, which considers businesses with 249 or fewer customers to be an SME. This definition was used for recruitment into all the test cells covered by this report. Within this category, there will be a tremendous amount of heterogeneity between factors such as:

- peak-time electricity usage (an industrial facility employing 100 workers would have considerably greater demand than a firm where most employees work away from the office);
- sector (for example, some sectors may commonly use specialised machinery);
- whether the SME has a single or multiple sites; and
- the energy performance of buildings.

The recruitment procedure used to select SME customers for these test cells aimed to include a variety of businesses from across these categories.

All participants already had a smart meter installed or were scheduled to do so. Data and technical information was provided at 10 minute intervals for:

- the total meter load; and,
- the disaggregated for loads beyond the meter which accounted for over 50% of on-site consumption.

The trial did not stipulate any changes to supply tariffs. The participants therefore remained on their existing tariff and were able to renew their contract during the course of the trial should this be required.

2.2 Test cell 9b

Test cell 9b was constructed in exactly the same way as 2b for a set of different SMEs. During the course of the 12 month monitoring period each participant was placed on a static 3-rate Time of Use Tariff as set out in **Table 1**. The tariff structure varied throughout the day with prices around 80% higher in the super peak period compared to the day time, and varied slightly depending on the profile class of each SME. However, the rates were not dynamic i.e. they did not change at short notice and were fixed for the whole 12 months monitoring period.

Table 1. 3-rate TOU tariff in Test Cell 9b

Tariff rate	Profiles 1-4	Profiles 5-8
Standing charge	21.73p/day	68.00p/day
Day peak [7am-4pm, 8pm-midnight]	13.61p/kWh	13.04p/kWh
Super peak [4pm-8pm]	24.55p/kWh	23.99p/kWh
Night off peak [midnight-7am]	9.25p/kWh	8.59p/kWh
Weekend	Super peak replaced by day peak	

In the same way as for test cell 2b, participants were rewarded for participation in the trial. Further, they were compensated at the end of the trial period if they were out of pocket relative to what they would have paid on their previous tariff. However they were able to keep any savings. Participants were therefore insulated from any downside as a result of participating in the trial. This may have dulled the incentive to shift their load to avoid peak pricing.

2.3 Test cell 10b

Test Cell 10b was designed to look at the impact of the same 3-rate TOU tariff used in TC9b and was therefore constructed in the same way. However, it also included the restricted use of electricity consuming equipment during the super peak period. In this period disaggregated loads were made available for direct control by the network operator, although the customer could override this signal.

It was extremely challenging to recruit for this test cell. While this has limited the insights from customer behaviour under the tariff from this test cell, we have gained significant learning about the problems associated with recruiting SMEs for DSR trials.

Over 20,000 SMEs were approached. Initially 350 were willing to participate in test cell 10b. However by the start of the trial, only two businesses remained willing to participate. The detailed data is presented for one of these in the results section of this report. We did not receive usable data from the other.

Difficulties in securing SMEs involvement in this trial were driven by the risks perceived by SMEs around the impact of electrical interruption on the daily running of the business. Feedback suggests that unwillingness to join in the trial did not reflect a fundamental opposition to the principles of the project as a whole, which was evidenced by many of those approached participating in other test cells.

SMEs cited a number of reasons why they were concerned about uncertain electrical interruptions.

- They are service providers and the hours and the type of process used are controlled and driven by the service users, and there is little or no movement on these time frames from the users.
- The need to capture passing trade in the case of shops, restaurants, hotels and public houses, as well as retaining clients, requires flexibility in opening times.
- Regulatory concerns are central for a lot of SMEs:
    - for example in the farming sector animal welfare is a major concern and is governed by the requirements of DEFRA and other agencies; and,
    - within hotels, public houses and restaurants the need for environmental and Health & Safety requirements is major consideration, for example the need to: prevent the loss of hot water in toilets; safely store prepared foodstuffs; and avoid prosecution due to infringement of regulations or personal injury.

In addition to concerns about electrical interruptions, there were also a range of practical issues which limited participation. For example, many of those sites initially interested in participation failed the physical survey to check the state of installation for metering equipment. Similarly there may have been issues with change of ownership on the site or security issues around the equipment.

3 Trial Results

Existing research about SME electricity demand is relatively limited, especially when compared to domestic consumers. CLNR has already added to this through the social science reports from Durham Energy Institute (DEI) and the analysis of test cell 1b in particular. This section builds on this work and provides new insights from test cells 2b, 9b and 10b.

3.1 Test cell 2b

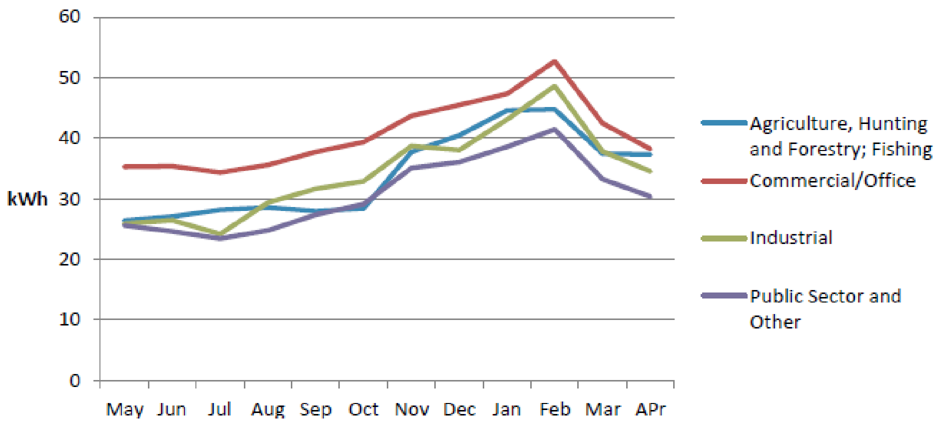
In this section we analyse the data collected from test cell 2b to meet the following learning objectives.

- Examine aggregate consumption profiles for SMEs in the trial.
- Determine detailed appliance-level consumption profiles.
- Determine the potential contribution of different appliances to DSR.

3.1.1 Aggregate SME consumption profiles

The previous work conducted by DEI as part of test cell 1b has already highlighted a number of key findings on SME energy consumption. First, SME consumption per customer tends to be an order of magnitude higher than domestic consumption, making these energy users of particular importance for understanding both current and future demand. The demand profiles of individual SMEs also vary to a much greater extent than households. 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. This heterogeneity presents particular problems when trying to extrapolate conclusions from the trials to the wider SME market.

Figure 1. Average daily SME demand by sector for 12 months



Source: CLNR, DEI Social Science report April 2014.

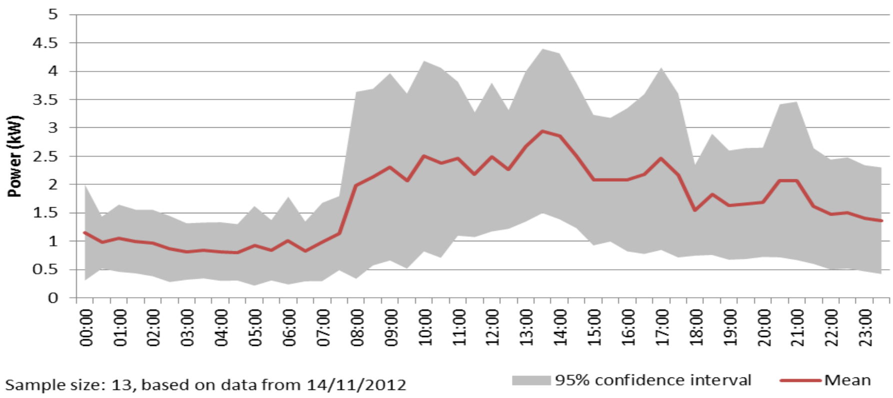
As expected, average daily demand is highest for all SMEs in the winter months of January and February. It is highest for Commercial & Office enterprises and lowest for those in the Public Sector & Other Industry classification. This means that the kind of businesses with the highest electricity demand could be those involved in the wholesale and retail trade, hotels and restaurants, transport, storage and communication, financial intermediation, real estate, renting and business activities, while lowest consuming group includes education, health and social, work other community, social and personal service activities.

The largest firms do not necessarily have the highest power demand. In terms of business size, evidence from TC1b showed organisations with 10-49 employees had the highest demand (more than those with 50-249), suggesting that the relationship between number of employees and electricity demand is not linear.

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 firm's specific business activity, which for many activities, may be relatively more constant throughout the working day. This was identified by the analysis of TC1b, and although the sample size in TC2b is much smaller, a similar picture is visible. The results presented below show the average daily profile for 13 firms during winter and summer.

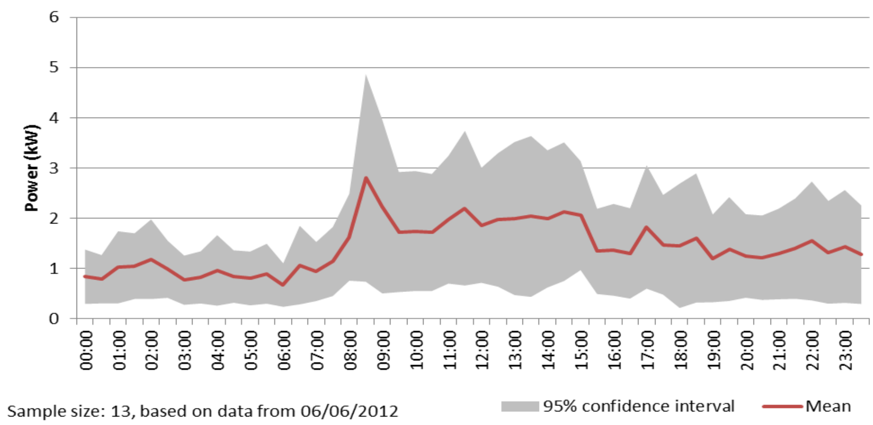
A much larger number of firms (over 40) were monitored for at least part of a year. However, to make meaningful comparisons between seasons, it is necessary to present results only for the 13 firms that have data for each season. This is because the extremely high heterogeneity of the monitored SMEs (in terms of power usage) means that firms entering and leaving the sample have a substantial impact on average power consumption. TC1b provides estimates of average SME power consumption for a much greater sample size.

Figure 2. Average winter weekday profile for firms in TC2b



Source: Smart meter data collected for CLNR by G4S

Figure 3. Average summer weekday profile for firms in TC2b



Source: Smart meter data collected for CLNR by G4S

In both the winter and summer charts above, we can see the higher usage throughout the working day, and the absence of a peak between 4pm and 8pm. In fact, demand appears to be slightly lower during the evening peak. It needs to be recognised however, that within the group of 13 firms there is substantial variation between the individual firm profiles. This is illustrated by the large confidence interval around the mean and the spike at 8:30, which is driven to a large extent by a single firm with a transitory spike in demand to almost 11kW. This variation means that conclusions about SME demand profiles are quite firm specific.

Earlier work on TC1b confirms the lower importance of the evening peak to SMEs. Many businesses (41% or 723 of the sample of 1762) on average consume less energy in the evening peak than at other times of the day. The equivalent figure for households is only 2%. Among SMEs it is the smaller businesses (1-9 employees), such as those in leisure and hospitality, that tend to consume a higher proportion of their total electricity in the evening peak. DEI concluded that larger businesses consume electricity more evenly across a 24 hour period, though they may have a larger total power demand per hour during the peak. This may suggest larger businesses are more capable of shifting load compared to smaller businesses who may have relatively fixed demands in the peak.

Evidence from TC1b also showed peak intensity also 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.

3.1.2 Determine detailed appliance-level consumption profiles and potential for DSR

In this section we investigate the key practices that give rise to energy use amongst SMEs and investigate the potential for DSR. We first look at evidence from the literature, and from the social science research carried out by DEI. We then look at the results from this trial.

Existing evidence

Energy use among SMEs is dominated by lighting, heating and cooling, refrigeration, and information technology. But the extent to which these loads can be flexible depends on the specific characteristics of each type of load.

Not all electricity uses will be suitable for DSR use given the potential impact on business operations. As set out earlier, concerns by SMEs about the potential impact on business operations was a key reason for the recruitment problems for test cell 10b.

Element Energy[1] in a paper for Ofgem identified that the loads most suitable for DSR include space cooling, ventilation, heating, hot water (with storage), refrigeration and lighting. These loads are more likely to be movable for short periods with minimal impact on business operation. For example immersion heaters could be shifted to run outside of the peak window with minimal impact on the business. This contrasts with loads related to computing or catering where uses are more likely to be time critical for the business, and substantial reductions in demand could only really be achieved by shifting working patterns. Some of the insights from Element Energy's report are summarised in Table 2.

[1] Element Energy, Demand-side response in the non-domestic sector, May 2012

Table 2. DSR potential by load

Load type	DSR potential	
Catering	Very low DSR potential	Major electricity consuming equipment includes ovens, electric hobs, grills microwaves etc. Operating patterns driven by consumer demand so limited ability to shift.
Computing	Very low DSR potential	Energy efficiency changes are possible, but shifting loads requires changes in working patterns
Space cooling and ventilation	DSR potential	Loads typically can be interrupted for up to 30minutes with no significant impact on the environment in the building. The extent of shifting will depend on specific technical factors, building characteristics and desired internal temperature range. Health and Safety regulations require adequate fresh air supplies.
Heating	DSR potential	Electric heaters can only be adjusted for short periods without impact on temperatures. However, the timing of storage heaters could potentially be adjusted.
Hot water	DSR potential	There is potential for shifting of immersion heater, though specific factors such as the size of the water tank, level of insulation, and water demand, will determine the period it can be shifted. Instantaneous hot water systems provide very limited potential for flexibility.
Lighting	DSR potential	Lighting is a significant part of overall load for SMEs and there is technical potential to reduce load at peak times, using dimmer switches and motion detectors. Some degree of dimming can be achieved with in an imperceptible manner over a period of a few minutes. However, this type of system requires significant investment.
Refrigeration	DSR potential	Refrigerators provide potential since they can be interrupted for periods of 15 minutes quite readily. There is potential for longer periods where cold stores and freezers can be 'super-cooled' and switched off, provided they are not opened.

Source: Summary of Element Energy findings, and findings from DEI social science reports

In the social science reports, DEI also identified a range of business specific practices that create specific load profiles for certain businesses. Some loads involve intermittent demand for high power, and these were found to be less fixed in time than lower power, day in day out processes and practices. There may be more potential for these 'high power' practices to be flexible and therefore amenable to DSR interventions.

DEI also found that connectedness is seen as a vital service that energy use provides, with servers and mobile devices often reported as being among the most critical appliances to business continuity. Therefore consistent with Element Energy's work, this may make communications and IT technology less amenable to DSR unless alternative forms of storage (e.g. batteries for computers) can provide a means of interesting the SME community in DSR.

Evidence from this trial

Detailed demand profiles have been collected as part of this trial for a range of different appliances used by SMEs. The full results for each appliance are presented in the annex. In this section we describe the data for each appliance and discuss its potential to provide DSR. Our conclusions on DSR potential are based on an assessment of the following two questions for each appliance:

- Does the demand profile suggest there sufficient demand in the peak hours currently to shift?
- Intuitively, (including based on past learning), could this load be interrupted and moved outside of the peak period?

The trial has produced detail demand profiles for 11 different technologies across six different SMEs. Therefore for some of the SMEs there is data for more than one appliance. While data on the exact nature of each business has not been available, it is helpful to group the appliances for the same firm as this provides some useful context when understanding the appliance profiles (Table 3).

Table 3: Appliances by firm in Test Cell 2b

Technology	Appliance
SME 1	Heating
SME 2	Air-conditioning
SME 3	Chillers
	Fridge/freezers
	Lighting – shop floor
SME 4	Welder
	Grinder, furnace and pillar drill (all these appliances are on a single circuit and therefore cannot be distinguished)
SME 5	Edging machine
	Extractor plant
	Table Saw
SME 6	Swimming pool

We now present the demand profiles for each appliance, including:

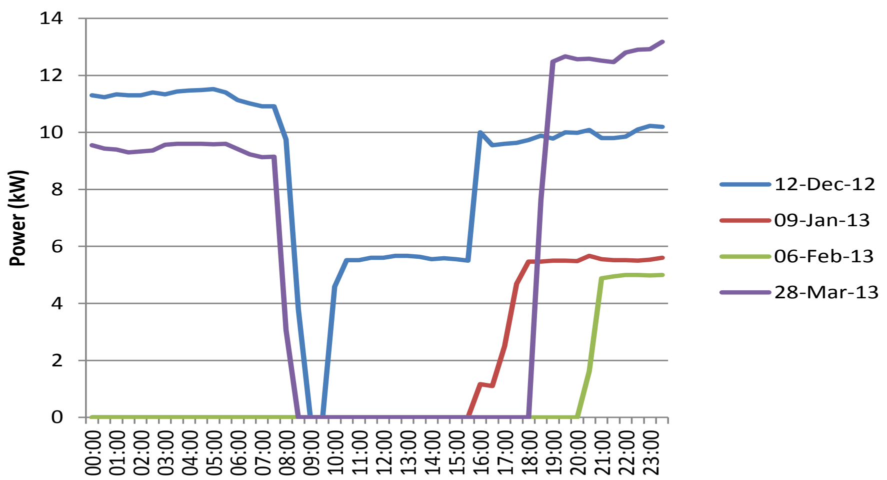
- power use for a series of randomly chosen representative days;
- average power use on weekdays and weekends;
- average power use by season (ELEXON definition); and

- mean power profile for winter weekdays, with a 95% confidence interval reflecting the certainty with which that level of peak demand could be expected. A narrow band indicates greater certainty that a particular load will be present on any given winter day.

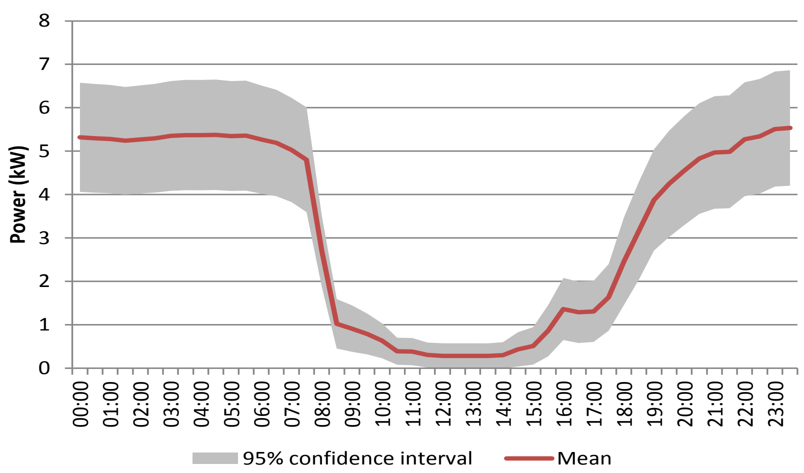
SME 4 and SME 5 are not covered in any detail in the main body of the report, as there is less clear evidence that such "process" actions as welding and sawing would be discretionary (instead, they may be driven by business requirements and order books). Nevertheless, if these activities are carried out intermittently, there may be some scope to shift demand. The annex to this report presents the power consumption profiles for these appliances.

3.1.2.1 SME 1 - Heaters

The four graphs below (**Figure** 4. Representative power use of heating (weekdays)



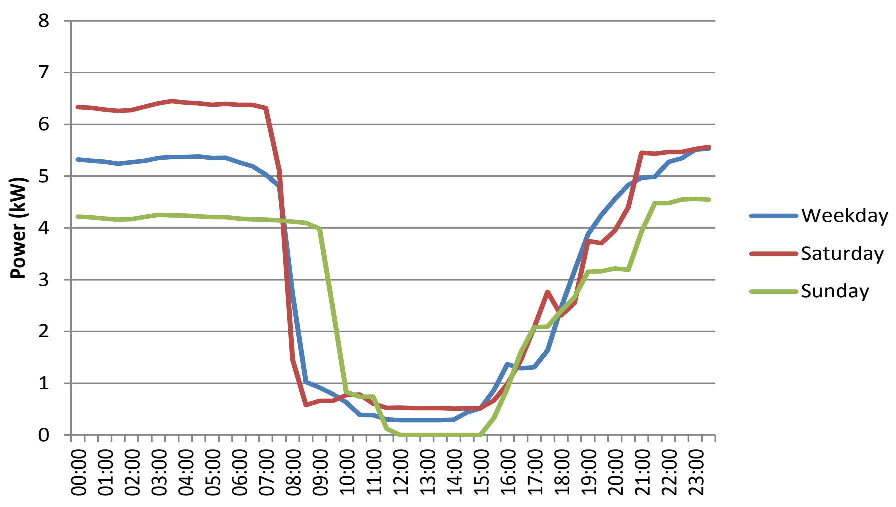
-**Figure 7.** Mean power profile for winter weekdays – 95% confidence interval



Source: Data collected for CLNR by Metasphere

) show the demand profiles from one of the SME heating circuits monitored as part of this test cell. A number of points are apparent:

- This heater is set to be on mostly between the hours of 5pm and 9am. This could be indicative of a form of storage heating, which may have the potential to be set to run at different times. In particular, this heater is currently set to run during the network peak (4pm – 8pm). If this is a common feature of SME heating systems, there may be benefits available to DNOs if it is possible to delay the start time of these systems.
- During cold days, the heater is turned on for longer periods during the daytime. For example, the 12th December had an average daily temperature of -4.8 degrees,[2] and the heater was on for all but half an hour during the day. On that day, the additional comfort provided by increased heating presumably outweighed the financial costs of running the heating for longer. This suggests that it may be harder for DNOs to incentivise load shifts on colder days, precisely when they may be most required.
- The representative days shown are all weekdays, however, the pattern remains broadly consistent for weekends, as shown by the average winter profiles in **Figure** 5. Average power use of heating by weekday and weekend



- although the power consumption on a Sunday is lower through the night.
- On average during the winter the heating system is turned on for more hours of the working day, and power demand picks up quickly during the evening peak hours.

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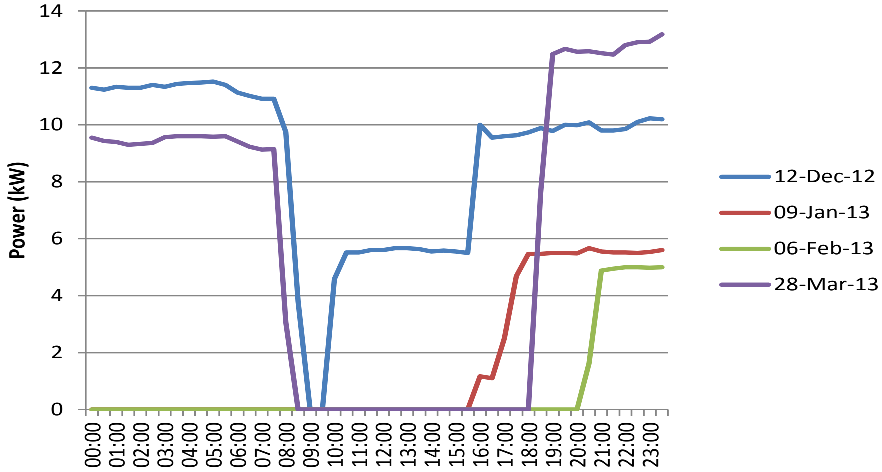
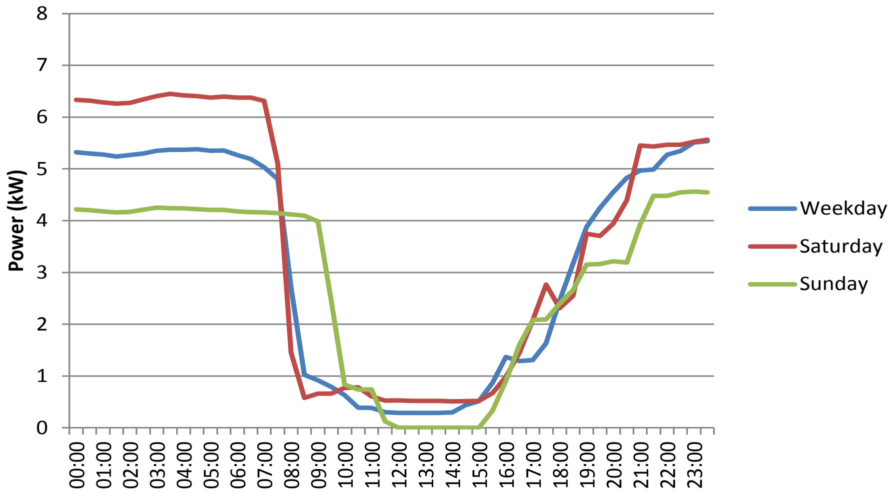
[2] Based on data from the European Climate Assessment and Dataset data (http://www.ecad.eu/), taken for Central England. For comparison, average temperatures for the other dates given above were 4.5 degrees, 3.8 degrees, and 0.3 degrees Celsius.

Figure 4. Representative power use of heating (weekdays)



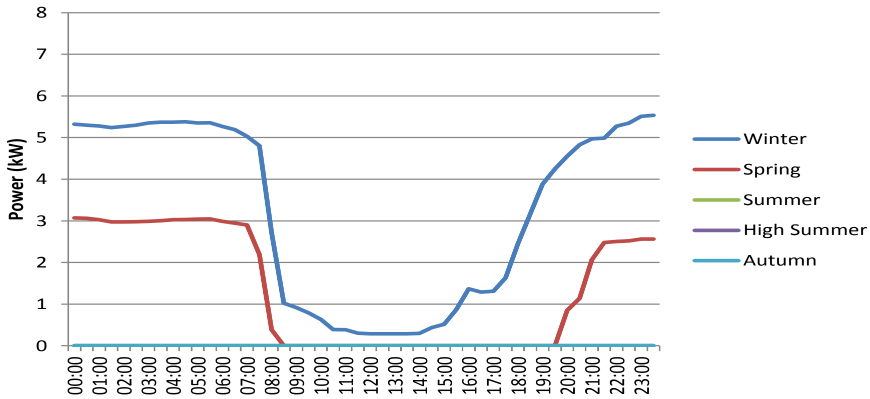
Source: Data collected for CLNR by Metasphere

Figure 5. Average power use of heating by weekday and weekend



Source: Data collected for CLNR by Metasphere

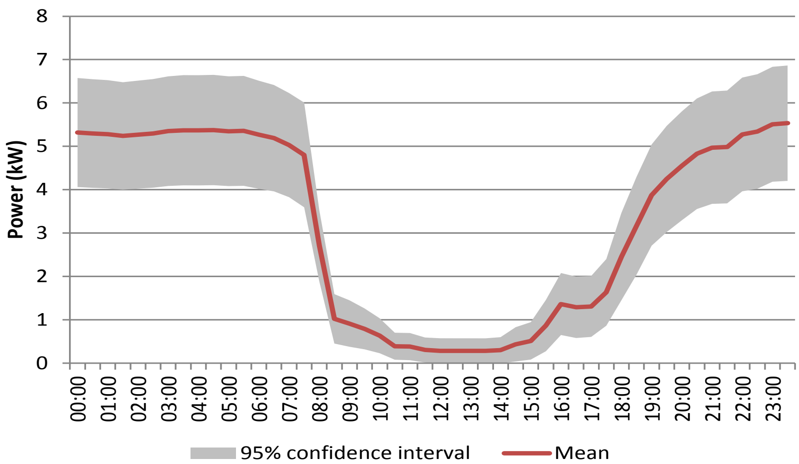
Figure 6. Average power use of heating by season (ELEXON definition3)



Source: Data collected for CLNR by Metasphere

The chart below shows a 95% confidence interval around the mean power profile for this heater on winter weekdays.

Figure 7. Mean power profile for winter weekdays – 95% confidence interval



Source: Data collected for CLNR by Metasphere

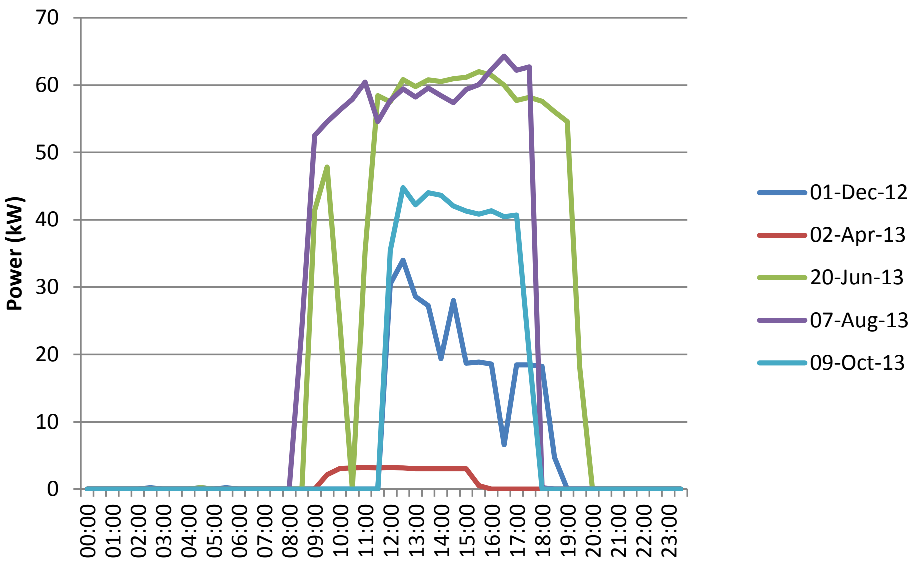
[3] The Elexon definition of winter is anytime day light saving time is not in use: the data is not related to Elexon itself

3.1.2.2 SME 2 - Air conditioning

The four graphs below show the demand profiles for air conditioning units on one of the SME circuits monitored. A number of points are apparent from this data:

- Demand for air conditioning by this firm is a diurnal activity, concentrated between 8am and 8pm. Usage of the air conditioning, while present in the evening peak period, is often tapering down between 5pm and 8pm.
- The peak usage is focused on the weekend, suggesting the activity of this firm may relate to a leisure activity. The potential for weekday reductions in peak demand are still present but much reduced compared to the weekend.
- Demand is very weather dependent, so winter demand is considerably lower.
- Overall air conditioning demand from this firm does not correlate well with winter system peaks. Demand is low on winter weekdays and is likely to be tapering off during the peak period anyway, suggesting that this type of appliance is not a strong candidate for DSR where networks face a winter peak. However, where the network faces a summer peak (as is already the case in some locations, such as London) there may well be value from DSR of air conditioning load.

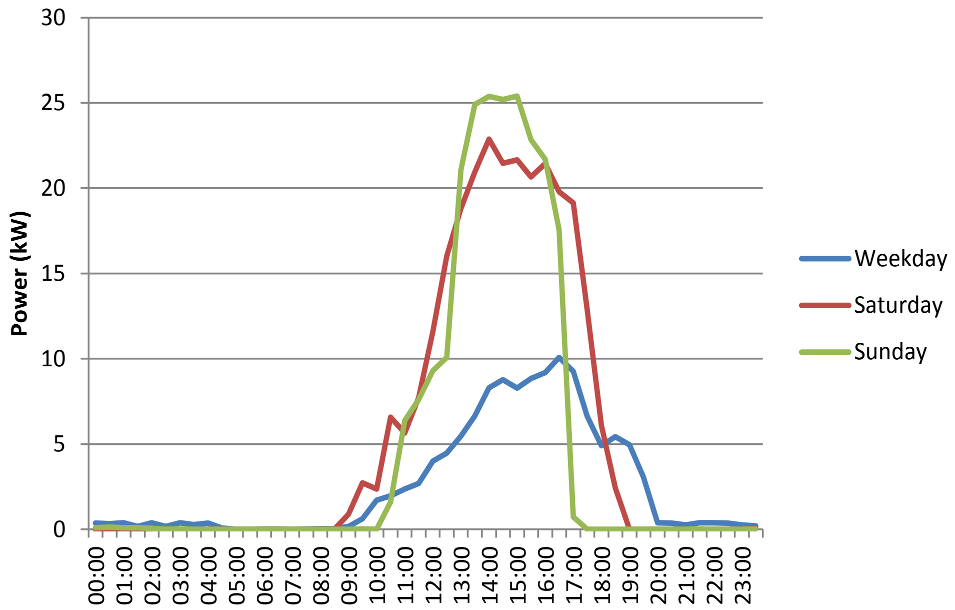
Figure 8. Representative power use of air conditioning



Source: Data collected for CLNR by Metasphere

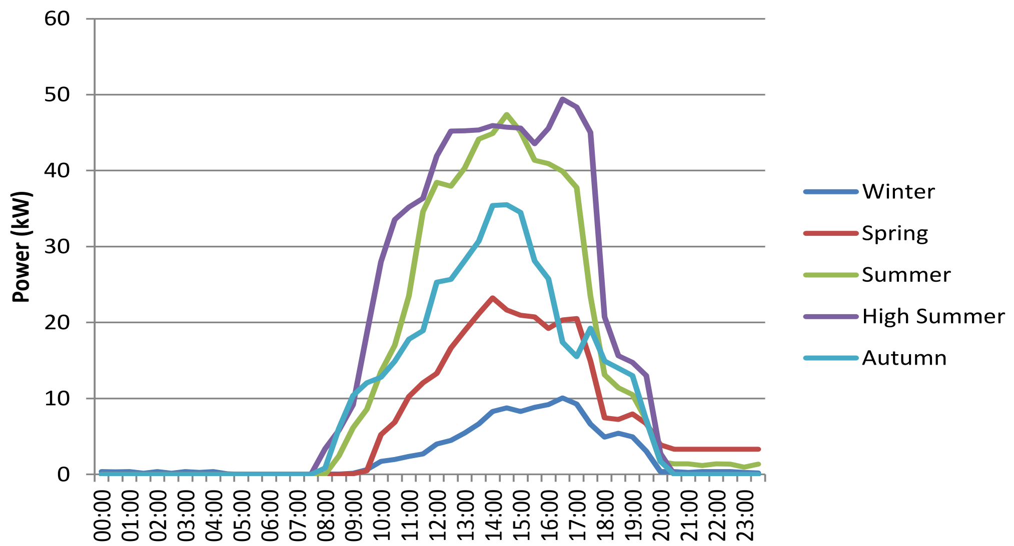
All the representative days were weekdays, except for 1st December 2012 which was a Saturday.

Figure 9. Average power use of air conditioning by weekday and weekend



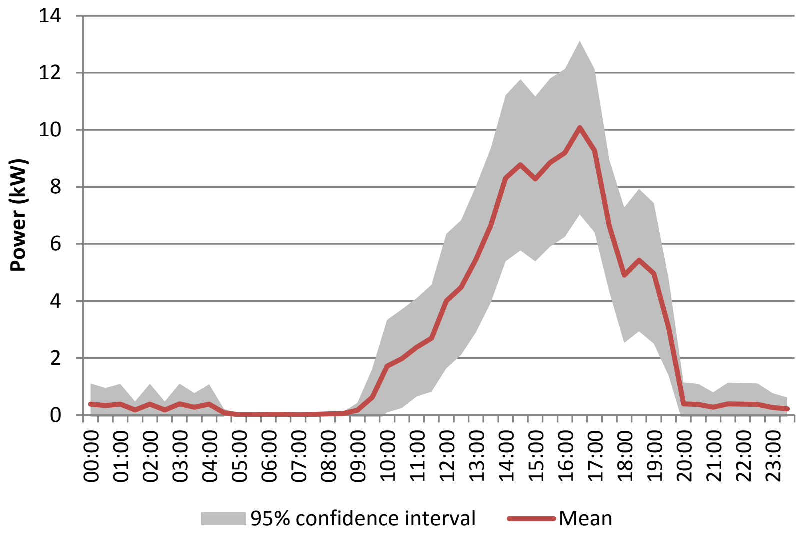
Source: Data collected for CLNR by Metasphere

Figure 10. Average power use of air conditioning by season (ELEXON definition)



Source: Data collected for CLNR by Metasphere

Figure 11. Mean power profile for winter weekdays – 95% confidence interval



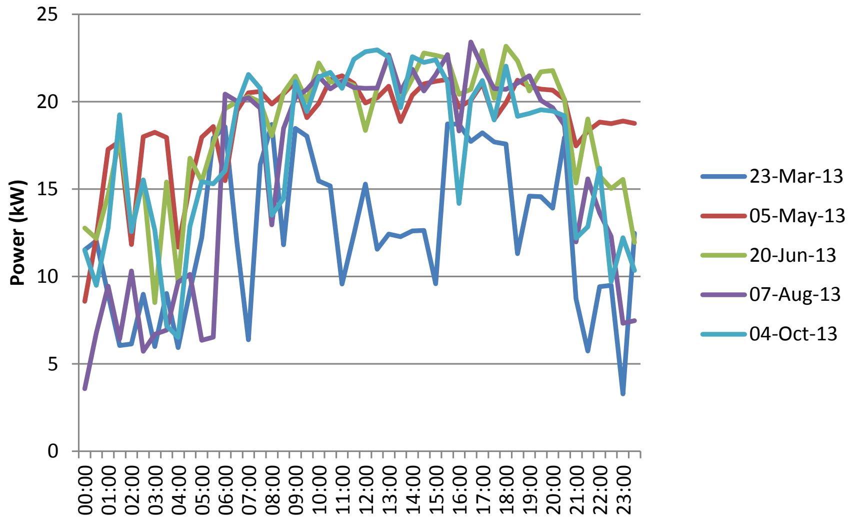
Source: Data collected for CLNR by Metasphere

3.1.2.3 SME 3 - Chillers

The four graphs below show the demand profiles for chiller units on one of the SME circuits monitored. A number of points are apparent from this data:

- Typical for a refrigeration load, the power cycles rapidly throughout the day, with greater demand between the hours of 7am and 8pm. Demand is therefore high throughout the evening peak suggesting there is some potential for load shifting.
- Intuitively demand should increase in warm weather, and this seems to be borne out in the data although it only has a small effect, with demand remaining high in each of the seasons.
- The firm has a consistent pattern of demand between weekdays and weekends suggesting it is operating seven days a week e.g. a retail business.
- In winter the average demand during the peak remains high with limited variability around the mean.
- This suggests there is some potential for load shifting if the chillers can be switched off earlier than currently is the case, without any adverse impact on the refrigerated products.

Figure 12. Representative power use of chillers



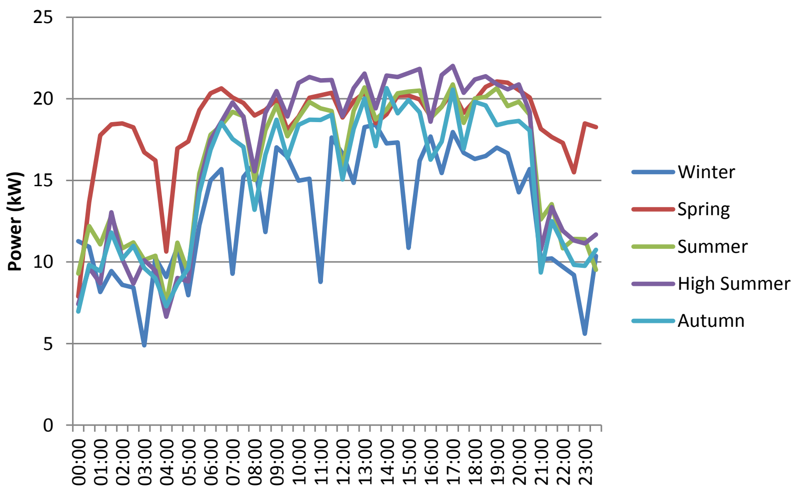
Source: Data collected for CLNR by Metasphere

All the representative days are weekdays, except for 23rd March 2013 which was a Saturday and 5th May which was a Sunday.

Figure 13. Average power use of chillers by weekday and weekend

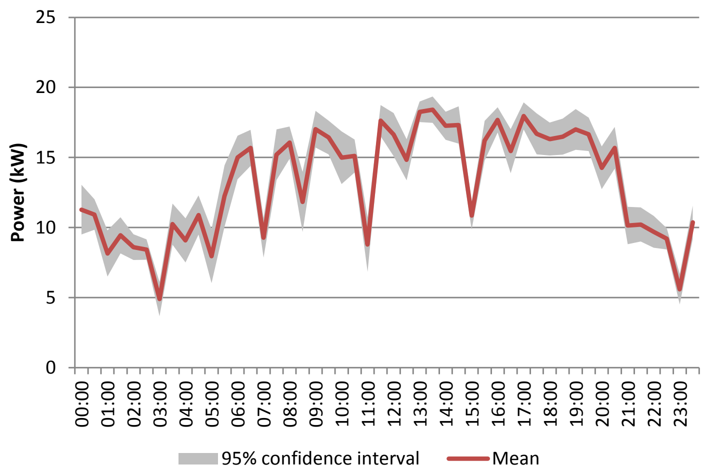
Source: Data collected for CLNR by Metasphere

Figure 14. Average power use of chillers by season (ELEXON definition)



Source: Data collected for CLNR by Metasphere

Figure 15. Mean power profile for winter weekdays – 95% confidence interval



Source: Data collected for CLNR by Metasphere

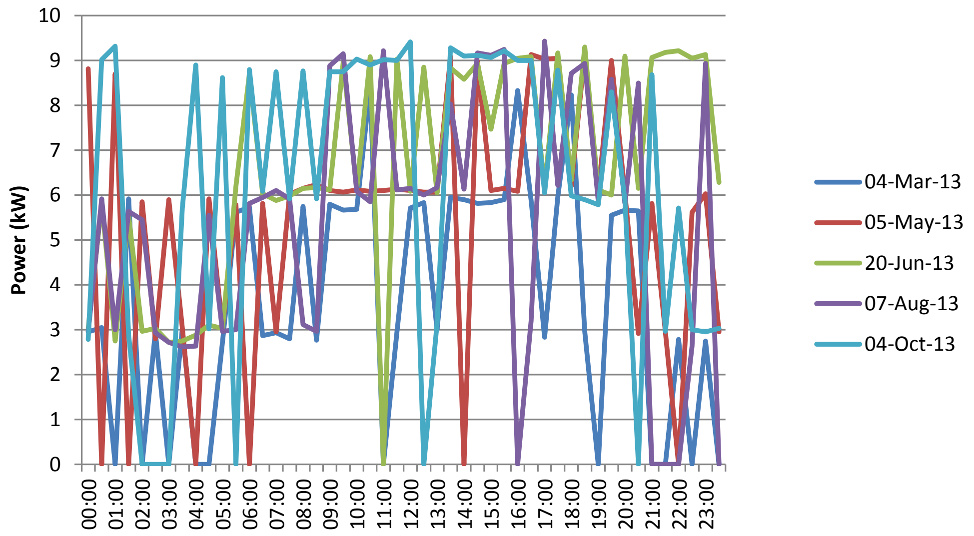
3.1.2.4 SME 3 - Fridges (shop floor)

The following graphs show the daily profiles for the fridges of one of the SMEs monitored in the test cell. The results are for the same SME and show a very similar story to the chillers assessed in 3.1.2.3 above.

- The demand for power from the fridge units is volatile during the day as is typical for this type of load. There is greater demand between the hours of 6am and 9pm, likely to be consistent with the opening hours of the business. Demand is therefore high throughout the evening peak.

- The profiles do seem to be weather dependent to a small degree with the highest demand in the high summer period.
- The pattern of demand is consistent between weekdays and weekends.
- In winter the average demand during the peak remains high suggesting there is potential to shift demand, for short periods of time provided the business can be assured of the refrigerated product quality being maintained.

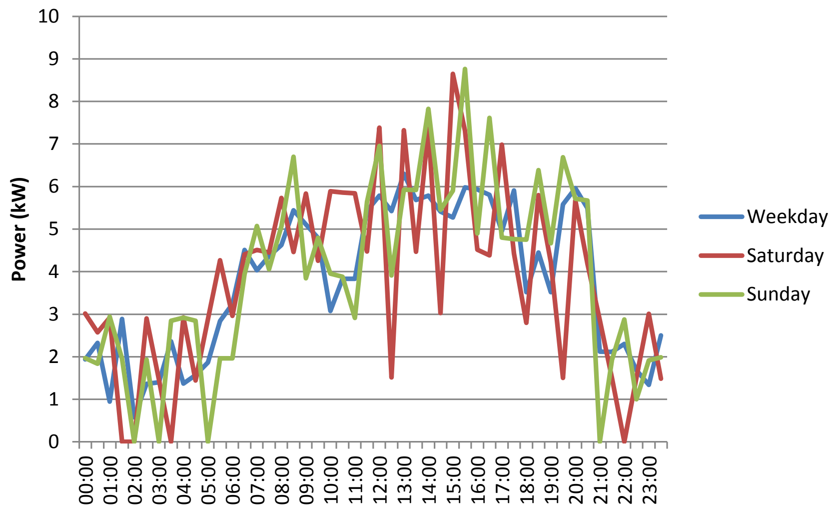
Figure 16. Representative power use of fridges shop floor



Source: Data collected for CLNR by Metasphere

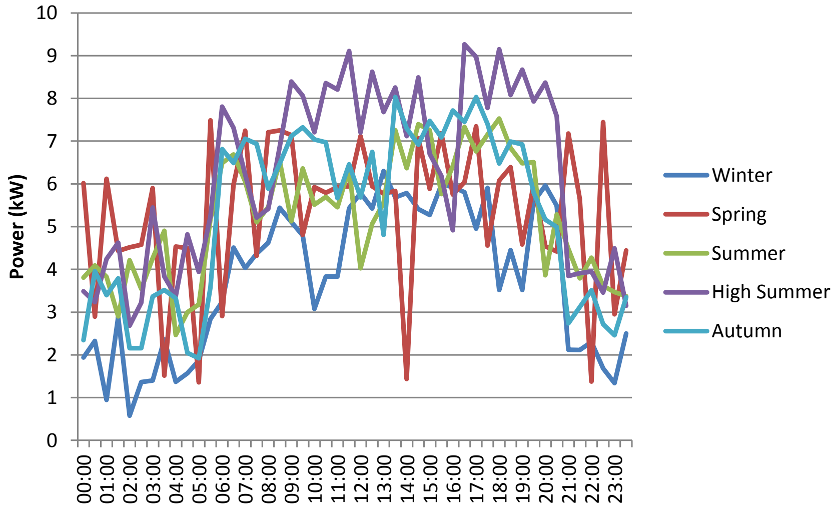
All representative days are weekdays, except for 5th May 2013 which was a Sunday.

Figure 17. Average power use of fridges shop floor by weekday and weekend



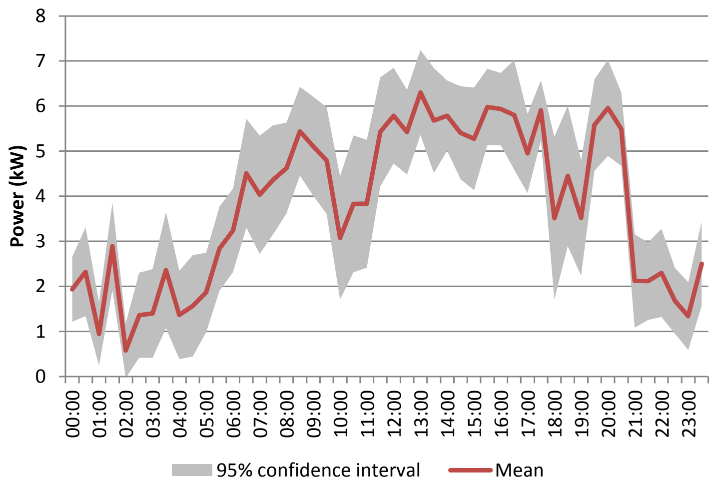
Source: Data collected for CLNR by Metasphere

Figure 18. Average power use of fridges shop floor by season (ELEXON definition)



Source: Data collected for CLNR by Metasphere

Figure 19. Mean power profile for winter weekdays – 95% confidence interval



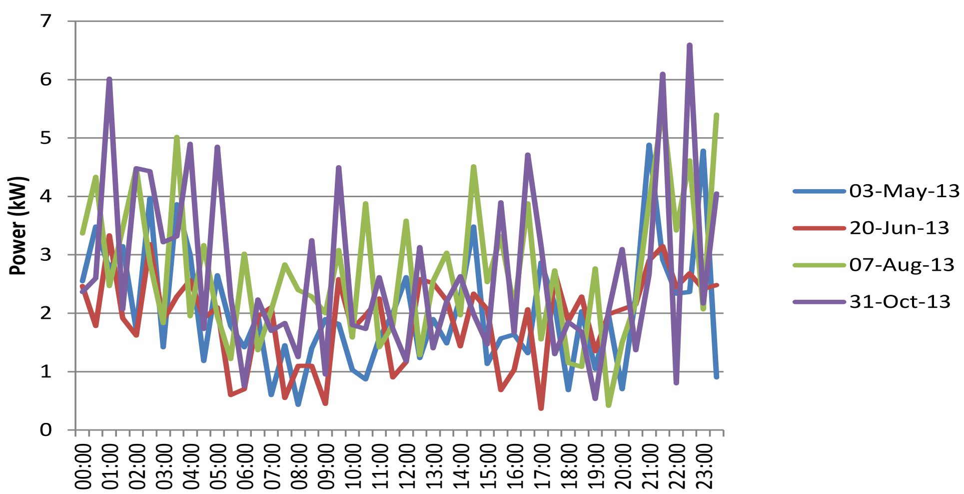
Source: Data collected for CLNR by Metasphere

3.1.2.5 SME 3 - Fridges (walk in)

The following graphs set out the profiles for walk-in fridges. The results are different to those of the chiller, and fridges on the shop floor, despite being from the same firm.

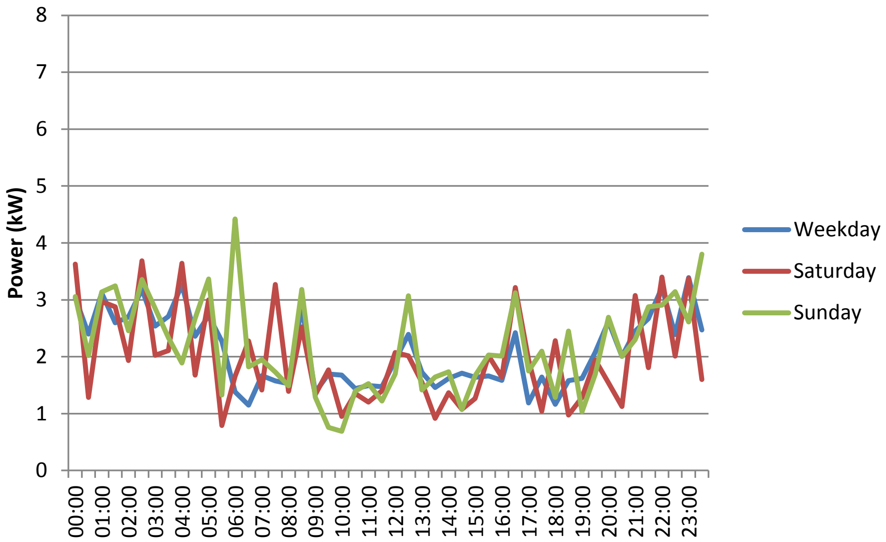
- There is still the considerable volatility as is expected for a fridge, however these fridges have their highest demand during the night. Suggesting that they may be used for restocking of the retail business overnight, and are less likely to be accessed during the working day.
- Throughout the peak period therefore the potential for DSR is considerably less. Although this is a refrigeration technology it has a very different profile to other fridges used by the same SME. This suggests that there are a broader set of factors which also determine the degree of flexibility potential, beyond simply the appliance itself.

Figure 20. Representative power use of walk in fridges



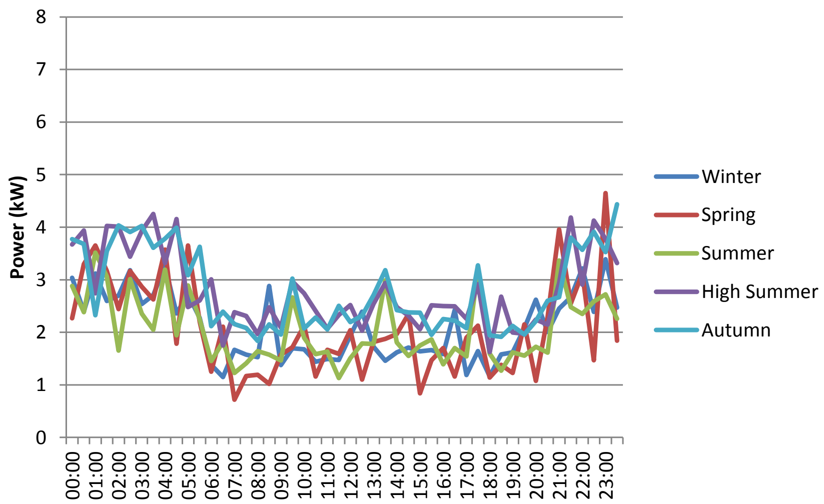
Source: Data collected for CLNR by Metasphere
All the representative days are weekdays.

Figure 21. Average power use of walk in fridges by weekday and weekend



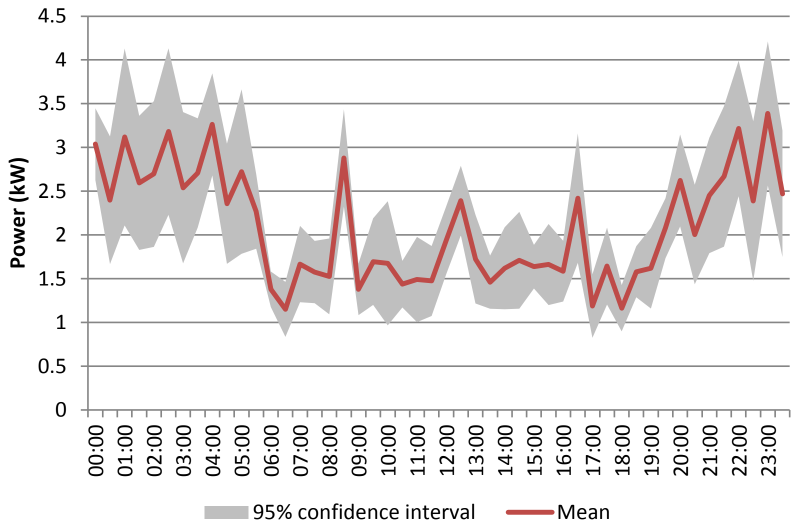
Source: Data collected for CLNR by Metasphere

Figure 22. Average power use of walk in fridges by season (ELEXON definition)



Source: Data collected for CLNR by Metasphere

Figure 23. Mean power profile for winter weekdays – 95% confidence interval



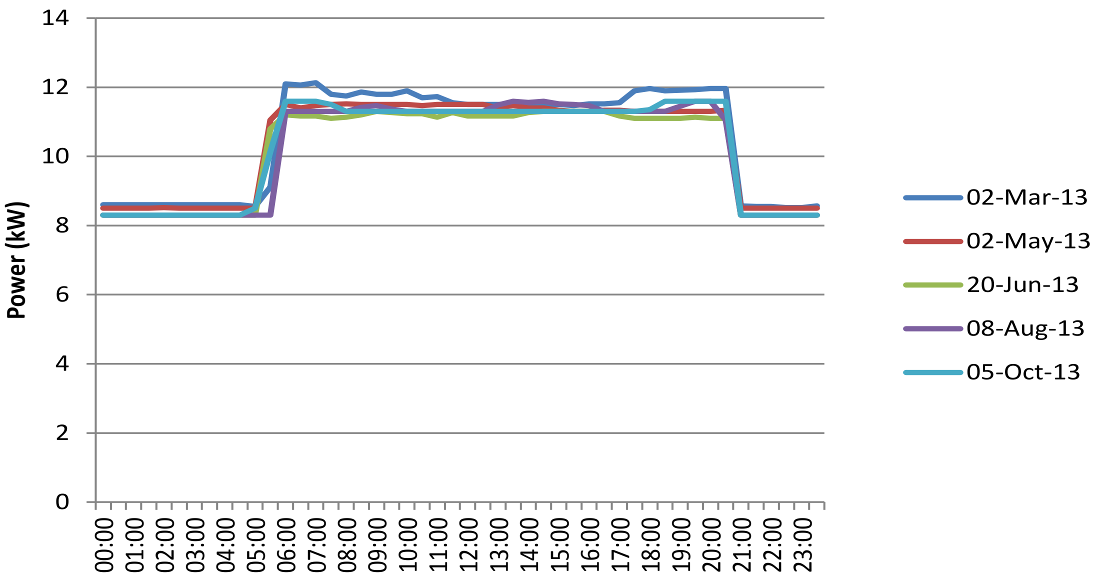
Source: Data collected for CLNR by Metasphere

3.1.2.6 SME 3 - Lighting (shop floor)

The following graphs show the lighting profiles for the same firm using the chillers and shop floor fridges.

- The picture in each of the following charts shows the consistent use of lighting throughout the working day, with somewhat lower power levels overnight. It is possible that the higher usage period corresponds to opening hours, while the rest of the day reflects times when the shop is empty. If this were the case, then significant energy savings could be made by turning off lighting at night– although this would be of less help to a DNO seeking to dynamically call DSR to avert network constraints.
- The power demand does not vary by day of the week or season.
- In one sense, the potential for DSR is high since demand is constant throughout the evening peak. This varies little during the winter period, as evidenced by the very small confidence interval around the mean
- However, the potential can only be realised if lighting can be reduced without impact on the retail experience for customers. The main benefits may therefore come by replacing older inefficient lighting systems to more energy efficient lighting.

Figure 24. Representative power use of lighting shop floor

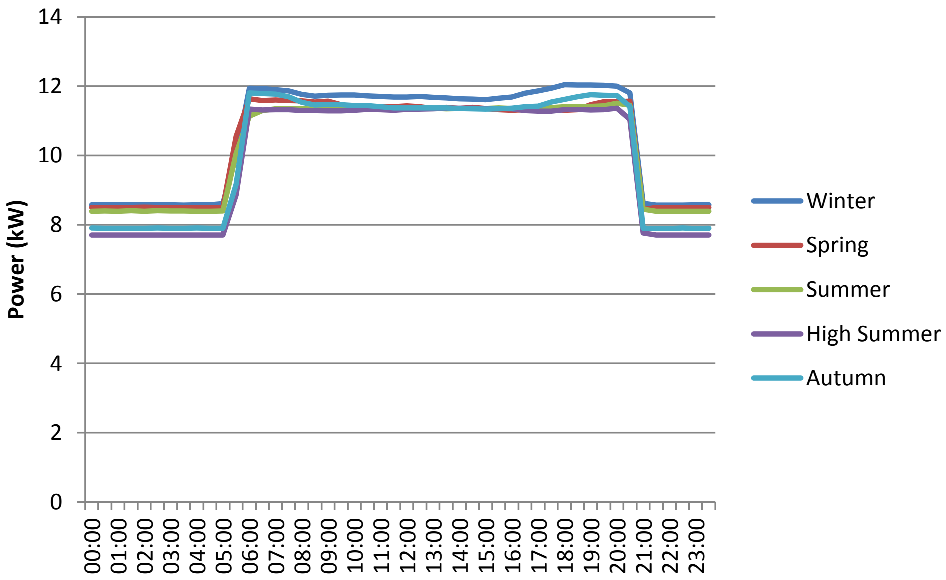


Source: Data collected for CLNR by Metasphere

Figure 25. Average power use of lighting shop floor by weekday and weekend

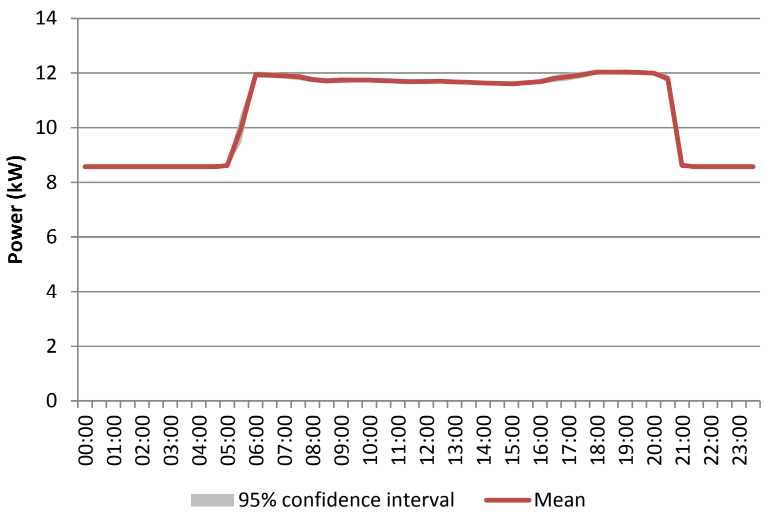
Source: Data collected for CLNR by Metasphere

Figure 26. Average power use of lighting shop floor by season (ELEXON definition)



Source: Data collected for CLNR by Metasphere

Figure 27. Mean power profile for winter weekdays – 95% confidence interval



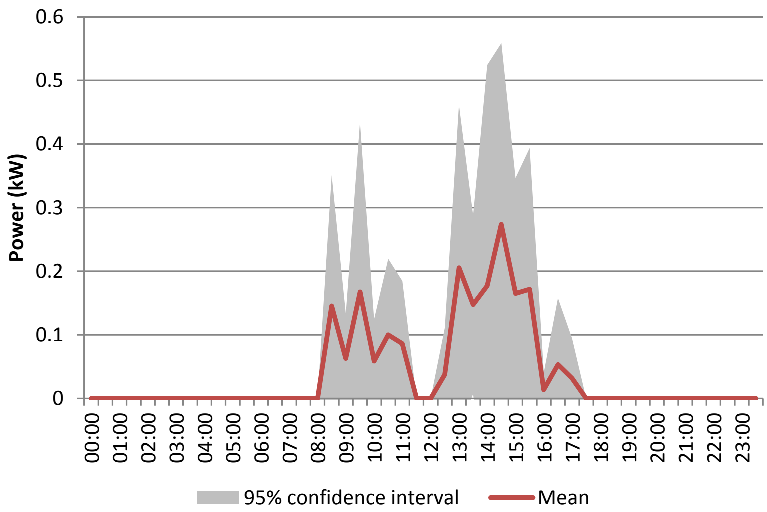
Source: Data collected for CLNR by Metasphere

3.1.2.7 SMEs 4 and 5

Previous insights from DEI have already highlighted some loads involve intermittent demand for high power, and these were found to be less fixed in time than lower power, day in day out processes and practices. In some instances, there may be some potential for these ‘high power’ practices to be flexible and therefore amenable to DSR interventions. However, for many businesses, it is likely that their usage of such appliances will be driven primarily by business needs.

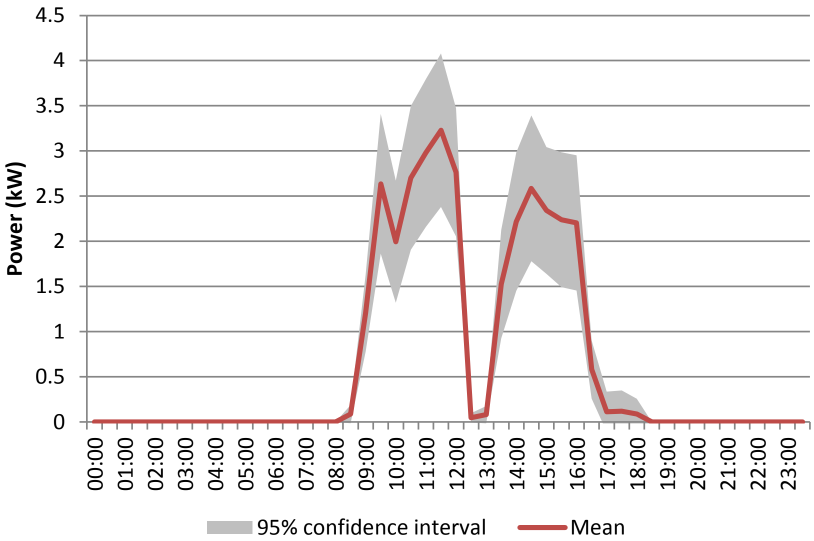
SMEs 4 and 5 both provide examples of this type of load. In the following examples the loads are generally focused during working hours, and the variability of when they will be used is high. However, they also usually fall outside of the evening peak periods suggesting their usefulness for DSR may be limited. The full results are contained in the annex, but the figures below illustrate these conclusions for a welder and a table saw.

Figure 28. Mean arc welder power profile for winter weekdays – 95% confidence interval



Source: Data collected for CLNR by Metasphere

Figure 29. Mean table saw power profile for winter weekdays – 95% confidence interval



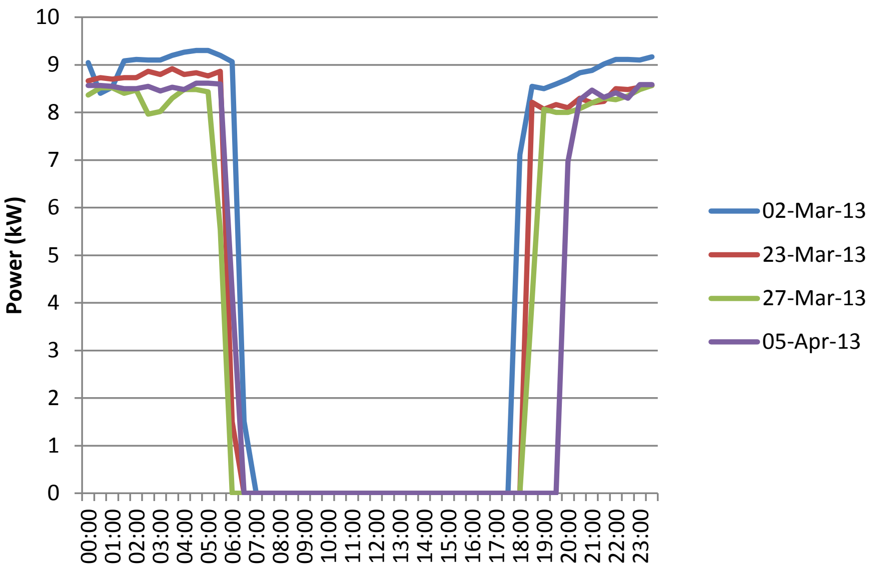
Source: Data collected for CLNR by Metasphere

3.1.2.8 SMEs 6 – swimming pool

SME 6 uses a heated swimming pool, the power usage of which is shown in the graphs below. The pool is heated between 5pm and 7am in winter, and 7pm and 5am in the summer. It then effectively retains its heat during the day (in essence acting as an extremely large storage tank).

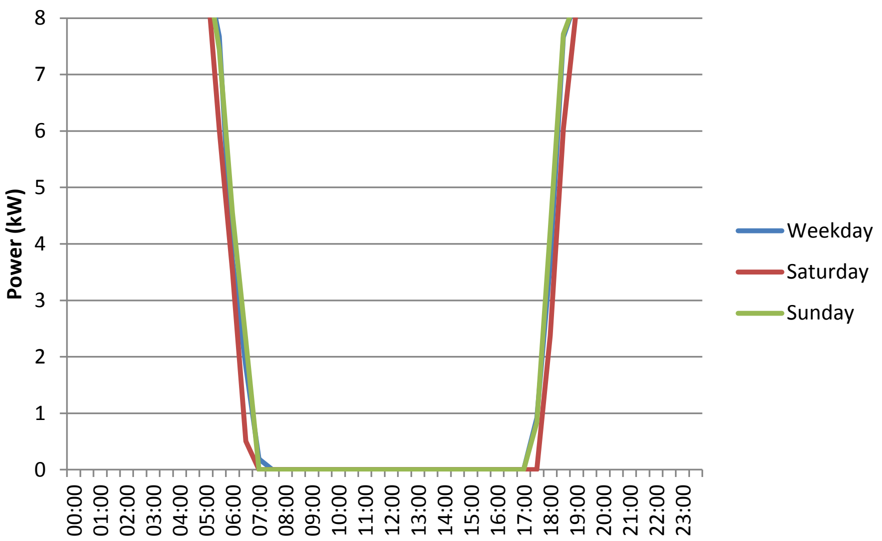
The chart below highlights the heating being turned on at 5pm in winter leading to a significant increase in demand during the evening peak period. Further, the low confidence interval highlights the high degree of certainty with which this increase in demand takes place during the winter. As a result there could be benefits if the heating of the pool could be delayed until after the evening peak.

Figure 30. Representative power use of swimming pool



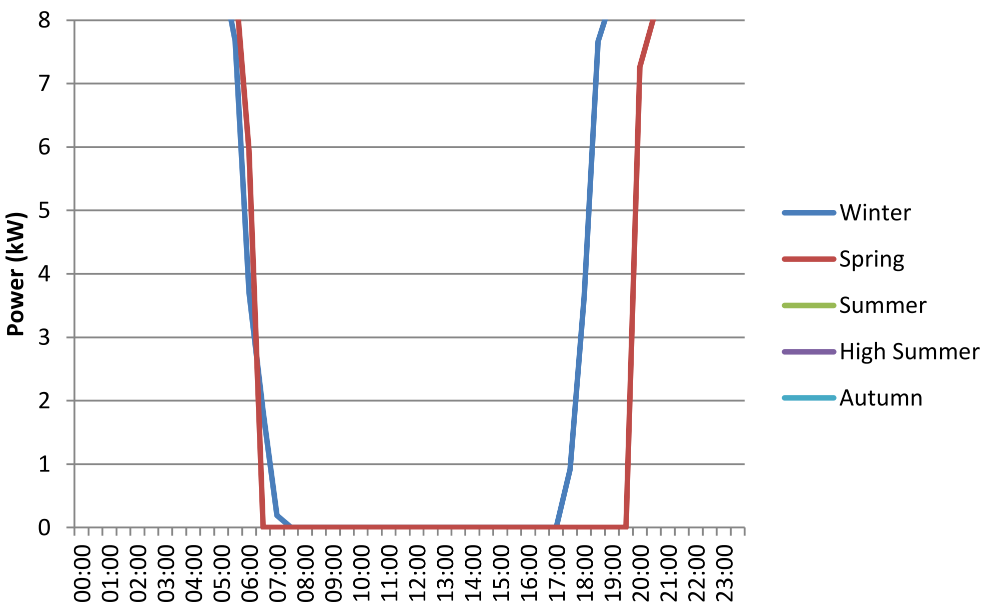
Source: Data collected for CLNR by Metasphere

Figure 31. Average power use of swimming pool by weekday and weekend



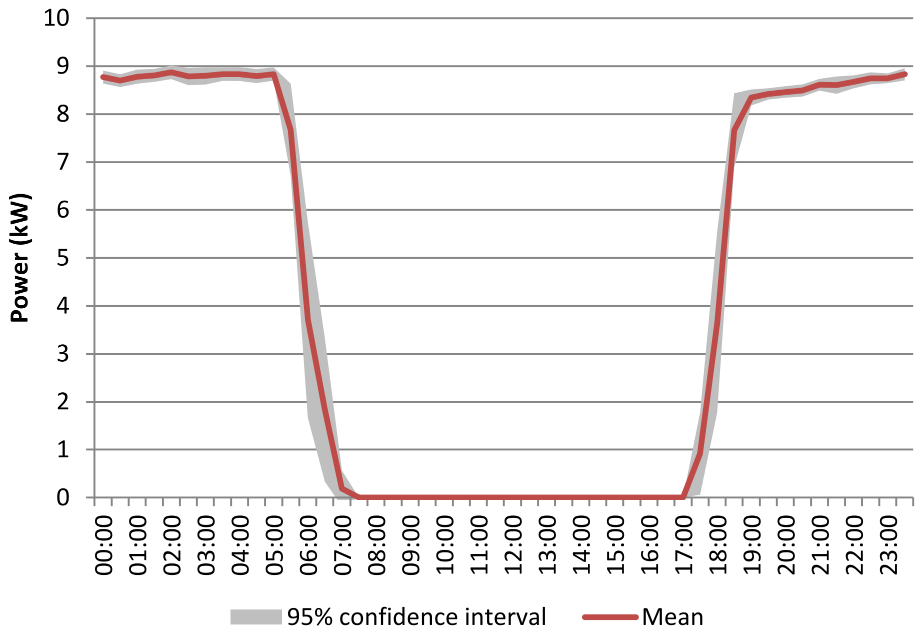
Source: Data collected for CLNR by Metasphere

Figure 32. Average power use of swimming pool by season



Source: Data collected for CLNR by Metasphere

Figure 33. Mean power profile for winter weekdays – 95% confidence interval



Source: Data collected for CLNR by Metasphere

3.2 Test cells 9b and 10b

These test cells examine the impact of DSR on SME daily demand profiles, in particular a TOU tariff and direct appliance control by a network operator.

3.2.1 Test cell 9b

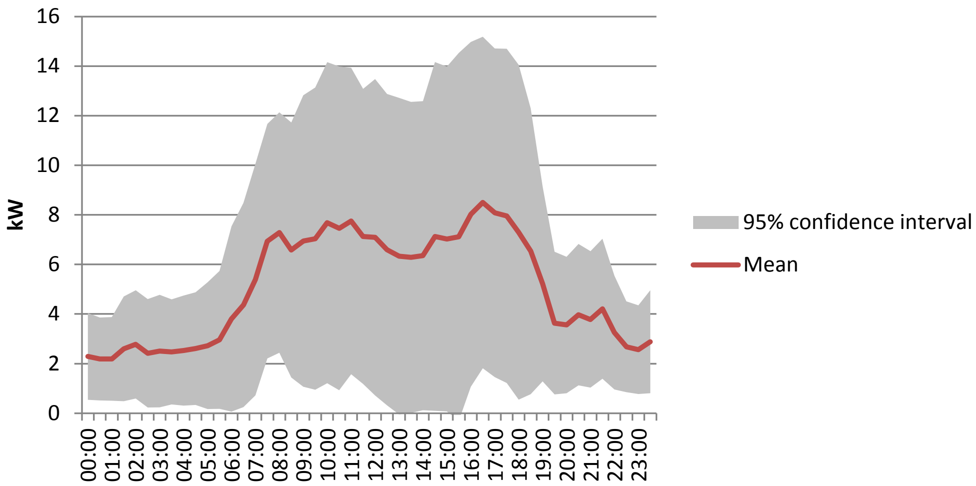
To examine the effect of the ToU tariff on the demand profile of a firm, we need to be able to compare:

- observations of the power consumed by the firm under the ToU tariff; and
- a control group showing what the firm would have done in the absence of the ToU tariff.

The control group could either include data from the same firms before or after the trial began, or for different, but similar, firms at the same time as the trial.

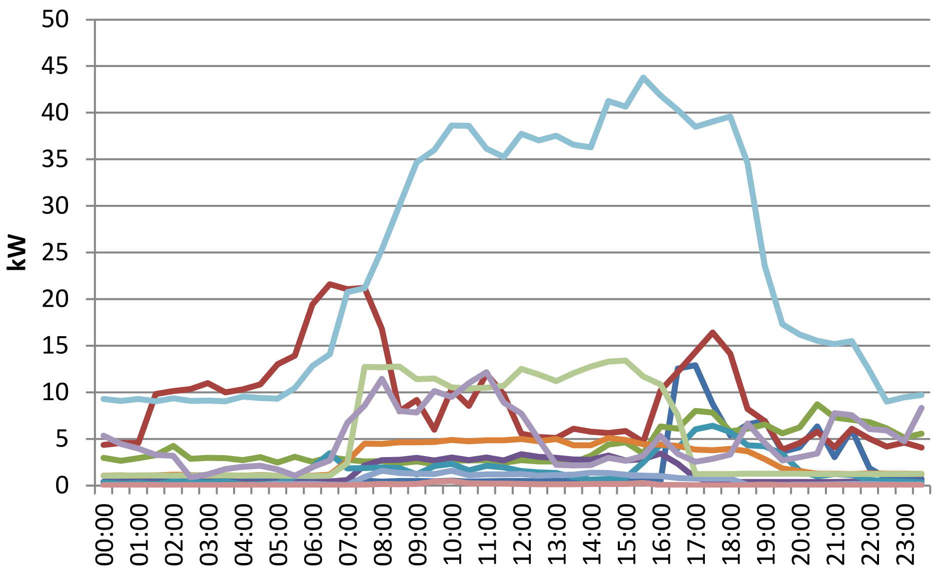
- **Control group with different firms** - We compare the aggregate load profiles observed in TC9b under the ToU tariff to those in either TC1b or TC2b, which didn't have a ToU tariff. However, given the heterogeneity of firms in terms of when they use energy (far more than households, who all generally have the same types of appliance) any differences in demand profiles may simply be due to different business processes the firms, rather than the TOU tariff. TC2b is therefore likely to be a poor control group for TC9b. We therefore do not pursue this option further although, for completeness, Figure 34 illustrates the mean and 95% confidence interval around this for TC9b on a winter day, while Figure 35 shows the profiles.

Figure 34: Mean and 95% confidence interval for TC9b profiles



Source: Data collected for CLNR by G4S

Figure 35: TC9b profiles for 13th November 2011



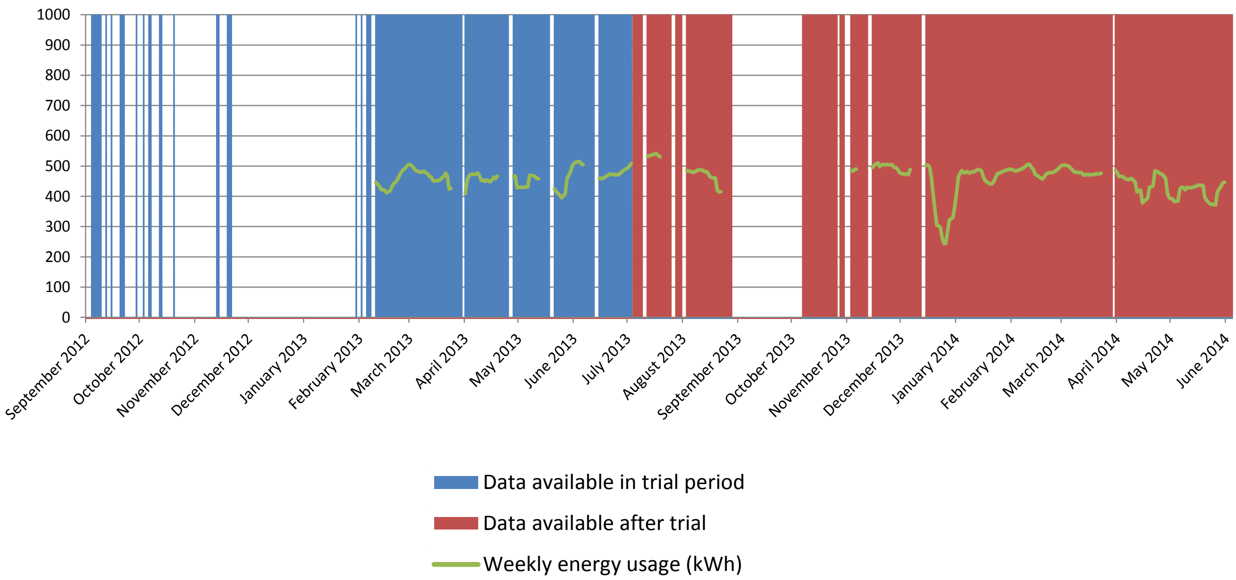
Source: Data collected for CLNR by G4S – each line represents an individual (anonymous) firm

- **Control group with the same firm** - For one firm in TC9b, we have data on usage during and after the trial. We can use the "after" data as a control, but need to bear in mind that this is only one firm, so their responses to the tariff will be very specific to their particular situation and will not necessarily be representative of all SMEs. We also need to be mindful of other influences on the firm's demand which have changed between the trial period and after. We pursue this case study further below.

Data is also available on the extent to which firms in TC9b lost out as a result of being on the trial tariff (this was logged so firms that did lose out could be compensated). Of the 24 firms for which this data is available, 11 gained under the trial tariff and 13 lost (the total amount refunded to the firms that lost out was just under £9,000). However, this does not provide any information regarding how customers responded to the tariff – those firms that won out may simply have had a load profile that was already concentrated in the cheaper periods of the day.

The graph below shows the availability of data for the one firm that was monitored both before and after the trial. It also shows the weekly energy usage over time. There does not appear to be a strong seasonal impact on overall electricity usage, giving us some comfort that any changes before and after the trial are less likely to be due to changes in the season. But we investigate this effect in more detail below.

Figure 36: data availability for a single SME during and after the trial



Source: Data collected for CLNR by Metasphere

To examine the impact on the daily demand profile we have compared a number of profiles during and after the trial. Differences in the shape of daily demand before and after the trial could indicate that the TOU of tariff has influenced the SME demand. However, it could also indicate other factors have changed. In the following section we have attempted to try and isolate the impact, if any, of the TOU tariff on the SME.

We first compared the average daily profiles for the whole period during and after the trial. This showed counterintuitively that during the trial, demand was reduced during the day peak, but increased (very slightly) during the super peak. We have therefore investigated whether changes in other demand drivers have dominated the impact of the tariff.

Therefore, we next compared the average daily profiles for the same winter period during and after the trial – by comparing the same period in the winter we can control for seasonality. However, this again showed the counterintuitive result of demand increasing in the super peak period. Other changes are therefore potentially important, for example, the SME may have changed its processes which decreased demand in the period after the trial.

Finally we compared the last 2 weeks of the trial and the first two weeks after the trial – by taking these two periods very close to each other, we can perhaps avoid the effects of any potential wider changes in the firms' business. In this comparison a reduction in demand throughout the day is apparent, but the largest reduction is during the day peak, rather than super peak. This again is a counterintuitive result suggesting that the TOU tariff is not the key driver of changes in demand.

We therefore conclude that based on the evidence of this case study, there is not sufficient evidence to suggest that the TOU tariff has had an effect on the daily demand profile of this firm. In the annex we have set out in more detail the charts underpinning this conclusion.

3.2.2 Test Cell 10b - Case study: effect of a restricted hours tariff on a refrigeration load

As described earlier, it was extremely challenging to obtain customer take-up of the restricted hours tariff used in TC10b. Ultimately, two customers signed up to this tariff.

- A hospitality business, where the interruptible load was a chiller unit in a beer cellar; and
- an office, where the interruptible load was an immersion heater (unfortunately, the data collected displayed irregularities that meant it could not be robustly analysed).

Both of these types of load involve thermal processes (cooling or heating) which store energy. Intuitively, they are therefore well suited to load interruption.

In the following sections, we briefly characterise the cellar chiller, and how effective the restricted hours tariff was. The restricted hours tariff switched off the chiller unit every day during the super peak hours (4pm – 8pm), unless the hospitality business chose to override this signal. In summary, the trial appears to have been successful in shifting load away from the network peak.

3.2.2.1 Characterisation of the appliance outside the trial period

The firm operates a beer cellar, which needs to be kept at a constant low temperature to ensure the optimal storage and presentation of beverages (the Cask Marque auditing scheme recommends that beers are dispensed at a temperature of between 11 and 13 degrees Celsius).[4] The business operates a chiller unit to perform this function, which was monitored (both before and after the trial) using the same metering technology as used for TC2b.

As shown in Figure 37, the daily energy consumption[5] of this unit has varied substantially over the year.

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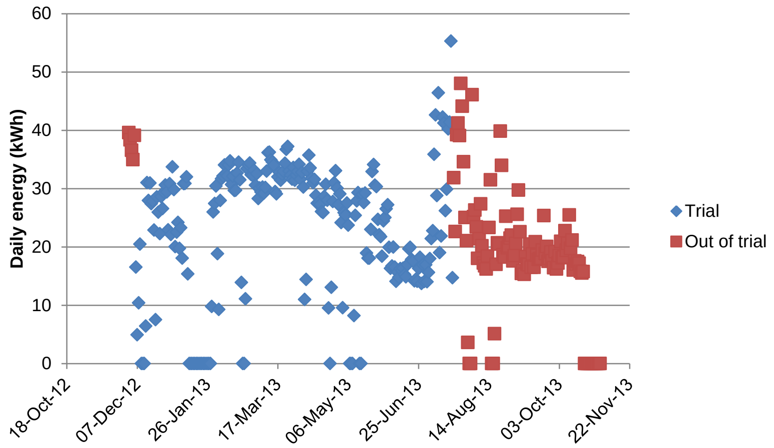
[4] http://cask-marque.co.uk/info-for-pubs/beer-temperature/

[5] Peak power consumption would be a more appropriate metric for a DNO. However, the DSR trial will have significantly affected this, making it difficult to disentangle seasonal trends. Overall energy consumption is likely to have been affected less by the DSR trial.

Figure 37 Daily energy consumption of cellar chiller over time

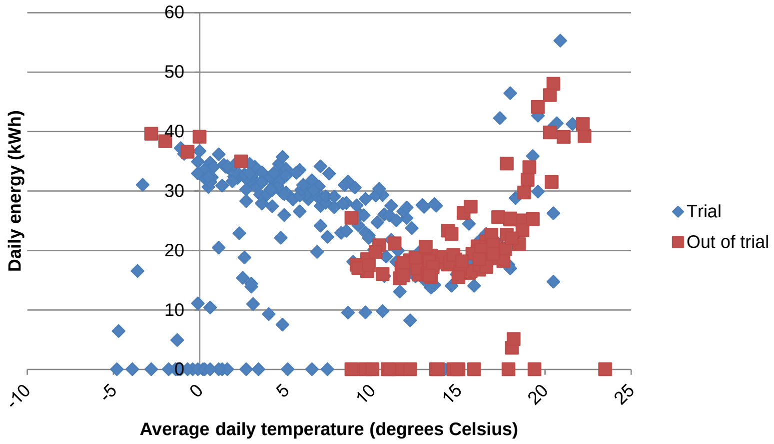


Source: Data collected for CLNR by Metasphere

The spike in consumption occurred during the summer where, intuitively, energy consumption for cooling purposes would be highest. Figure 38 examines the relationship between the energy consumption of the chiller unit and ambient external temperatures (measured as average UK daily temperatures).[6]

[6] Based on data from the European Climate Assessment and Dataset data (http://www.ecad.eu/), taken for Central England

Figure 38 Relationship between cellar chiller energy consumption and ambient temperature

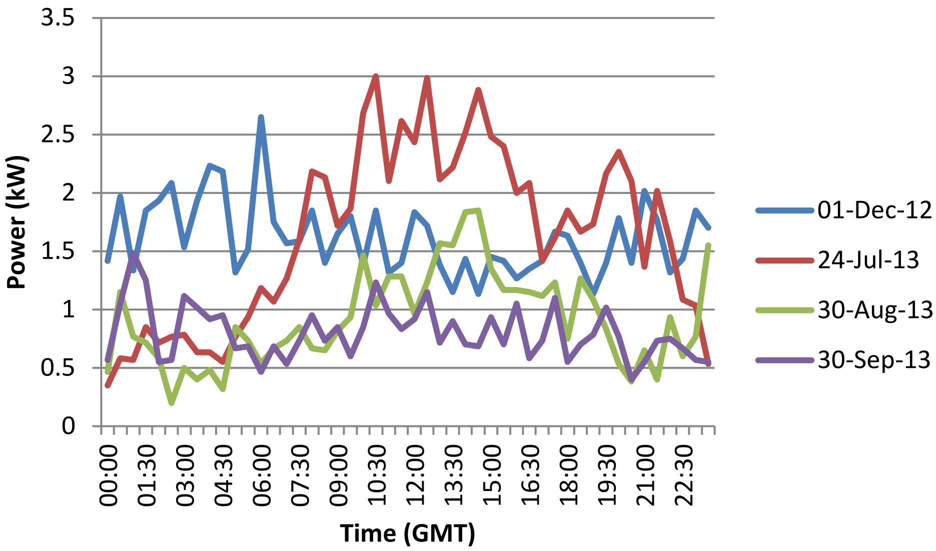


Source: Data collected for CLNR by Metasphere

The relationship between temperature and energy consumption is clear, and is driving much of the seasonal variation. For temperatures above approximately 15 degrees Celsius, energy consumption rises rapidly with temperature (from approximately 15kWh to 55kWh). Below this temperature, decreasing temperatures appear to be associated with a rise in power consumption. It is plausible that the "chiller" unit may also be acting as a heater when ambient temperatures fall below the optimal range of 11 to 13 degrees Celsius.

The figure below shows a random selection of typical half-hourly load profiles for the cellar chiller. Typical for a refrigeration load, the power cycles rapidly throughout the day. Power requirements increase during hot summer days, but remain relatively constant through the day in the winter.

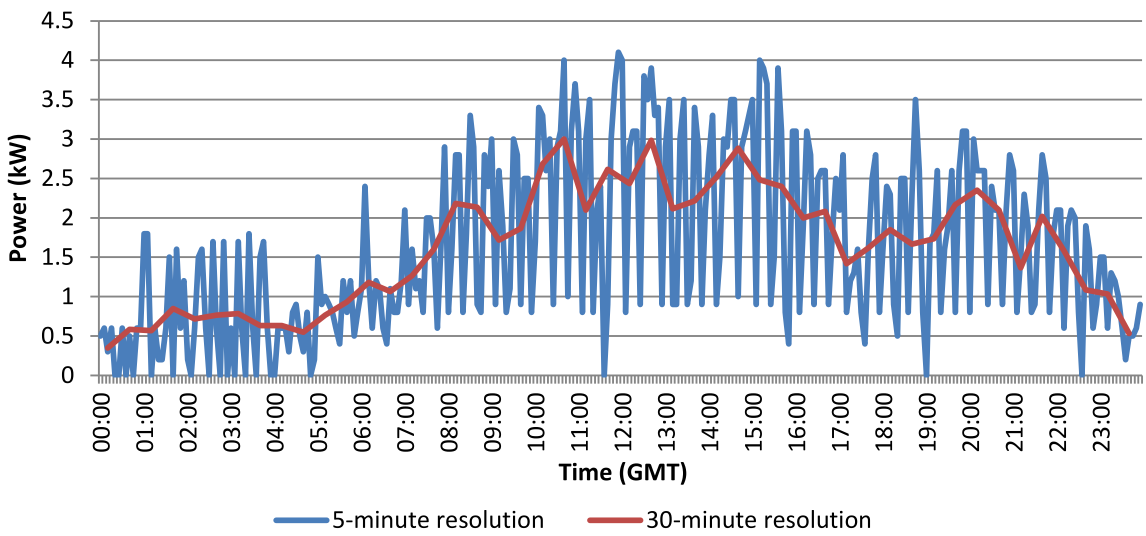
Figure 39 Example load profiles for the cellar chiller



Source: Data collected for CLNR by Metasphere

Although these load profiles are displayed on a half-hourly basis, the meter is capable of monitoring every five minutes. The figure below shows the five-minute version of the load profile for 24th July 2013. It can be seen how the unit modulates between a small number of pre-set power levels.

Figure 40. 5-minute load profile for the cellar chiller



Source: Data collected for CLNR by Metasphere

3.2.2.2 Effect of the trial

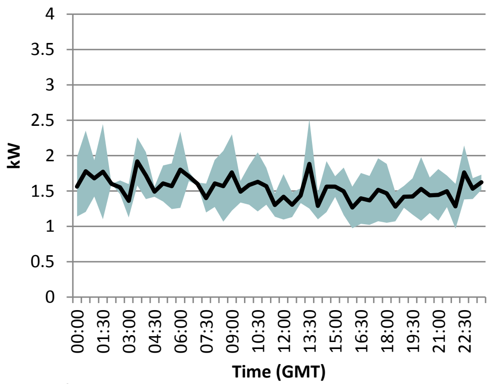
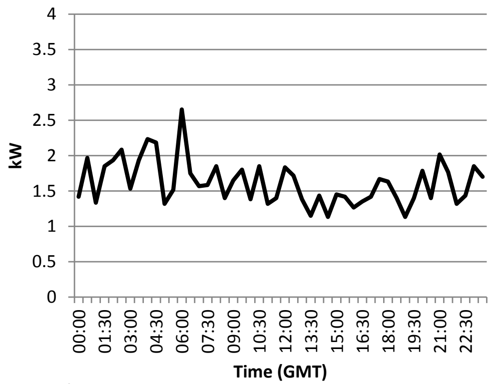
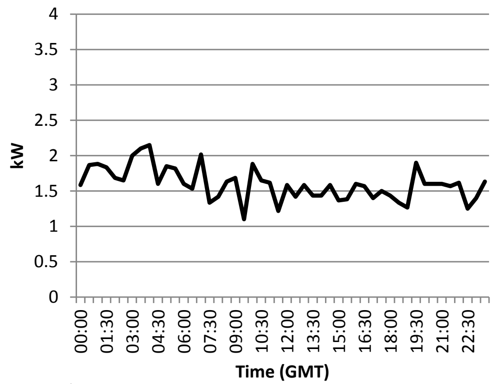
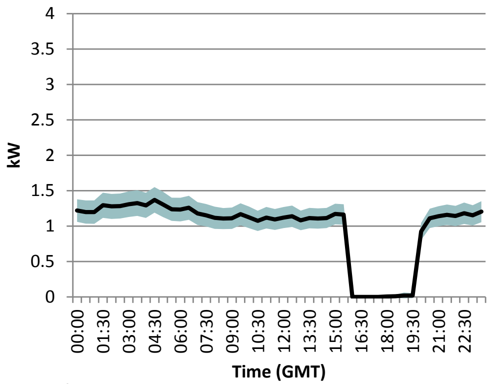
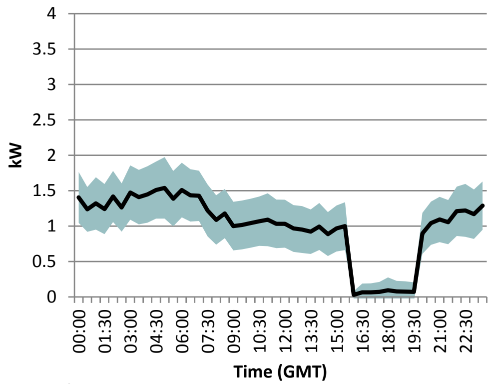
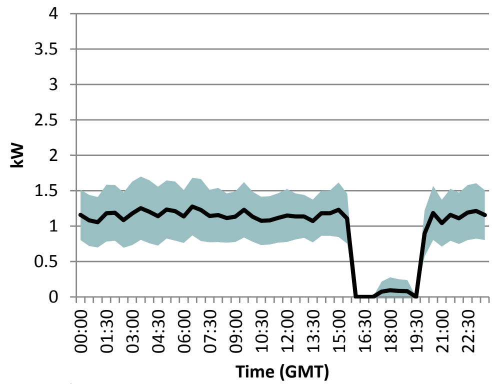
For the purposes of the trial, the cellar chiller was connected to a timer which would disconnect it between the hours of 4pm and 8pm.[7] The owner of the business expressed a concern that the trial could lead to product spoilage. As a result, an override function was built in that the business owner could control.

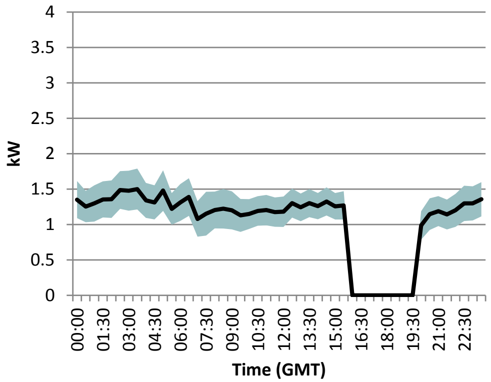
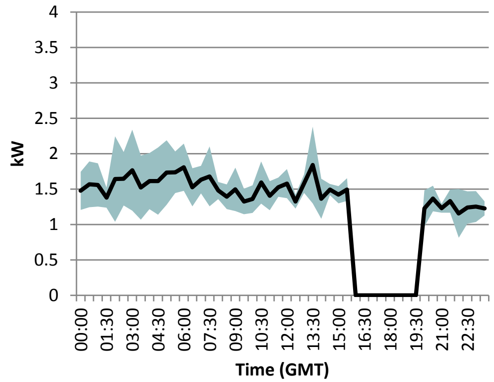
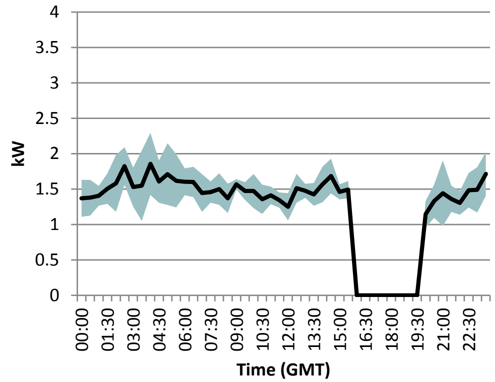
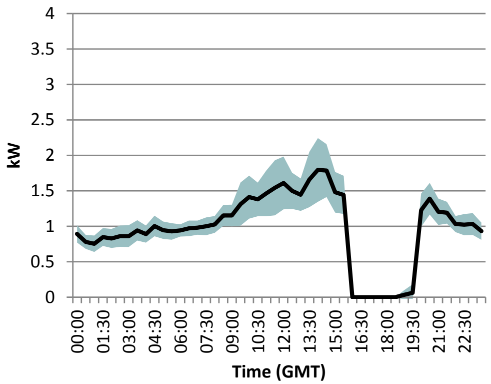
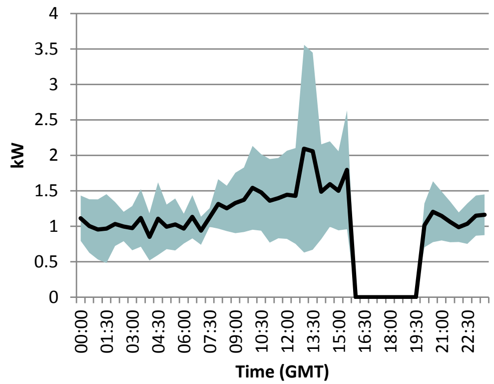
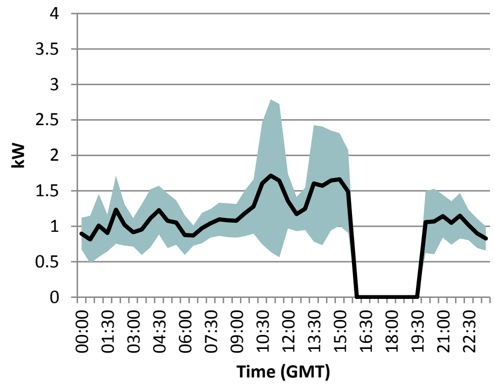
The trial was in effect from 6th December 2012 to 19th July 2013. The graphs below show average (mean and 95% confidence interval[8]) load profiles for the chiller, by:

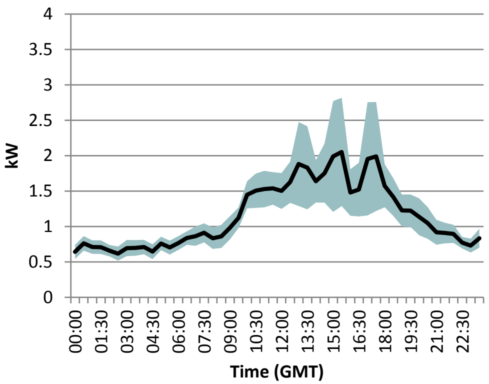
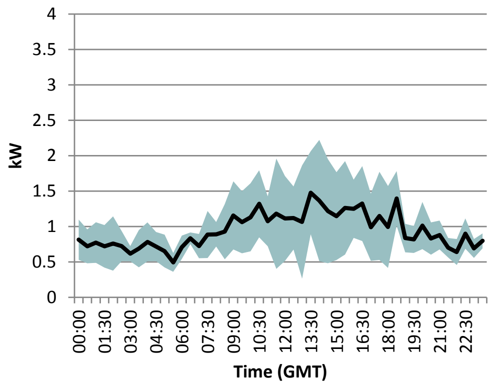
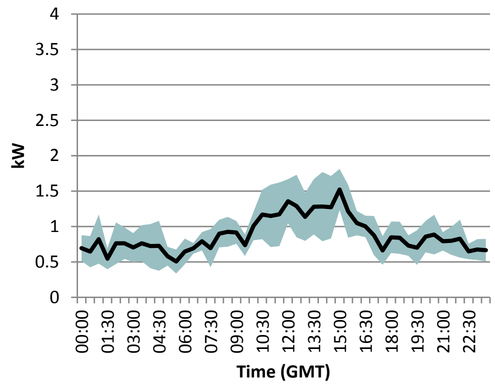
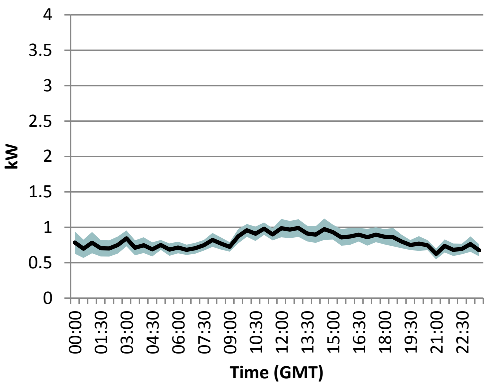
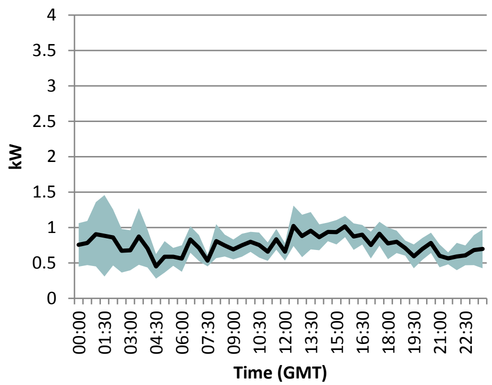
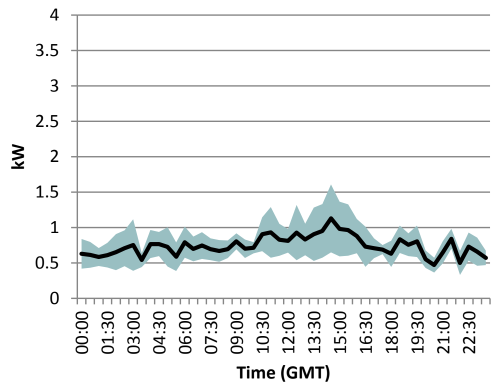
- season (as defined by ELEXON);
- day type (weekday, Saturday or Sunday); and
- whether the trial was active.

[7] This was intended to adjust for daylight savings. However, analysis of the data shows that the timer continued to function on GMT after the switch to BST. We have therefore carried out all our analysis on a GMT basis, to avoid the complication of the timed "peak" period changing midway through the trial. This is in contrast to the other analysis within this document, where times are shown as GMT or BST according to the prevailing civil time when the measurements were taken.

[8] Confidence intervals cannot be drawn for some winter days, since only one day worth of data is available.

	Weekday	Saturday	Sunday
Winter, no trial	 Sample of 3 days	 Sample of 1 days	 Sample of 1 days
Winter, trial	 Sample of 79 days	 Sample of 17 days	 Sample of 16 days

	Weekday	Saturday	Sunday
Spring, trial	 Sample of 27 days	 Sample of 4 days	 Sample of 6 days
Summer, trial	 Sample of 48 days	 Sample of 10 days	 Sample of 10 days

	Weekday	Saturday	Sunday
High Summer, no trial	 Sample of 27 days	 Sample of 5 days	 Sample of 6 days
Autumn, no trial	 Sample of 35 days	 Sample of 7 days	 Sample of 7 days

It is evident from the profiles above that the DSR generally worked: load during the 4pm-8pm window is almost always zero (as shown by the narrow confidence intervals). Closer examination of the data reveals that there were only three occasions on which the business owner used the override and ran the chiller. Two of these occurred within the first week, and one on the final day. They could therefore represent technical issues in setting up the timer. Absolutely no usage of the chiller occurred in the intervening 214 days, despite the increasing temperatures in summer. Although we can't be sure of the temperature of the beer, this is evidence that the owner was satisfied with the temperatures achieved.

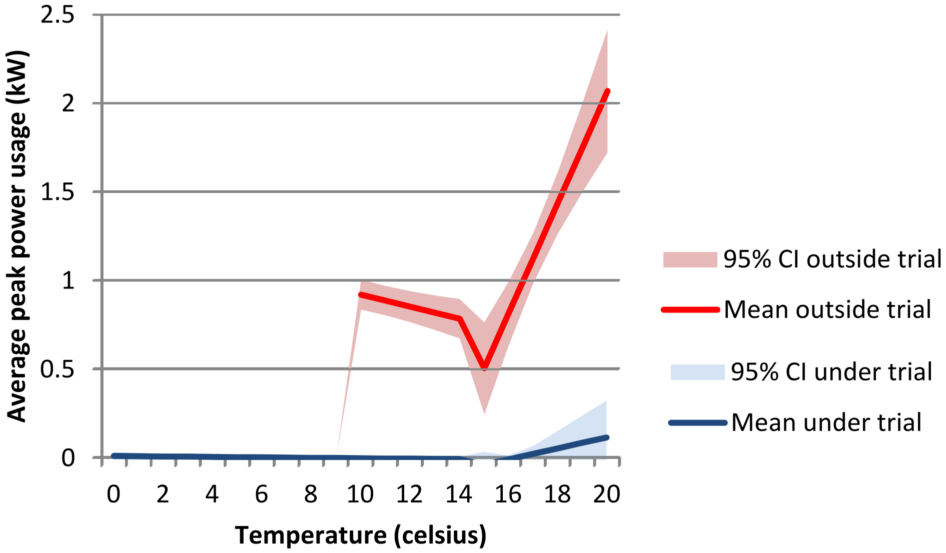
It is evident from the graphs above that the restricted hours DSR was successful in reducing load during the peak window.

To explore the effect of the trial in more detail (taking into account the fact that power usage changes over time due to fluctuations in temperature), basic regression analysis was used. To capture the basic relationship shown in Figure 38, daily average power usage was modelled as depending on temperature, with a multiplicative dummy variable for temperatures of 15 degrees or above used to enable the non-linear nature of the relationship between temperature and power. A further multiplicative dummy variable was included for whether the trial was taking place. Following estimation of the model parameters, predicted power usage (and a 95% confidence interval) could be estimated for any temperature, whether within or outside the trial period.

Figure 41 shows the result of this analysis for average power usage within the peak window (4pm-8pm). Outside the trial, average power usage follows the non-linear pattern observed in Figure 38.[9] Within the trial, power usage is predicted as being zero for virtually any temperature. Although the predicted power usage increases as the temperature rises above 16 degrees, this is simply the result of the one DSR override occurring the day before the trial finished, which happens to have been a summer day.

[9] The predictions have not been shown for low temperatures, since there was only a very limited number of non-trial days with such temperatures.

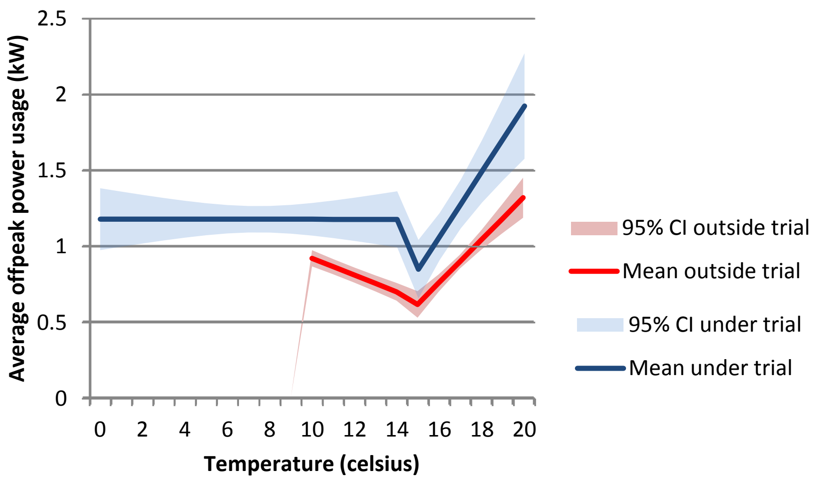
Figure 41. Predicted power usage during peak window



Source: Data collected for CLNR by Metasphere

Figure 42 shows this analysis for the remaining hours of the day. The relationship between power and temperature is once again as expected. However, once we restrict the temperature in this way, there is a clear tendency for non-peak power consumption to be higher under the trial. This is consistent with a DSR "payback" (i.e. load is only deferred, rather than entirely removed). However, as shown in the average load profiles in the table above, there is clearly no sudden spike in energy usage after the cooler turns back on. Therefore, any payback is unlikely to produce additional network problems.

Figure 42. Predicted power usage during off-peak window



Source: Data collected for CLNR by Metasphere

4 Conclusions

The insights from these test cells have supported Learning Outcomes 1 and 2, by building on previous learning from the baseline in TC1b, about SME demand profiles in a number of areas. Specifically, we have:

- examined in detail the load profile for a set of SME appliances, and qualitatively assessed their potential to provide flexibility to network owners;
- developed learning about the difficulties in recruiting for DSR trials with restricted use; and,
- finally, through two case studies, investigated the impact of a TOU tariff and a restricted hours direct control tariff on the shape of consumer demand.

4.1.1 Appliance profiles and DSR potential

The overall load profiles for SMEs (as seen in **Figure 2.** Average winter weekday profile for firms in TC2b

for TC2b) tends to decrease just as the evening peak starts. All else being equal, this may reduce the usefulness of SME DSR to DNOs, however:

- SMEs still account for a considerable absolute value of peak-time power consumption;
- they are highly hetrogenous – some SMEs will have load profiles which reflect the needs of DNOs well; and
- even for SMEs where this is not the case, there are other applications of DSR (for example, for use by suppliers to reduce wholesale costs, or by the TSO to balance the system) where peak-time reduction is not required.

SMEs therefore represent a substantial resource for DSR. However, the sheer heterogeneity of these firms[10] means it will be necessary to examine the individual types of load that SMEs have.

Based on previous findings in the literature, the appliances that are most amenable to providing flexibility are those where interruptions have the least impact on business operations. This is likely to be appliances such as space cooling, heating and refrigeration, where thermal inertia means that the effects of transitory decreases in power usage will not be significant.

TC2a looked in detail at the appliances of 6 SMEs to investigate whether their usage of any of their main appliances suggests there is potential to provide DSR. The table below summarises these findings.

[10] This heterogeneity also means it is extremely difficult to assess the success of the TC9b trial, as described above.

Table 4: Conclusions from the appliance analysis in test 2b

Technology	Appliance	Conclusion
SME 1	Heating	Storage heaters are potentially a good source of DSR. In this case study the heater typically ran through the night and was consistently on during the super peak period in winter.
SME 2	Air-conditioning	The air-conditioning unit examined as part of this case study could in theory be flexible, however its peak usage was not well correlated with winter system peaks. Instead it may provide value in managing network summer peaks (this is a particular issue in London, where the annual peak demand on some networks is already occurring in the summer due to air conditioning load).
SME 3	Chillers	Chillers and fridges in this case study, which is likely to be a retail business, were typically using most power on a consistent basis throughout the day including the evening peak period. Small adjustments to power demand potentially could be achieved if product quality can be assured.
	Fridge/freezers	
	Lighting – shop floor	In this case, lighting was an extremely consistent demand throughout the day and across all week days and weekends. Lighting is therefore a crucial service during their hours of operation which could have potential for flexibility should small amounts of dimming be imperceptible to the SME customers, or if inefficient lighting systems can be replaced with more efficient systems. The observed load profile in the case study considered here is potentially indicative of significant amounts of lighting been used when the premises are closed. If this is the case for many such businesses, it suggests that there may be overall power consumption gains to be made from the implementation of more efficient lighting schemes.
SME 4	Welder	Earlier analysis from DEI has highlighted the potential for DSR from infrequent high powered loads. Intuitively they could be more flexible in terms of their hours of operation and therefore be used less in the peak period when required by the network operator. However, some of these processes may be business-critical and not amenable to peak shifting – the overall effect probably differs substantially by business. The evidence from these case studies however showed their usage was unlikely to coincide with the evening peak period removing their value to the network operator.
	Grinder, furnace and pillar drill (appliances are on a single circuit and therefore cannot be distinguished)	
SME 5	Edging machine	
	Extractor plant	
	Table Saw	
SME 6	Swimming pool	A swimming pool intuitively acts much like a storage heater so could have potential to provide flexibility. The evidence showed it to be a very consistent demand profile through the night, ramping up during the evening peak period. This suggests there may be scope to delay switching on the heater if the temperature during

		the day is unaffected.

The analysis does highlight the potential of some appliances to provide flexibility to DSR owners. A number of circuits examined highlighted strong matching of usage with system peaks. However, the most promising appliances are likely to be those that have a storage capability such as fridges, heaters and also a swimming pool. Other demands are high in the system peak, but may be harder to adjust without an impact on the business activities.

Overall, this suggests that parties wishing to procure DSR may find it most effective to offer a “menu” of DSR contracts to reflect features of the diversity of loads available from SME customers.

TOU tariffs and direct control

Identifying the impact of a TOU tariff on the demand profile for an SME requires a comparison with a control demand profile. In this paper we have compared the consumption of a SME during the TC9b trial with its consumption once the trial had ended. We conducted a number of pieces of analysis attempting to isolate the impact of the TOU tariff on demand. However, on the basis of this case study we could not conclude that the tariff had any impact on the consumption of the firm. This result is specific to this participating firm. It does not mean that TOU tariffs will not work in the SME sector. Given the heterogeneity of firms in the sector, it suggests that more work is needed to investigate which type of SME would be most suited to TOU tariffs.

It was extremely challenging to recruit for test cell 10b, which ultimately meant only two SMEs participated (with data only available on one). There were a range of issues highlighted, however the principal concern focused the risk that a potential electrical interruption could have on their business operations. For example, the power demand for many businesses is driven by the service requirements of customers, and so cannot be flexible. For others there were concerns about still meeting standards set down in regulation. These concerns not only highlight the problems that need to be overcome in the SME sector before DSR can be widely deployed. First, there may only be a small subset of SMEs that is suitable. Even then, there are problems identifying and engaging with them. However, the example in this report shows that it can be a success.

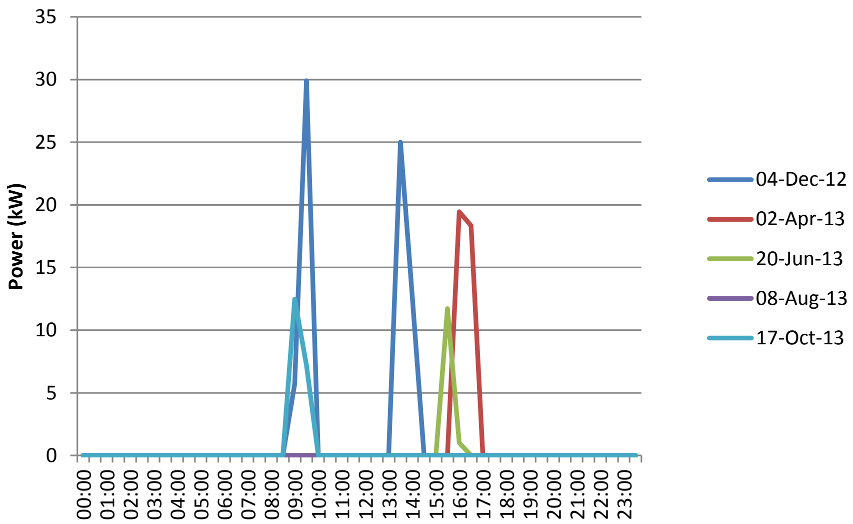
In the case study of the hospitality business, they were only willing to participate if they were provided with an override function of the direct control signal. This may be a necessary requirement widespread rollout of DSR contracts in the SME sector. Based on the evidence from the single case study presented in this paper, despite having the override it was only used on extremely rare occasions. The regular demand reduction during the super peak period therefore appears not to have had any adverse impact on the service level provided by the beer chiller. This is therefore one example of the type of specialised contract that suppliers or DNOs may wish to offer to SMEs.

5 Annexe of potentially low DSR potential appliances

As explained in section 3.1.2 a number of other appliance were monitored, which are industrial and may have less potential for DSR. This annex display typical and average load profiles for these appliances.

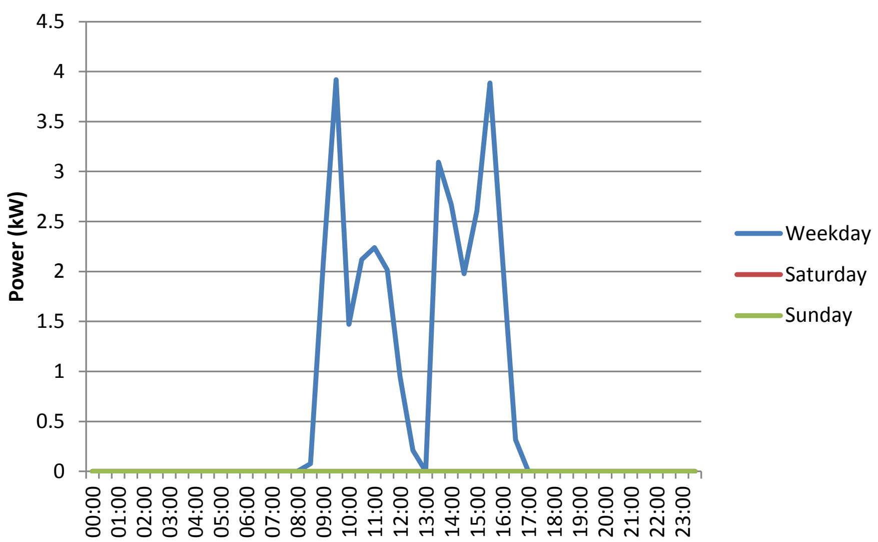
5.1.1 Edging machine

Figure 43. Representative power use of edging machine



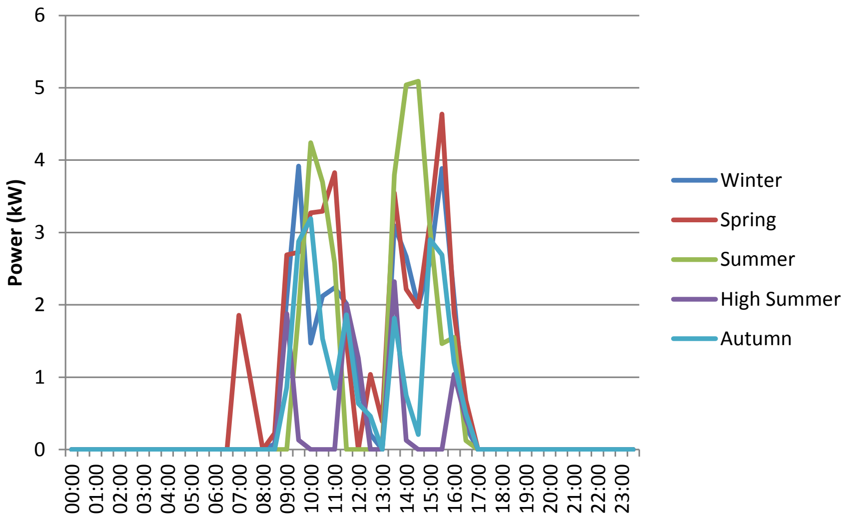
Source: Data collected for CLNR by Metasphere

Figure 44. Average power use of edging machine by weekday and weekend



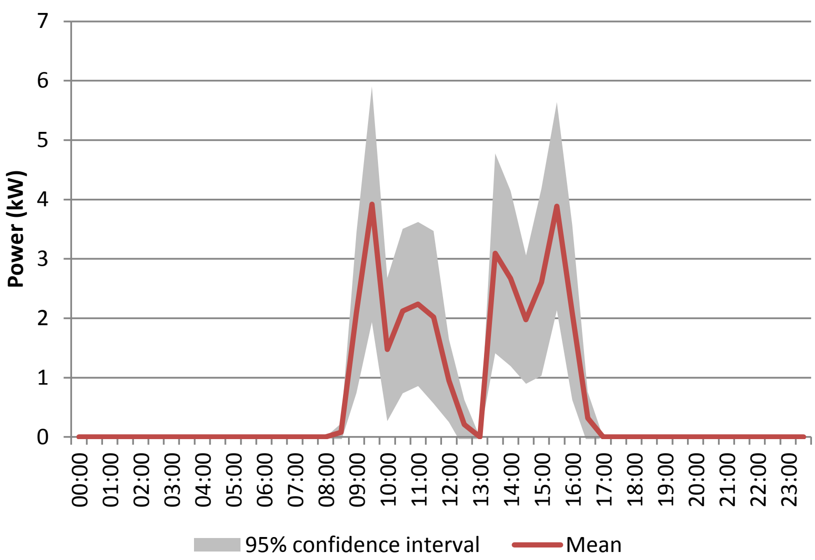
Source: Data collected for CLNR by Metasphere

Figure 45. Average power use of edging machine by season



Source: Data collected for CLNR by Metasphere

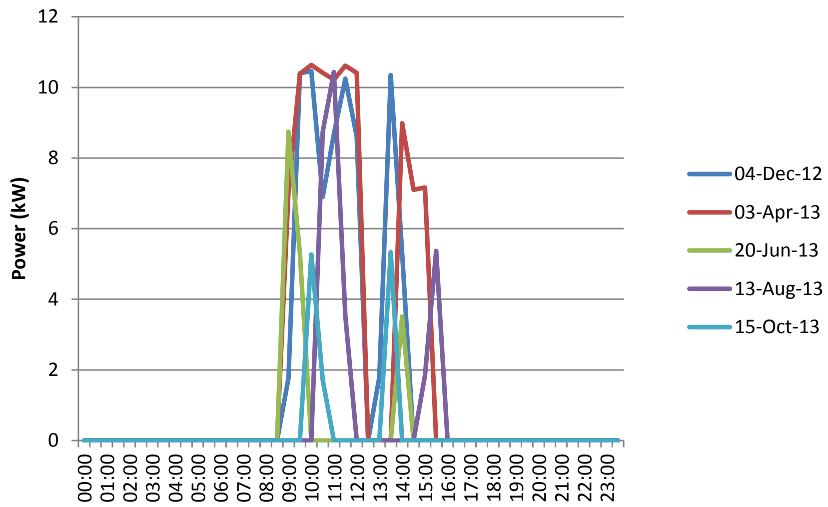
Figure 46. Mean power profile for winter weekdays – 95% confidence interval



Source: Data collected for CLNR by Metasphere

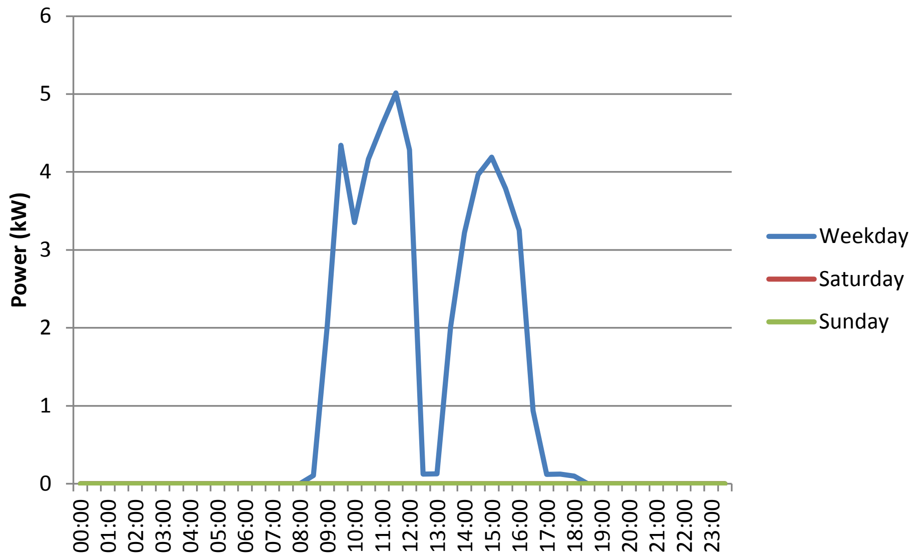
5.1.2 Extractor plant

Figure 47. Representative power use of extractor plant



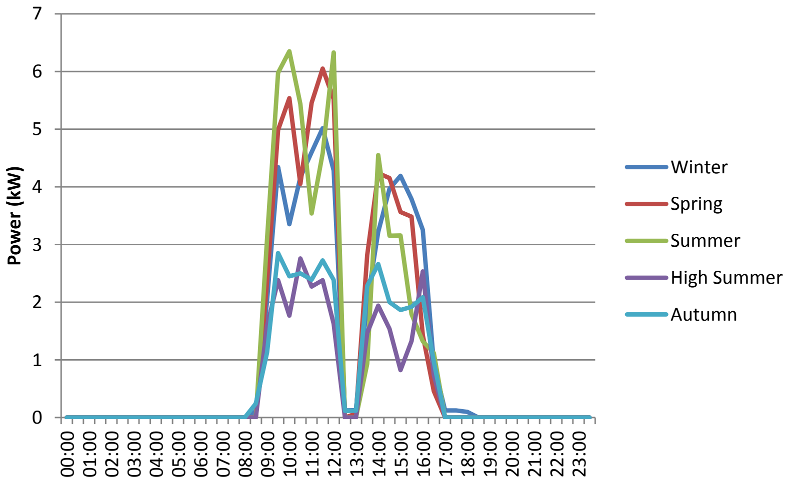
Source: Data collected for CLNR by Metasphere

Figure 48. Average power use of extractor plant by weekday and weekend



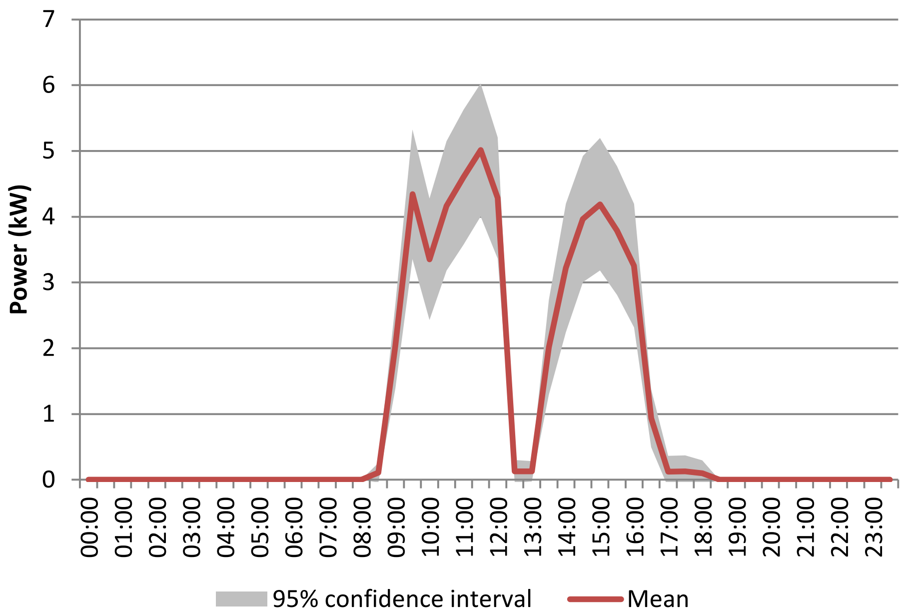
Source: Data collected for CLNR by Metasphere

Figure 49. Average power use of extractor plant by season



Source: Data collected for CLNR by Metasphere

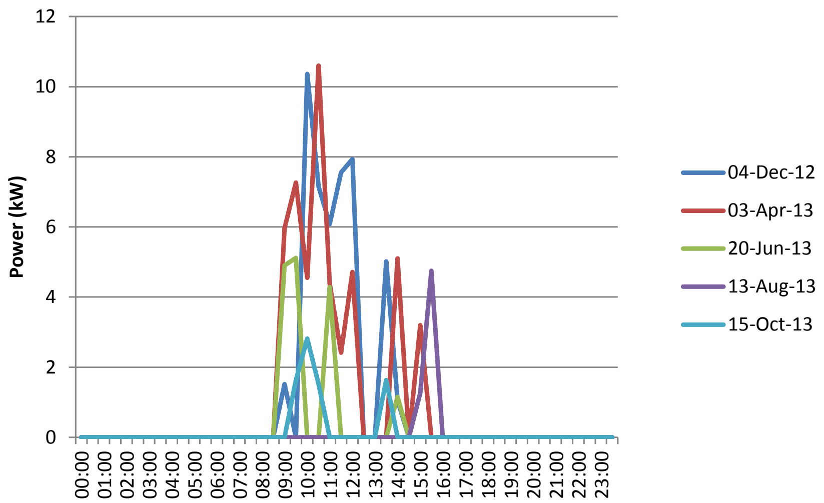
Figure 50. Mean power profile for winter weekdays – 95% confidence interval



Source: Data collected for CLNR by Metasphere

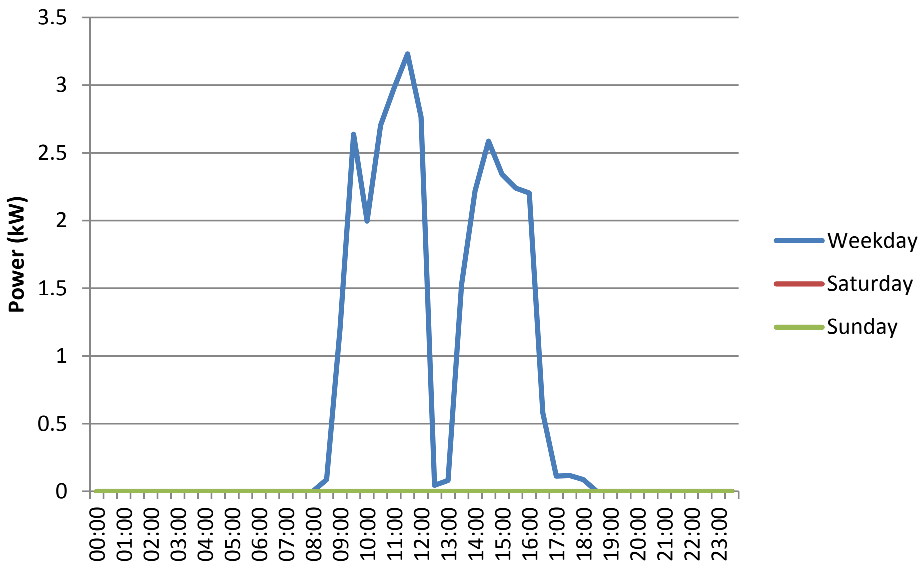
5.1.3 Table saw

Figure 51. Representative power use of table saw



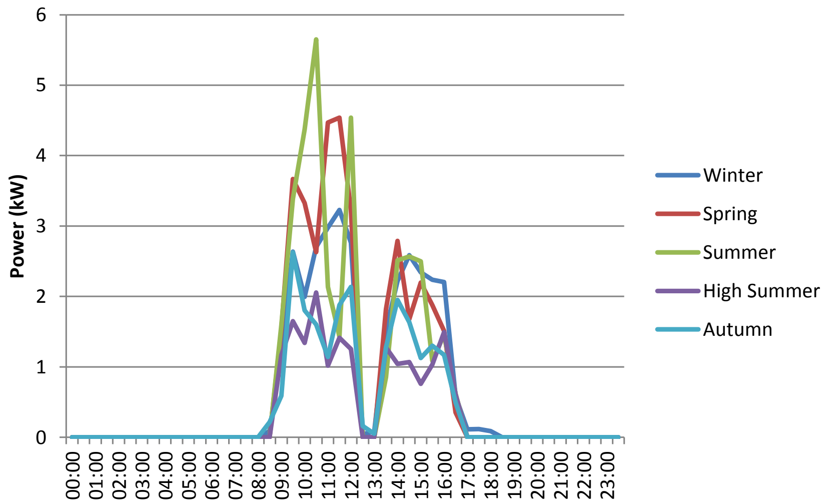
Source: Data collected for CLNR by Metasphere

Figure 52. Average power use of table saw by weekday and weekend



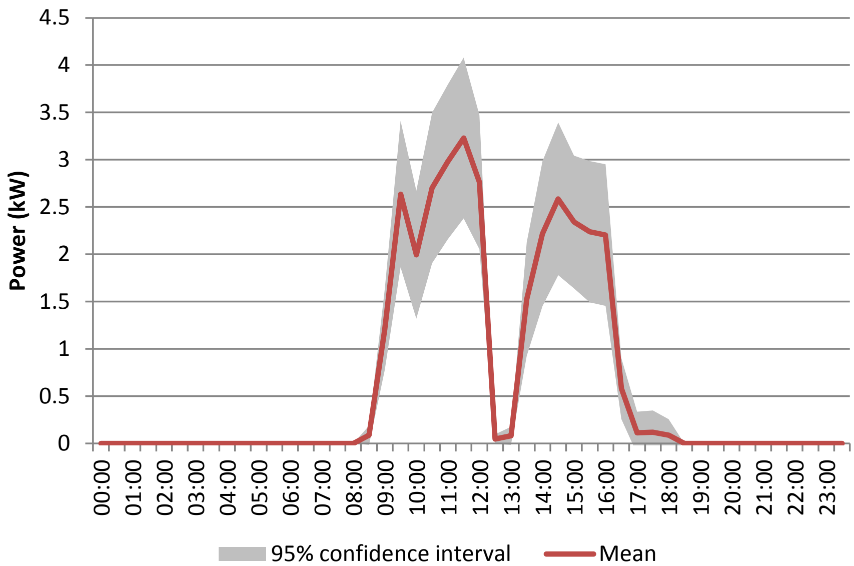
Source: Data collected for CLNR by Metasphere

Figure 53. Average power use of table saw by season



Source: Data collected for CLNR by Metasphere

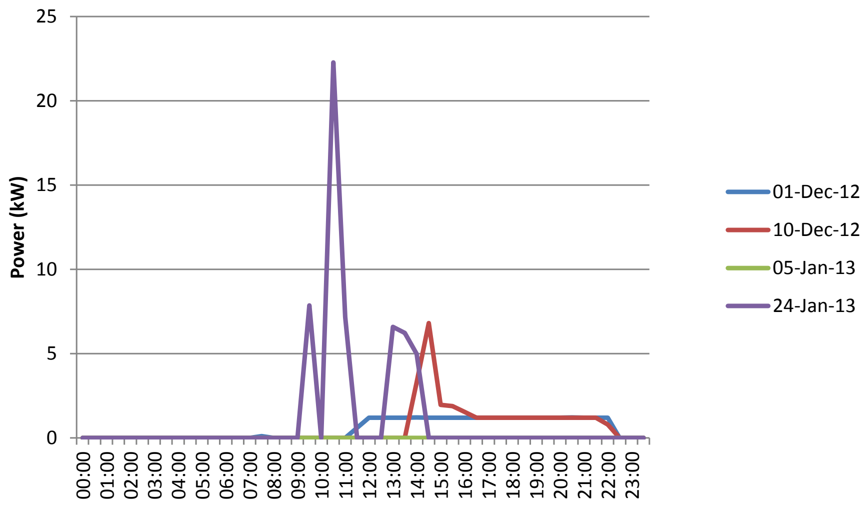
Figure 54. Mean power profile for winter weekdays – 95% confidence interval



Source: Data collected for CLNR by Metasphere

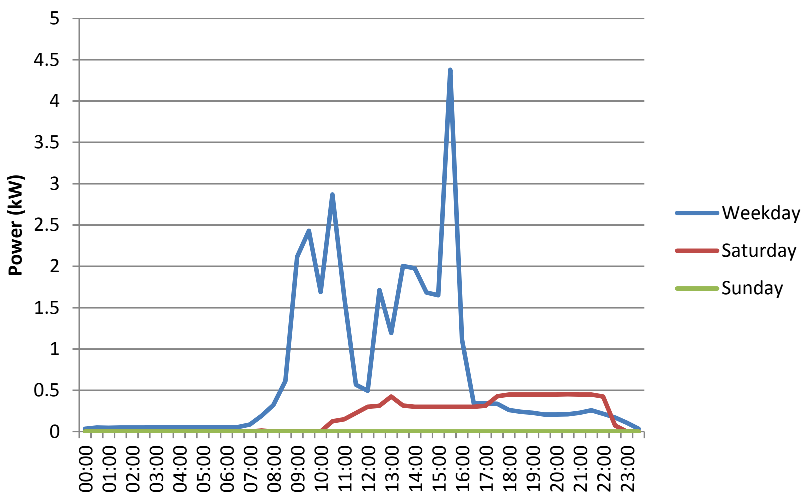
5.1.4 Grinder / furnace / drill

Figure 55. Representative power use of grinder furnace drill



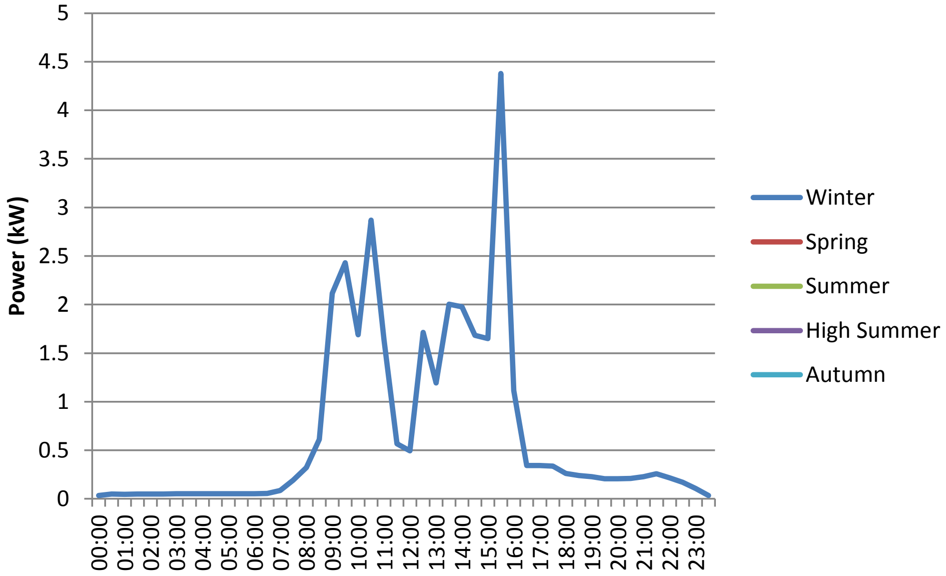
Source: Data collected for CLNR by Metasphere

Figure 56. Average power use of grinder furnace drill by weekday and weekend



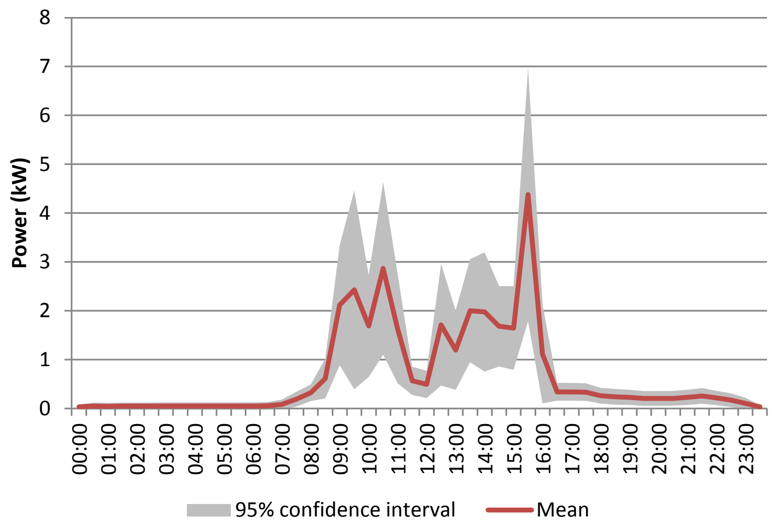
Source: Data collected for CLNR by Metasphere

Figure 57. Average power use of grinder furnace drill by season



Source: Data collected for CLNR by Metasphere

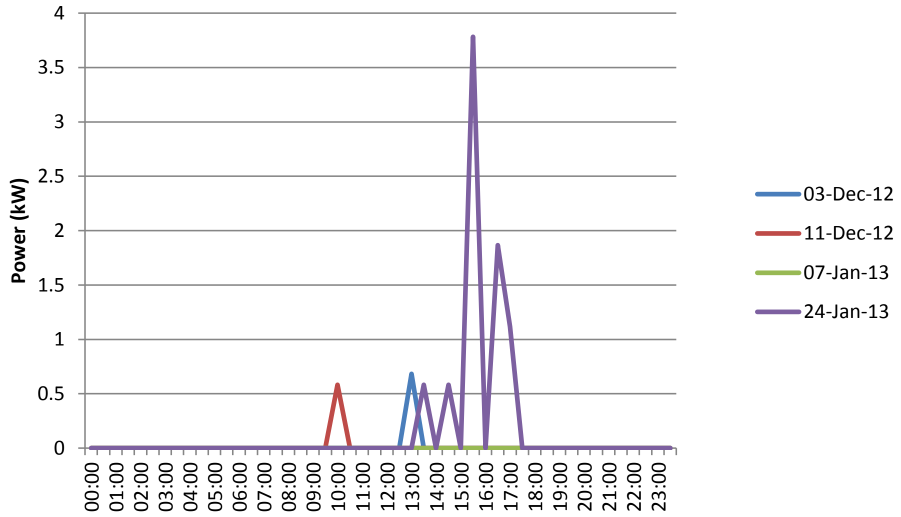
Figure 58. Mean power profile for winter weekdays – 95% confidence interval



Source: Data collected for CLNR by Metasphere

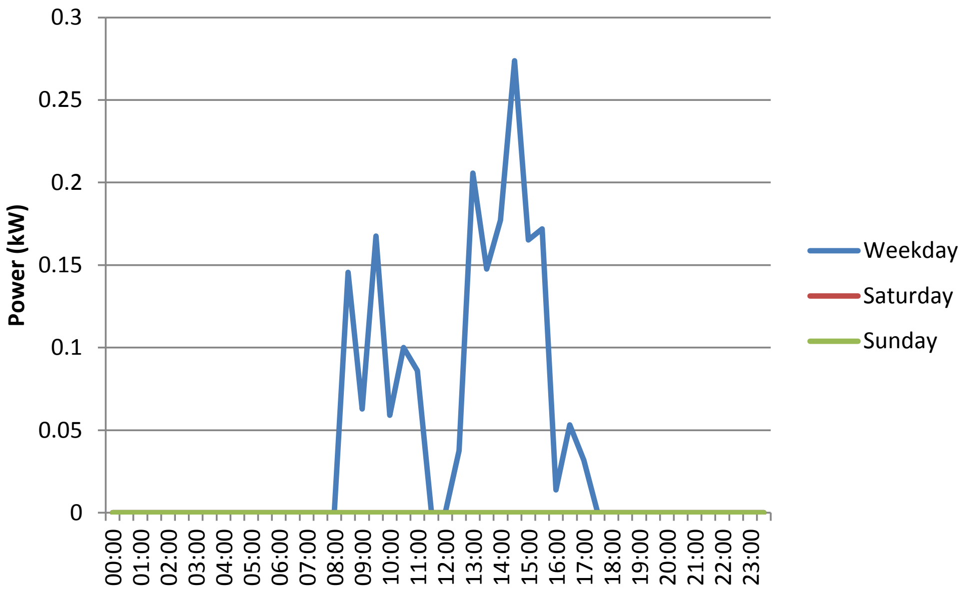
5.1.5 Welder arc

Figure 59. Representative power use of welder arc



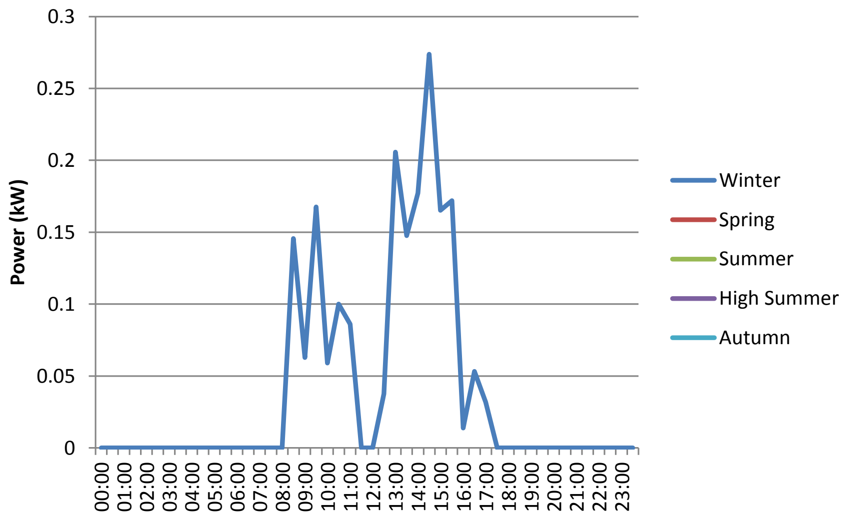
Source: Data collected for CLNR by Metasphere

Figure 60. Average power use of welder arc by weekday and weekend



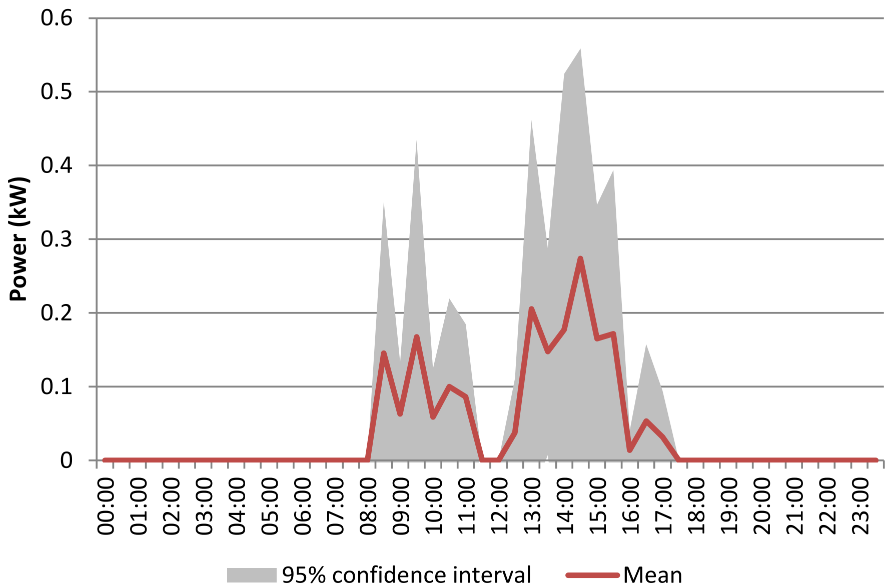
Source: Data collected for CLNR by Metasphere

Figure 61. Average power use of welder arc by season



Source: Data collected for CLNR by Metasphere

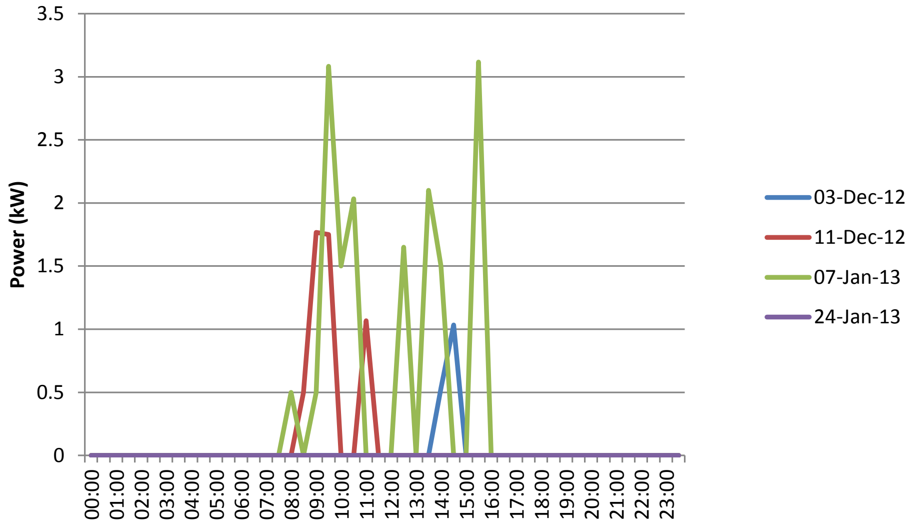
Figure 62. Mean power profile for winter weekdays – 95% confidence interval



Source: Data collected for CLNR by Metasphere

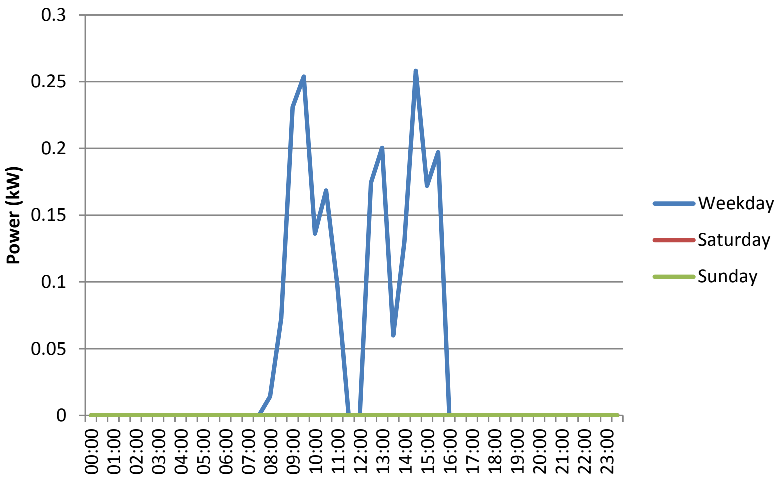
5.1.6 Welder MIG

Figure 63. Representative power use of welder MIG



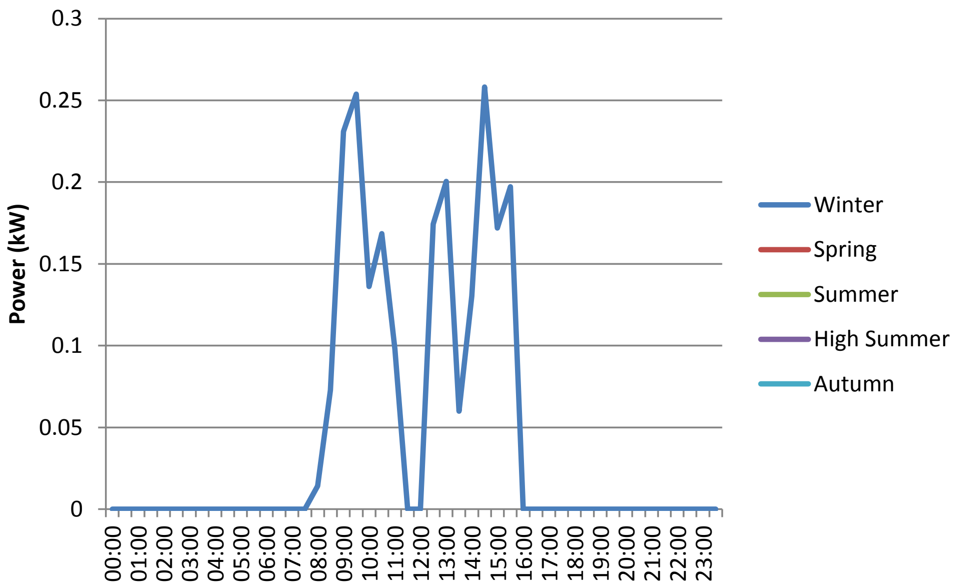
Source: Data collected for CLNR by Metasphere

Figure 64. Average power use of welder MIG by weekday and weekend



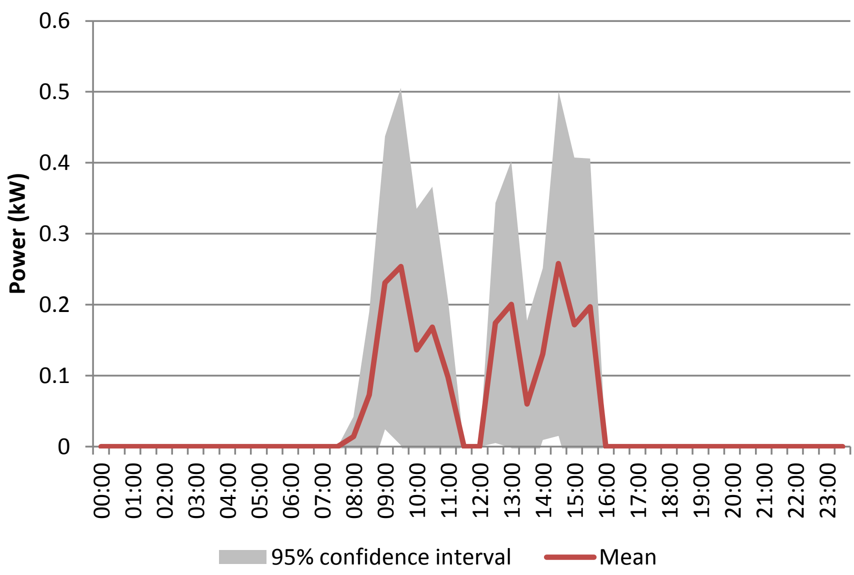
Source: Data collected for CLNR by Metasphere

Figure 65. Average power use of welder MIG by season



Source: Data collected for CLNR by Metasphere

Figure 66. Mean power profile for winter weekdays – 95% confidence interval



Source: Data collected for CLNR by Metasphere

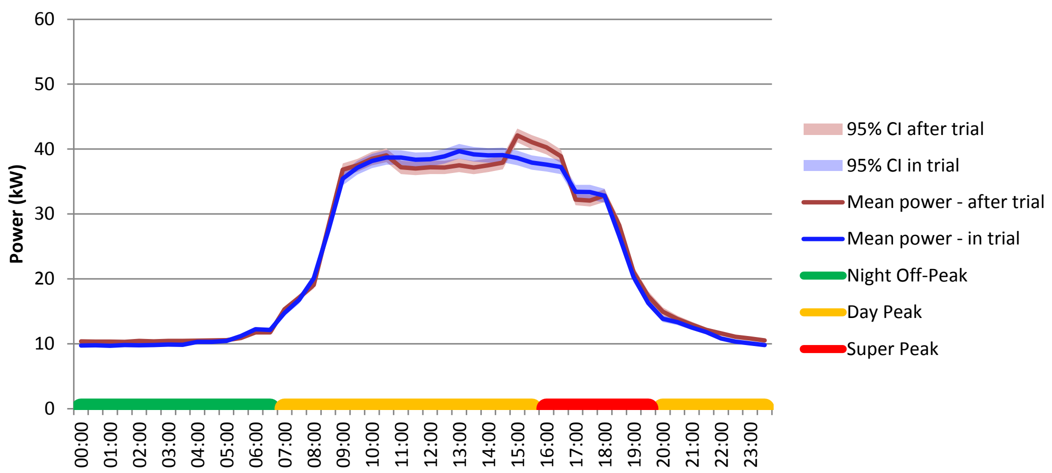
6 Annexe TC9b analysis

Comparing the average daily profiles for the whole period during and after the trial

This annexe presents the case study of a firm participating in TC9b that is summarised in section 3.2.1. We have compared load during and after the trial, and do not find a consistent effect of DSR for this particular SME.

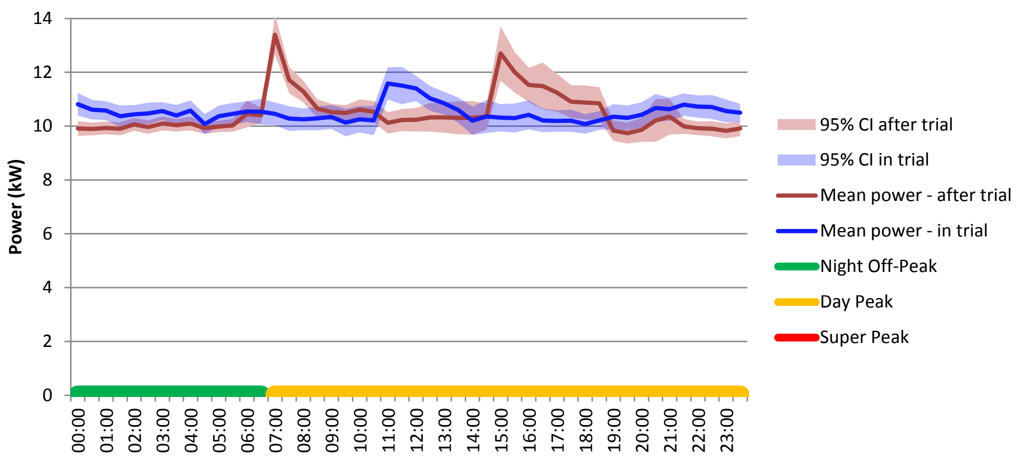
In the chart below showing average weekday profiles, there is a very slight increase in consumption in the super peak period during the trial. Power usage immediately prior to this also appears to be lower under the trial. This is the opposite of what we'd expect, so might indicate other changes in consumption that we have not controlled for. We see a similar pattern on Saturday when the super peak tariff was not in effect, suggesting the TOU tariff is not driving this change.

Figure 67: Average weekday daily demand profiles during and after the trial.



Source: Data collected for CLNR by Metasphere

Figure 68: Average Saturday daily demand profiles during and after the trial.

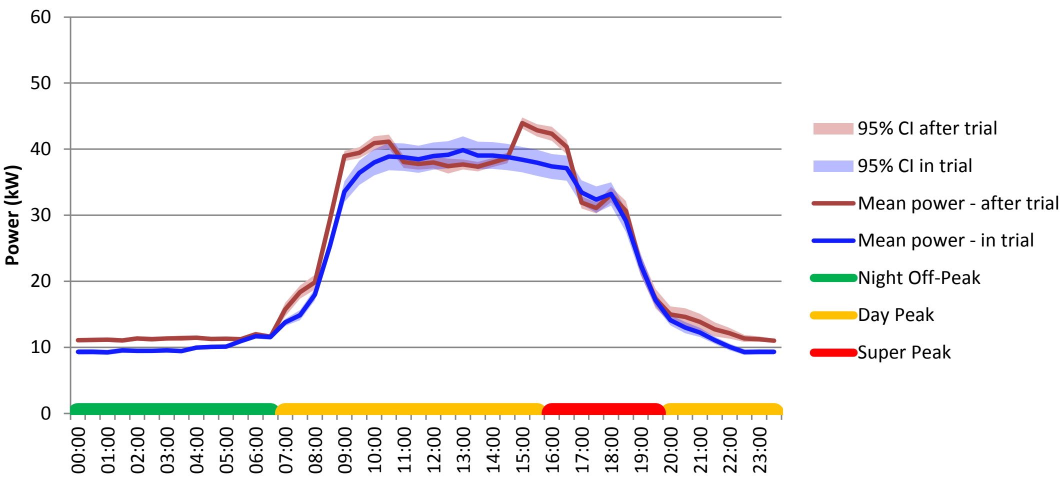


Source: Data collected for CLNR by Metasphere

Comparing the average daily profiles for the same winter period during and after the trial

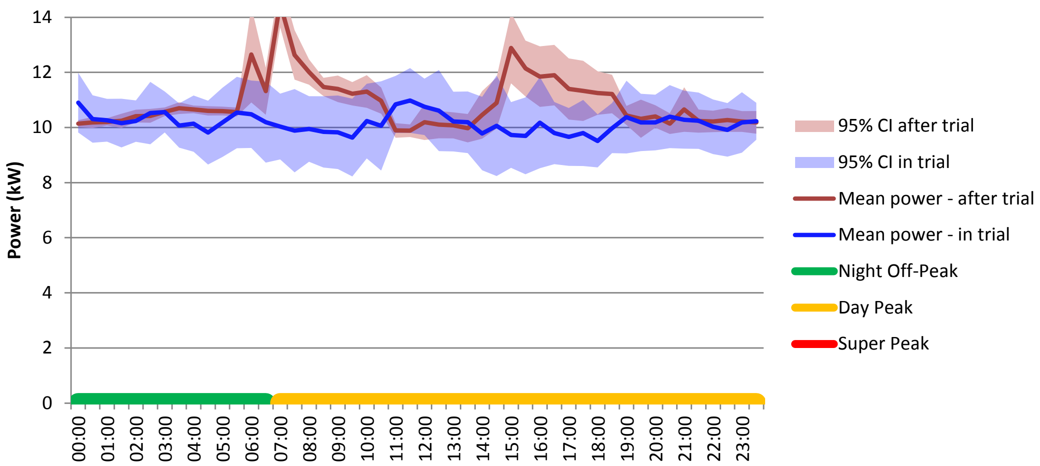
Again, controlling for seasonality has not changed the overall picture. We are still seeing similar changes in the pattern of demand on both the weekday and Saturday charts below.

Figure 69: Average weekday daily demand profiles for the same winter period during and after the trial.



Source: Data collected for CLNR by Metasphere

Figure 70: Average Saturday daily demand profiles for the same winter period during and after the trial.

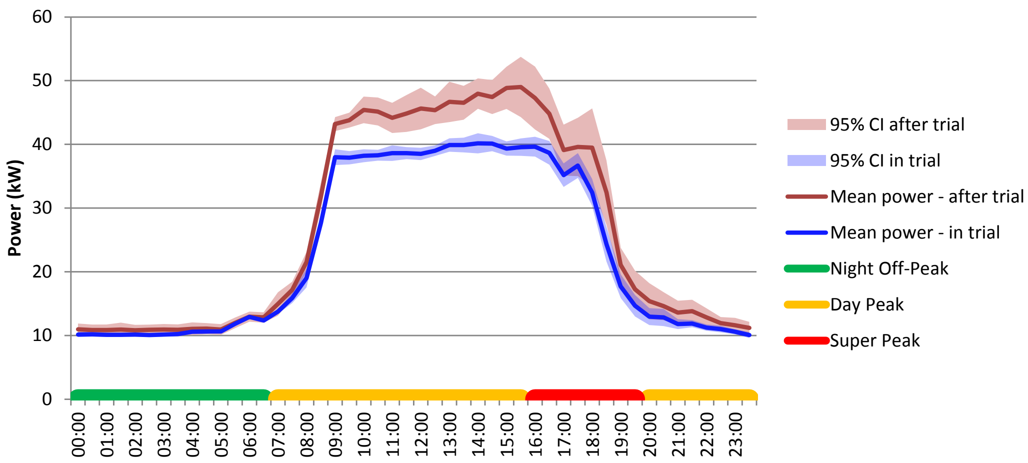


Source: Data collected for CLNR by Metasphere

Comparing the last 2 weeks of the trial and the first two weeks after the trial

In the charts below we see that electricity consumption during the trial seems to be systematically lower throughout the day, but most during the day peak rather than the super-peak. We have tested[11] to see whether these changes in demand are statistically significant and have concluded that only the reduction in demand between 9am and 11am passes the test. Therefore the reduction in demand during the day peak is greater than any reduction in the super peak. This is counterintuitive and does not support the hypothesis that the TOU tariff has impacted on demand.

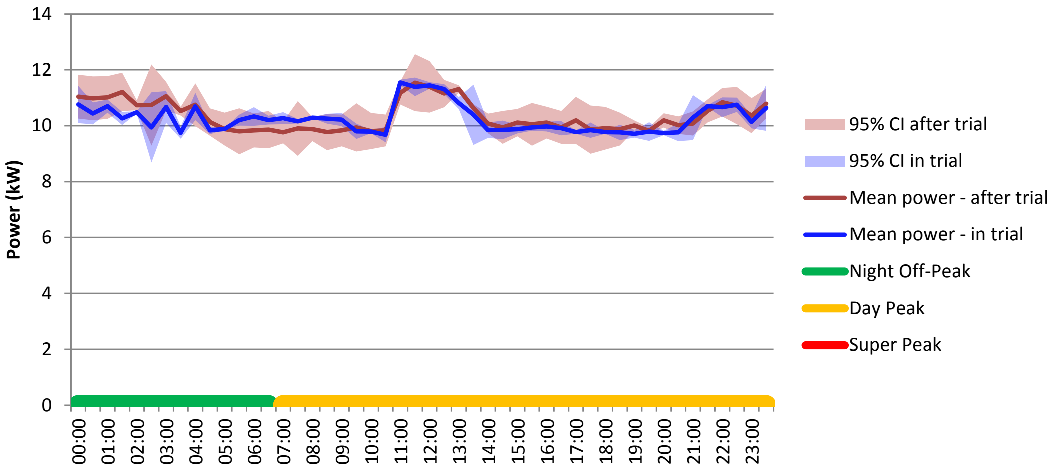
Figure 71: Average weekday daily demand profiles for the last two weeks of the trial and the first two weeks after the trial.



Source: Data collected for CLNR by Metasphere

[11] We have conducted a series of t-tests for each 10-minute interval (after Bonferroni correction), at 5% significance level.

Figure 72: Average Saturday daily demand profiles for the last two weeks of the trial and the first two weeks after the trial.



Source: Data collected for CLNR by Metasphere

Customer-Led Network Revolution

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