Sector Guide

Industrial Energy Efficiency Accelerator

Contract Catering Sector

Report for DEFRA and the Carbon Trust

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Executive summary

This report presents the findings and recommendations of the Industrial Energy Efficiency Accelerator (IEEA) for the contract catering sector. The aims of the study were to gain key insights into the sector such as

- Sector background;
- Process operations and energy use;
- Issues and opportunities;
- Existing data available for performance assessment.

The lack of metered data on a range of catering equipment in sector segments was the key driver for undertaking the study as this was needed by Defra to support UK government policy development on sustainable products.

This study builds on a previous industry work and in particular “Energy Efficiency in Commercial Kitchens” (CIBSE TM50:2009) which was a guide published by CIBSE (Chartered Institute of Building Services Engineers). This guide collated published benchmarks for different types of commercial kitchen that date from before 1999.

Whilst this new study was limited in scope to four sites with differing catering requirements from selected segments (i.e. Business and Industry, Healthcare, Education and Defence – see below for details), the findings have been extrapolated to the contract catering sector as a whole based on the sites being representative of the key segments. Overall, the findings indicate that the carbon footprint of the contract catering sector is approximately **80% higher** than previously thought.

Specifically, the sector carbon footprint based on these benchmarks collated by CIBSE was 730,000 tonnes CO_2e/year, which compares to the new estimate from this study based on metered data of 1,300,000 tonnes CO_2e/year.

Size of the contract catering sector

Often referred to as Food and Service Management (FSM), contract catering covers the provision of food services to people at work in business and industry, catering in schools, colleges and universities, in hospitals and healthcare as well as welfare and local authority catering and other non-profit making outlets.

For the purposes of this study the sector constitutes food and beverage provision for companies and organisations for whom catering is not their primary activity. Between them, these companies are estimated to have served 1,607 million meals through 16,583 outlets in 2009. The energy used in generating these meals through these outlets forms the scope for this IEEA study. Self-operated outlets (catering provided in the workplace by the employer) provide the balance of workplace catering. One estimate gives a total of 3,244 million meals served in the workplace, giving FSM companies 50% of the market.[1]

Self-operated facilities were outside the scope of this study that focussed solely on industrial or multi-scale facilities. If self-operated outlets had been included then the overall CO_2 emissions would have been higher.

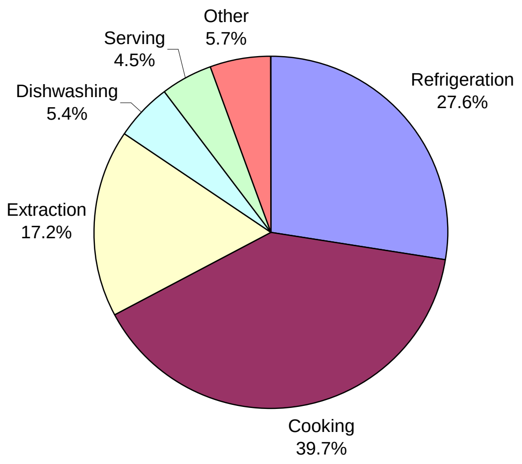
[1] Insiders Guide to Foodservice 2009/10

Energy use at host sites

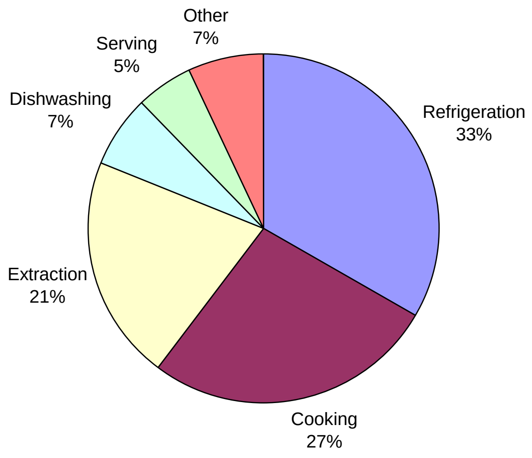
The four sites selected were chosen to be representative of the four main client sectors for Contract Catering. This means that they have different scales and patterns of operation as summarised below:

Site	Meals served per day	Days per week	Weeks per year	Meals served per year
Business and Industry (B&I)	Main lunch + occasional evening meals.	5	52	93,330
Hospital	3 meals per day.	7	52	129,792
School	Lunch + plus small no of breakfasts and mid-morning snacks.	5	39	84,045
MOD	Three meals per day – less at weekend.	7	52	45,000

Catering energy use - 4 sites

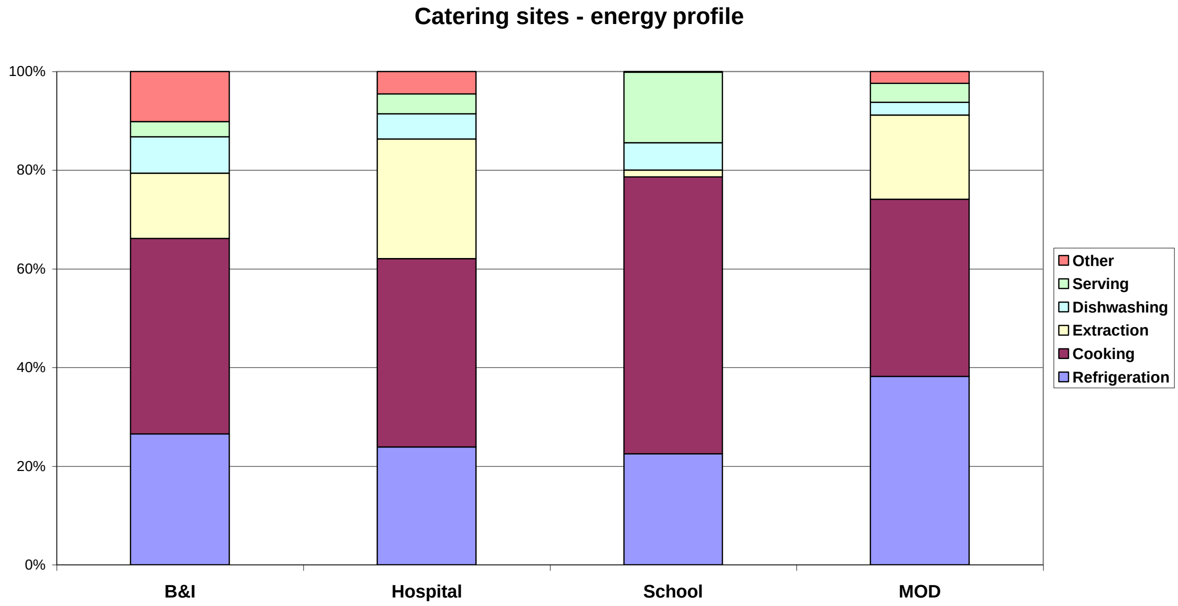


Catering CO_2 - 4 sites

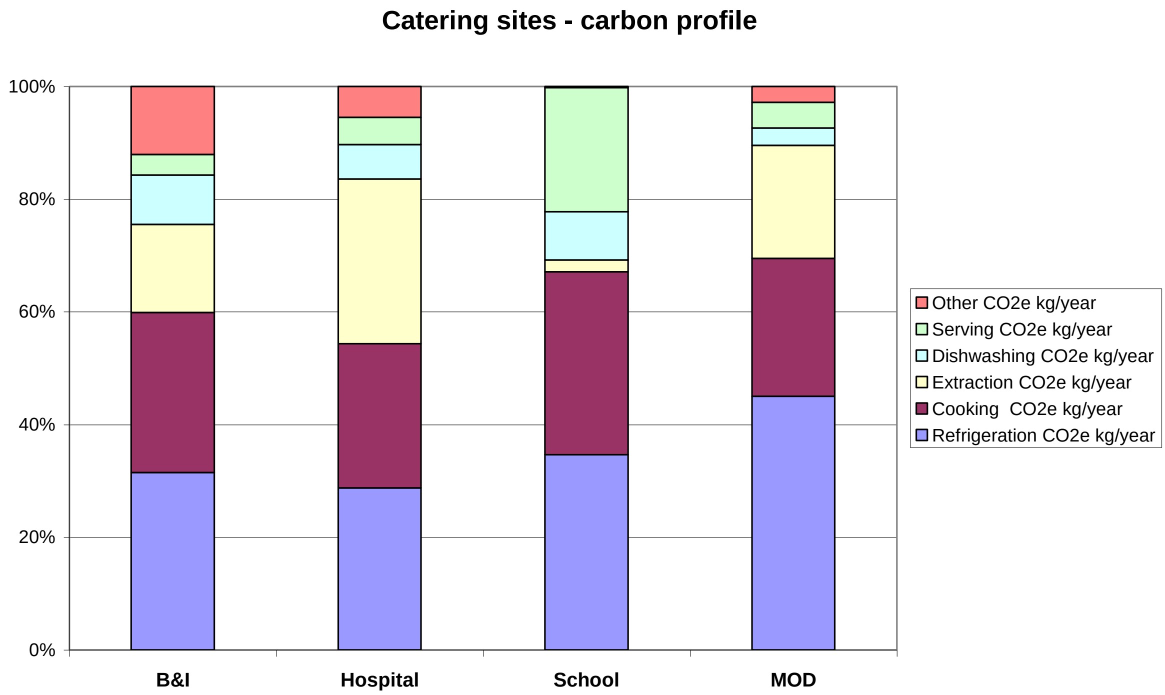


About 40% of the energy is used for cooking with refrigeration at 28%, extraction at 17% and dishwashing at 5%. In carbon terms cooking at 27% is less important than refrigeration at 34%. This is due to the lower carbon impact of gas which accounts for 68% of cooking energy.

The energy profiles for the individual host sites are shown below, indicating the range of variation found from one operation to another.



The carbon profiles for the different sites are shown below, illustrating the impact of the variation in operation between sites on equivalent carbon emissions.



Energy use, energy cost and carbon footprint of the sector

This study has collected for the first time metered data on energy use in the contract catering sector. Over a four week period data was collected from 55 metering points across four host sites. In total 60% of the catering energy used on the host sites was directly metered and good estimates made for the remainder.

Based on a scale up of this metered data, the carbon footprint of the sector is estimated at 1,320,000 tonnes CO_2e. The contract catering sector is also estimated to spend £292m per year on catering energy with an average cost of 18p per meal sold. This energy bill is borne almost exclusively by the caterer's clients.

Based on the scale up of the detailed metering, the following table also provides segment breakdown illustrating the variation of carbon footprint between different market segments.

Segment	Number of sites[2]	Meals served[3] (m)	kWh/ meal[4]	GWh /year	Cost /meal[5]	Cost £m /year	kg CO_2e /meal[6]	kT CO_2e /year
Business & Industry	8,183	582	2.43	1,412	£0.24	£139	1.07	624
Healthcare	810	250	1.95	488	£0.19	£46	0.85	213
Education	5,423	353	0.64	228	£0.05	£16	0.22	78
MoD	566	215	3.01	647	£0.30	£64	1.34	288
Other[7]	1,601	207	1.88	394	£0.18	£38	0.82	170
Total for sector[8]	**16,583**	**1,607**	**1.90**	**3,056**	**£0.18**	**£292**	**0.82**	**1,320**

The figures above in the row labelled 'Total for Sector' figures are a site average used to provide an estimate for the sector.

Factors driving host site energy use

The number of hot menu options prepared per day at three of the sites is used as an indicator of menu and operational complexity. Here there is a clear relationship between complexity and energy use per meal for refrigeration energy, cooking energy and total energy use. It seems that menu and operational complexity may influence energy use by driving the amount of equipment installed and the way in which it is used.

Refrigeration is the second largest use for energy in the sector and this is driven by the installed refrigeration capacity at each site. There is a wide range of capacity installed from 3,000 litres on the school site to 38,000 litres on the B&I site. Energy use does not rise linearly with capacity, but drops off as capacity increases. This is due to the greater energy efficiency of the larger units.

Changes in the weekly number of meals served have no clear impact on the energy use at the sites. It is likely that other factors such as the amount and hours of operation of the equipment have more impact than the number of meals. Similarly, the weekly number of hot meals prepared at the study sites has little influence on the amount of cooking energy used. There is a similar picture for the influence of daily meal volume on cooking energy, refrigeration energy and dishwashing energy. Daily variations of +/- 13% in meal volume are not linked to energy use for any of these classes of equipment.

Good practice opportunities

There is great potential for improvements based on good practice within the sector. The sector survey indicates low uptake of standard energy efficiency measures within the sector. Measures suggested by site managers indicated an awareness of the potential. However, there is a lack of objective data on energy saving opportunities, and features of the business model which inhibit effective implementation, such as that a Contract Caterer operates on their Client's premises, do not own the equipment they use and are not aware of their energy use.

[2] BHA Food and Service Management survey 2010
[3] BHA Food and Service Management survey 2010
[4] Data for study sites
[5] Data for study sites
[6] Data for study sites
[7] Site average used
[8] Site average used

Innovative opportunities

Many of the opportunities relate to good practice measures. However the potential for innovation in the sector includes changes to operations and business models, as well as technical innovation, for example, combined messing at weekends in the Ministry of Defence segment, and potential for sharing of financial benefits between caterer and client to improve incentives.

Technical innovation potential includes centralised heat recovery from refrigeration, dishwashing and extraction systems for pre-heating water, increasing the capacity of low-carbon cooking methods such as combination microwave/air impingement ovens, and induction hobs, and potential innovations in dishwashing and refrigeration technology that are currently not close to market.

Summary of Opportunities

The study confirms that significant opportunities for energy efficiency and hence carbon savings exist in the contract catering sector. This study identifies potential for energy savings of 43% from behaviour change in cooking, 27% for behaviour change in dishwashing, 55% from improving control of extraction, 42% cost saving from replacing electric combis with gas combis, 19% from purchasing more efficient ovens, and 25% from purchasing more efficient refrigeration cabinets. Taken together these measures could reduce carbon emissions by 425,000 tonnes (around 33%) and save the industry £90m per year, or 32% of current energy costs.

Typically in catering the client pays for equipment and invests in new equipment. This means that the caterer obtains no financial benefit from improved energy efficiency. A new business model is needed for the sector that provides caterers with incentives to specify and use equipment efficiently, while providing clients with incentives to invest in the most efficient equipment. Transferring energy management responsibility to the caterer via sub-metering could facilitate savings through behaviour change saving 20% in energy use on applicable sites.

The biggest saving identified above is from behaviour change. For this sector there is a very important link to be made between behaviour and innovation. Implementing widespread behaviour change in contract catering will be a challenge due to the large number of staff, the turnover of staff members, the focus on the core business of cooking and the in-direct link to energy bills. Innovation can address these barriers, for example by reducing start up times, making controls easier to use, and alerting staff to equipment that has been left on etc.

Summary of cost-effective business cases for the contract catering sector

Measure	Implementation cost £	Cost reduction £	CO_2e reduction tonnes
Behaviour change for cooking	£10,000,000	£30,000,000	150,000
Behaviour change for dishwashing	£3,300,000	£5,300,000	23,000
Good Practice - Gas combi's ovens as replacement for electric ovens	£40,000,000	£14,000,000	60,000
Good Practice - More efficient ovens	£34,000,000	£8,300,000	37,000
Good Practice - Improving control of extractors	£15,200,000	£9,200,000	84,000
Good Practice - Refrigerator replacement with ETL standard	£18,650,000	£13,000,000	56,600
Innovation - Installation of sub-	£30,000,000	£34,500,000	156,000

Measure	Implementation cost £	Cost reduction £	CO_2e reduction tonnes
metering and transfer of energy costs to caterer			
Total[9]	**£120,000,000**	**£90,000,000**	**425,000**

Many of the business cases presented here will also apply to self-catered sites, which between them serve a similar number of meals per year to the contract caterers studied in this report.

Next steps

The next steps will involve:

- Dissemination of the findings from this study to the sector.
- Further investigation and analysis of the data to see what this may mean for UK government policy on sustainable products.
- Evaluate options for future work and, explore these with the sector taking consideration of current financial restraints in relation to further UK government funding.

[9] Total discounted by 20% to compensate for overlap between cases

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Appendices

1 Introduction

This report presents the findings of the Industrial Energy Efficiency Accelerator (IEEA) for the **Contract Catering** sector. The aims of the project were to:

1. Investigate energy use within the Contract Catering sector-specific processes.
2. Provide key insights relating to opportunities for CO_2 savings.
3. Identify opportunities for step change reduction in carbon emissions, by getting to the heart of the process.

The project ran from August 2010 to March 2012 and involved the British Hospitality Association, the Catering Equipment Suppliers Association, the Catering Equipment Distributors Association, DEFRA and the Carbon Trust. The Contract Caterers directly involved included Elior, Sodexo, Baxter Storey/Caterlink and Aramark.

Sections 2 to 7 outline our **key findings** and briefly discuss what they might mean in terms of opportunities for the sector.

Section 8 outlines the specific **opportunities** identified in the sector, including outline business cases where it has been possible to quantify these.

Section 9 describes our recommended **next steps** for the opportunities identified by this project.

1.1 Methodology

The methodology used in this study included:

- A workshop to introduce the IEEA study to the sector.
- Working with the British Hospitality Association (BHA) and Catering Equipment Suppliers Association (CESA) to engage companies in the sector.
- Working with key companies to identify potential host sites.
- Site visits and discussions with host site personnel and their clients.
- Gathering and analysing data from host sites.
- A second workshop to report to the sector on progress.
- Development of metering plans for the host sites.
- Desk based research of potential energy efficiency opportunities and innovations.
- A questionnaire to caterers on priorities, barriers, progress to date and their ideas.
- On-site metering at three host sites representative of major sector segments plus behavioural observations.
- Analysis of metering data and observations including estimates for fourth site relevant to another sector segment.
- Final workshop to present findings from host sites.

1.2 Acknowledgements

The British Hospitality Association (BHA) and Catering Equipment Suppliers Association (CESA) were key to engaging with the sector - we are grateful to them for facilitating initial contact with host sites, distributing communications and the questionnaire and providing insight, guidance and feedback throughout the project.

AEA are also grateful to the host sites for providing access to their sites and sharing process and energy data with the project.

AEA also wishes to thank all individuals who assisted us throughout this project.

2 Sector findings

This section outlines the key findings from the research and monitoring work carried out for the project. For details of the metering, please refer to Appendix 3.

2.1 Energy use and carbon intensity of host sites

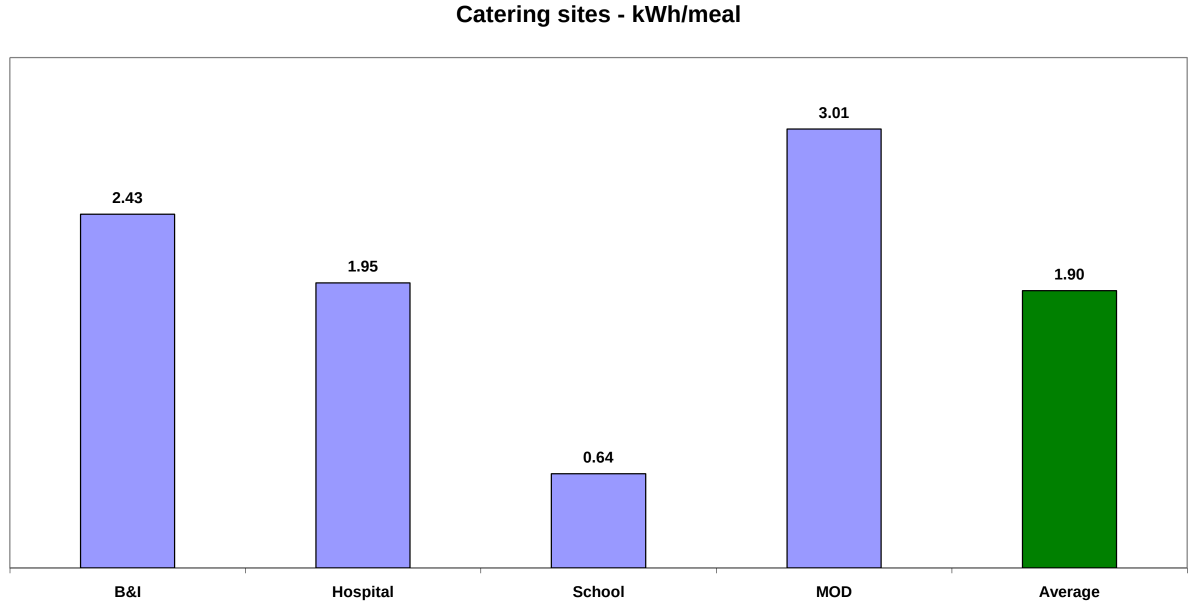
Energy use was measured directly at 3 sites, and detailed estimates were made for a fourth site as outlined in Appendix 3. The metering covered 60% of the catering energy consumed. This section presents the key findings of the data.

Table 1 Overview of annual energy consumption by end-use by site[10]

	Units	B&I	Hospital	School	MOD	Total
Energy use	**kWh/yr**	**226,445**	**253,594**	**54,201**	**135,413**	**669,653**
Refrigeration	kWh/yr	60,031	60,605	12,206	51,730	184,571
Cooking	kWh/yr	89,856	96,746	30,418	48,633	265,653
Extraction	kWh/yr	29,848	61,620	741	23,088	115,297
Dishwashing	kWh/yr	16,692	12,948	3,003	3,510	36,153
Serving	kWh/yr	7,065	10,114	7,761	5,202	30,142
Other	kWh/yr	22,953	11,562	72	3,250	37,836
Energy cost	£	£22,231	£24,497	£3,875	£13,398	£64,002
Carbon as CO_2 eq	kg	100,068	110,551	18,474	60,234	289,327
No of meals served	meals/yr	93,330	129,792	84,045	45,000	352,167
kWh/meal	kWh/meal	2.43	1.95	0.64	3.01	1.90
Energy cost/meal	£/meal	£0.24	£0.19	£0.05	£0.30	£0.18
CO_2 kg/meal	kg/meal	1.07	0.85	0.22	1.34	0.82

[10] Energy cost estimated using prices of 12 pence/kWh for electricity and 3 pence/kWh for natural gas.
Carbon factor used for gas 0.1836 kg CO_2e/kWh. Carbon factor used for grid electricity 0.5246 kg CO_2e /kWh (Source Carbon Trust).

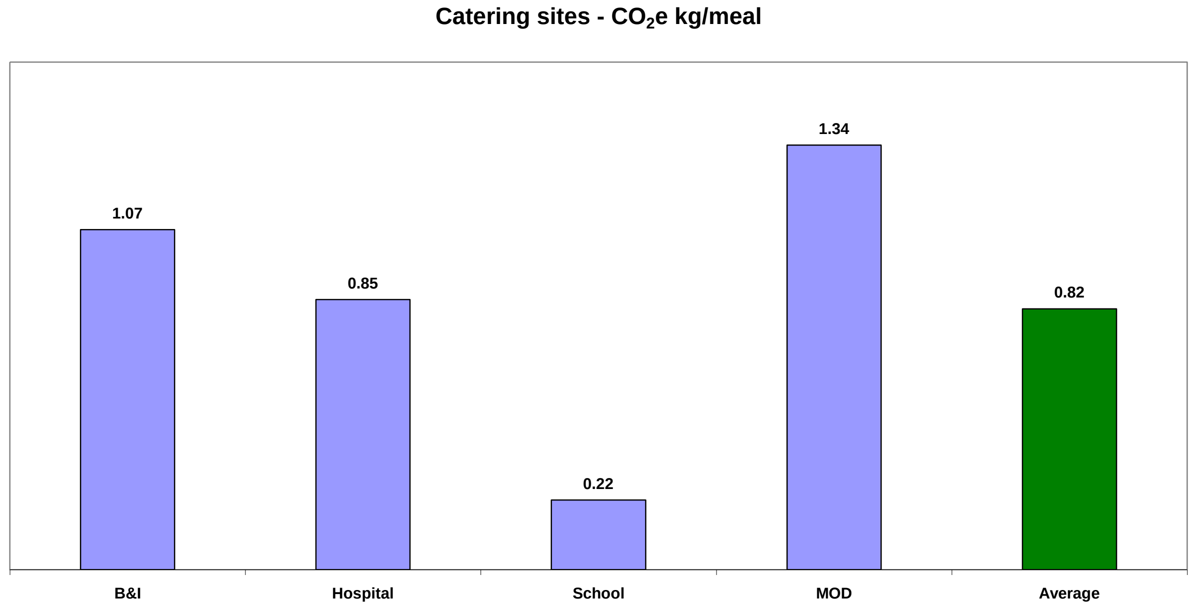
Figure 1 – Overview of energy consumption per meal by site



The energy used per meal ranges from 0.64 kWh to 3.01 kWh with an average of 1.90 kWh.

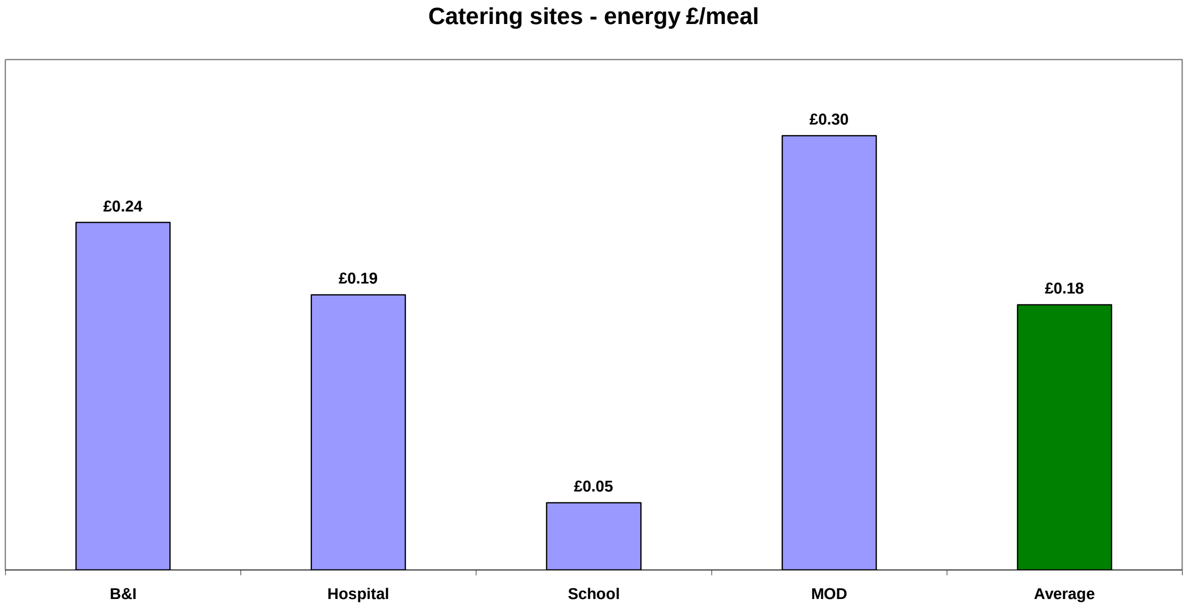
Factors driving these site differences include the amount of equipment installed, hours of operation, and meal types served. Some of these factors are explored in Section 2.4.

Figure 2 – Overview of carbon footprint per meal by site



The carbon footprint is measured in kilograms carbon dioxide equivalent (i.e. kg CO_2e) per meal, this ranges from 0.22 kg CO_2e to 1.34 kg CO_2e with an average of 0.82 kg CO_2e. Fuel mix is a factor influencing carbon footprint. The school site has mainly gas cooking, whereas the B&I site uses mostly electricity. Furthermore, the B&I and Hospital sites have satellite operations which have their own dishwashing and refrigeration facilities and therefore electricity use is proportionately higher.

Figure 3 – Overview of energy cost per meal by site



The energy cost per meal ranges from 5p to 30p with an average of 18p. Fuel mix is also a factor influencing cost per meal due to the lower unit cost of gas.

2.2 Energy use and carbon intensity of the Contract Catering sector

The energy use and carbon footprint for the contract catering sector were estimated using the site average for the sector. The carbon footprint of the sector is estimated at 1,320 kT CO_2e per year. Energy costs for the sector are estimated at £292m per year.

Table 2 Estimated carbon footprint for the Contract Catering sector

Segment	Number of sites[11]	Meals served[12] (m)	kWh/ meal[13]	GWh /year	Cost /meal[14]	Cost £m /year	kg CO_2e /meal[15]	kT CO_2e /year
Business & Industry	8,183	582	2.43	1,412	£0.24	£139	1.07	624
Healthcare	810	250	1.95	488	£0.19	£46	0.85	213
Education	5,423	353	0.64	228	£0.05	£16	0.22	78
MoD	566	215	3.01	647	£0.30	£64	1.34	288
Other[16]	1,601	207	1.88	394	£0.18	£38	0.82	170
Total for sector[17]	**16,583**	**1,607**	**1.90**	**3,056**	**£0.18**	**£292**	**0.82**	**1,320**

The segment footprints are shown for illustration, but should be treated with caution as they are each based on a single site.

[11] BHA Food Service sector survey 2010
[12] BHA Food Service sector survey 2010
[13] Data for study sites
[14] Data for study sites
[15] Data for study sites
[16] Site average used
[17] Site average used

2.2.1 Sector benchmarks

CIBSE (Chartered Institute of Building Services Engineers) has published a guide to "Energy Efficiency in Commercial Kitchens" (CIBSE TM50:2009), which collates published benchmarks for different types of commercial kitchen. It should be noted that the benchmarks date from before 1999.

Table 3 Carbon Footprint of sector using CIBSE benchmarks

Segment	No sites (000) [18]	Meals served (m) [19]	kWh/ meal [20]	kg CO_2e /meal [21]	MWh	tCO_2e
Business & Industry	8,183	582	1.00	0.30	582,000	174,600
Healthcare	810	250	1.20	0.54	300,000	135,950
Education	5,423	263	0.73	0.18	190,780	46,821
Local Authority	200	24	0.73	0.18	17,410	4,273
MoD	566	215	4.67	1.46	1,004,050	313,384
Other	1,401	183	1.00	0.30	183,000	54,900
Total	**16,583**	**1,517**			**2,277,240**	**729,928**

The estimate for the sector carbon footprint shown in Table 3 based on these benchmarks is 730,000 Tonnes CO_2e/year, compared to the new estimate from this study of 1,300,000 kT CO_2e/year. This could indicate that the benchmarks need to be revised. Data from a much larger sample of sites would be necessary to establish new segmental benchmarks.

2.2.2 Grid decarbonisation

Table 4 Forecast impact of grid decarbonisation to 2020.

Forecast for sector footprint	Scenario	Current	2020	2030
Grid electricity[22]	**kg CO_2e/kWh**	**0.5246**	**0.3100**	**0.0500**
Gas use	kT CO_2e/year	152	152	152
Electricity use	kT CO_2e/year	1,168	690	111
Total	**kT CO_2e/year**	**1,320**	**842**	**264**
CO_2 per meal	**kg CO_2 / meal**	**0.82**	**0.52**	**0.16**

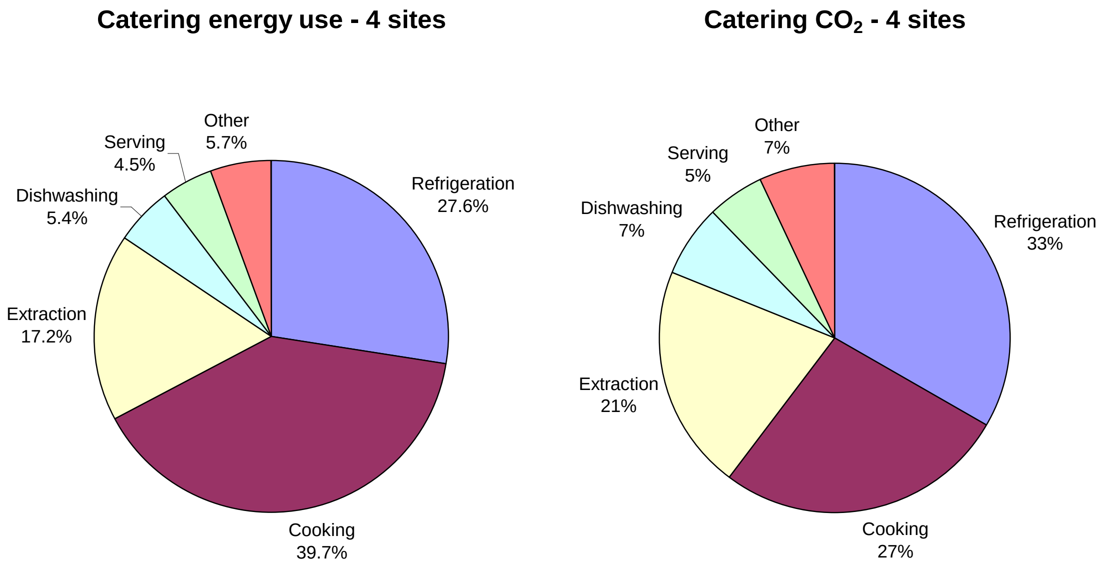
Table 4 shows the impact of expected changes in the carbon intensity of grid electricity over the next 18 years. The 2020 scenario shows a drop of 37% in the sector footprint assuming energy use and fuel mix remain the same. By 2030 the footprint shows a drop of 80% as the grid becomes almost completely decarbonised.

These changes will have an impact on the carbon footprint of equipment purchased today which may still be in operation after 2020, and also on the choice between gas and electric appliances, with the relative carbon advantage of gas over electricity narrowing over time.

[18] BHA Food service sector survey 2010
[19] BHA Food service sector survey 2010
[20] CIBSE TM50: Energy efficiency in Commercial Kitchens
[21] Derived from CIBSE TM50: Energy efficiency in Commercial Kitchens
[22] Carbon factor for grid electricity for 2020 is 0.3100 kg CO_2e /kWh and 0.050 g kg CO_2e /kWh for 2030. Source: The Committee on Climate Change, 4th Carbon Budget, chapter 6 April 2012.).

2.3 How the energy is used on the sites

Figure 4 – Overview of energy consumption and CO_2 emissions by end-use



Overall, almost 40% of the energy is used at the four sites is for cooking with refrigeration at 28%, extraction at 17% and dishwashing at 5%.

In carbon terms cooking at 27% is less important than refrigeration at 34%. This is due to the lower carbon impact of gas which accounts for 68% of cooking energy.

The energy profiles for the individual host sites are shown in Figure 5, indicating the range of variation found from one operation to another. Some of the factors driving these differences are explored in Section 2.4.

Figure 5 – Energy profile by site

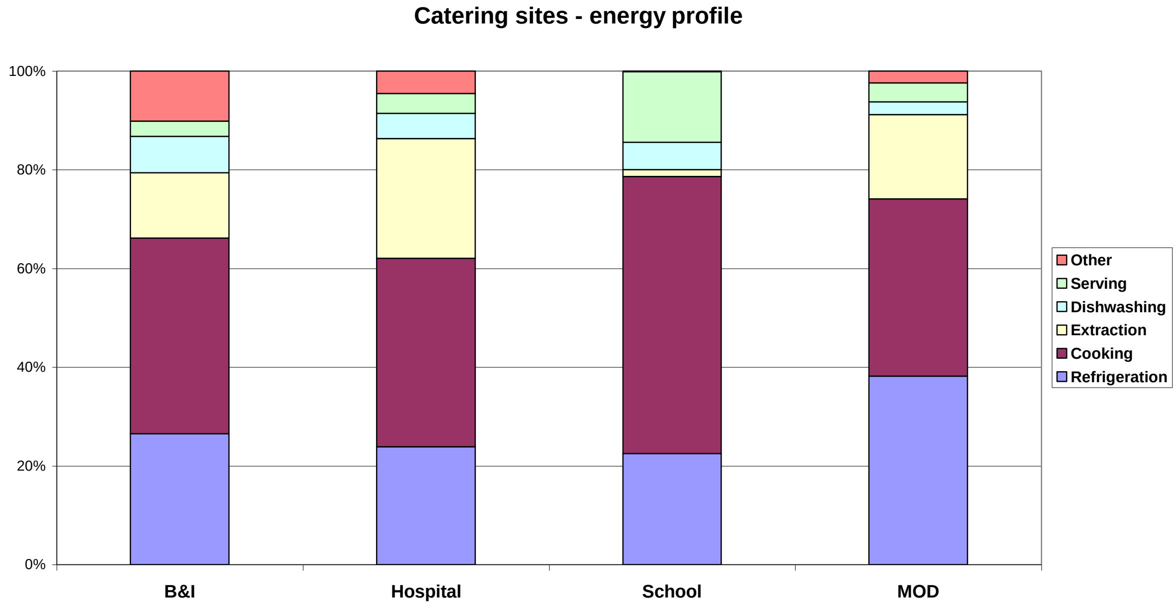


Figure 6 – Carbon profile by site

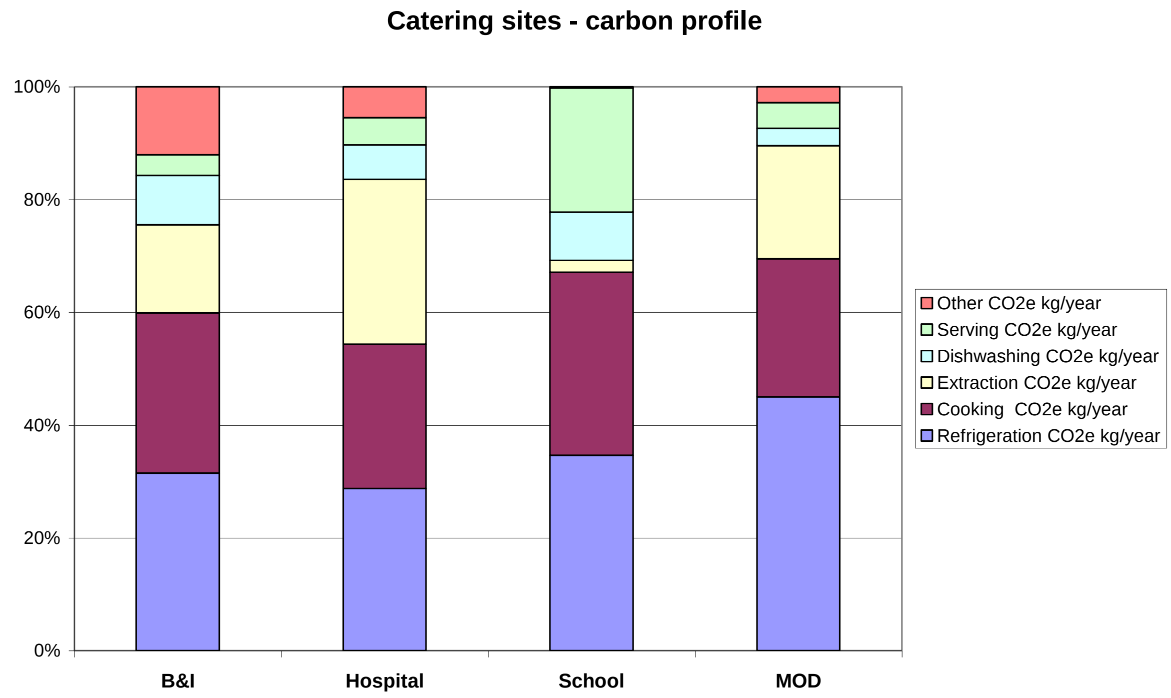


Figure 6 shows the carbon profile of the different host sites.

2.4 Factors driving energy use

The data shows large differences between sites in kWh per meal served. Some of the factors influencing these variations are explored in this section. However, staff behaviour can also have a large impact on energy use and in Section 3 various examples of this are highlighted. In addition, Section 8.1 explores the potential impact of behaviour change on energy use reduction. Site profiles are given in Appendix 3 and summarised here in Table 5.

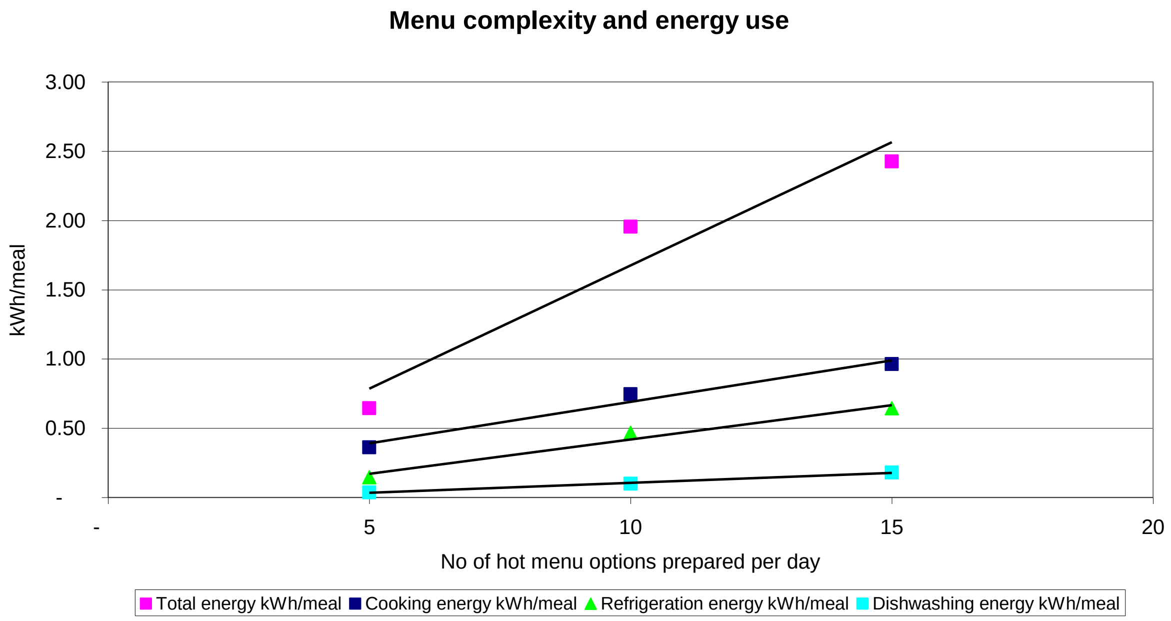
Table 5 Site profiles

Site	B&I	Hospital	Education	MOD
Description	A prestige city-centre office housing 850 staff.	An 85-bed specialist hospital with 4 patient wards.	A 1,500 pupil secondary school.	Junior-rank's mess on a base housing 1,600 when at full strength.
Catering operations	Self-service staff restaurant, café, hospitality service ranging from buffet lunches and fine dining to functions.	Self-service restaurant, café, patient meals.	Self-service restaurant	Self-service restaurant. Meals provided on pay-as-you dine basis. High calorie intake when service personnel are training.
Meals per year	93,330	129,792	84,045	45,000

Site	B&I	Hospital	Education	MOD
Weeks per year	52	52	39	52
Days per week	5	7	5	7
Days per year	260	365	195	365
Meal services	Breakfast and lunch, occasional evening hospitality.	Breakfast and lunch in restaurant. Three patient meals per day.	Morning snack and lunch.	Three meals per day M-F. Brunch plus evening meal at weekends.
Typical age of equipment	Less than 5 years.	5-10 years or more.	5-10 years or more.	Less than 2 years.

2.4.1 Drivers impacting energy use

Figure 7 – Menu complexity and energy use per meal



The number of hot menu options prepared per day is used as an indicator of menu and operational complexity. Here there is a clear relationship between complexity and energy use per meal for refrigeration energy, cooking energy, dishwashing energy and total energy use.

It seems that menu and operational complexity may influence energy use by driving the amount of equipment installed and the way in which it is used:-

- A wider range of refrigerated ingredients needed for a more complex menu would lead to greater installed refrigeration capacity.
- Cooking several different dishes requiring different cooking methods and temperatures would require more cooking equipment to be available.
- Providing several different types of service with different hours, such as restaurant, café, buffet service and fine dining requires longer operational hours and additional equipment such as dishwashers and service fridges.

- The number of satellite operations such as pantries, cafes and serveries remote from the main kitchen will also be factors driving energy use, as they will each have additional equipment such as refrigerators and dishwashers.

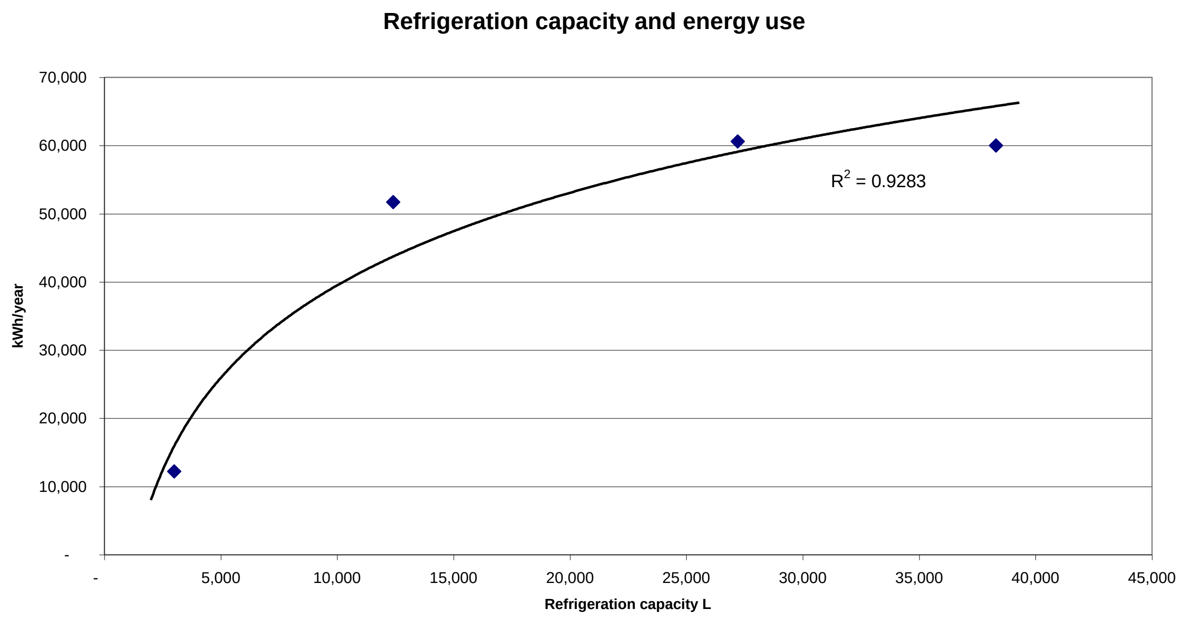
Table 6 – Comparison of two sites with similar meal numbers

Factor	B&I	School
Meals per year	93,330	84,045
Hot menu options per day	15	5
Self-service restaurant	Yes	Yes
Hospitality service	Yes	No
Coffee bar	Yes	No
Fine dining service	Yes	No
Satellite operations	6	1
Number of dishwashers	6	1
Refrigeration capacity L	38,300	3,000
Kitchen (extractor) annual hours	3,770	1,365
Ovens	5	2
Energy use kWh/year	**226,445**	**54,201**

Table 6 gives a comparison of two sites with similar numbers of meals per year indicating some of the factors other than meal numbers that may be driving energy use.

Despite the similar number of meals the B&I site is clearly a much more complex operation with more services, more satellite operations, more dishwashers, more refrigeration capacity, longer kitchen hours and more cooking equipment. These factors are all thought to be driven by operational complexity.

Figure 8 – Installed refrigeration capacity and energy use.



The installed refrigeration capacity is the primary driver for refrigeration energy use. There is a wide range of capacity installed from 3,000 litres on the school site to 38,000 litres on the B&I site.

The graph shows that energy use does not rise linearly with capacity, but drops off as capacity increases. This is due to the greater energy efficiency of the larger units installed on sites with larger capacity, which includes several walk-in units.

The R^2 figure of 0.9283 indicates a good fit between the trend line and the data.

2.4.2 Drivers not appearing to impact on energy use

Figure 9 – Weekly meals and energy use.

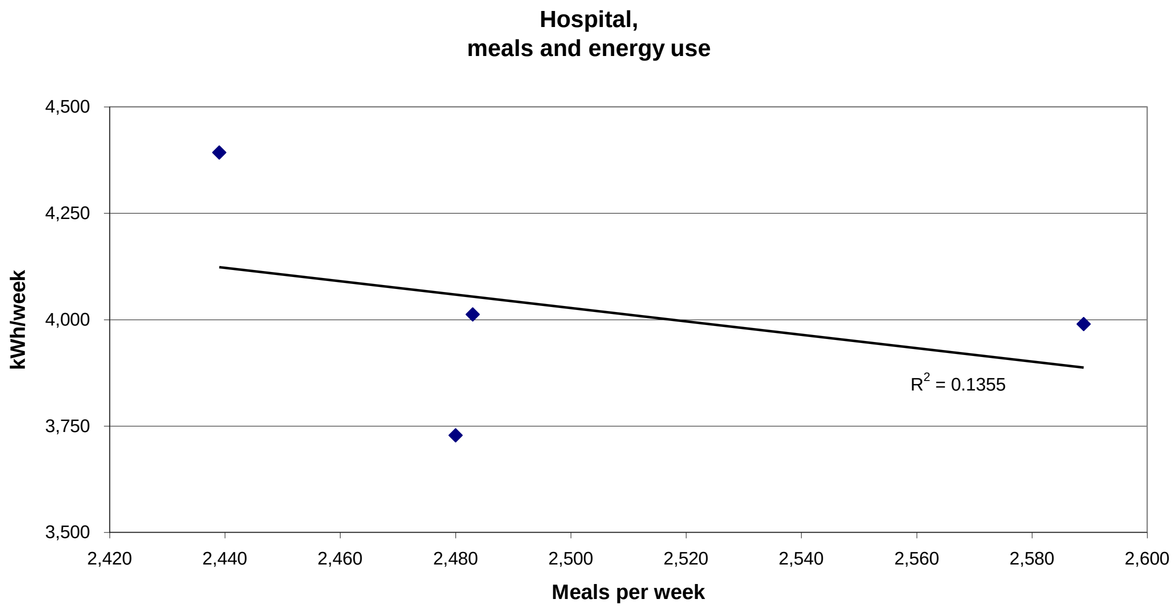


Figure 9 shows that changes in the weekly number of meals served at this site have no clear impact on the energy use, and similar results were obtained at the other sites. It is likely that other factors such as the amount and hours of operation of the equipment have more impact than the number of meals. Increasing meal volume would be likely to increase energy efficiency as more meals could be produced with little change in energy use.

The R^2 figure of 0.1355 indicates a poor fit between the trend line and the data.

Figure 10 – Weekly hot meals and cooking energy

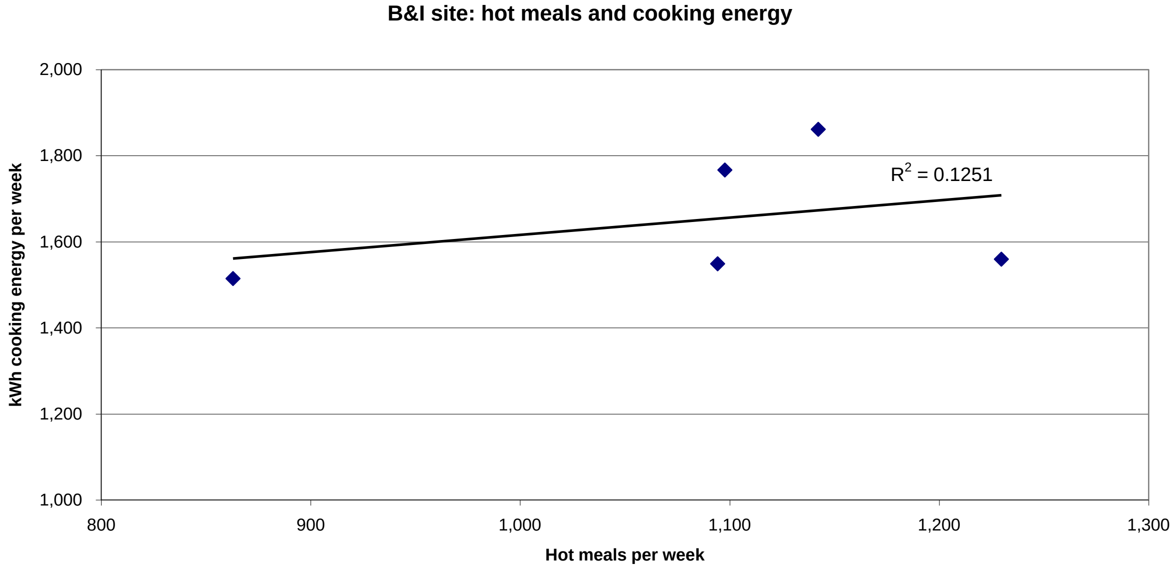


Figure 10 shows that the weekly number of hot meals prepared at this site has little influence on the amount of cooking energy used. This indicates that much energy use is fixed by factors such as the amount of equipment and the hours of operation and is insensitive to the number of meals cooked. Behaviour changes such as switching unneeded equipment off or purchasing more efficient equipment would have a greater influence on energy use than the variation in the number of meals cooked.

The R^2 figure of 0.1251 indicates a poor fit between the trend line and the data.

Figure 11 – Daily meals and energy use.

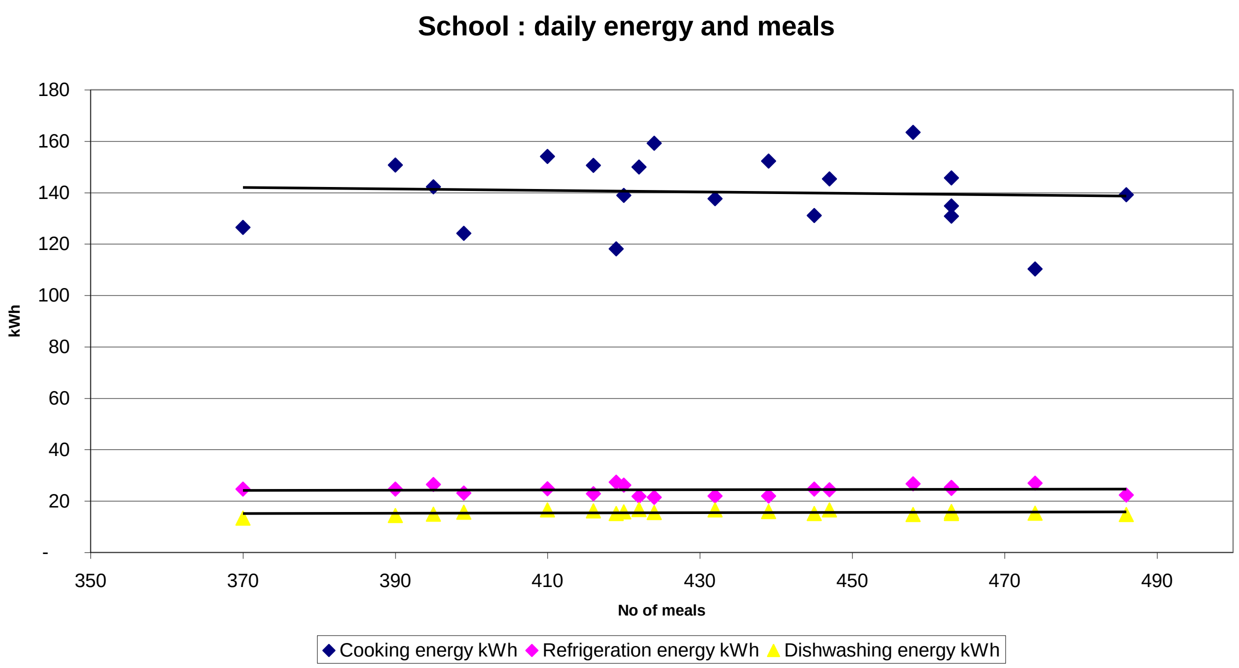


Figure 11 shows a similar picture for the influence of daily meal volume on cooking energy, refrigeration energy and dishwashing energy. Daily variations of +/- 13% in meal volume are not linked to energy use for any of these classes of equipment.

3 Cookers, ovens and hobs findings

Cooking accounts for 40% of energy use and 27% of carbon emissions at the four sites. After a brief overview of cooking equipment this section looks in more detail at ovens, hobs and other cooking, and then considers the carbon saving opportunities. Recommendations for cooking equipment are summarised in section 3.7.

3.1 Cooking equipment

Table 7 shows the amount and type of cooking equipment at each site. Some common types of equipment include Combi Ovens (Electric/Gas), Microwave Oven, Solid top hob (Gas), Salamander Grill, Panini Grill, Griddles (Gas/Electric), Hobs with ovens, and Bratt Pans.

Table 7 Host site cooking equipment

Fuel	Equipment	B&I	Hospital	School	MOD
Electricity	Microwave	2	5	1	1
	Combi Oven	5	2		2
	Panini Grill	1	1	1	1
	Electric Grill	1			1
	Pressure Steamer				1
	Microwave impingement oven				1
	Potato oven		1		
	Pizza Oven	1			
	Hob (4) /oven	1			
	Griddle Electric	1			
	Pasta Well	1			
Gas	Solid-top hob / oven	1	1		1
	Salamander Grill		2		1
	Griddle	1			
	Single Fryer				1
	Hob (4) / oven		2		1
	Convection oven			1	
	Bratt Pan		1		1
	Hob (2)	1			1
	Double Fryer	1	1	1	1
	Hob (6) / oven			1	
	Combi oven			1	
Total cooking appliances		17	16	6	14
Meals per year		93,330	129,792	84,045	45,000
Cooking energy kWh/year		89,856	96,746	30,418	48,633
Cooking energy kWh / meal		**0.96**	**0.75**	**0.36**	**1.08**

The variation in amount and type of cooking equipment shows that equipment is not closely matched to the number of meals served. The B&I site has spare capacity for occasional large functions, while the school site serves a similar amount of meals every day.

3.2 Ovens

3.2.1 Ovens – patterns of use

Table 8 – Ovens that were monitored in the study

Site	Hospital		B&I				School		Ovens	EuP Study	
Oven	Combi1	Combi2	Combi1	Combi2	Combi3	Combi4	Combi G	Fan G	Average	Combi E	Combi G
Fuel	Elec	Elec	Elec	Elec	Elec	Elec	Gas	Gas		Elec	Gas
Typical mode	C	S	S	C	S	C	Both	C	Both	Both	Both
Avg load when on, kW	2.17	4.49	3.85	2.22	4.18	2.29	4.77	5.47	3.68	4.24	5.44
Rating kW Cooking	17.40	19.00	11.00	11.00	11.00	11.00	18.00		14.06	19.00	22.00
Rating kW Control	-	-	-	-	-	-	0.80				0.80
Cooking duty cycle %	12%	24%	35%	20%	38%	21%	27%		26%	22%	25%
Hours on per week	76	84	47	47	49	53	33	36	53	42	42
Size (GN 1/1 containers)	10	10	6	6	6	6	10		8	10	10
kWh/week Electricity	165	376	181	105	205	121	26	-	147	178	34
kWh/week Gas							158	196			229
Weeks per year	52	52	52	52	52	52	39	39	52	52	52
Annual kWh Electricity	8,587	19,550	9,435	5,457	10,635	6,298	1,031	-	7,624	9,266	1,747
Annual kWh Gas							6,151	7,638			11,887
Annual cost	£ 1,030	£ 2,346	£ 1,132	£ 655	£ 1,276	£ 756	£ 308	£ 229	£ 967	£ 1,112	£ 566
Annual CO_2 e kg	4,505	10,256	4,950	2,863	5,579	3,304	1,670	1,402	4,316	4,861	3,099

S= Steaming mode, C = Convection mode

Table 8 summarises the energy use for the ovens that were metered at three sites.

On average the duty cycle was 26% of the rated cooking capacity of the ovens. The duty cycle is calculated as the average load when operational divided by the connected load.

The sites stated that the Combi ovens tended to be used either in steaming mode or convection mode, and this was backed up by observation. The average duty cycle for the combi ovens used in steaming mode was 31% and 17% for the ovens used in convection mode.

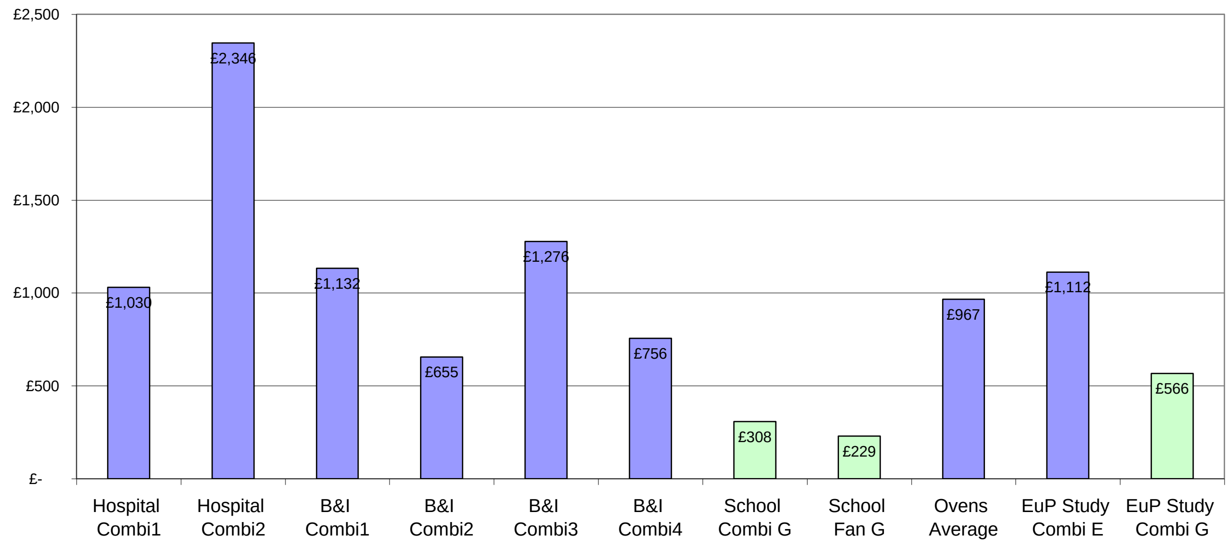
On average each oven was in use for 53 hours per week, with a range from 33 hours to 84 hours. The ovens at the B&I site were used more intensively for a shorter time than the ovens at the hospital, and the school ovens were in use for the fewest hours per week.

The oven capacity is shown in terms of Gastronorm (GN) 1/1 containers, a standard type of container measuring 325 x 530mm. Ovens of 10 and 6 pan capacity were prevalent.

The energy consumption for the base cases for the EuP (Energy using Products) study[23] on ovens are included for comparison. The base cases represent the “typical” ovens in use in the EU today, and can be seen to be very similar to the ovens in our study.

[23] Preparatory study for Ecodesign requirerments of EuPs (III) Lot 22 Domestic and Commercial Ovens, Task 5 Definition of Base Case. P15, Table 5-12. Feb 2011 European Commission (DG ENER)

Figure 12 – Ovens annual energy costs



The annual energy costs for the ovens are shown in Figure 12, with gas ovens highlighted in green. The factors influencing energy cost include fuel choice as well as rating, duty cycle and operating hours. In general gas ovens have lower annual utility costs for the same duty as electric ovens.

3.2.2 Ovens – life cycle costs and comparison with standards

Table 9 – Life Cycle costs for Combi Steamers[24]

EuP Study: life cycle costs over 10 years	Base-case 4: Commercial electric combi-steamer		Base-case 5: Commercial gas combi-steamer	
Product price	£ 9,917	48%	£ 11,000	62%
Installation/acquisition costs	£ 167	1%	£ 250	1%
Gas		0%	£ 4,275	24%
Electricity	£ 9,733	47%	£ 1,377	8%
Water	£ 334	2%	£ 334	2%
Repair and maintenance costs	£ 473	2%	£ 608	3%
Total	**£ 20,624**		**£ 17,844**	

Table 9 shows the comparative costs over a 10 year life cycle for electric and gas Combi ovens taken from the EuP study on ovens. The energy cost for an electric combi equals the purchase price over 10 years, while the energy costs for the gas combi are 42% lower. Based on these figures the additional purchase and install cost of the gas Combi is paid back in lower running costs in less than 3 years. Over 10 years purchasing the gas Combi would save £2,800 on utility costs after accounting for increased maintenance costs. The business case for this option is considered in section 8.2.1.

It is estimated that the carbon advantage of the gas combi at current emission factors would be 17.6t CO_2e over 10 years. However this advantage would be neutralised at a carbon factor of 0.334kg CO_2e/kWh for grid electricity which is expected to occur within the operating life of equipment purchased now.

Given the clear business case it is interesting that the EuP study gives only 18% market share to gas Combis. All the electric Combi ovens in our study are situated under extract

[24] Preparatory study for Ecodesign requirements of EuPs (III) Lot 22 Domestic and Commercial Ovens, Task 5 Definition of Base Case. P42, Table 5-32. Feb 2011 European Commission (DG ENER). Converted into GBP at a rate of 1.20 Euros/GBP

ventilation suggesting that they could be directly substituted with a gas Combi[25], assuming adequate airflow. One factor sited by industry representatives at our workshops is the focus in purchasing decisions on initial cost at the expense of life-cycle costs.

Table 10 – Oven comparison with Energy Star standard[26]

Study of oven performance	Food Energy Efficiency	Idle Power kW
Study combi convection mode	**65%**	**1.65**
Energy Star Standard convection	70%	1.00
Study combi steamer mode	**48%**	**3.45**
Energy Star Standard steamers	50%	0.80

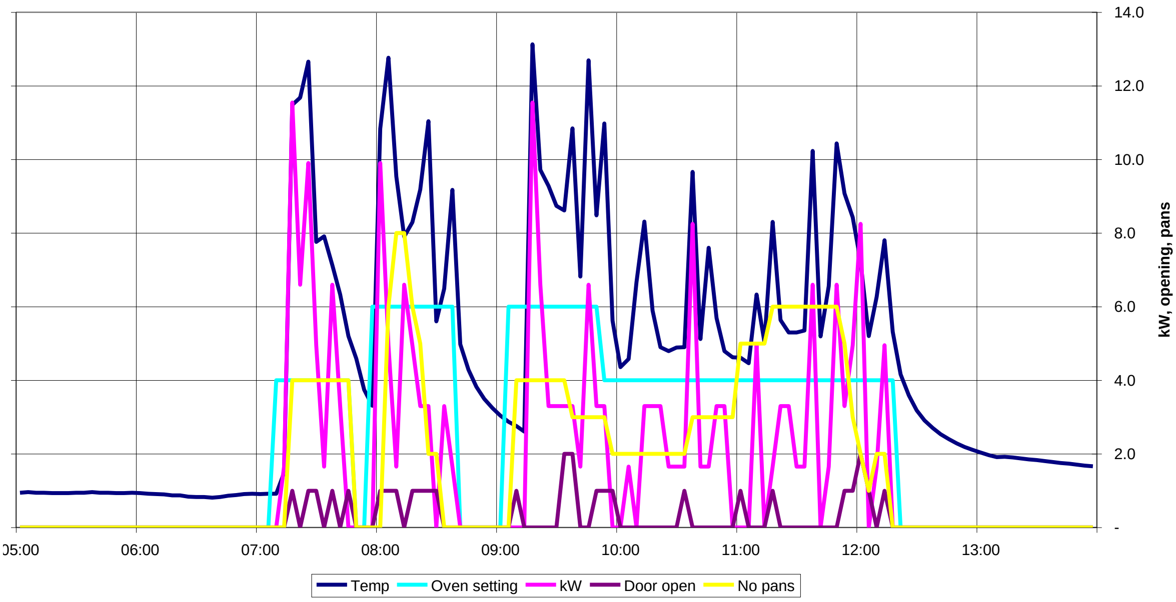
Table 10 shows published test results for one of the oven models in our study compared with the US Energy Star Standards for convection and steamer ovens. The results show that the ovens, which are only 3 years old, do not meet the standard for Food Energy Efficiency or Idle Power in either mode.

If more efficient ovens meeting the Energy Star standard had been purchased they would use 19% less energy for the same duty cycle. The business case for this option is considered in section 8.2.2.

Specific energy-saving design features of combi ovens which should be considered in purchasing include: direct steam, triple-glazed door, auto fan switch-off, heat exchange to pre-heat steam water and low-loss exhaust.[27]

3.2.3 Ovens – observation results

Figure 13 – Oven observation example 1



[25] Industry sources suggest that gas ovens require 25% more ventilation than electric ovens. A suitable interlock system may be required.
[26] Food Service Technology Center, CA, USA. Oven performance on heavy cooking load test.
[27] Energy efficiency in commercial kitchens CIBSE TM50: 2009 p38.

Figure 13 shows the observations made during one day of operation on one of the Combi ovens in the study. Observations included temperature settings, door openings and the number of pans.

The warm-up time of the oven is about 12 minutes. The oven was switched off for two periods during the day. After reheat the 8 minute switch-off did not save any energy, but the second 24 minute switch-off saved about 2kWh which is good practice. From about 11:15 to 12:20 the oven was used for holding cooked food, which may not be the most efficient way to keep the food hot.

Figure 14 – factors driving oven energy consumption – example 1

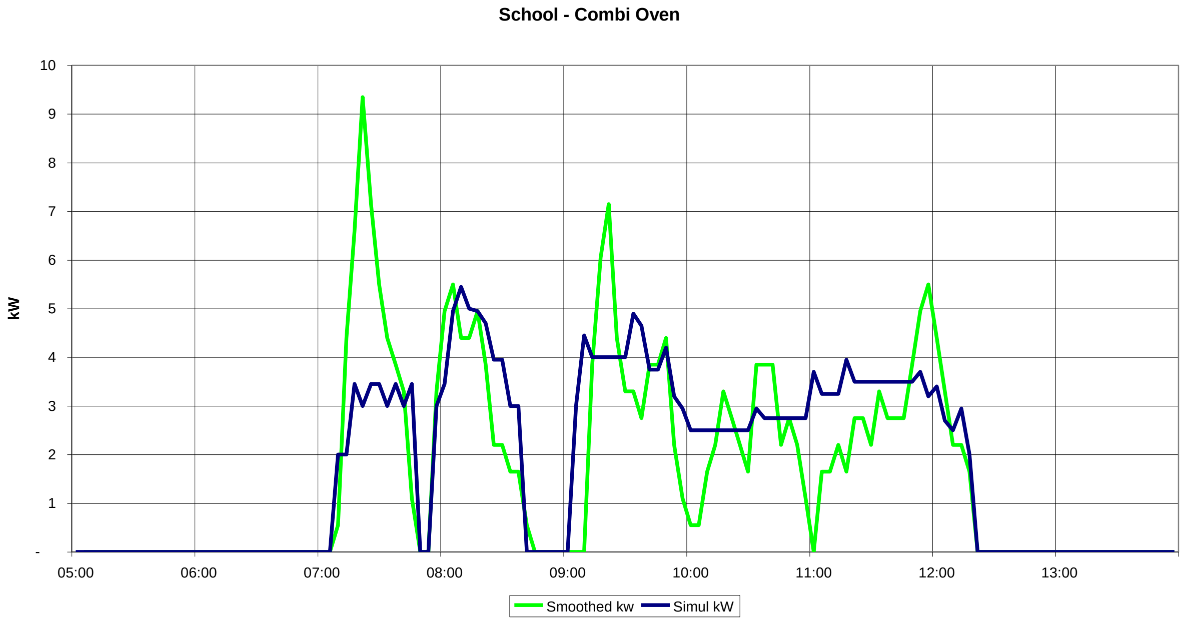


Figure 14 shows a simulation of power use [28]for the oven based on the setting, the number of pans and the door openings compared to the actual (smoothed) energy use showing good agreement. The factors used in the simulation include 0.25kW for each pan and 0.03kWh per door opening. This shows the need to keep door openings to a minimum and the small impact of each additional pan on energy use.

[28] Formula for simulation. kW=Oven setting (C) / 50 + Pans x 0.25 + Door openings x 0.45.
Impact per door opening is 0.45kW x 4mins/60 mins = 0.03kWh

Figure 15 – Oven observation example 2

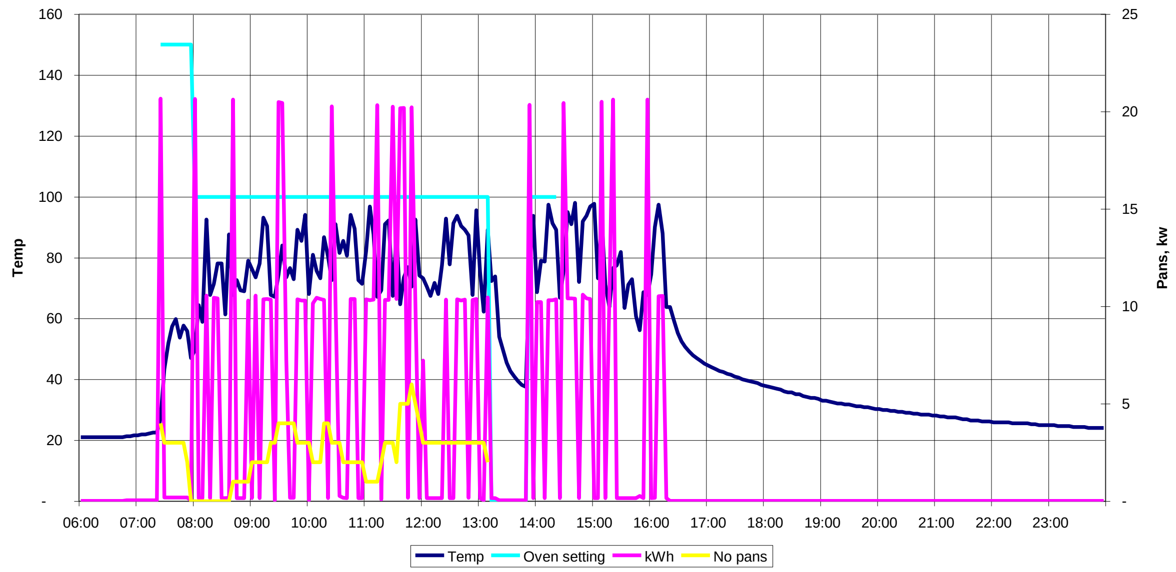


Figure 15 shows another example of an oven observed for one day. The average occupancy of the oven was 24% with a peak of 60% for a 4 minute period. The oven was switched off for 40 minutes saving 2.8kWh after reheat which is good practice. From about 12:00 to 13:15 the oven was used for holding cooked food for the lunch service. After 14:00 the oven is in use preparing the evening meals.

3.2.4 Ovens – energy efficiency and load

During our site observations the observed average oven occupancy rate was 30% indicating potential for improvements in oven utilisation.

Figure 16 – Oven Energy Efficiency and Load[29]

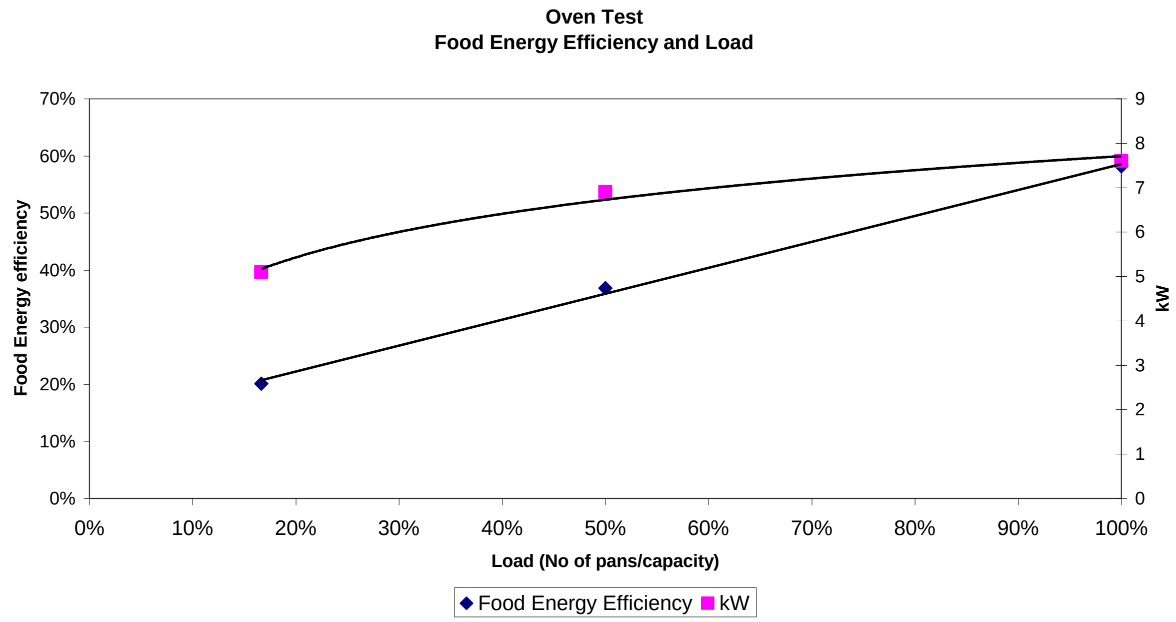


Figure 16 gives test results for a Combi oven showing how Food Energy Efficiency (measured by an ASTM test method) and power use relate to oven loading. Lower loading results in poor food energy efficiency. The power use increases only slightly between 50%

[29] Food Service Technology Center, CA, USA. Oven performance test results.

and 100% loading showing that the marginal energy cost of using spare oven capacity is small.

Increasing oven utilisation and energy efficiency could in general be achieved in two ways :-

1. Improving the utilisation of the existing ovens, examples of this include:
   - Switching on only the ovens required and using them more intensively rather than switching on all the ovens and using them lightly will increase energy efficiency and reduce costs. Options may be limited by the number of ovens and the temperature settings required for different cooking methods.
   - Spare capacity in the ovens could be used in preference to switching on other equipment such as grills, hobs or fryers, and this would also save energy and reduce costs as the marginal cost of using the spare capacity is low.
   - It may be possible to time shift some oven operations to avoid switching on an additional oven.
   - Ovens could be switched off earlier by transferring cooked food to a well-insulated hot cupboard rather than using the ovens for holding. Hot cupboards are often used for storing food for service and are frequently on in advance of service. Earlier transfer would save energy if the idle rate of the hot cupboard is less than the idle rate of the oven. However, in the short to medium term, a gas oven might have lower emissions and cost for holding than an electric hot cupboard.
2. Having a flexible combination of oven sizes

   By having several smaller ovens rather than a few large ones the operational flexibility is increased. A choice of oven sizes can also increase the number of operational options. This increased flexibility could enable better matching of capacity to demand. Better matching of operated capacity to demand can reduce energy use and improve cost control.

Table 10 – Oven capacity and operational flexibility

Oven sizes pans	Total capacity pans	Number of operating options	Operating Options
6	6	2	6S (capacity for 6 oven pans steaming), 6C (capacity for 6 oven pans convection)
10	10	2	10S, 10C
6 + 6	12	5	6S, 6C, 6S/6C, 12S, 12C
10 + 10	20	5	10S, 10C, 10S/10C, 20S, 20C
6 + 10	16	8	6S, 10S, 6C, 10C, 6S/10C, 10S/6C, 16S, 16C
6 + 6 + 6	18	9	6S, 12S, 18S, 6C, 12C, 18C, 6S/6C, 6S/12C, 12S/6C
6 + 6 + 10	22	17	6S, 6C, 10S, 10C, 12S, 12C, 16S, 16C, 22S, 22C, 6S/6C, 6S/10C, 6C/10S, 12S/10C, 12C/10S, 16S/6C, 16C/6S
S=steam, C= convection.			

The cost-benefits of increasing operational flexibility require further study; oven costs are not directly related to size, and installation costs may be higher with more ovens. It is not clear to what extent the increased operational flexibility would be used in practice.

3.3 Hobs

3.3.1 Hobs – patterns of use

Table 11 – Hobs that were monitored in the study

Site	**Hospital**	**Hospital**	**Hospital**	**B&I**	**School**	**EuP Study**	**EuP Study**
Cooker	**Large hob/ oven**	**Hob/ oven**	**Flat top/ oven**	**Hob**	**Hob/ oven**	**Electric Hob**	**Gas Hob**
Fuel	Gas	Gas	Gas	Gas	Gas	Electricity	Gas
Number of burners	4	4	3	2	6	4	4
Burner rating kW	8.25	5.80	6.00	4.60	5.80	4.00	7.00
Oven rating kW	10.00	5.30	10.00		7.80		
Total rating kW	43.00	28.50	28.00	9.20	42.60	16.00	28.00
Oven used?	No	No	No	None	Yes	None	None
Effective rating kW	33.00	23.20	18.00	9.20	42.60	16.00	28.00
Duty cycle	8%	11%	47%	74%	28%	100%	100%
Avg load when on, kW	2.51	2.47	8.47	6.81	11.96	16.00	28.00
Hours on per week	105	23	6	37	30	24	24
kWh/week	264	57	50	248	360	384	672
Annual kWh	13,728	2,964	2,600	12,922	14,040	14,976	26,208
Annual cost	£ 412	£ 89	£ 78	£ 388	£ 421	£ 1,797	£ 786
Annual CO_2e kg	2,520	544	477	2,372	2,578	7,856	4,812

Table 11 summarises the energy use for the hobs that were monitored in the study.

The ovens associated with the hobs were generally not used, the kitchens having adequate combi oven capacity. The hours of use and duty cycle for the hobs is very variable, with most of them very lightly used.

The EuP base cases for hobs are included for comparison[30]. Note that the hours of operation for the EuP base case are expressed as equivalent to 100% operation, and other combinations could be used, for example 96 hours per week of 25% duty would give the same energy use as the base case presented.

[30] Preparatory study for Ecodesign requirements of EuPs (III) Lot 23 Domestic and Commercial Hobs and Grills, Task 5 Definition of Base Case. P14, Table 5-12. Feb 2011 European Commission (DG ENER)

Figure 17 – Hob observations, example 1

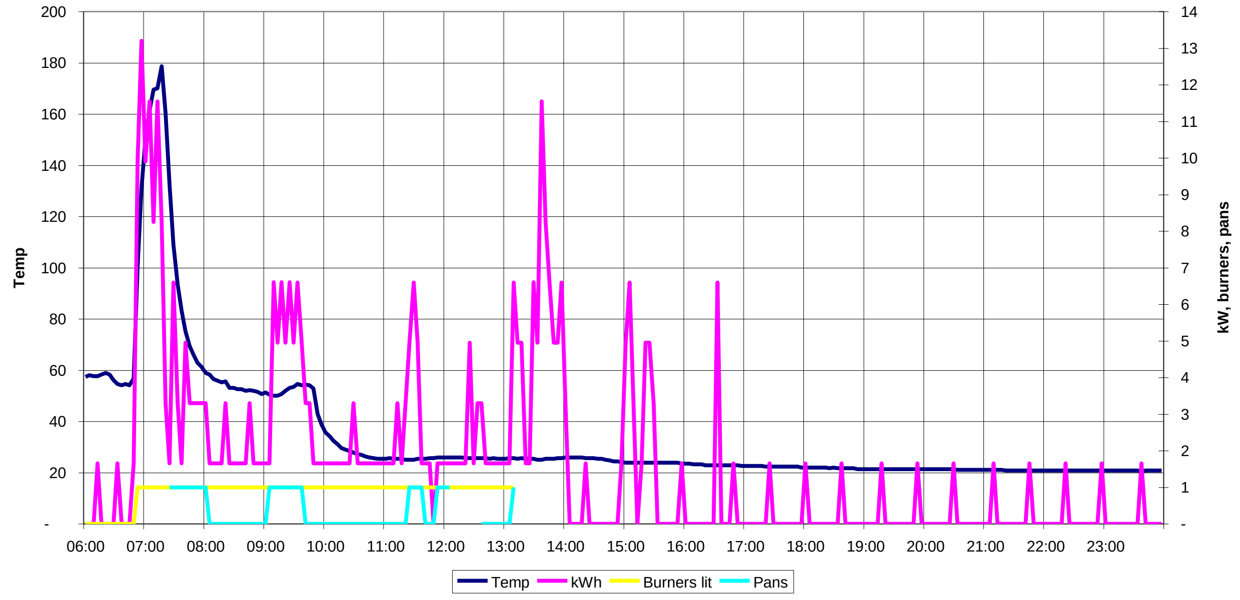


Figure 17 shows the observations made on one of the hobs in the study. Observations included the number of burners lit, the no of pans in use and the impact this had on the temperature and power use.

One burner on the hob was left on a low setting most of the day and was occupied for 35% of the time. The pilot light is on 24/7. There are opportunities to save energy by switching the burner off when not in use and to use piezo-electric ignition rather than leaving the pilot on.

Observation on another gas hob showed rings were lit and switched off as needed, despite the need to use a taper. This is good practice, but tapers have largely been superseded in the industry by use of pilot lights or piezo-electric ignition. Some dishes were left on the hob for extended periods, e.g. curry 170 minutes, pasta water 120 minutes and custard 92 minutes total time. Energy could be saved by avoiding these extended cooking times.

Figure 18 – Hob observation, example 2

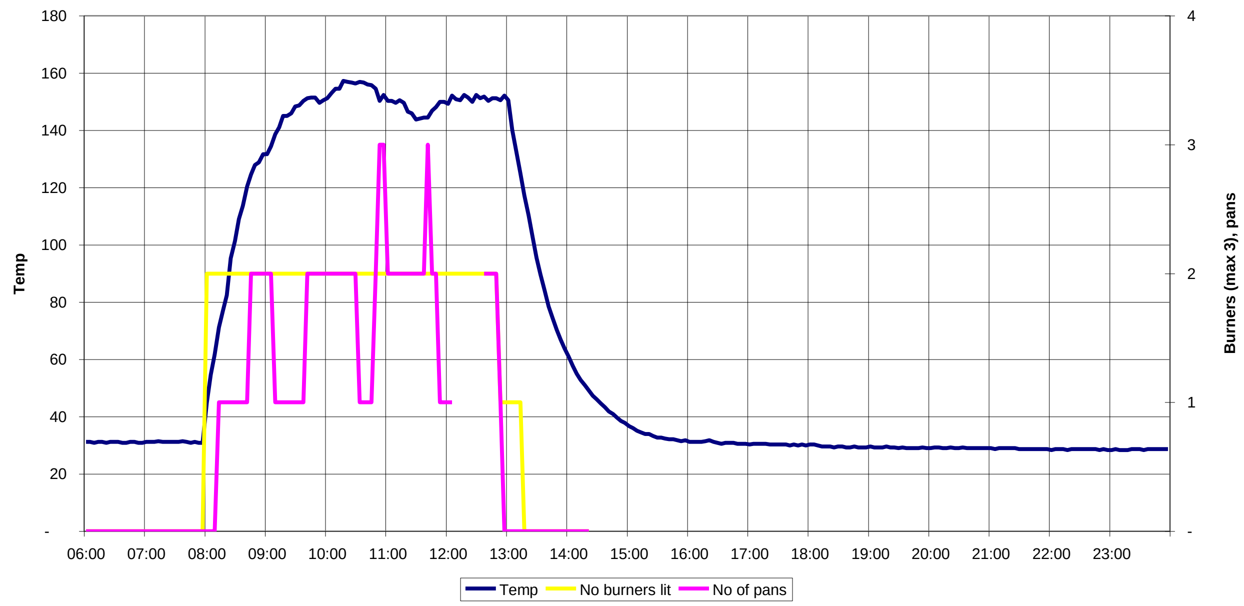


Figure 18 shows observations made on a flat-top hob, sited next to the open hob shown in the previous example. The hob is typically used one day per week according to the chef's preference. The hob has three zones and two of them were used. A maximum of two pans were used compared with a capacity of four pans on the two lit zones. The warm-up time is well over an hour. In general flat-top hobs have lower food energy efficiency and less adjustability than open-topped hobs and there is an opportunity in this case to save energy by using the adjacent open hob in preference to the flat-top.

The EU minimum energy efficiency standard[31] for domestic hobs are:-

- Open burners > 52%
- Covered burners from cold > 25%
- Covered burners from hot > 35%

These figures indicate the relative differences in energy efficiency of the different technologies. The standard for commercial hobs requires a minimum efficiency for open burners of 50%.

3.3.2 Hobs – induction and electric hobs

There were no induction or electric hobs included in the study so it has not been possible to assess the relative performance of induction hobs compared to conventional gas or electric hobs.

Studies of induction hobs suggest that they can achieve high levels of energy transfer efficiency. The illustrative figures in Table 10 suggest that the theoretical carbon impact of induction hobs will equal that of gas hobs when the electricity supply carbon factor drops below about 0.297 kg CO_2e per kWh, which is forecast to happen around 2020[32].

Table 12 – Theoretical comparison of gas, electric and induction hobs

Hob type	Gas	Electric	Induction
Transfer efficiency [33]	52%	74%	84%
kg CO_2e/kWh supply	0.184	0.525	0.525
kg CO_2e/kWh delivered	0.353	0.709	0.625
kg CO_2e/kWh supply target equal to gas	0.186	0.261	0.297

Induction hobs have other advantages which are not captured here:

- Power is only used when a pan is in contact with the hob. This eliminates waste of energy due to poor practice. It would be of interest to study the relative performance of induction and conventional hobs in practice.
- Indirect savings due to lower extraction requirements.

The cost advantage of gas hobs over induction or electric hobs is not expected to change significantly.

[31] Preparatory study for Ecodesign requirements of EuPs (III) Lot 23 Domestic and Commercial Hobs and Grills, Task 1 Definition. P30. January 2011 European Commission (DG ENER)
[32] The Committee on Climate Change, 7980 TSO 2011. Chapter 5. Decarbonising Electricity Generation.. Figure 5.25
[33] Technical support document for residential cooking products. Volume 2: Potential impact of alternative efficiency levels for residential cooking products. (see Table 1.7). U.S. Department of Energy, Office of Codes and Standards.

3.4 Other cookers

Table 13 – Other cookers that were monitored in the study

Site	Hospital	Hospital	Hospital	B&I	B&I	School
Cooker	Grills	Bratt pan	Fryers	Fry top	Fryers	Fryers
Fuel	Gas	Gas	Gas	Gas	Gas	Gas
Number of burners	2	1	2	1	2	2
Burner rating kW	12.00	11.50	12.00	8.00	17.20	12.00
Total rating kW	24.00	11.50	24.00	8.00	34.40	24.00
Duty cycle	45%	54%	26%	74%	74%	50%
Avg load when on, kW	10.77	6.25	6.14	5.92	25.46	12.00
Hours on per week	39.00	5.60	45.60	49.40	21.00	2.90
kWh/week	420	35	280	292	535	35
Annual kWh	21,840	1,820	14,560	15,207	27,798	1,357
Annual cost	£ 655	£ 55	£ 437	£ 456	£ 834	£ 41
Annual CO_2 kg	4,010	334	2,673	2,792	5,104	249

Table 13 summarises energy use for the other cookers that were monitored in the study. This is a very diverse group of equipment performing different functions. The utilisation and hours of operation are very variable.

Figure 19 – Grill observation example

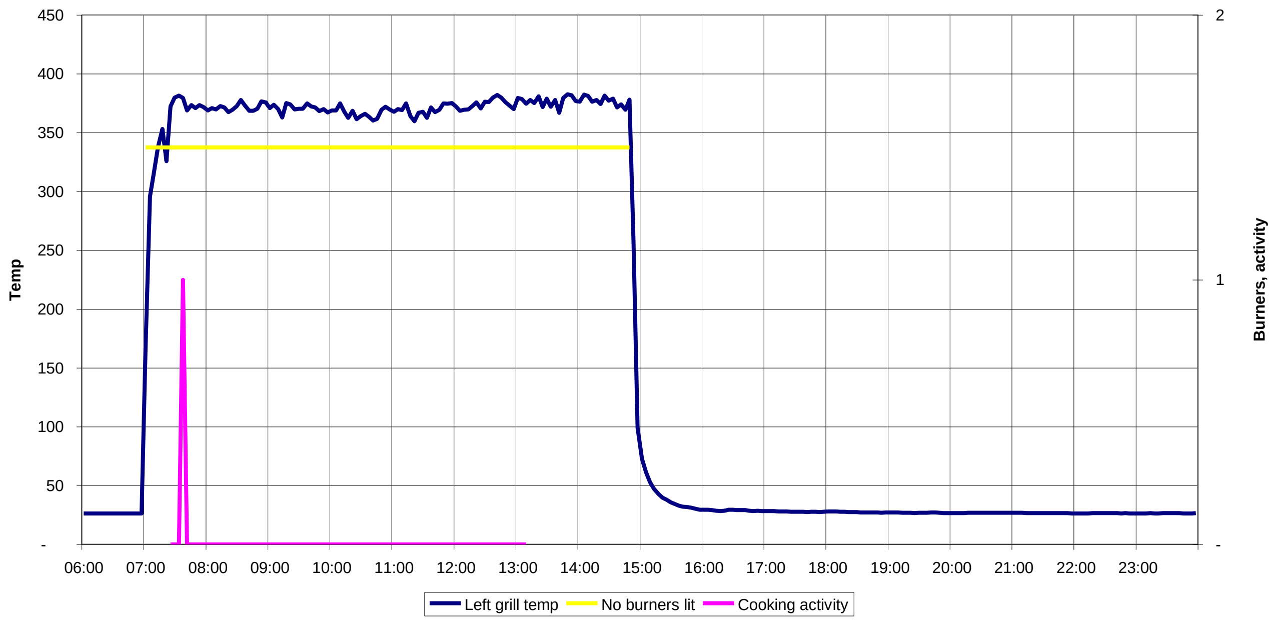


Figure 19 shows the observations made for a day on one of the grills. The grill was on for 8 hours and used for only one cooking operation, browning oven-cooked sausages, lasting a only few minutes. Switching this grill off when not needed would save significant amounts of energy, carbon and cost.

Options for reducing energy use included extending the oven-cooking time to include browning, and switching off the grill after use. The non-automatic ignition of this grill could be a barrier to switching it off, as well as the warm-up time of ~20 minutes.

The grill has two burners, front and back, and both were on. One of the burners could be switched off to reduce the standby energy use and reduce re-heat time should the grill be required.

Figure 20 – Double fryer observation example

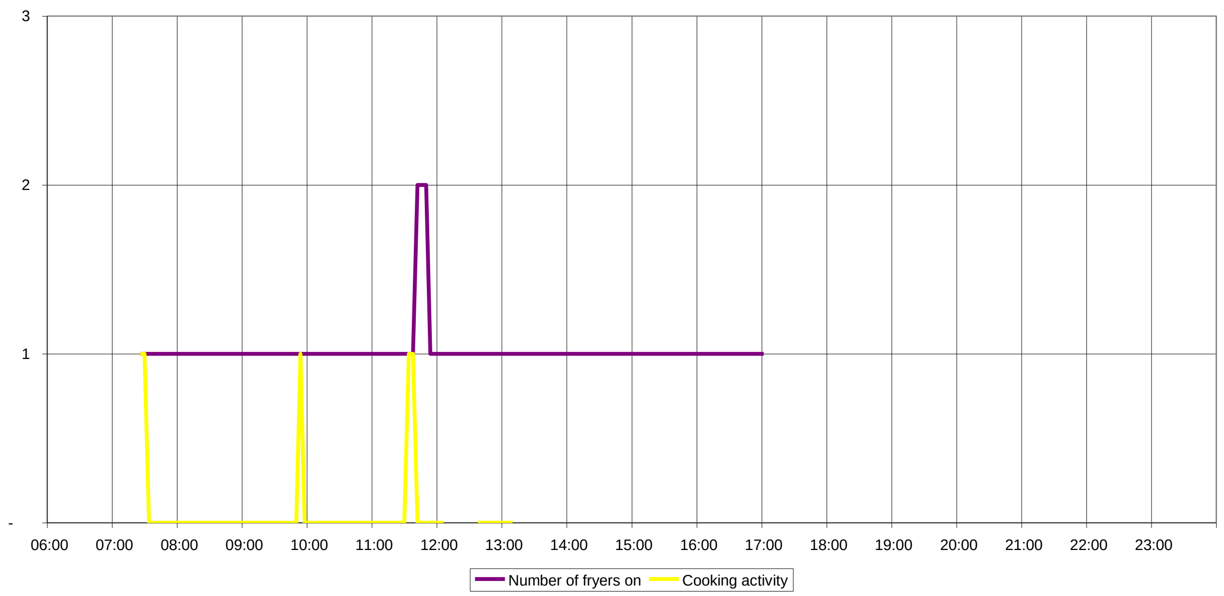


Figure 20 shows activity on a double fryer unit observed for one day. The fryer was on for 9.5 hours and used for three short periods of cooking activity totalling 10 minutes. There are opportunities to switch the fryer off when not needed or to use spare capacity in the ovens for some of the frying operations (roast potatoes, hash browns). The fryer could also be operated at a lower temperature when not in use to reduce standby power use and reheat time.

Energy efficient features of fryers include: twin-tanks, immersed elements (electric), pre-mix air (gas), flat-bottomed tanks, auto-standby.[34] Energy-saving features of fryers: reach cooking temp in 10-12 mins, immersed tube combustion (gas), allow easy filtration, low oil capacity, fast recovery time, do not lose heat through combustion discharge.[35]

[34] Energy efficiency in commercial kitchens CIBSE TM50: 2009 p41.
[35] Carbon Trust guide: Food preparation and catering CT035: 2008 p6

3.5 Cooking - other observations

Table 14 Choice of cooking methods

Operation	Method 1	Method 2
Cooking pasta	Boil in pan of water on hob	Steam in combi oven
Roast potatoes	Steam in combi, fry off, then finish in combi	Boil in pan on hob, roast in combi
Sausages	Cook in combi, brown under grill	Cook and brown in combi (longer cooking time)
Hash browns	Deep fry	Roast in combi
Heating beans	In pan on hob	In combi
Heating soup	In pan on hob	In combi

Cooking operations were observed in two kitchens over two days during the study period. Many cooking operations observed could be done by more than one method, see Table 12 above. Where there is spare oven capacity there may be energy savings if some non-oven cooking operations can be avoided.

One of the study sites won an award for a low carbon meal. The cooking method used was to steam fish over the pan in which the potatoes were cooked, reusing the steam from the cooking. As well as using sustainably sourced fish the meal was considered healthy due to the low fat content. It would be interesting to explore low-carbon cooking methods and whether there is a link between low-carbon cooking and healthy eating in general due to the cooking methods used, e.g. steaming/boiling rather than frying/roasting.

Table 15 Observations - Potential daily savings due to behaviour change

Equipment	Usage kWh	Saving kWh	Saving %
Hob/Oven	26	16	62%
Fan oven	22	0	0%
Combi oven	15	0	0%
Bratt pan	7	0	0%
Grills	60	60	100%
Fryer	40	32	80%
Flat-top	40	24	60%
Large hob	30	4	13%
Small hob	5	2	40%
Combi E	24	0	0%
Combi R	55	0	0%
Total	**324**	**138**	**43%**

Table 15 shows the potential for 43% energy savings from behaviour change based on the observations made at two sites and the energy usage on those days. The behaviour changes include switching off the grills, fryer and hobs when not needed, avoiding switching on ovens unnecessarily, using the open hob rather than the flat-top, and avoiding extended hob cooking times. The business case for energy savings from behaviour change in cooking is considered in Section 8.1.1.

Additional savings could potentially be achieved by changes in cooking methods, improving oven utilisation and avoiding using ovens for holding.

3.6 Cooking – Drivers

As is apparent from the discussion above, cooking energy use is not directly driven by the amount of meals produced on a particular day or week, but indirectly by operational requirements which drive the choice and amount of equipment that is installed and the hours of operation.

Decision making in design and purchasing of the equipment and matching them to the operational requirements are therefore key determinants of the cooking energy used. Equipment choices that could reduce energy use include:

- Correct sizing of capacity,
- Operational flexibility,
- Low idle energy,
- High food energy efficiency, and
- Design features that facilitate good energy behaviour.

Conversely, the conventional focus on low initial cost may lead to selection of equipment with higher life cycle costs.

Behaviour in operating the equipment can have a very significant impact on energy use for a given set of equipment. Key aspects of behaviour that drive energy use include:

- Avoiding switching on equipment that is not immediately required,
- Ensuring equipment is switched off when not immediately required,
- Ensuring that equipment that is on is effectively utilised, especially ovens and
- The choice of cooking method.

Menu choice also drives the choice of cooking methods and it would be interesting to explore the concept of low-carbon menus and a possible link to healthy eating.

The carbon footprint of cooking is also influenced by fuel choice, with gas appliances having lower running costs and carbon emissions than their electric equivalents. The carbon advantage of gas appliances is likely to be eroded over the next 10 years or so, as electricity becomes less carbon-intensive, but the cost advantage is expected to remain.

3.7 Cooking – Opportunities

Table 16 Cooking – summary of opportunities.

<table>
<tr><th>Type</th><th>Ovens</th><th>Hobs</th><th>Other cookers</th></tr>
<tr><td>Behaviour change</td><td>Switch on only the ovens required to match the demand

Switch ovens off when not in use for periods of 20 minutes +

Use spare oven capacity to perform other cooking operations and avoid switching on other equipment, or allow it to be switched off.

Avoid using electric ovens for holding, use a well-insulated hot cupboard instead and switch the ovens off as soon as possible.</td><td>Switch on hob rings when needed, switch off after use.

Avoid leaving pilot lights on over night.

Where possible use open hobs in preference to flat-tops.

Avoid extended cooking times on hobs, use them intensively for shorter periods and switch off.

Use spare oven capacity to perform some hob operations (eg cooking pasta).</td><td>Switch on equipment when needed, switch off after use, e.g. Grills, Fryers.

Reduced settings to reduce warm-up times: grills, fryers.

Use spare oven capacity to perform some grill and fryer operations (roasting, browning, frying).</td></tr>
<tr><td rowspan="2">Purchasing</td><td>Specify more smaller ovens and a choice of oven sizes to increase operational flexibility and reduce energy use.

Purchase ovens with highest food energy efficiency and lowest idle rate e.g. Energy Star.

Purchase gas ovens in preference to electric ovens, where possible.</td><td>Purchase gas hobs in preference to electric hobs, where possible.</td><td>Specify cookers with the shortest warm-up times and automatic ignition (cf behaviour).

Purchase gas cookers in preference to electric cookers where possible.</td></tr>
<tr><td colspan="3">Purchase equipment with the lowest lifecycle cost.</td></tr>
<tr><td rowspan="2">Innovation</td><td>The EuP preparatory study identifies potential energy savings of 2-3% for combi ovens with the least lifecycle cost compared to the base case.</td><td>The EuP preparatory study identifies potential energy savings of 28-34% for hobs with the least lifecycle cost compared to the base case.</td><td>The EuP preparatory study identifies potential energy savings of 16-35% for fry tops with the least lifecycle cost compared to the base case.</td></tr>
<tr><td colspan="3">Design of models which facilitate good energy behaviour, quick start-up, automatic ignition, energy-saving controls, standby modes, low idle energy.</td></tr>
<tr><td rowspan="2">Further study</td><td>Cost-benefit analysis of optimal oven sizing methods.

Relative performance of different oven models.</td><td>Comparison of electric induction hobs and conventional gas and electric hobs.</td><td>Relative performance of different fryers and grills.</td></tr>
<tr><td colspan="3">Comparison of energy use for oven cooking with other cooking methods.</td></tr>
</table>

Type	Ovens	Hobs	Other cookers
	Low-carbon cooking methods, possible link to healthy eating?		

4 Extractor findings

Extraction accounts for 21% of the emissions from catering on our four study sites, and shows some of the starkest differences from one site to another.

Cooking and extraction are strongly related as gas appliances must be sited under extraction and the gas supply cut-off is interlocked to extractor fan operation. Gas supply may also be interlocked to air supply and Electric Combi ovens are also under extraction due to steam emissions. Some dishwashers have their own extraction units due to vapour emissions.

Space heating requirements will be significantly impacted by extraction but space heating was outside the scope of this study, and so that impact has not been included.

Recommendations for extraction are summarised in Section 4.4.

4.1 Extraction equipment

Table 17 – Site extraction equipment

Site	B&I	Hospital	School
Extraction distance (floors)	2	6	0
Number of extractors	3	2	1
Control	BMS timer	Always on	Manual
Hours of operation	M-F 6:30-22:00	24/7	M-F 7:00–13:30
Weekly hours	77.5	168	32.5
Air supply	Dedicated	Common	None
Annual kWh	29,848	61,620	741
kWh/meal	0.32	0.47	0.01

There are significant differences between the three sites regarding the extraction systems resulting in considerable variation in the extraction energy used.

The system resistance and air flow achieved by these extraction systems is not known. The type of filters and their state of maintenance will also have an impact on system resistance.

4.2 Other extraction observations

Figure 21 – Extractor example – BMS (Building Management System) control

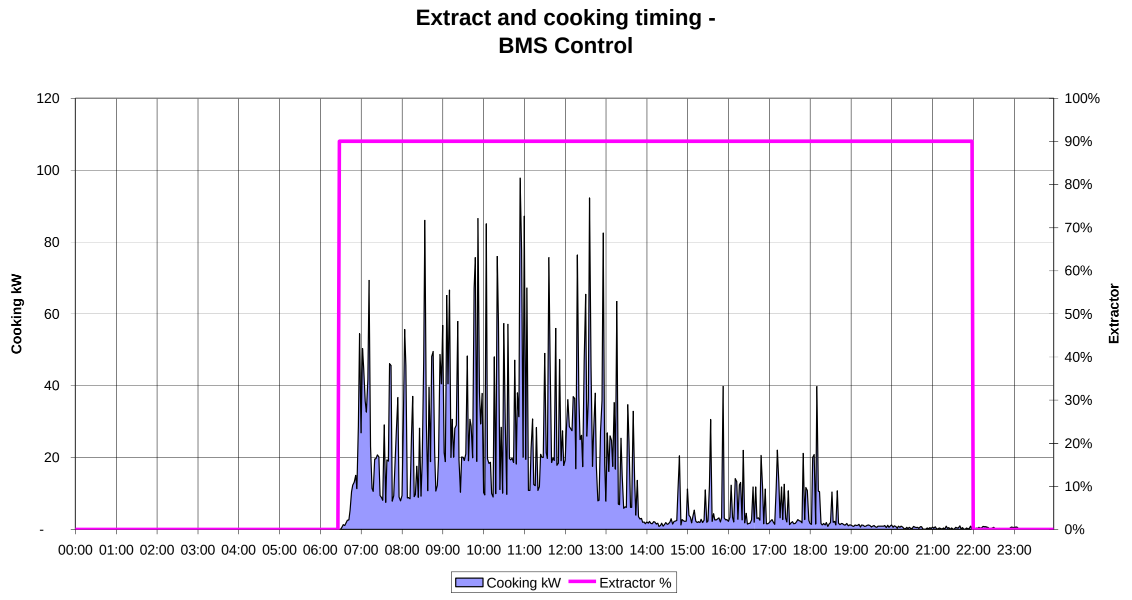


Figure 21 shows the operation of extractors under timer control compared with the average cooking energy used at the same times across the four week study period. The extractors and air supply are operated at 90% of capacity. The BMS (Building Management System) control has 50/70% settings that are not used. The extraction is timed to operate until 22:00, but the kitchen is only in use some evenings. The conveyor dishwasher extractor is on the same timing as the kitchen, but the dishwasher is only operated up till lunch time. There are opportunities to reduce the timing, and perhaps the load of the extraction system. Given the variable hours of the kitchen a mechanism to vary the timing would be useful; generally the kitchen knows what functions are planned for the next week, so the BMS timing plan could be set up each week for the next. Alternatively an evening override control could be provided via the kitchen office PC.

Figure 22 – Extractor example – Manual control

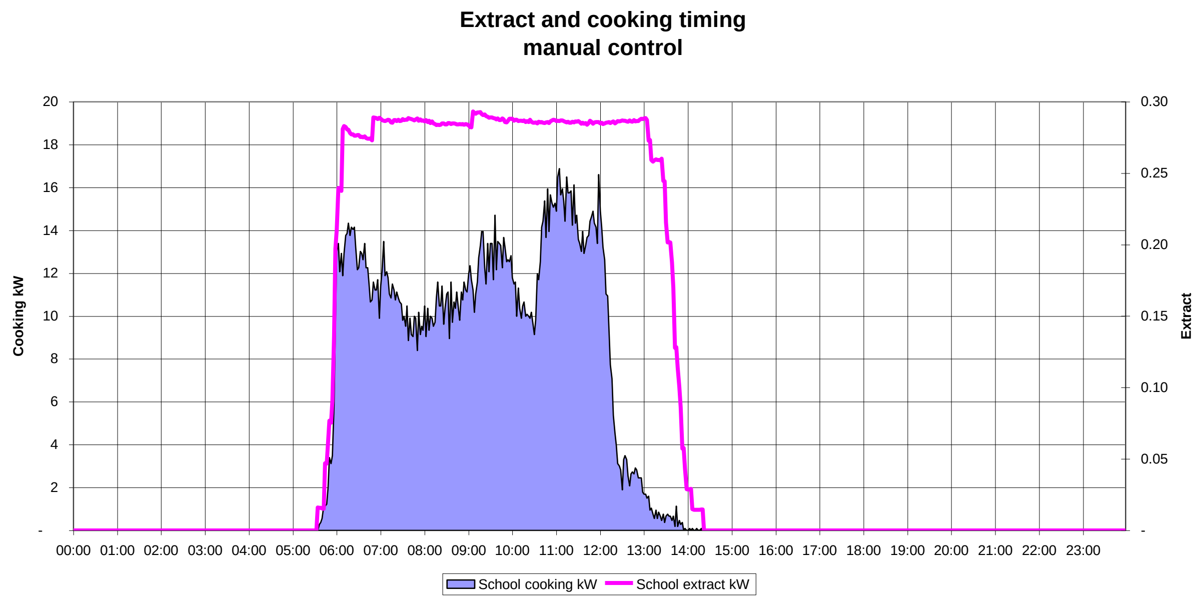


Figure 22 shows the operation of extractors under manual control compared with the average cooking energy used at the same times across the four week study period, showing a very good match. Note that the sous-chef in this kitchen was observed to be assiduous in switching equipment off when it was no longer in use.

Figure 23 – Extractor example – Always on

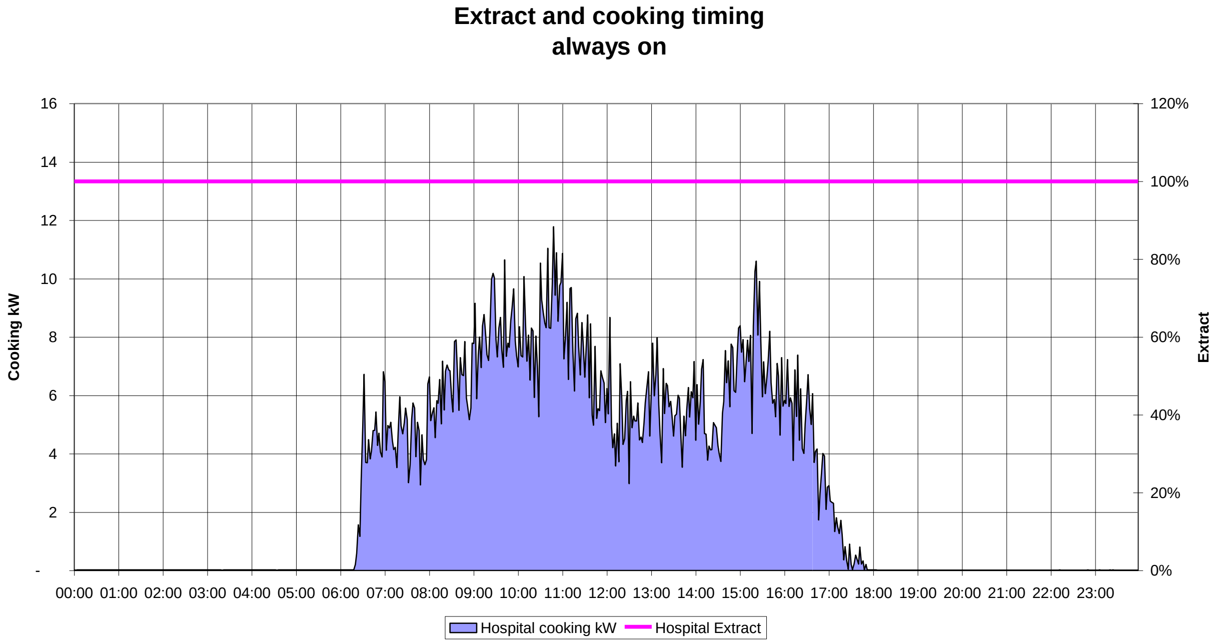


Figure 23 shows the extractors which are always on compared with the average cooking energy used at the same times across the four week study period. The extractors are not linked to the BMS and there are no controls in the kitchen. If the extractor fans stop then the gas supply reset is in the control cabinet 6 floors above the kitchen.

Potential savings of 50% could be achieved by matching the extractor operation to the kitchen operation, more savings are possible if fan speeds could be reduced subject to achieving the required air changes.

Extraction energy is a power function of fan speed, so operating the fan at 70% speed can reduce power use by 66%, and at 50% speed power use is reduced by 87%.[36]

Table 18 Extractors, potential savings from control change

Changes	Usage kWh/week	Saving kWh/week	Saving %
School: no change	19	0	0%
Hospital: reduce hours and rate	1,188	772	65%
B&I air supply: hours	278	83	30%
B&I kitchen extract hours	152	45	30%
B&I dishwasher extract hours	63	29	46%
Total	**1,700**	**929**	**55%**

Analysis of the specific opportunities at the study sites indicates potential to save 55% of extraction energy. The business case for improving control of extraction systems is examined in Section 8.2.3.

[36] Energy efficiency in commercial kitchens CIBSE TM50: 2009 p22.

The control changes at the hospital would require investment of £4-5k to automate the gas reset and bring the motors under BMS control. Payback for the investment would occur within 18 months. The improvements at the other sites do not require investment.

4.3 Extraction drivers

The extraction system in a kitchen is primarily designed to ensure capture of the plume of gases from cooking appliances containing gas combustion products so that these can be safely extracted from the building, and ensure sufficient air flow for satisfactory combustion.

The key factors driving the specified power of the extraction system include the choice of cooking fuel, the layout of the appliances, the fan efficiency and the system resistance to be overcome including any filtration requirements. The key operational factors include the control method and the hours of operation.

For the same size and capacity, industry sources indicate that gas ovens need ~25% more extraction than electric ovens. The requirements for extraction of a plume from electric cookers or dishwashers depends on their emissions of steam/water vapour. Some electric appliances are designed to minimise vapour emissions to the point where they can be operated without extraction. Vertical stacking of ovens can reduce the extraction requirements.

4.4 Extraction opportunities

Type	Opportunity
Behaviour change	Where extraction is manually controlled ensure a staff member has responsibility for switching it off. Where extraction is timer/BMS controlled ensure the settings match the operating hours of the kitchen. Where the operating hours are variable put control measures in place to vary the extraction hours accordingly. Where the extractor/air supply has variable speed control determine the setting that gives adequate air flow and use that setting. Use a reduced setting at times of lower activity. Ensure filters and vents are cleaned regularly to reduce system resistance.
Purchasing/design	Consider vertical stacking of ovens to reduce the area of the extraction hood. Ensure that the minimum air flow required for plume extraction from the cooking equipment is calculated to avoid over-specification. Specify high efficiency fans types and fan motors.[37] Install variable speed drives on the fan motors so that system power can be varied to minimise energy use. Ensure automatic or manual control is in place with automatic reset of the gas control valve.
Innovation	Sensors linked to variable speed drives may automatically vary the fan speed with the cooking load.[38]

[37] Energy efficiency in commercial kitchens CIBSE TM50: 2009 p25.

Type	Opportunity
Further study	Impact of extraction on space heating requirements. Potential for heat recovery from extraction to pre-heat water.

[38] Energy efficiency in commercial kitchens CIBSE TM50: 2009 p18.

5 Dishwasher findings

Dishwashing accounts for some 7% of the emissions from catering on our four study sites. This section reviews the study findings and the drivers for dishwashing energy use. Recommendations for dishwashing are summarised in section 5.4.

5.1 Dishwashing equipment

Table 19 shows the amount and energy use of dishwashing equipment at the study sites. The use per meal ranges from 0.04 kWh/meal to 0.10 kWh/meal with an average of 0.08 kWh/meal.

Table 19 Host site dishwashing equipment

Dishwashing equipment	B&I	Hospital	School	MOD	Total
Undercounter one-tank	3	4			7
Hood-type one-tank	2	1	1	1	5
Conveyor type multi tank	1				1
Meals / year	**93,330**	**129,792**	**84,045**	**45,000**	**352,167**
Dishwashing energy kWh	16,692	12,948	3,003	3,510	36,153
Dishwashing - kWh /meal	**0.18**	**0.10**	**0.04**	**0.08**	**0.10**

Table 20 lists the dishwashing equipment which was metered as part of this study. The data analysis presented in this section relates to this equipment.

Table 20 Metered dishwashing equipment

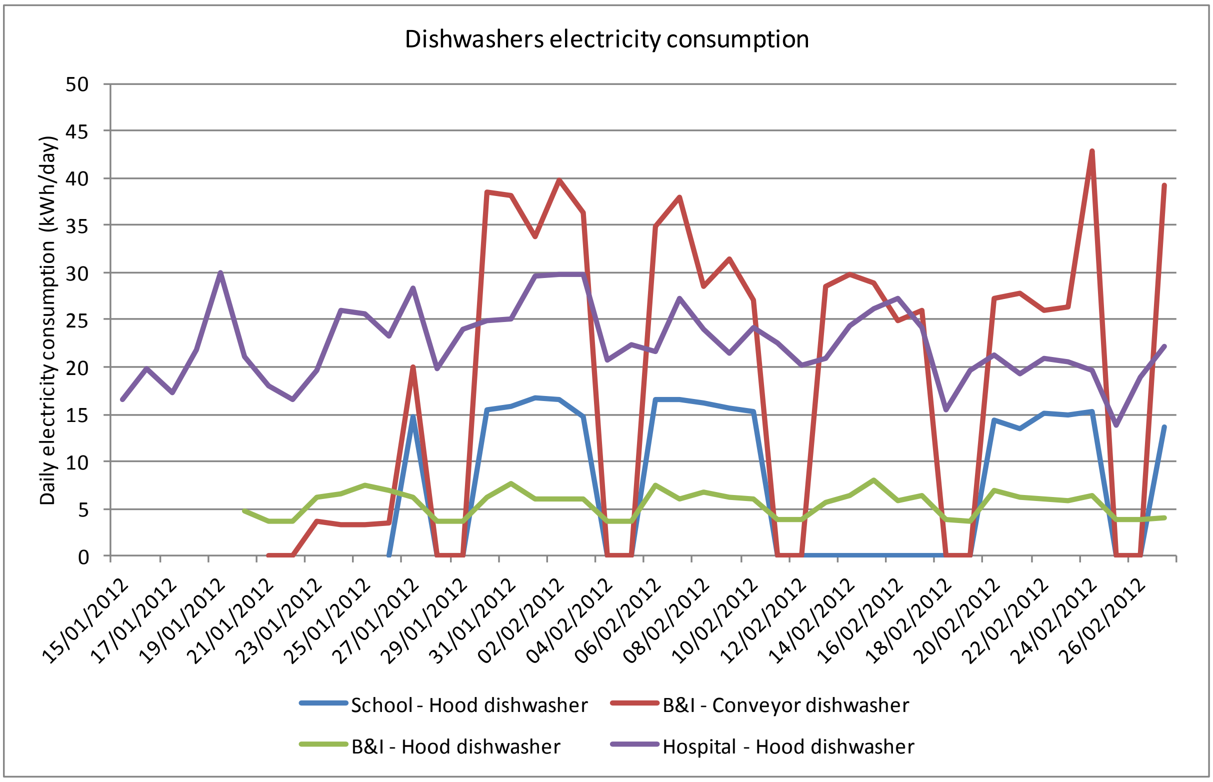
Site	Equipment	Tank	Feed
School	Hood	Single	Hot
B&I	Conveyor	Multiple	Hot
B&I	Hood	Single	Hot
Hospital	Hood	Single	Hot

Comparison of dishwasher energy consumption against published benchmarks[39] was not possible, as data on the number of dishes washed was not collected during this study. Benchmarks are measured as Energy consumption use phase per 100 dishes (kWh), Water consumption use phase per 100 dishes (litres) and Energy consumption ready-mode per hour (kWh/h).

Figure 21 below shows the daily electricity consumption for each of the 4 dishwashers over the measurement period.

[39] http://www.ecowet-commercial.org/

Figure 24 Daily electricity consumption for dishwashers



The Hospital hood dishwasher is in operation 7 days per week (though not to its full capacity), which explains the increased electricity consumption compared to the other units.

The B&I site and the school operate 5 days per week. The B&I hood dishwasher consumes electricity at weekends though, which relates to its heater as shown in Figure 24.

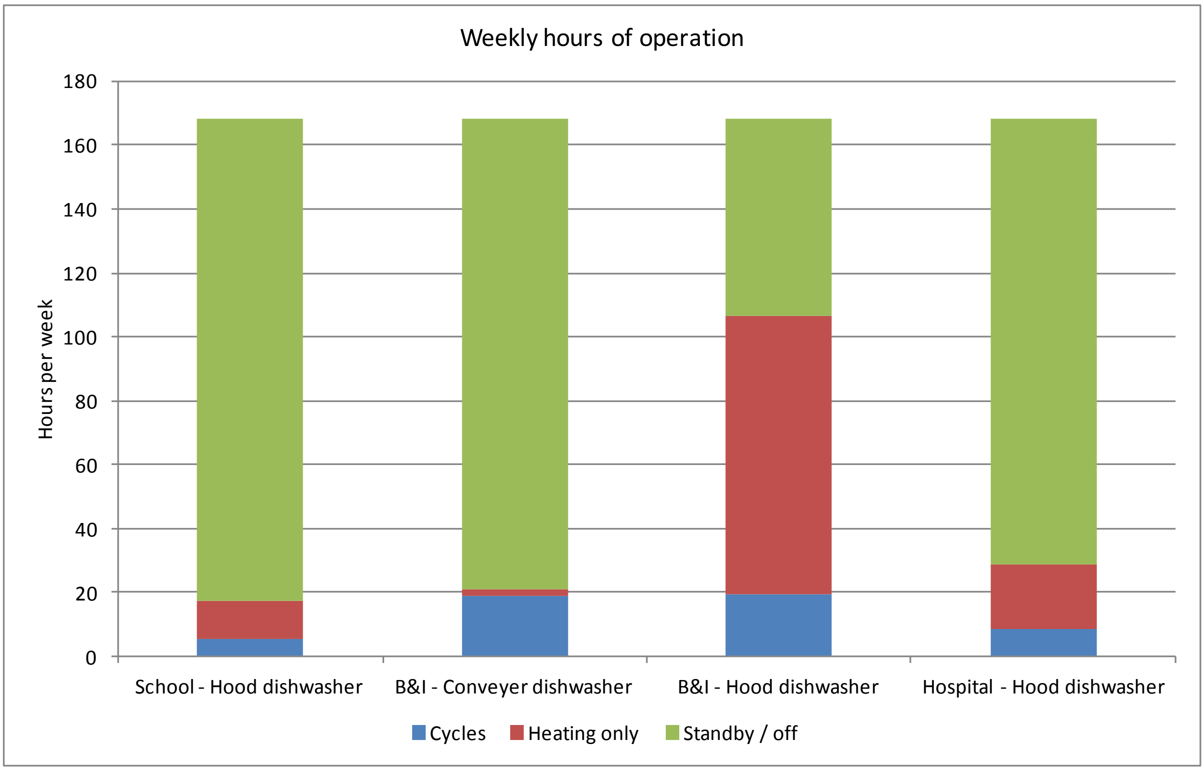
Figure 25 below shows the weekly hours of operation for each of the 4 dishwashers, based on the measurement period.

Staff should be trained to switch the unit off completely whenever possible.

The conveyor dishwasher is by far the largest of the dishwashers in the study. Whilst the conveyor dishwasher uses the most electricity when it is operational, further data analysis (see below) indicates it only uses electricity when it is washing dishes, and it has very little standby electricity consumption. Standby electricity is defined here as the amount of electricity used by the dishwasher when it is not operating, and its electrical heater is switched off. Some dishwashers consume a small amout of electricity for controls which are on permanently.

Figure 25 below shows the weekly hours of operation for each of the 4 dishwashers, based on the measurement period.

Figure 25 Weekly hours of operation

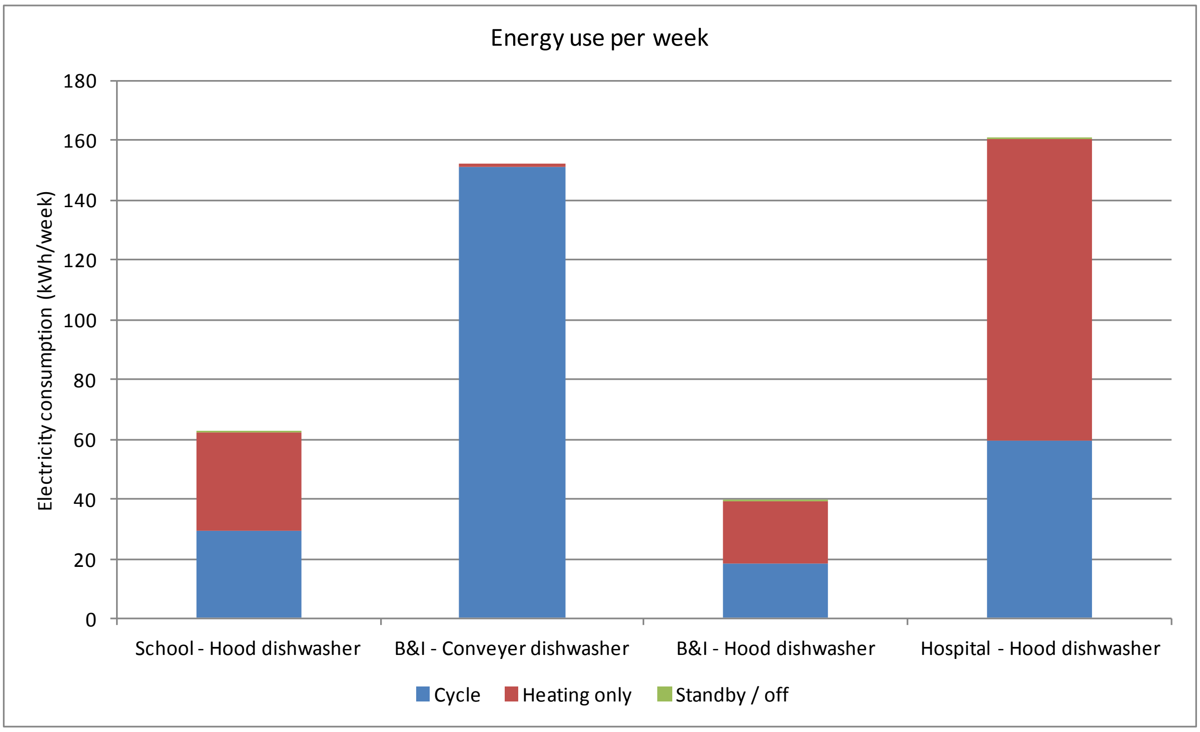


'Cycles' refer to active dishwashing, with a corresponding peak in electricity demand. 'Heating only' refers to periods where the electric heater is used to maintain the water temperature, but no dishwashing occurs, and 'Standby/off' refers to any periods where both the dishwasher and the heater are off, but controls may still be on, or the unit is completely switched off.

The B&I hood dishwasher is shown to have a significantly higher 'Heating only' energy consumption compared to the other units, mainly as it is left on over weekends and evenings.

Figure 26 below shows the electricity consumption per dishwasher, based on an average week.

Figure 26 Dishwasher energy use per week

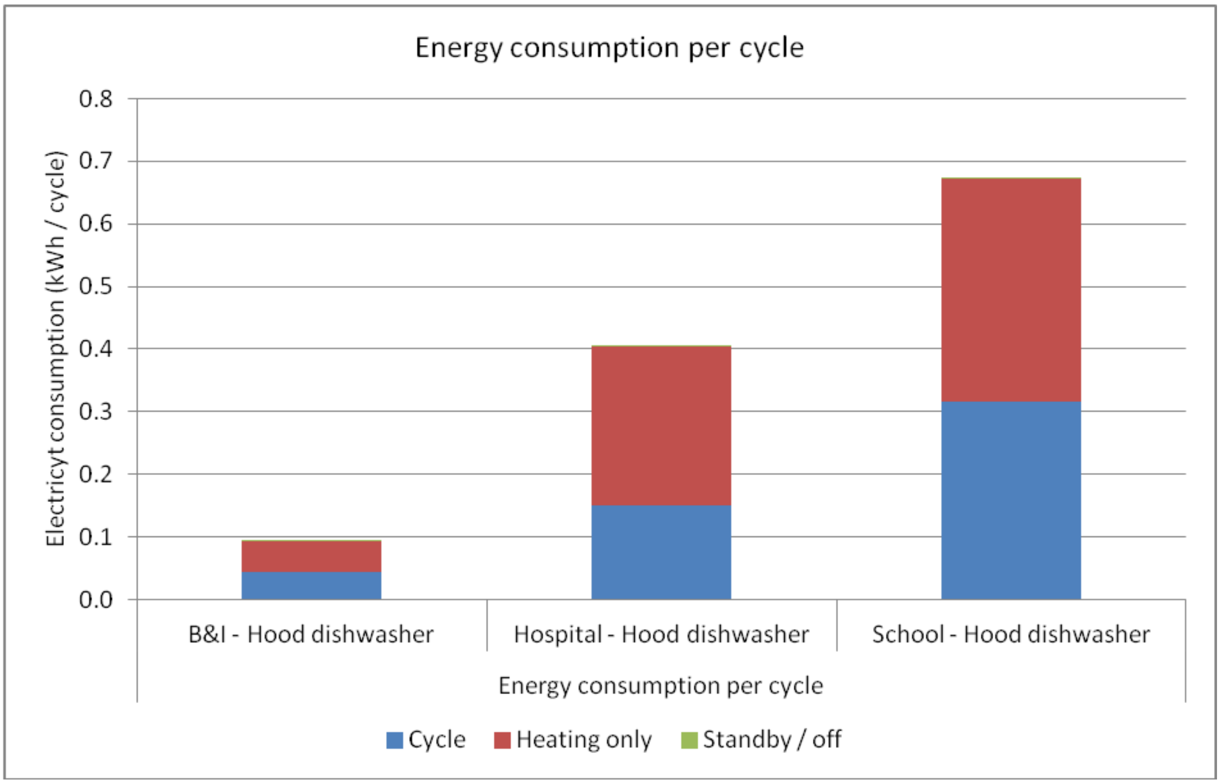


Though the B&I conveyor dishwasher has a high weekly electricity consumption, it also has a high utilisation. The Hospital dishwasher has very similar weekly electricity consumption, but a much lower utilisation. This highlights the importance of switching equipment off whenever possible.

The B&I and School hood dishwashers have lower weekly energy consumptions due to their lower number of operating hours per week.

Figure 27 below illustrates the dishwasher energy consumption per cycle for the hood dishwashers in the study.

Figure 27 Dishwasher energy use per cycle – Hood dishwashers

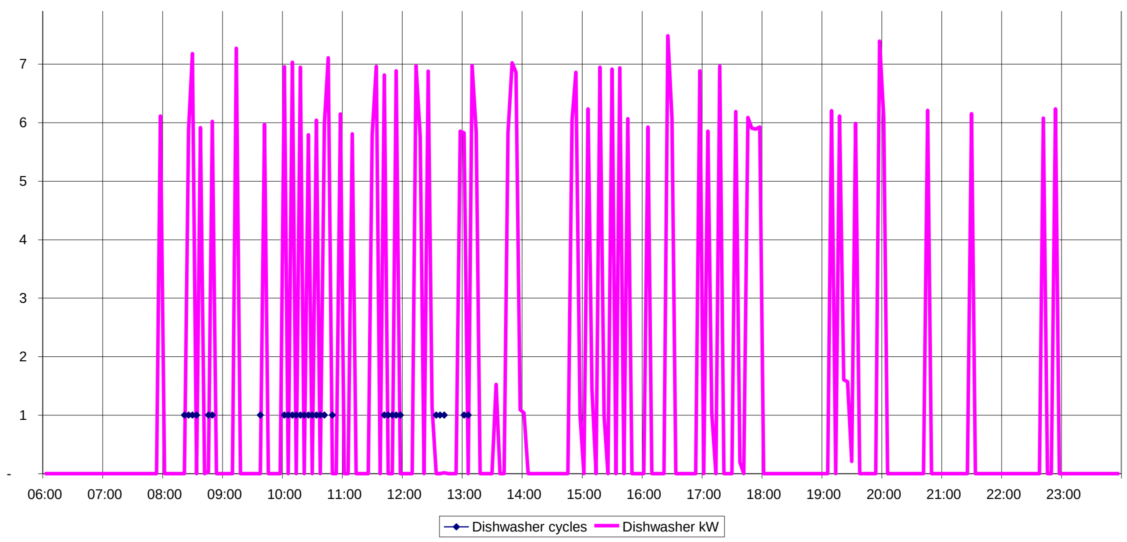


For the school, the energy consumption per cycle is high, as it has a relatively small number of cycles. For the hospital the higher consumption is caused by the unit being on 24/7 without necessarily washing dishes.

For comparison, the single conveyor dishwasher in the study consumed 3.1 kWh per cycle.

Figure 28 below shows an example of one of the dishwashers observed in the study. Under loading of trays was not an issue. Most items are pre-washed to remove soil before dishwashing.

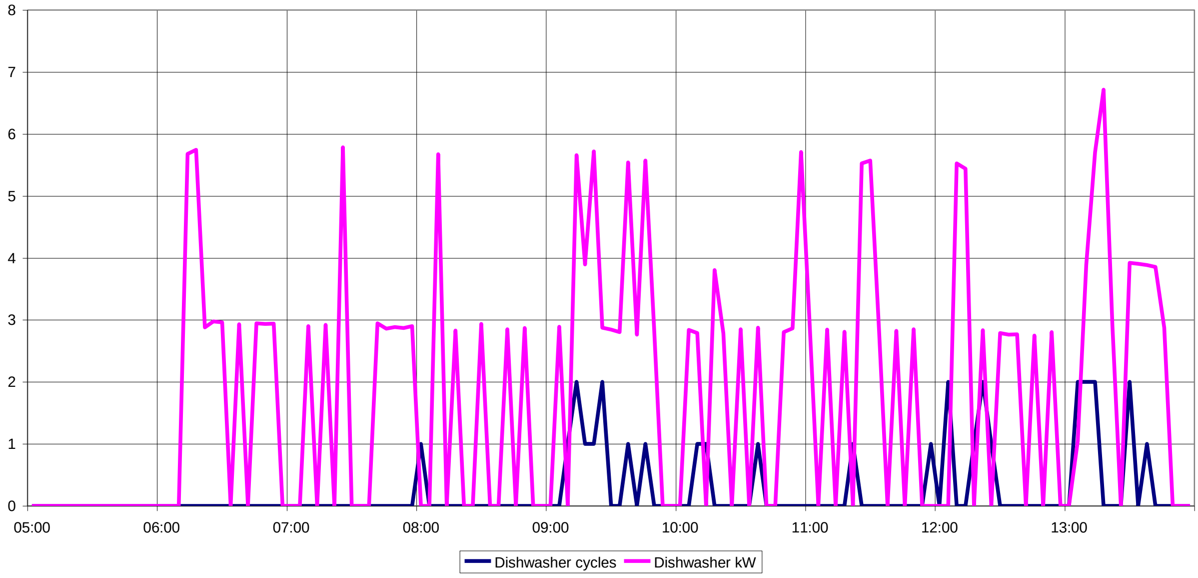
Figure 28 Dishwasher observation example 1



The cycles from 19:00-20:00 were due to breakdown of one of the pantry dishwashers. The pantry staff not being familiar with the drain-down cycle then leave the kitchen dishwasher on overnight. There is an opportunity pending replacement of the pantry dishwasher to train the staff to drain down and switch off the kitchen dishwasher after use.

Figure 29 shows another example of one of the dishwashers observed in the study.

Figure 29 Dishwasher observation example 2



The dishwasher was switched on at 06:10, the first operating cycle was at 08:00 and the second at 09:00. The dishes were pre-washed by immersion so that all visible soil was removed, the dishwasher being used more for sanitisation than washing. There are opportunities to switch the dishwasher on three hours later and to save hot water by reducing amount of pre-washing.

Figure 30 – Half-hour consumption for hood dishwasher, example 3

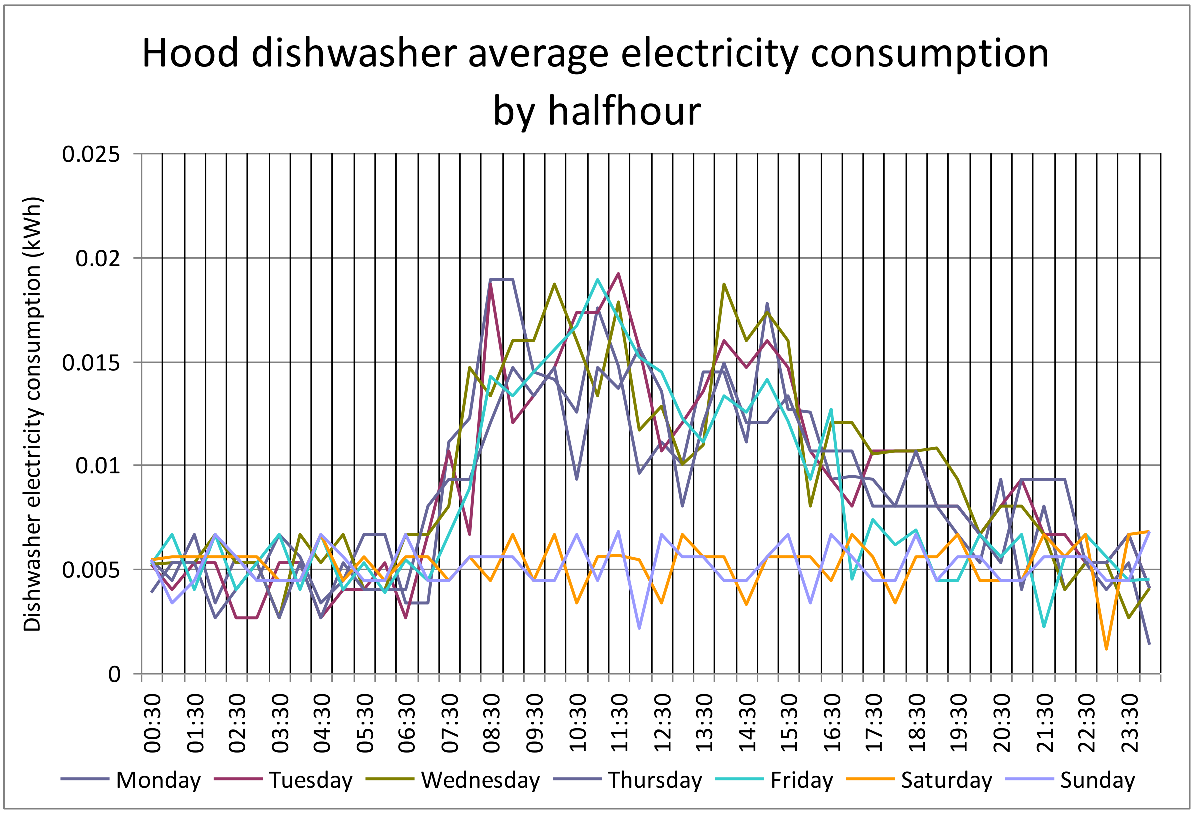


Figure 30 shows the half-hourly consumption for one of the hood dishwashers. This machine is on standby at night and at weekends consuming energy to maintain washing temperature. There is an opportunity to reduce energy use by 50% by switching off when not in use.

5.2 Dishwashing drivers

The major driver for dishwasher energy consumption is thought to be the number of racks requiring washing. As this information was not available for this study, the relationship could not be established or quantified.

As outlined in section 5.1 above, one of the drivers identified is the time the dishwasher is on for, compared to the time it is operational. Long idle periods lead to increased electricity consumption by the electric heater. It is therefore recommended that dishwashers are switched off when operations allow.

During the presentation of the major findings, the impact of water quality on dishwashing energy consumption was raised. Units operating in hard water areas might be prone to increased energy consumption through the fouling of the heater, as well as increased chemicals consumption.

Also during the presentation of the major findings, the possibility of heat recovery from dishwashers was raised. Some modern units are capable of recovering heat from the outflow to pre-heat the cold-feed. Water vapour heat recovery is another option. Both would reduce the need for additional electricity or hot water to meet the temperature demand of the dishwasher. It is recommended that heat recovery options are considered when purchasing new equipment.

5.3 Other dishwashing observations

During the site visits, the practice of using hot water to pre-rinse plates was observed. Rather than removal of lumps, the hot pre-rinse was used to essentially clean the plates before they were loaded into the dishwasher. The dishwasher then provided a sanitisation function. This practice leads to increased energy consumption through the use of hot water. It is recommended that cold water is used for pre-rinse, and that pre-rinse is used only to remove large lumps. This leaves the dishwasher to wash the dishes.

5.4 Dishwashing opportunities

Table 21 Dishwashers, observed potential from behaviour change

Dishwashers Behaviour change	Weekly usage kWh	Weekly saving kWh	Saving %
Example 1 - Switch on later	81	25	31%
Example 2 - Switch off overnight	197	42	21%
Example 3 – Switch off overnight and at weekends	40	20	50%
Total	**318**	**87**	**27%**

Table 21 shows potential weekly energy savings of 27% from behaviour change for dishwashers. The business case for behaviour change in dishwashing is examined in Section 8.1.2.

Table 22 below summaries the dishwashing opportunities. Section 8 contains the business cases for all opportunities.

Table 22 Dishwashing opportunities

Type	Opportunities
Behaviour change	Ensure dishwashers are switched off whenever possible, in order to minimise standby energy consumption. Wherever possible ensure that racks are full in order to minimise the amount of energy used per plate. Use cold-water for pre-rinse to minimise the use of hot water.
Purchasing and installation	Purchase the most energy efficient equipment (in kWh/100 dishes) when replacing. Consider models with heat recovery from hot sanitation. Purchase water-efficient dishwashers as these tend to be the most energy-efficient.[40] Where centrally-generated hot water is available provide hot feed to the dishwasher as this can reduce running costs. Where local hot water generation exists, it may enable heat recovery from refrigeration. Hot feed from a central gas-fired boiler can reduce running costs.
Innovation	The EuP preparatory study identifies potential energy savings of 12-36% for dishwashers with the least lifecycle cost compared to the base case.
Further study	Comparative performance of different models.

[40] Carbon Trust Food preparation and catering. CTV035. Page 5.

6 Refrigeration findings

Refrigeration accounts for 33% of the carbon emissions from the four study sites. This section reviews the study findings and discusses the drivers for refrigeration energy use. Recommendations for refrigeration are summarised in Section 6.4.

6.1 Refrigeration equipment

Table 23 shows the estimated refrigerated storage capacity (excluding display equipment) at the four sites.

Table 23 Host site refrigerated storage capacity

Refrigeration Chilled Storage	Volume l	B&I	Hospital	School	MOD	Total (l)
Walk-in fridge	14,500	1				14,500
Walk-in fridge	9,000	1				9,000
Walk-in fridge	7,800		1			7,800
Double fridge	1,200	1	1		3	6,000
Single Fridge	600	4	3	3	7	10,200
Undercounter Fridge	500	4	8		2	7,000
Fridge capacity, litres		**29,100**	**14,800**	**1,800**	**8,800**	**54,500**
Fridge as % total		72%	67%	60%	68%	70%

Refrigeration Frozen Storage	Volume l	B&I	Hospital	School	MOD	Total (l)
Walk-in freezer	9,600	1				9,600
Walk-in freezer	5,500		1			5,500
Double freezer	1,200		1			1,200
Single freezer	600		1	2	6	5,400
Undercounter Freezer	300	4				1,200
Blast chiller	500	1			1	1,000
Freezer capacity litres		**11,300**	**7,300**	**1,200**	**4,100**	**23,900**
Freezer as % total		28%	33%	40%	32%	30%

Summary	B&I	Hospital	School	MOD	Total
Total refrigerated capacity, litres	**40,400**	**22,100**	**3,000**	**12,900**	**78,400**
Refrigeration energy kWh/yr	60,031	60,605	12,206	51,730	184,571
Meals/year	93,330	129,792	84,045	45,000	352,167
Refrigeration energy kWh/meal	0.64	0.47	0.15	1.15	0.52
Capacity in litres/meal	0.43	0.17	0.04	0.29	0.22
kWh/litre/year	1.49	2.74	4.07	4.01	2.35

The differences in storage capacity are quite large and reflect site service type as well as capacity requirements. For example, the B&I site has three walk-in units. These are used for daily storage but also provide capacity for servicing occasional large functions.

Figure 31 below shows the percentage fridge volume versus percentage freezer volume for the sites in the study. The average site has 70% of its refrigerated volume as fridges, and 30% as freezers.

Figure 31 Proportion of refrigerated capacity by site

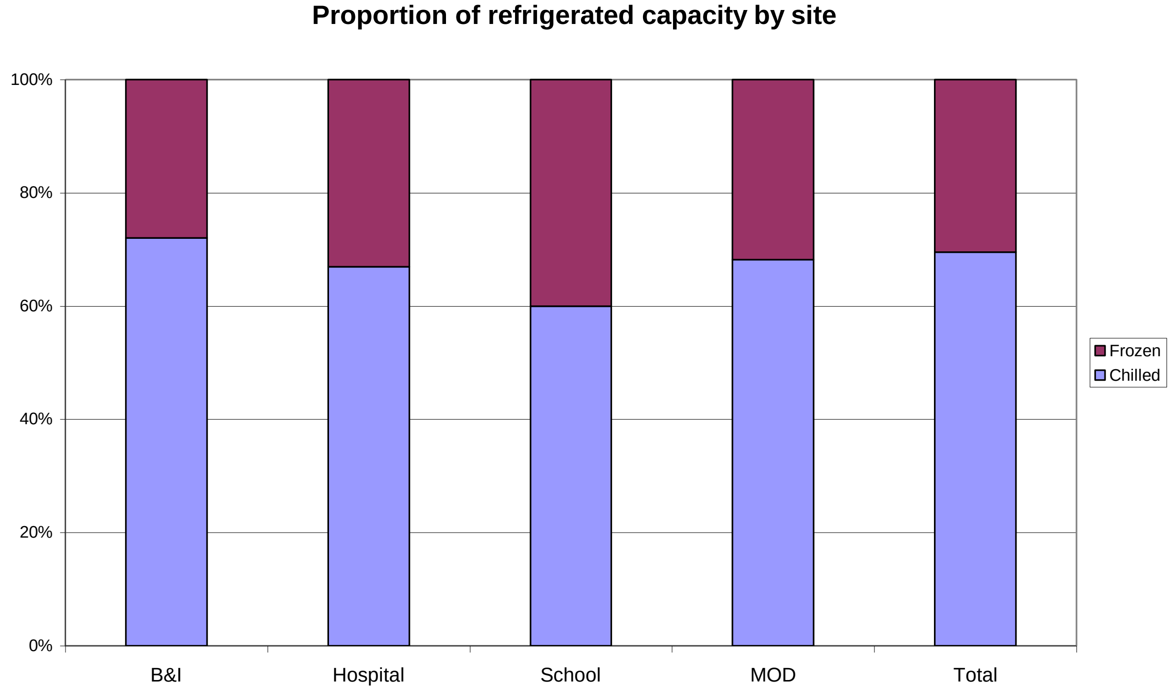


Table 24 lists the refrigeration equipment which was metered as part of this study. The data analysis presented in this section relates to this equipment.

Table 24 Metered refrigeration equipment

Site	Equipment	Size	Age	Refrigerant
School	Fridge 1 (single door)	574 litres	1994	R134A
School	Fridge 2 (single door)	647 litres	>5 years	R134A
Hospital	Upright fridge (double door)	1,230 litres	>10 years	R404A
Hospital	Walk-in fridge	7.8 m^3	>10 years	R404A
B&I	Walk-in fridge	14.5 m^3	2007	R744
Hospital	Upright freezer (double door)	1.32 m^3	>10 years	
School	Freezer 1 (single door)	0.62 m^3	2008	R404A
School	Freezer 2 (single door)	0.574 m^3		R404A
B&I	Walk-in freezer	9.6 m^3	2007	R744
Hospital	Walk-in freezer	5.5 m^3	>10 years	R404A
Hospital	Upright freezer (double door)	1.32 m^3	>10 years	

Table 25 below compares the actual energy consumption of single and double door units against published benchmarks. Benchmarks for walk-in units were either not available (for freezers) or the collected data did not allow for a comparison (fridges). It must be noted that the actual consumption was measured against the individual operating temperatures of the units, and the individual ambient temperatures, i.e. no provision has been made to normalise these results to standard internal and external temperatures.

Table 25 Performance against benchmarks[41]

Unit	Benchmark (kWh/48 hours/m^3)	Actual (kWh/48 hours/m^3)	Difference (kWh/48 hours/m^3)	Difference (%)
School fridge 1 (single door)	6.2	7.6	1.4	23%
School fridge 2 (single door)	6.2	5.4	-0.8	-13%
Hospital fridge (double door)	7.1	11.6	4.5	63%
School freezer 1 (single door)	24.1	29.3	5.2	22%
School freezer 2 (single door)	24.1	32.4	8.3	34%
Hospital freezer (double door)	23.7	27.6	3.9	16%
Total	**91.4**	**113.9**	**22.5**	**25%**

The Table shows that, on average, energy consumption of single and double door fridges and freezers can be improved by 25% by purchasing units which meet the benchmark standard for energy efficiency. The business case for this change is examined in Section 8.2.4.

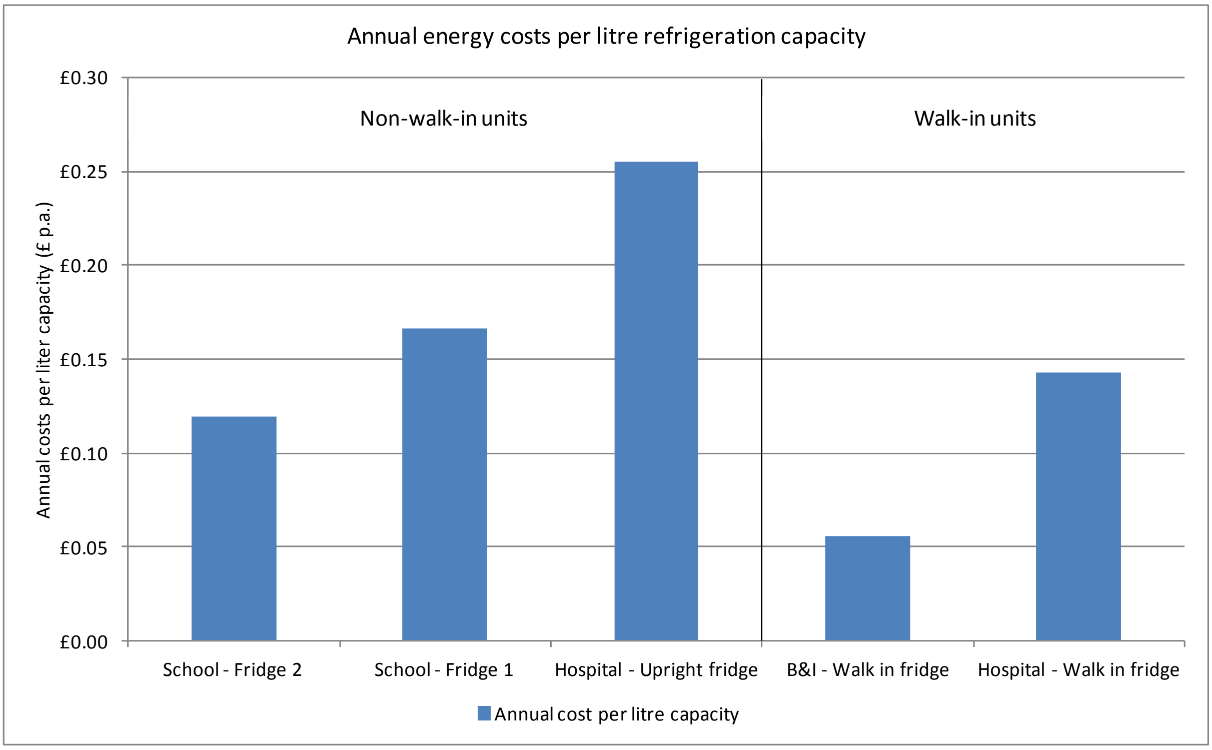
Amongst the metered units the single largest improvement opportunity relates to the hospital double door fridge. This is a fairly old (>10 years) and fairly large unit (1.23 m^3), which is hindered by its location which reduces the amount of cooling air that is available to its condenser. This increases its energy consumption above what might otherwise be expected.

The benchmark[42] for walk-in cold rooms is given by the Coefficient of System Performance (COSP), defined as: The cooling duty provided (kW) / the electrical energy consumed by the system from all sources (kW). The COSP for the walk-in cold rooms in this study could not be calculated as data on the electrical energy consumed by the system from all sources was not available.

Figure 32 below shows the annual energy costs per litre of refrigerated capacity for all the fridges in the study. The energy costs have been calculated based on the measured energy consumption of each fridge, and extrapolated to a year. Energy costs and energy consumption correlate directly.

Figure 32 Annual energy costs per litre of refrigeration capacity – Fridges

[41] BNCR CS04: Commercial Service Cabinets Government Standards Evidence Base 2009: Best Available Technology Scenario (http://efficient-products.defra.gov.uk/cms/product-strategies/subsector/commercial-refrigeration#viewlist)
[42] BNCR CR04: Walk-in Cool Rooms Government Standards Evidence Base 2009: Best Available Technology Scenario (http://efficient-products.defra.gov.uk/cms/product-strategies/subsector/commercial-refrigeration#viewlist)

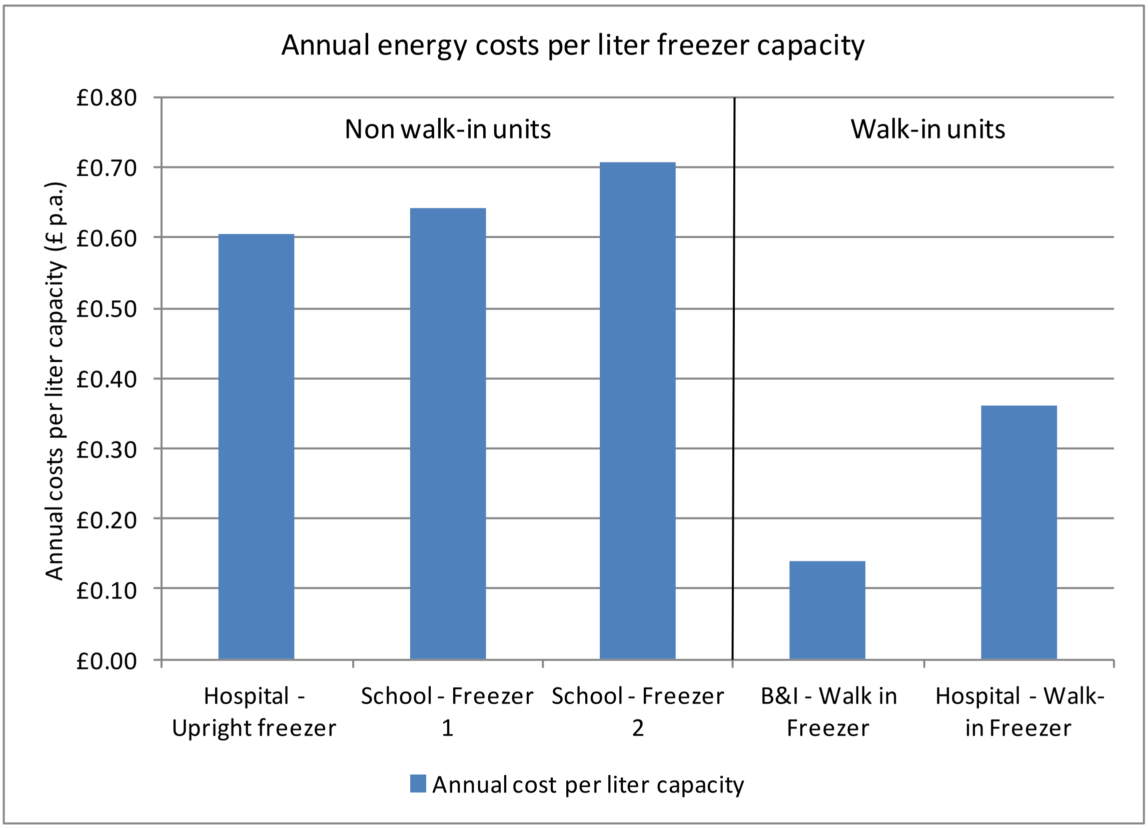


The analysis shows a wide variation between similar fridges. For the walk-in fridges for example, the B&I unit operates at £0.06 / litre / year, and the hospital unit operates at £0.14 / litre / year. The hospital unit suffers from poor ventilation which contributes to higher energy consumption. A reduction of 61% would be achieved if the hospital unit could operate at the same efficiency as the B&I unit. This equates to £681 and 3 tonnes CO_2 per year.

It is recommended that particular attention is paid to levels of insulation, degree of control, and size of each refrigeration unit when new units are specified or procured.

Figure 33 below shows the annual energy costs per litre of refrigerated capacity for all the freezers in the study. The energy costs have been calculated based on the measured energy consumption of each fridge, and extrapolated to a year. Energy costs and energy consumption correlate directly.

Figure 33 Annual energy costs per litre of refrigeration capacity - Freezers



The analysis shows variation between similar freezers, particularly for walk-in units. For the walk-in freezers for example, the B&I unit operates at £0.14 / litre / year, and the hospital unit operates at £0.36 / litre / year. A reduction of 62% would be achieved if the hospital unit could operate at the same efficiency as the B&I unit. This equates to £1,230 and 5.4 tonnes CO_2 per year.

The upright double door freezer at the hospital suffers with poor ventilation, which contributes to increased energy consumption. Even so, it is slightly more efficient than the single door units at the school.

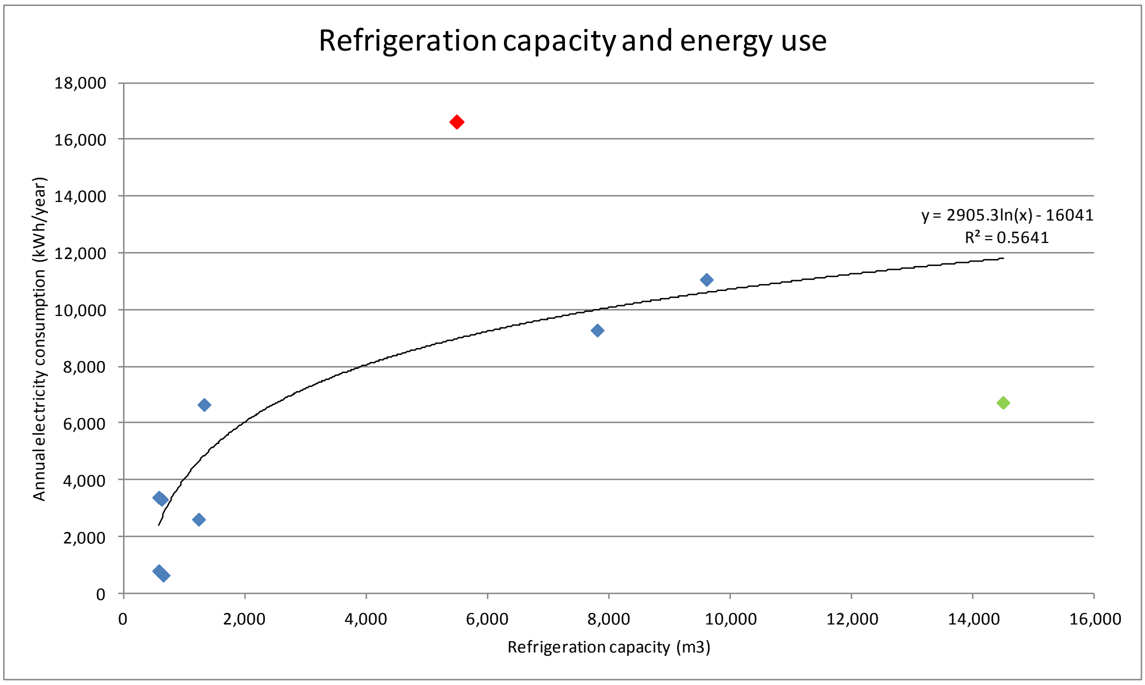
As with the fridges, it is recommended that particular attention is paid to levels of insulation, degree of control, and size of each refrigeration unit when new units are specified or procured.

6.2 Refrigeration drivers

6.2.1 Correlation between refrigeration energy consumption and refrigerated volume

Figure 34 below shows the correlation between the size of refrigeration equipment, and its energy consumption. Except for two outliers (shown in red and green), the correlation is good.

Figure 34 Correlation of refrigeration capacity and refrigeration energy consumption



The two outliers are:-

- The B&I walk-in fridge below the line (indicated with green marker - very efficient).
- The Hospital walk-in freezer above the line (indicated with red marker - very inefficient).

The B&I walk-in fridge is a large, modern unit with good levels of insulation, modern controls and an efficient refrigerant (R744 or CO_2). All these factors combine to reduce its energy consumption by some 5,000 kWh p.a. (-43%), compared to the expected consumption for a unit of its size. This reduces annual running costs by £611 and emissions by 2.7 tonnes CO_2e.

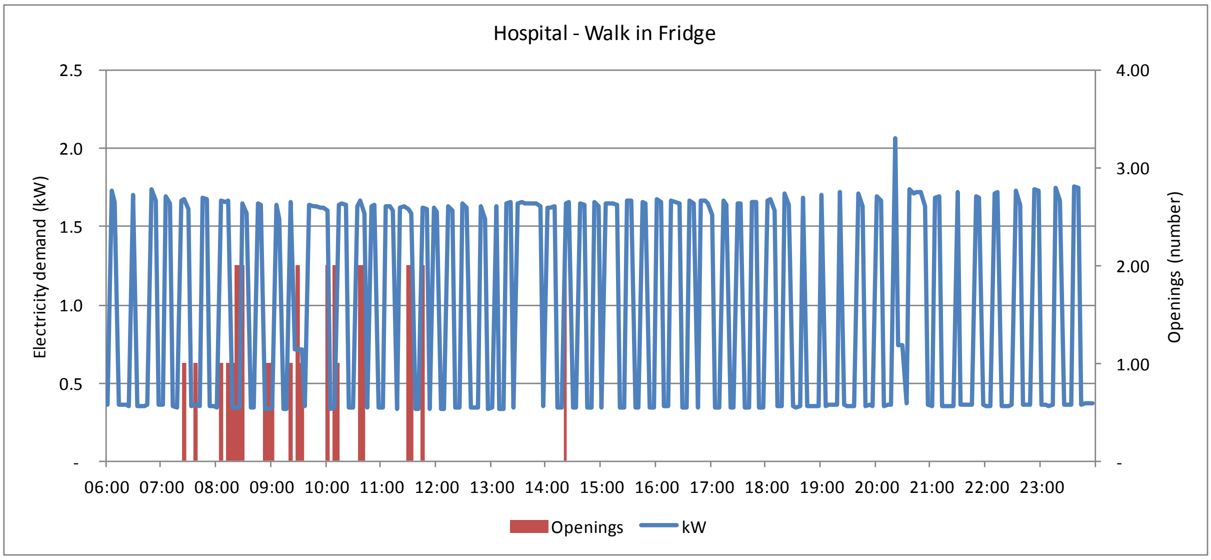
The Hospital walk-in freezer however is a smaller unit, older than the B&I walk-in fridge, and lacks some of the energy efficiency features of that unit. As a result, its energy consumption is some 7,600 kWh (85%) higher than the expected consumption for a unit of its size. This increases annual running costs by £914 and emissions by 4 tonnes CO_2e.

This analysis highlights the need for appropriate regard for energy efficiency and lifetime costs during the specification and procurement of equipment.

6.2.2 Correlation between refrigeration energy use and door openings

Figure 35 below shows the energy consumption of the hospital walk-in fridge as well as the number of door openings for a period of 18 hours. The door is opened to remove cold material for processing, or to put warm material into the fridge for cold storage. As a result, energy consumption is expected to have a correlation with the number of door openings.

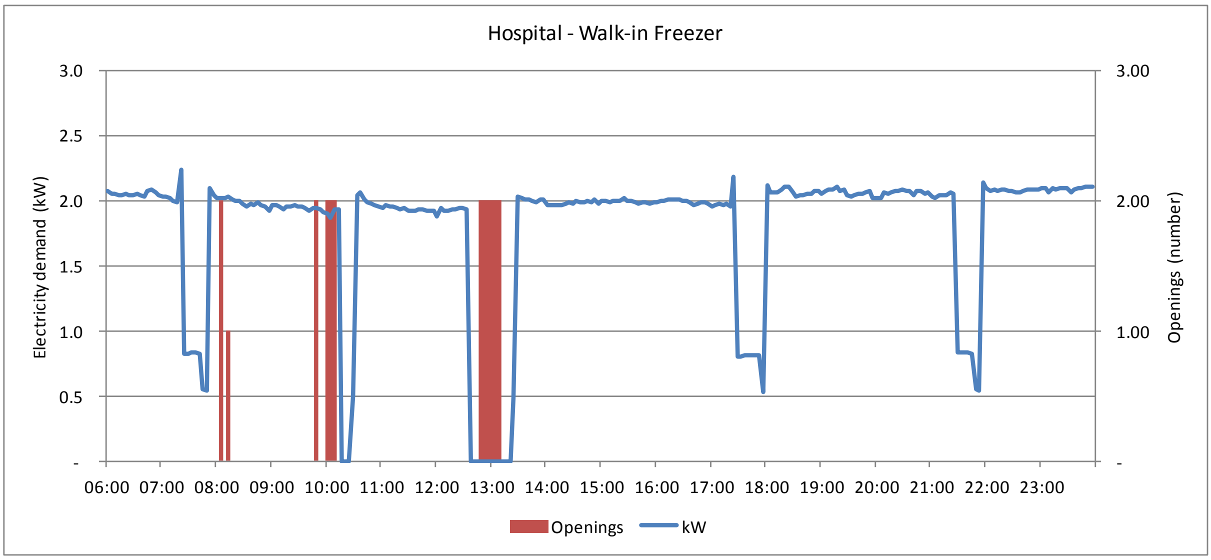
Figure 35 Energy consumption and number of door openings – Hospital walk-in fridge



In the period covered by the graph above, the fridge door was opened 35 times. The number of door openings does not appear to affect the length or frequency of compressor cycles, and as a result does not appear to increase the energy consumption of the unit. This is somewhat unexpected, and may be explained by the existence of more dominant drivers for energy consumption (such as heat loss through the fabric of the fridge), or by unresponsive controls of the fridge.

Figure 36 below shows the energy consumption of the hospital walk-in fridge as well as the number of door openings for a period of 18 hours. As with the fridge, a correlation is expected between energy consumption and the number of door openings.

Figure 36 Energy consumption and number of door openings – Hospital walk-in freezer

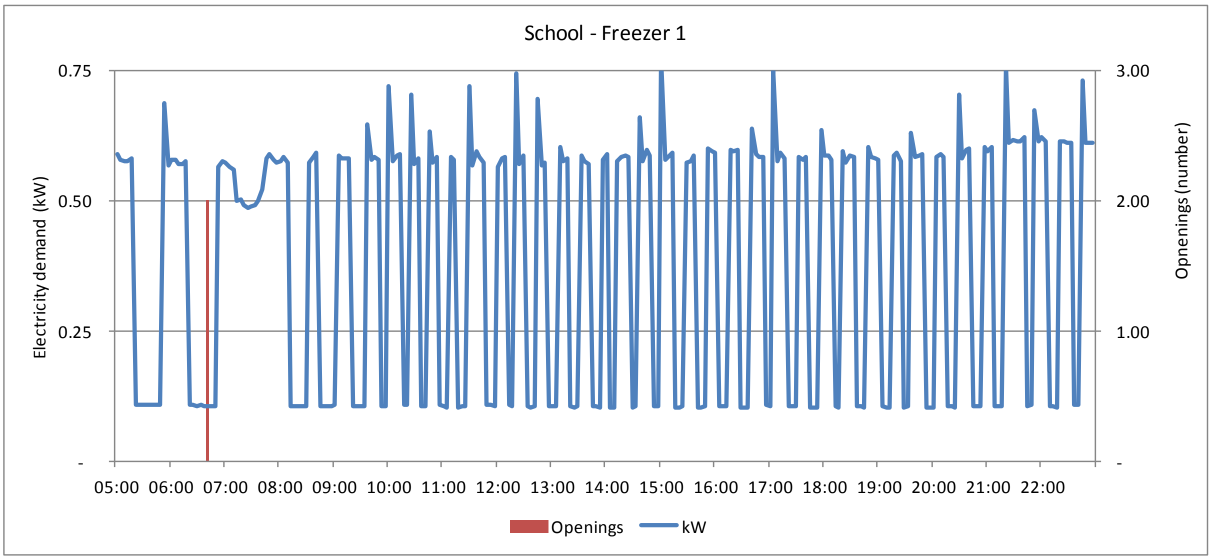


In the period covered by the graph above, the fridge door was opened 23 times, including for one long period where the door was wedged open whilst the contents of the freezer were re-sorted.

For this freezer the number of door openings does appear to affect the length and the frequency of compressor cycles, and as a result increases the energy consumption of the unit. This can be explained by the existence of better insulation and more responsive controls.

Figure 37 below shows the energy consumption of the school freezer 1 (a single door upright unit) as well as the number of door openings for a period of 18 hours. A correlation is expected between energy consumption and the number of door openings.

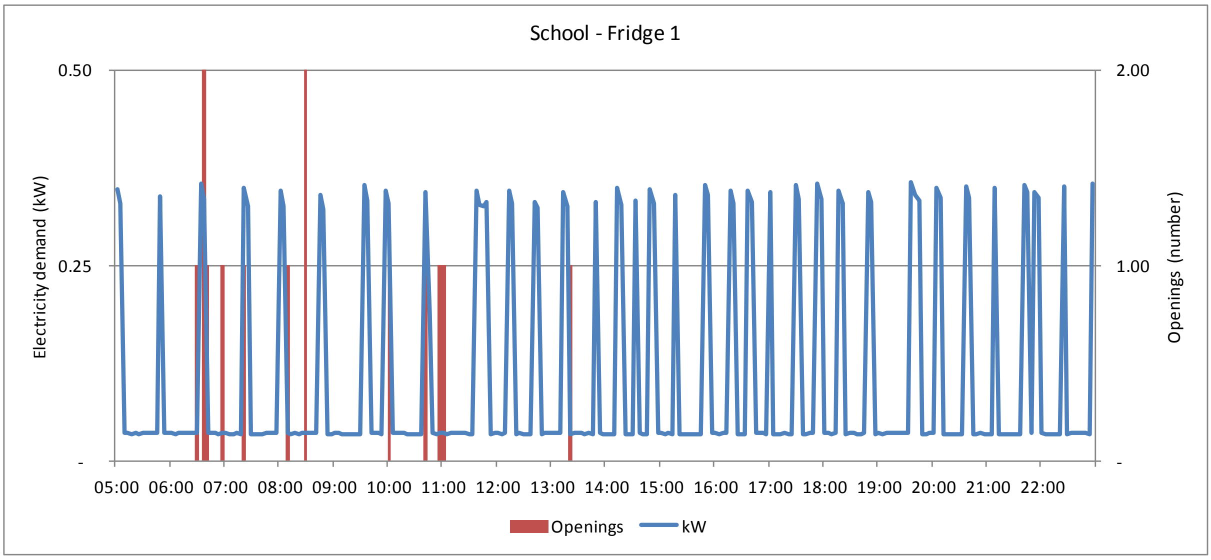
Figure 37 Energy consumption and number of door openings – School freezer 1



In the period covered by the graph above, the fridge door was opened twice. For this freezer the number of door openings does appear to affect the length and the frequency of compressor cycles, and as a result increases the energy consumption of the unit. As the unit is fairly new (2008) insulation and controls are both thought to be good.

Figure 38 below shows the energy consumption of the school fridge 1 (a single door upright unit) as well as the number of door openings for a period of 18 hours. A correlation is expected between energy consumption and the number of door openings.

Figure 38 Energy consumption and number of door openings – School fridge 1



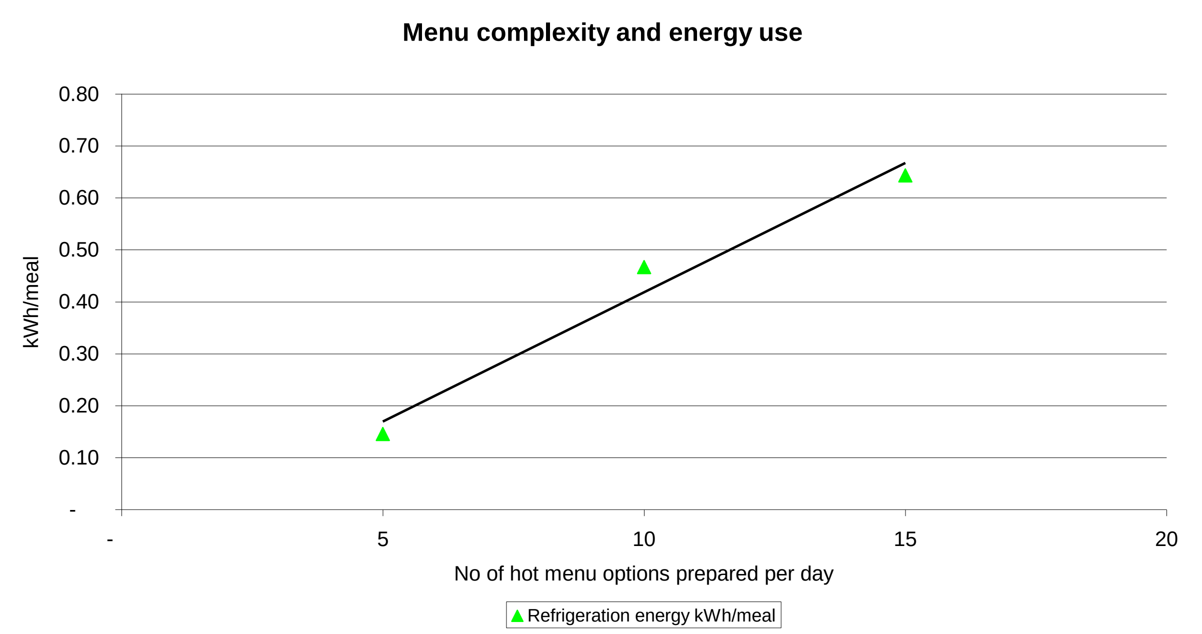
In the period covered by the graph above, the fridge door was opened 14 times. The number of door openings does not appear to affect the length or frequency of compressor cycles, and as a result does not appear to increase the energy consumption of the unit. This is somewhat unexpected, and may be explained by the existence of more dominant drivers for energy consumption (such as heat loss through the fabric of the fridge), or by unresponsive controls of the fridge. The unit is 18 years old (1994).

Feedback received during the presentation of the key study results suggests that the lack of influence of door openings on energy use is not surprising, as the controllers may not recognise what is happening in the unit. This may be particularly true for older and for smaller units.

6.2.3 Correlation between refrigeration energy use and menu complexity

Figure 39 below shows the relationship between the number of hot meal options (used as a proxy for menu complexity) and refrigeration energy consumption.

Figure 3 Menu complexity and energy use per meal



There is a clear relationship between complexity and energy use per meal for refrigeration energy, cooking energy and total energy use. It seems that menu and operational complexity could influence energy use by driving the amount of equipment installed and the way in which it is used, for example a wider range of refrigerated ingredients needed for a more complex menu would lead to greater installed refrigeration capacity.

6.3 Other refrigeration observations

During the site visits, refrigeration units were observed which were situated behind panels. This reduces their ability to reject heat from their condensers, leading to increased energy consumption. Whilst the impact on energy consumption could not be measured, it is still recommended that refrigeration heat exchangers are provided with sufficient air flow to enable effective operation.

Some heat exchangers were observed where the filters had not been cleaned. This reduces the airflow to the heat exchangers, leading to increased energy consumption. Refrigeration units situated behind panels (e.g. serveries) are more prone to a lack of filter and heat exchanger maintenance. It is recommended that appropriate maintenance regimes are implemented.

6.4 Refrigeration opportunities

Table 26 below summaries the refrigeration carbon saving opportunities. Section 8 contains the business cases for all opportunities.

Table 26 Refrigeration opportunities

Type	Opportunities
Behaviour	Efficient use – least amount of door-openings possible. Maintenance – Ensure seals are maintained and heat exchangers cleaned. Ensure refrigerators have sufficient ventilation for their heat exchangers. Right capacity – decommission units if poorly utilised.
Purchasing	A larger fridge/freezer can be more efficient than 2 smaller ones. If possible choose an efficient refrigerant (such as R744 / CO_2). Renewal of equipment – make sure fridge/freezer is the most efficient possible, and meets or exceeds the energy performance benchmarks. Specify equipment from the Energy Technology List to benefit from enhanced capital allowances. Double-door units are in general more efficient than single-door.
Innovation	The EuP preparatory study identifies potential energy savings of 52-62% for refrigeration units with the least lifecycle cost compared to the base case. Advanced technologies such as magnetic refrigeration are probably some way from market.
Further study	Potential for recovery of heat from walk-in units for pre-heating water for dishwashing, where local water heating is possible.

7 Other findings

7.1 Metering in the sector

Typically it is the caterers' clients who pay for the utilities used by the caterer, and also own the equipment. This leads to a lack of incentives for caterers to manage energy use, and for clients to invest in energy-efficient equipment.

Sub-metering of catering energy use is not thought to be common in most segments of the sector, though in the MOD estate it is prevalent. It should be noted that on three of the four study sites sub-meters were installed for the main kitchen electricity and gas supplies, but the data was not being fed back to the caterer or used to recharge the caterer for energy use. Where sub-meters are installed they cover only the main kitchen, and do include satellite operations or items remote from the kitchen such as ventilation fans.

Increasing the prevalence of metering in the sector could increase incentives for caterers and enable new business models where the caterer takes on responsibility for energy costs as part of the catering contract. The business case for transferring energy management responsibility to the caterer through sub-metering is examined in Section 8.3.1.

A new business model is needed that provides incentives for clients to invest in efficient equipment and caterers to adopt best practice in using it.

7.2 Food Waste

WRAP recently published a major study of waste in the Hospitality and Food Service sector[43]. The study concluded that 41% of mixed waste from the sector is food waste, and that 67% of this could in theory have been avoided. Prevention of a tonne of food waste is estimated to save £1,800 in disposal and purchasing costs.

While the study focuses on hotels and restaurants, rather than catering, the implications are clear: preventing food waste is a significant opportunity for the sector, both in terms of cost saving and carbon emissions.

Some food waste prevention practices observed included:-

- Reserving a prepared pan of a dish and only cooking it if needed. If not needed it can be refrigerated and served another time.
- Use of blast chillers / freezers to rapidly chill food so it can be stored or served cold.
- Off-site cooking and chilling of meals with on-site regeneration is common practice in the healthcare sector.
- Planning the number of portions of a main course to allow for patient meals plus service in the restaurant. While patient meals are reasonably predictable, the volume of meals in the restaurant is more variable and this can lead to food waste. Changes are being considered to this practice to reduce over-preparation.

The issues of food waste and energy use are linked but the potential savings in energy use and carbon impact remain to be quantified.

[43] The Composition of Waste Disposed of by the UK Hospitality Industry. WRAP 2011

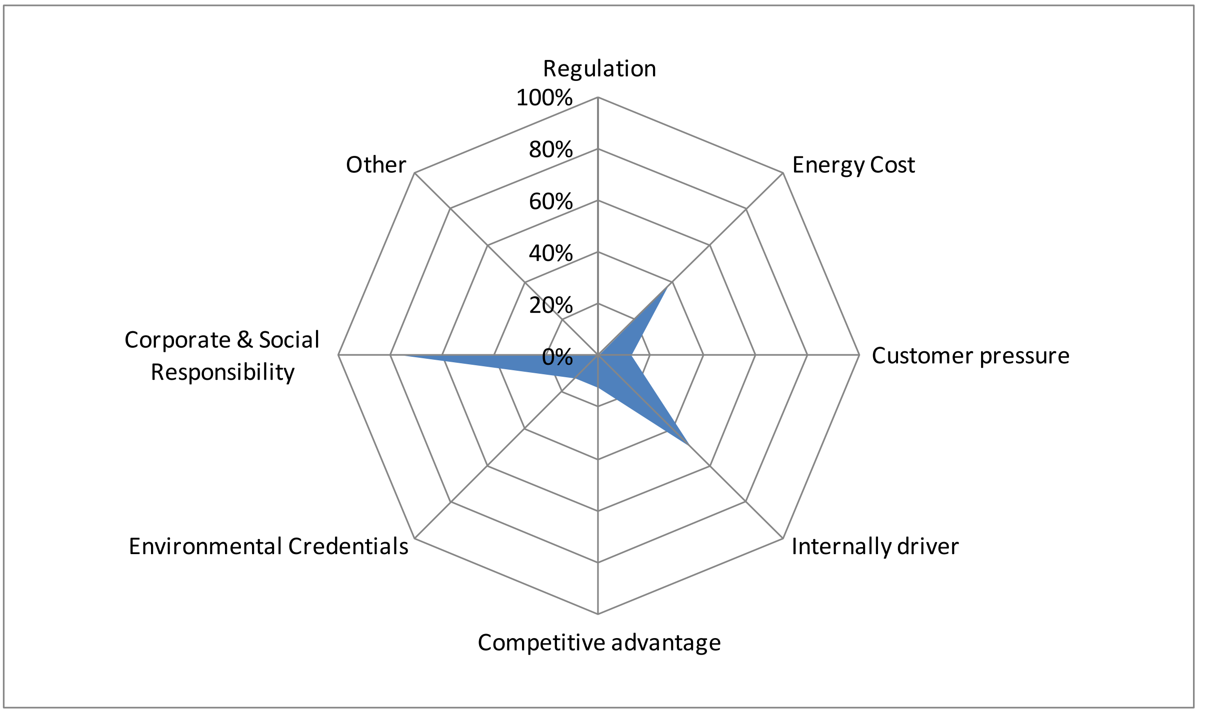
7.3 Drivers and barriers in the sector.

Drivers and barriers to energy saving were assessed using site interviews and questionnaires and discussed in the sector workshops. We received 10 responses to our questionnaire survey.

7.3.1 Business drivers

The contract catering industry is exposed to many business drivers and barriers, which influence the take-up of energy efficiency measures. Responses to our questionnaire by caterers (Figure 40) shows that of the sites that responded to our questionnaire, 75% identified corporate and social responsibility (CSR) as an important driver for their company's energy and carbon reduction activities; 50% said that it was internally driven and around 40% said that energy costs were an important driver (despite the limited accountability of Contract Caterers for energy use). Customer pressure, environmental credentials and competitive advantage were seen as drivers for energy efficiency by a minority of respondents. None of the respondents identified regulation as a driver for energy efficiency.

Figure 40 Perceptions of drivers for energy and carbon reduction activities – questionnaire results



Corporate Social Responsibility

The responses to our questionnaire suggest that CSR could be the strongest driver of energy and carbon reduction activities, with 75% of respondents identifying it as an important driver. The main players in the Contract Catering industry have awards accrediting their Corporate Responsibility which drives their competitors to follow.

Two of the host sites have sustainability policies and the caterers on those sites see it as part of their role to contribute to delivery of client objectives.

Energy Prices

Typically it is the caterers' clients who pay for the utilities used on the site, and feel the effect of increased energy prices. The clients often do not have good data on the energy used by the caterer, but rising energy prices may increase client awareness of utility costs, and this may lead some to consider transferring these costs to the caterer through sub-metering of energy use.

On two of the host sites such transfer of costs was a subject for discussion, though the method of charging was subject to debate.

Where caterers can reduce energy demand this will lead to lower energy costs for the client. If caterers can demonstrate reduced energy use to the customer it can be used as a unique selling point and help the client deliver CSR goals. Energy prices are also a driver for investment in energy efficient equipment.

Internal drivers

Around 50% of respondents mentioned that energy efficiency was internally driven. Caterers do not derive a financial benefit from energy saving, but they are nevertheless motivated to take some action.

7.3.2 Market Barriers

Investment Horizon

Typically a catering contract may last 3-5 years, giving a short horizon for payback on investment.

The number of contract catering outlets has reduced by 2.3%[44] in the last year, and there is continual retendering going on. Caterers are having to retender more often and seek to differentiate themselves by looking for value-added opportunities.

The continual movement of contracts with sites changing regularly between contract caterer and variability in length can be a significant barrier to investment in new equipment.

Equipment replacement cycle

Catering equipment tends to be replaced when it reaches the end of its life, typically 8-10 years or more. It does not tend to be replaced solely from an energy efficiency perspective.

Equipment may be added or changed when the demands of the service change. However, this is not always the case and as shown by our host sites, equipment does not always match the needs of the service, leaving the caterer to “make do” with the equipment available. This can lead to inefficiencies.

Equipment purchasing criteria

Criteria for equipment purchase include other performance factors, such as convenience, hygiene, service performance, capacity, staff familiarity, and purchase cost, rather than whole-life cost or energy performance, and these may be barriers to energy-efficiency.

The EuP studies suggest use of a Least-Life Cycle Cost approach can lead to significant energy savings, but this method does not seem to be widely used.

Tax incentives

The Energy Technology List currently provides a tax incentive to invest in energy-efficient refrigeration equipment. The ETL does not currently include cooking and dishwashing equipment, and this reduces the incentive to invest in efficient equipment.

[44] BHA Food and Service Management Survey 2010

Lack of data

Caterers and their clients lack good objective data on which to base investment decisions and identify, evaluate and prioritise energy-saving opportunities. This creates a barrier to implementation of energy-saving measures.

There is a lack of objective data concerning claims made by manufacturers about the energy performance of equipment, which may be a barrier to lower-carbon investment.

Split Incentives

In the investment cycle payback of investments is evaluated based on the expected operational savings. In contract catering the client invests in the equipment, the caterer operates it, and the client benefits financially from any energy efficiency gains.

The caterer therefore has no financial incentive to adopt energy-efficient practices, and no financial incentive to invest. The client, on the other hand will be cautious about the potential return on investment since they have little operational control of the equipment.

The EuP studies show significant energy savings are available in several categories by adopting a Least Life Cycle Cost approach, and split incentives will be a barrier to this.

8 Opportunities

Significant opportunities for energy efficiency exist in the contract catering sector. The main opportunities include good energy behaviour, matching equipment capacity to service requirements, matching equipment operation to service demand, improved controls, upgrading to more energy-efficient equipment, use of lower-carbon cooking methods, prevention of food waste, and heat recovery.

This section outlines the opportunities identified in the four sector, including outline business cases where it has been possible to quantify these. All business cases are presented on both a sector and an average site basis. The business cases have been constructed based on information from energy meters installed during the IEEA project, from process data made available by IEEA host companies, analysis of responses to the questionnaire, publicly available information and AEA's internal expertise. References to publicly available information have been provided where possible.

Table 27 below outlines the generic assumptions made during the calculation of the business cases. Where further assumptions have been made for individual business cases, these have been stated in the text of each business case.

The business cases are presented for an average site as well as the total for applicable sites. The average site refers to the total divided by the number of sites that the measure is applicable to. The savings and costs on individual sites will vary considerably.

Table 27 Business case assumptions

Assumption	Value
Sector annual natural gas consumption	829 GWh
Sector annual electricity consumption	2,226 GWh
Average natural gas price	3 p/kWh
Average electricity price	12 p/kWh
Electricity CO_2 emission factor	0.5246 kg CO_2e/kWh
Natural Gas CO_2 emission factor	0.1836 kg CO_2e/kWh
Number of sites in sector	16,583
Proportion of electricity consumption accounted for by use	Refrigeration 38% Extraction 24% Ovens 15% Other cooking 2% Dishwashing 7%
Proportion of natural gas consumption accounted for by use	Ovens 10% Hobs 32% Other cooking 58%

Each business case is presented as a separate opportunity, and there will be overlap between them.

8.1 Behaviour change

There is considerable potential for improvements based on behaviour change in the sector, and business cases are developed for behaviour change in cooking and dishwashing. We did not include business cases for behaviour change in ventilation or refrigeration as we were not able to quantify the impacts of behaviour change in these two areas of energy use.

Behaviour change can also be facilitated by design features of equipment that facilitate low energy use.

The current arrangements in the sector where the caterer typically does not pay the energy bill, provide no financial incentive for caterers to invest in achieving behaviour change in their staff. The caterer may be motivated by internal drivers or by the wish to contribute to the client's CSR targets.

Table 28 Recommendations for behaviour change

<table>
<tr><th colspan="4">Behaviour Change Recommendations</th></tr>
<tr><th>Type</th><th>Ovens</th><th>Hobs</th><th>Other cookers</th></tr>
<tr><td>Cooking</td><td>Switch on only the ovens required to match the demand.

Switch ovens off when not in use for over 20 minutes

Use spare oven capacity to perform other cooking operations and avoid switching on other equipment, or allow it to be switched off.

Avoid using electric ovens for holding, use a well-insulated hot cupboard instead and switch the ovens off as soon as possible.</td><td>Switch on hob rings when needed, switch off after use.

Avoid leaving pilot lights on over night

Where possible use open hobs in preference to flat-tops.

Avoid extended cooking times on hobs, use them intensively for shorter periods and switch off.

Use spare oven capacity to perform some hob operations (e.g. cooking pasta).</td><td>Switch on equipment when needed, switch off after use, e.g. Grills, Fryers.

Reduced settings to reduce warm-up times: grills, fryers.

Use spare oven capacity to perform some grill and fryer operations (roasting, browning, frying).</td></tr>
<tr><td>Extraction</td><td colspan="3">Where extraction is manually controlled ensure a staff member has responsibility for switching it off.

Where extraction is timer/BMS controlled ensure the settings match the operating hours of the kitchen.

Where the operating hours are variable put control measures in place to vary the extraction hours accordingly.

Where the extractor/air supply has variable speed control determine the setting that gives adequate air flow and use that setting. Use a reduced setting at times of lower activity.

Ensure filters and vents are cleaned regularly to reduce system resistance.</td></tr>
<tr><td>Dishwashers</td><td colspan="3">Ensure dishwashers are switched off whenever possible, in order to minimise standby energy consumption.</td></tr>
</table>

Behaviour Change Recommendations			
Type	Ovens	Hobs	Other cookers
	Wherever possible ensure that racks are full in order to minimise the amount of energy used per plate. Use cold-water for pre-rinse to minimise the use of hot water.		
Refrigeration	Efficient use – least amount of door-openings possible. Maintenance – Ensure seals are maintained and heat exchangers cleaned. Ensure refrigerators have sufficient ventilation for their heat exchangers. Right capacity – decommission units if poorly utilised.		

8.1.1 Behaviour change in cooking

The business case for behaviour change in cooking assumes that the site observations are potentially applicable to the whole sector, and could achieve savings in cooking energy of 43% (see section 3.5). Training costs are estimated based on £200 for a half-day's training per staff member and 3 staff members per site needing training.

Table 29 Business case for behaviour change - cooking

Summary	Total for applicable sites	Average site
Implementation costs	£ 10,000,000	£ 600
Cost reduction	£ 30,000,000	£ 1,800
Cost reduction p/meal	1.9p	1.9p
Payback period	4 months	4 months
CO_2 reduction	150,000 tonnes CO_2 p.a.	9 tonnes CO_2 p.a.
Sites applicable	100%	
Barriers	Number of people to be trained, training costs, lack of incentives for caterers. Turnover of staff.	
Barrier mitigation	Site metering and sharing of benefits between caterers and clients	

8.1.2 Behaviour change in dishwashing

The business case for behaviour change in dishwashing assumes that the site observations are potentially applicable to the whole sector and could achieve savings of 27% REF in dishwasher energy. Training costs are estimated based on £100 per staff member needing a brief training, and 2 staff members per site needing training.

Table 30 Business case for behaviour change - dishwashing

Summary	Total for applicable sites	Average site
Implementation costs	£ 3,300,000	£ 200
Cost reduction	£ 5,300,000	£ 300
Cost reduction p/meal	0.33p	0.33p
Payback period	8 months	8 months
CO_2 reduction	23,000 tonnes CO_2e p.a.	1.4 tonnes CO_2e p.a.
Sites applicable	100%	

Summary	Total for applicable sites	Average site
Barriers	Number of people to be trained, training costs, lack of incentives for caterers. Turnover of staff.	
Barrier mitigation	Site metering and sharing of benefits between caterers and clients	

8.2 Good practice

There is great potential for improvements based on good practice within the sector, and four business cases are developed, most of which require capital investment. Given the current arrangements in which the caterer's client purchases the equipment and pays the energy bill these options will be of interest to the clients.

Table 31 Good practice recommendations

Good Practice Recommendations			
Equipment	**Ovens**	**Hobs**	**Other cookers**
Cooking	Specify more smaller ovens and a choice of oven sizes to increase operational flexibility and reduce energy use Purchase ovens with highest food energy efficiency and lowest idle rate e.g. Energy Star Purchase gas ovens in preference to electric ovens, where possible.	Purchase gas hobs in preference to electric hobs, where possible.	Specify cookers with the shortest warm-up times and automatic ignition (cf behaviour) Purchase gas cookers in preference to electric cookers where possible.
	Purchase equipment with the lowest lifecycle cost		
Extraction	Consider vertical stacking of ovens to reduce the area of the extraction hood. Ensure that the minimum air flow required for plume extraction from the cooking equipment is calculated to avoid over-specification. Specify high efficiency fans types and fan motors.[45] Install variable speed drives on the fan motors so that system power can be varied to minimise energy use. Ensure automatic or manual control is in place with automatic reset of the gas control valve.		
Dishwashers	Purchase the most energy efficient equipment (in kWh/100 dishes) when replacing. Consider models with heat recovery from hot sanitation. Purchase water-efficient dishwashers as these tend to be the most energy-efficient.46		

[45] Energy efficiency in commercial kitchens CIBSE TM50: 2009 p25.

Good Practice Recommendations			
Equipment	**Ovens**	**Hobs**	**Other cookers**
	Where centrally-generated hot water is available provide hot feed to the dishwasher as this can reduce running costs. Where local hot water generation exists, it may enable heat recovery from refrigeration. Hot feed from a central gas-fired boiler can reduce running costs.		
Refrigeration	A larger fridge/freezer can be more efficient than 2 smaller ones. If possible choose an efficient refrigerant (such as R744 / CO2). Renewal of equipment – make sure fridge/freezer is the most efficient possible, and meets or exceeds the energy performance benchmarks. Specify equipment from the Energy Technology List to benefit from enhanced capital allowances. Double-door units are in general more efficient than single-door.		

8.2.1 Replacing electric combi ovens with gas combi ovens

The business case for replacement of electric combis with gas combis assumes that 80% of sites in the sector are able to do this. The implementation cost is the additional cost for the gas combi assuming that the alternative replacement would be an electric combi, and is based on the data in Section 3.2.2.

The implementation period for this business case would be 10 years or more since it would not be economic to replace an oven before the end of it's life. Over a 10 year period the carbon advantage of the gas combi may be eroded, but it is assumed that the cost advantage would remain.

Table 32 Business case for gas combi ovens as replacement for electric combis

Summary	Total for applicable sites	Average site
Implementation costs	£ 40,000,000	£ 3,000
Cost reduction	£ 14,000,000 p.a.	£ 1,000 p.a.
Cost reduction p/meal	1.1p	1.1p
Payback period	3 years	3 years
CO_2 reduction[47]	60,000 tonnes CO_2e p.a.	6 tonnes CO_2e p.a.
Sites applicable	80%	
Barriers	Equipment replacement cycle, not economic until equipment is at end of life. Sites without gas supply, sites which would need to upgrade ventilation, lack of data about life-cycle costs.	
Barrier mitigation	Access to data on life-cycle costs	

[46] Carbon Trust Food preparation and catering. CTV035. Page 5.

[47] The carbon saving may be less than this depending on the carbon factor for electricity at the time of replacement.

8.2.2 Purchasing more efficient ovens

The business case for upgrading ovens to the Energy Star standard assumes that all sites would be able to do this as ovens reach the end of their lives, and that savings of 19% in oven energy costs would be achieved. An additional cost of £2,000 per site is assumed. The implementation period for this business case would be 10 years or more since it would not be economic to replace an oven before the end of it's life. This saving is additional to the case for gas combis.

Table 33 Business case for upgrading ovens to Energy Star standard

Summary	Total for applicable sites	Average site
Implementation costs	£ 34,000,000	£ 2,000
Cost reduction	£ 8,300,000 p.a.	£ 500 p.a.
Cost reduction p/meal	0.5p	0.5p
Payback period	4 years	4 Years
CO_2 reduction	37,000 tonnes CO_2 p.a.	2 tonnes CO_2 p.a.
Sites applicable	% 100	
Barriers	Equipment replacement cycle, not economic until equipment is at end of life. Availability and additional cost of compliant product.	
Barrier mitigation	Understand additional costs involved and availability of compliant equipment	

8.2.3 Improving extractor control

The business case for improving control of kitchen extractors assumes that:-

- 50% of sites can make improvements by changing the timing and fan speed of an existing installation, saving 35%.
- 20% of sites would need to spend £4.5k to move from an always-on system to one with BMS timing and speed control, and would save 65%.
- The remaining sites are assumed to be operating optimally.

See Table 27 for the source data for these assumptions.

Table 34 Business case for improving control of kitchen extractors and air supplies

Summary	Total for applicable sites	Average site with existing control	Average site without control
Implementation costs	£ 15,200,000	£0	£4,500
Cost reduction	£ 19,200,000 p.a.	£1,300 p.a.	£2,400 p.a.
Cost reduction p/meal	1.7p	1.4p	2.5p
Payback period	Varies	Immediate	2 years
CO_2 reduction	84,000 tonnes CO_2 p.a.	5.8 tonnes CO_2 p.a.	10.8 tonnes CO_2 p.a
Sites applicable	70%	50%	20%
Barriers	Number of sites. Payback of 2 years for some sites, no cost for others		
Barrier mitigation	Clear business case		

8.2.4 Purchasing energy efficient refrigeration cabinets

Table 35 below outlines the business case for the purchasing of single and double door refrigeration cabinets with energy efficiencies equal to the Market Transformation Programme best practice benchmark standards[48].

The following assumptions have been made in this business case:

- The purchasing costs for the best practice standard units have been assumed to be 10% higher than for standard units.
- The payback period has been based only on the additional cost of an efficient unit compared to a standard unit. The business case therefore assumes that the existing unit would be replaced anyway, and will not be replaced purely for energy efficiency purposes.
- Only applies to single, double door and undercounter fridges and freezers, which have been assumed to be responsible for 50% of the sector's annual refrigeration electricity consumption.

Table 35 Business case for upgrading refrigeration cabinets to MTP best-practice standard

Summary	Total for applicable sites	Average site
Implementation costs	£18,650,000	£1,100
Cost reduction	£13,000,000 p.a.	£700 p.a.
Cost reduction p/meal	0.81	0.81
Payback period	1.5 years	1.5 years
CO_2 reduction	56,600 tonnes CO_2 p.a.	3.4 tonnes CO_2 p.a.
Sites applicable	100%	
Barriers	Initial capital costs. Only viable when replacing existing or purchasing new equipment. Need to convince landlord to purchase energy efficient equipment.	
Barrier mitigation	Contract caterers may be able to assume responsibility for purchasing equipment and for energy management.	

8.3 Innovation

Many of the opportunities relate to good practice measures. However the potential for innovation in the sector includes changes to operations and business models, as well as technical innovation, for example, combined messing at weekends in the Ministry of Defence segment, and potential for sharing of financial benefits between caterer and client to improve incentives.

Technical innovation potential includes centralised heat recovery from refrigeration, dishwashing and extraction systems for pre-heating water, increasing the capacity of low-carbon cooking methods such as combination microwave/air impingement ovens, and

[48] http://efficient-products.defra.gov.uk/cms/product-strategies/subsector/commercial-refrigeration#viewlist

induction hobs, and potential innovations in dishwashing and refrigeration technology that are currently not close to market.

Table 36 Innovation opportunities

<table>
<tr><th colspan="4">Innovation Opportunities</th></tr>
<tr><th>Equipment</th><th>Ovens</th><th>Hobs</th><th>Other cookers</th></tr>
<tr><td rowspan="2">Cooking</td><td>The EuP preparatory study identifies potential energy savings of 2-3% for combi ovens with the least lifecycle cost compared to the base case.</td><td>The EuP preparatory study identifies potential energy savings of 28-34% for hobs with the least lifecycle cost compared to the base case. The payback on the additional purchase costs for these improvements are estimated at 0.2 years or less.</td><td>The EuP preparatory study identifies potential energy savings of 16-35% for fry tops with the least lifecycle cost compared to the base case. The payback on the additional purchase costs for these improvements are estimated at 1 year or less.</td></tr>
<tr><td colspan="3">Design of models which facilitate good energy behaviour, quick start-up, automatic ignition, energy-saving controls, standby modes, low idle energy.</td></tr>
<tr><td>Extraction</td><td colspan="3">Sensors linked to variable speed drives may automatically vary the fan speed with the cooking load.[49]</td></tr>
<tr><td>Dishwashers</td><td colspan="3">The EuP preparatory study identifies potential energy savings of 12-36% for dishwashers with the least lifecycle cost compared to the base case. The least-cost option for non-conveyor dishwashers is warm-water feed, which has no additional purchase cost. For conveyor dishwashers the payback on the additional purchase costs is 3-7 years for the least life-cycle cost options.</td></tr>
<tr><td>Refrigeration</td><td colspan="3">The EuP preparatory study identifies potential energy savings of 52-62% for refrigeration units with the least lifecycle cost compared to the base case. The payback on the additional purchase costs for these improvements are estimated at 0.25-2.33 years for different types of unit.

Advanced technologies such as magnetic refrigeration are probably some way from market.</td></tr>
<tr><td>Business model</td><td colspan="3">A new business model is needed that provides incentives for clients to invest in efficient equipment and caterers to adopt best practice in using it.

Transfer of energy management responsibility to the caterer with installation of submetering.

Joint messing at weekends (MOD).</td></tr>
</table>

[49] Energy efficiency in commercial kitchens CIBSE TM50: 2009 p18.

8.3.1 Energy management responsibility

Table 37 below outlines the business case for the transfer of energy management responsibility from landlord to the contract caterer. This would require the installation of suitable energy metering to separate the utility supply to the kitchen, and a contractual agreement stipulating roles and responsibilities.

The business case for installation of sub-metering and transfer of energy costs to the caterer is based on the following assumptions:-

- Feasible and cost-effective on 60% of sites. Submetering will not be cost-effective on smaller sites, and will not be physically feasible on others.
- Transfer of energy costs via the catering contract is cost-neutral for the caterer.
- 20% savings on the metered energy could be achieved through behaviour change.
- Training costs per site £1,000.
- Metering cost per site £2,000 (1 gas meter and 1 electricity meter per site).

The implementation would take time due to the need to renegotiate contracts (typical contract length in the sector is 3-5 years).

This recommendation must be seen as an enabling recommendation, as metering and contracts alone will not result in cost reductions. Contract caterers must ensure action is taken based on the metered information before savings will result.

Table 37 Business case for submetering and transfer of energy management responsibility to the caterer

Summary	Total for applicable sites	Average site
Implementation costs	£30,000,000	£3,000
Cost reduction	£35,000,000 p.a.	£3,500 p.a.
Cost reduction p/meal	3.6p	3.6p
Payback period	1 year	1 year
CO_2 reduction	158,000 tonnes CO_2 p.a.	15.9 tonnes CO_2 p.a.
Applicable sites	60%	
Barriers	Contract length, contract negotiation, achieving cost-neutrality when there is no historic data, not cost-effective for small sites, not physically feasible for some sites.	
Barrier mitigation	Pilot with some sites and report case studies.	

8.4 Recommendations for further work

The Table 38 below summarises some of the recommendations for further work identified in the course of the study.

Table 38 Recommendations for further study

Recommendations for further study			
Equipment	**Ovens**	**Hobs**	**Other cookers**
Cooking	Cost-benefit analysis of optimal oven sizing methods. Relative performance of different oven models.	Comparison of electric induction hobs and conventional gas and electric hobs.	Relative performance of different fryers and grills.
	Comparison of energy use for oven cooking with other cooking methods. Low-carbon cooking methods, possible link to healthy eating?		
Extraction	Impact of extraction on space heating requirements. Potential for heat recovery from extraction to pre-heat water.		
Dishwasher	Comparative performance of different models.		
Refrigeration	Potential for recovery of heat from walk-in units for pre-heating water for dishwashing, where local water heating is possible.		

8.5 Summary of business cases for the sector

The business cases are summarised below. Some of the business cases overlap, for example with more efficient equipment the potential for behaviour change improvements is reduced, and some of the business cases address the same opportunities. The overlap between cases is assumed to reduce the total potential by 20%, giving a total for the sector of 425,000 tonnes CO_2 and £90,000,000 per year potential savings with a cost of £120,000,000 for implementation.

The timing of implementation would be up to 10 years due to contract length and equipment replacement cycles. This would impact the carbon savings due to the expected reduction in grid carbon intensity over the implementation period.

Table 39 Summary of business cases

Measure	Implementation cost £	Cost reduction £	CO_2e reduction tonnes
Behaviour change for cooking	£10,000,000	£30,000,000	150,000
Behaviour change for dishwashing	£3,300,000	£5,300,000	23,000
Gas combi's as replacement for electric	£40,000,000	£14,000,000	60,000
More efficient ovens	£34,000,000	£8,300,000	37,000
Improving control of extractors	£15,200,000	£9,200,000	84,000
Refrigerator replacement with ETL standard	£18,650,000	£13,000,000	56,600
Installation of submetering and transfer of energy costs to caterer	£30,000,000	£34,500,000	156,000
Total[50]	**£120,000,000**	**£90,000,000**	**425,000**

The potential savings represent 31% of cost and 32% of carbon emissions for the sector.

[50] Total discounted by 20% to compensate for overlap between cases

9 Next steps

From a limited number of sites and a short period of energy data collection this IEEA study has shown that:

- Energy use and hence carbon emissions in the contract catering sector are much higher than previously thought.
- That the potential value of energy savings and carbon emissions will be similarly higher.
- That a wide range of energy and carbon saving measures are practical and worthwhile.

Given the scope and value of the current analysis there is a strong case for further action to build the evidence and to work with the sector to address the barriers to energy and carbon savings.

With this in mind, the next steps will involve:

- Dissemination of the findings from this study to the sector.
- Further investigation and analysis of the data to see what this may mean for UK government policy on sustainable products.
- Evaluate options for future work and, explore these with the sector taking consideration of current financial restraints in relation to further UK government funding.

Appendices

Appendix 1 – Sector background

Appendix 2 – Methodology

Appendix 3 – Indicative metering locations

Appendix 4 – List of stakeholders

Appendix 5 – Workshop summary

Appendix 6 – Confidential data for host sites

Appendix 1 – Sector background

This section provides an overview of the contract catering sector including an overview of the main organisations currently operating in this area, the key industry bodies and an overall scale of the sector including production volumes, number of outlets, energy use and carbon. The section then provides the reader with an insight into contractual arrangements in the sector, market, business, legislative and energy saving drivers affecting the sector before providing a brief international perspective on the sector.

A1.1 Contract Catering

Often referred to as Food and Service Management (FSM), contract catering covers the provision of food services to people at work in business and industry, catering in schools, colleges and universities, in hospitals and healthcare as well as welfare and local authority catering and other non profit making outlets.

For the purposes of this study the sector constitutes food and beverage provision for companies and organisations for whom catering is not their primary activity. Contract caterers provide the skills, equipment and personnel, and sometimes investment in premises, to operate the catering function, allowing their customer organisation to concentrate on its core activity[51].

The contract catering sector had annual revenues of around £4.1bn in 2008 in the UK within the larger catering market of £30.9bn (which includes hotels, restaurants and clubs). Previous estimates based on CIBSE benchmarks gave a carbon footprint for the sector of 730,000 tCO_2. There are circa 17,000 contract catering outlets and the food service industry uses 2½ times more energy/m^2 than typical commercial buildings[52].

Contract catering is an industry that supplies both the public and private sector. It is estimated that the public sector spends over £2bn on food and food services. Approximately half of this is spent on food ingredients, the rest being on catering services, kitchen equipment etc. The majority of public expenditure on food is undertaken by schools and colleges, prisons, the armed services and the NHS[53].The NHS spends £500million on catering every year. The Business and Industry (B&I) market continues to be the largest market for FSM companies, with just under half of the sites in the industry.

The contract catering sector refers to the various sub-sectors within the industry as ‘segments’. The four major segments are:

- Business and Industry – offices, factories and other workplaces.
- Healthcare – hospitals and nursing homes.
- Education – schools and higher/further education.
- Ministry of Defence (MOD).

A1.1.1 Major catering companies

The British Hospitality Association Food and Service Management survey 2010 is the 21st annual survey of the UK food and service management industry. The survey includes all the major contractors and it estimated to represent between 90-95% of the total UK contract catering market. Those companies involved in the survey are:

[51] P2 MINTEL, (2002), Contract Catering, November 2002, Mintel International Group Ltd
[52] http://www.energystar.gov/ia/business/small_business/restaurants_guide.pdf
[53] P.7 http://www.defra.gov.uk/foodfarm/policy/publicsectorfood/documents/100226-food-proc-initiative.pdf

- Accent Catering Services
- Aramark PLC
- Bartlett Mitchell
- Baxter Storey
- Blue Apple Contract Catering Ltd
- Brookwood Partnership
- Charlton House Catering services
- Compass Group
- Cygney Foods
- Elior UK
- Harrison Catering Services
- Hosts Contracts Management Ltd
- Initial catering Services Ltd
- ISS Eaton
- Lexington Catering
- OCS UK Ltd
- Sodexo UK
- Vacherin

Between them, these companies served 1,607 million meals through 16,583 outlets. The energy used in generating these meals through these outlets forms the scope for this IEEA study. Self-operated outlets (catering provided in the workplace by the employer) provide the balance of workplace catering. One estimate gives a total of 3,244m meals served in the workplace, giving FSM companies 50% of the market.[54]

Self-operated facilities were outside the scope of this study that focussed solely on industrial or multi-scale facilities.

A1.1.2 Contractual arrangements in the sector

There are a number of common contractual arrangements between contract caterers and their clients. Common types of contract include cost plus (the client is billed for the cost of the service plus a management fee), fixed price (the client agrees a maximum subsidy per meal and costs cannot rise above that figure) and profit/loss/concession/total risk (where the caterer and client share the profit (or loss); in total risk contracts the caterer invests in the facility and earns all the revenue. Significantly, the number of profit and loss contracts increased by over 75 per cent 2007 – 2009. Contractors are being asked to take greater commercial risks. Cost plus/management fee contracts remain the least popular with clients but they still represent almost a quarter of all contracts. The trend towards fixed price/performance guarantee contracts continues, though it lost some momentum through the year.[55]

Typically the client will own and supply the equipment used in the catering operation, and will also meet the cost of utilities used in providing the service.

During the study we were able to visit sites in each major segment including Business and Industry, Schools, Healthcare and MOD. Further details are given in Section 3 of this report.

A1.2 The Industry Bodies

The two key industry bodies involved in the study were British Hospitality Association (BHA), which represents the contact catering companies and the broader hospitality sector and the Catering Equipment Suppliers Association (CESA), representing equipment suppliers. However there are a number of others that support organisations in this sector. These include Catering Equipment Distributors Association, Catering for a Sustainable Future Group and the Foodservice Consultants Society International.

- The British Hospitality Association (BHA) is the main trade association for the hotel, restaurant and catering industry the UK. The BHA are about to launch their sustainability network for members, a place where BHA members will be able to discuss sector energy use.

[54] Insiders Guide to Foodservice 2009/10
[55] BHA Food and Service Management Survey 2010

- The Catering Equipment Suppliers Association (CESA) represents 140 equipment suppliers in the UK, including manufacturers, distributors of overseas manufacturers, and spare parts producers.
- Catering Equipment Distributors Association (CEDA) represents 80 member companies throughout the UK providing advice on choosing commercial catering equipment, kitchen design and installation, service, maintenance & breakdown repair, and equipment training.
- The Catering for a Sustainable Future Group (CSFG) is a voluntary organisation, formed in March 2006 from people within the UK catering equipment industry interested in developing ideas and initiatives to promote energy savings and sustainability in commercial kitchens, in the face of growing public awareness of this issue. The CSFG was formed as a sub-committee of CEDA, CESA and the Foodservice Consultants Society International (FCSI).
- The Foodservice Consultants Society International (FCSI) is an association of catering consultants and professionals. They assist companies around foodservice strategy, hygiene, contract tendering and design and equipment solutions. FCSI has over 1000 members in 38 countries, with almost 60 professional member companies in the UK.

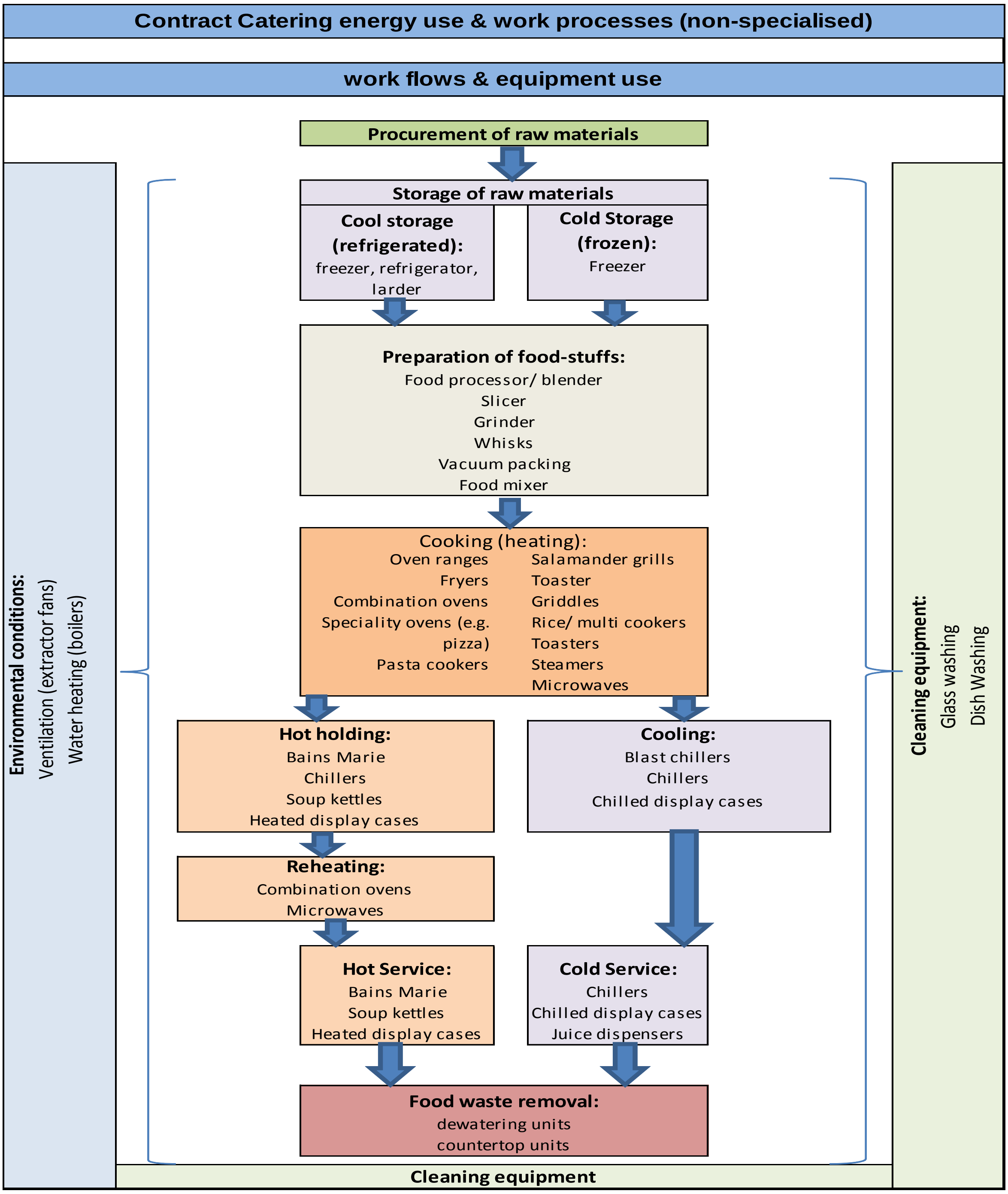
A1.3 Main energy using processes in Contract Catering

Figure A1-1 shows a schematic diagram of contract catering key work processes.

The main steps in the contract catering process are:

- Storage and preparation of raw materials.
- Cooking/heating/hot holding.
- Cooling/refrigeration.
- Dish and glass washing.

Figure A1-1 Schematic diagram of contract catering processes



The scope of this IEEA project includes process energy use in kitchens but excludes lighting, space heating and cooling. However, kitchen energy use will impact to some extent on heating and cooling demand through heat replacement, excess heat generation, and heat loss through extraction.

A1.5 Legislation impacts

While caterers do not mention legislative pressures as a driver in survey results there are increasing legislative pressures on the industry. These are:

- Climate Change Agreement.

- Carbon Reduction Commitment (CRC) Energy Efficient Scheme.
- Market Transformation Programme and the Energy Technology List.
- Eco-design of energy related products (ERP Directive).

A1.5.1 Climate Change Agreement

Since contract catering, nor the market segments, are not part of a Climate Change Agreement (CCA), there is no centrally available historical data available for benchmark comparison, as in other IEEA sectors. This places the sector at a major disadvantage for monitoring energy data as there is no available data for comparison or in order to determine energy related performance over time.

A1.5.2 Carbon Reduction Commitment (CRC) Energy Efficiency Scheme

The CRC Energy efficiency Scheme is a mandatory carbon emissions reporting and pricing scheme to cover all organisations using more than 6,000MWh per year of electricity (equivalent to an annual electricity bill of about £500,000). The CRC came into force in April 2010 and aims to significantly reduce UK carbon emissions not covered by other pieces of legislation. The CRC is likely to encourage caterers' clients to focus on energy use in catering operations within their business to help them achieve the commitment. The government is currently looking at simplifying the CRC Energy Efficiency Scheme. The first allowance sales for 2011-12 emissions will now take place in 2012 rather than 2011 and revenues from allowance sales to be used to support the public finances rather than being recycled to participants as originally planned.

The CRC regulations are thought to represent key drivers for uptake of energy efficiency measures by clients within the contract catering sector over the coming years.

A1.5.3 Market Transformation Programme and Energy Technology List

The Market Transformation Programme (MTP) supports the development and implementation of UK Government policy on sustainable products. MTP aims to reduce the environmental impact of products across the product life cycle by:

- **Collecting information**. Stock, sales, usage and resource consumption data is gathered on household and industrial products.
- **Building evidence**. The information gathered is used to model how products will evolve in the market place and to estimate future environmental impacts.
- **Working with industry and other stakeholders**. A common understanding is reached on how these impacts can be mitigated; action plans are agreed and the measures implemented.

MTP supports the UK Government's strategy on Sustainable Development. In particular, MTP underpins the product policy aspect of the framework for Sustainable Consumption and Production.

The Enhanced Capital Allowance (ECA) scheme is a key part of the Government's programme to manage climate change, and is designed to encourage businesses to invest in energy saving equipment. The most applicable ECA scheme for this IEEA is for energy-saving equipment. The ECA Energy scheme provides a tax incentive to businesses that invest in equipment that meets published energy saving criteria. It provides 100% first year capital allowances on investments in energy saving equipment against taxable profits of the period of investment. The Energy Technology List (ETL) details the criteria for each type of technology, and lists those products in each category that meet them and are therefore able to be covered by the ECA scheme.

Currently the ECA scheme in the UK covers refrigeration equipment, but not cooking or dishwashing equipment.

Refrigeration categories relevant to catering which can qualify for the ECA include:

- Commercial Service Cabinets.
- Curtains Blinds Doors and Covers for Refrigerated Display Cabinets.
- Refrigerated Display Cabinets.
- Refrigeration Compressors.

A1.5.4 Eco Design of Energy related products (ERP Directive)

The Energy-Related Products Directive (ErP), previously known as Energy-Using Products (EuP) Directive, aims to improve the environmental performance of products throughout the life-cycle, by integration of environmental measures at a an early stage in product design. One aspect of that is to remove the worst performers from the market. The ErP Directive aims to achieve this via a series of individual implementing measures which are targeted at individual energy using product groups, excluding transport, or a specific function of those products (as in the case of stand-by function).

A number of eco-design studies have been set up as part of the process of implementing the Ecodesign directive 2005/32/EC.

In the UK the eco-design studies feed into the Market Transformation Programme and the Energy Technology List. The ErP studies will propose new minimum energy performance standards (MEPS) for particular categories of equipment within these product groups, and identify the potential for Least Life-Cycle Cost Equipment (LLLC), Best Available Technology (BAT), the best-performing equipment currently on the market, and for Best Not-Yet Available Technology (BNAT), equipment incorporating known technologies which are not yet on the market.

In some equipment categories agreement will be needed on performance measurement standards in order to set new MEPS, and to qualify equipment which meets those standards. The relevant product groups for catering are shown in

Table A1-2.

Table A1-2 Relevant product groups subject to eco-design studies

Lot	Product Groups	Website	Status
ENTR 1	Commercial refrigerators and freezers, including chillers, display cabinets and vending machines.	www.ecofreezercom.org	Published
TREN 22	Domestic and commercial ovens (electric, gas, microwave), including when incorporated into cookers.	http://www.ecocooking.org/lot22/	Task 7 Improvement Potential
TREN 23	Domestic and commercial hobs and grills including when incorporated into cookers.	http://www.ecocooking.org/lot23/	Task 7 Improvement Potential
TREN 24	Professional washing machines, dryers and dishwashers.	http://www.ecowet-commercial.org/	Draft final dishwasher report available

Commercial Refrigeration and Freezers

The report on this study has now been published and submitted to the European Commission.

The report includes new proposed MEPS (Minimum Energy Performance Standards) for Service Cabinets, Blast Cabinets, Walk-in Cold Rooms, Process Chillers and Remote Condensing Units.

The study looks at the Policy Impact of various scenarios, and concludes that adoption of Least Life Cycle Cost could reduce electricity consumption of the EU stock of appliances by 26% in 2025 compared with Business as Usual. The improvement potential for individual categories is given in ***Table A1-3***.

Table A1-3 Ecodesign study of improvement potential for commercial refrigeration

Improvement potential Primary Energy Compared to Base Case			
Category	**LLLC**	**BAT**	**BNAT**
Service cabinet HT	62%	62%	Not analysed in the study
Service cabinet LT	52%	52%	
Blast Cabinet	60%	60%	
Walk-in Cold Room	55%	55%	
Process Chillers MT	50%	50%	
Process Chillers LT	30%	30%	
Remote condensing unit MT	50%	50%	
Remote condensing unit LT	50%	50%	

Table A1-4 Explanation of acronyms

Acronym	Short for	Notes
LLLC	Least Life Cycle Cost	Purchase cost plus energy cost over product life
BAT	Best Available Technology	Lowest energy use, but may have higher life cycle cost
BNAT	Best Not Available Technology	Combining existing technologies, not yet on market)
MT	Medium Temperature	Fridges and Chillers
LT	Low Temperature	Freezers

The study shows significant potential for improvement in commercial refrigeration equipment ranging from 30-62% energy savings compared to the base case. The savings from moving to Least Life Cycle Cost (LLLC) are the same as those for Best Available Technology (BAT), meaning that in all cases the BAT also has the least cost over the equipment life cycle. The LLLC is arrived at by combining initial purchase cost with energy costs over the life of the equipment.

The study did not identify any Best Not Available Technology (BNAT), which could take energy savings beyond the BAT.

Commercial Ovens

The study has reached stage 7 of the preparatory report stage, Improvement Potential, and considers Commercial Electric Combi-Steamers, Commercial Gas Combi-Steamers, Commercial In-Store Convection Ovens, Commercial Electric Deck Ovens and Commercial Gas Deck Ovens. The improvement potential for individual categories is given in ***Table A1-5***.

Table A1-5 EcoDesign study of improvement potential for commercial ovens

Improvement potential Primary Energy Compared to Base Case			
Category	**LLLC**	**BAT**	**BNAT**
Combi Electric	2.6%	2.6%	Not analysed in the study
Combi Gas	1.9%	3.9%	
Convection oven	2.9%	5.0%	
Electric Deck Oven	3.0%	3.9%	
Gas Deck Oven	4.9%	6.3%	

The study identified limited potential for energy savings in commercial ovens with least-cost (LLLC) savings of 1.9 - 4.9%. Energy savings for the best available technologies were higher, but at a higher total cost. No BNAT technologies were identified.

Commercial hobs and grills

The study has reached stage 7, Improvement Potential, and considers Commercial Electric Hobs, Commercial Gas Hobs, Commercial Electric Fry Tops and commercial Gas Fry Tops.

The improvement potential for individual categories is given in Table A1-6.

Table A1-6 EcoDesign study of improvement potential for commercial hobs and grills

Improvement potential Primary Energy Compared to Base Case			
Category	**LLLC**	**BAT**	**BNAT**
Electric Hob	28%	28%	Not analysed in the study
Gas Hob	34%	34%	
Electric Fry Top	16%	16%	
Gas Fry Top	35%	35%	

The study identified good potential for energy savings in commercial hobs and fry tops with least-cost (LLLC) savings of 16 – 35%. Energy savings for the best available technologies were the same, meaning that the BAT was also the lowest-cost option. No BNAT technologies were identified.

Professional washing machines, dryers and dishwashers

A draft final report on the dishwasher study has been published and considers Undercounter water-change, Undercounter one-tank, Hood-type dishwashers, Utensil/pot dishwashers, Conveyor-type one-tank and Conveyor-type multi-tank dishwashers.

The improvement potential for individual categories is given in Table A1-7.

Table A1-7 EcoDesign study of improvement potential for commercial dishwashers

Improvement potential Primary Energy Compared to Base Case			
Category	**LLLC**	**BAT**	**BNAT**
Undercounter water change	25%	25%	Not analysed in
Undercounter one-tank	30%	30%	
Hood type	30%	30%	

Pot / utensil washer	27%	27%	the study
Conveyor One Tank	12%	28%	
Conveyor Multi Tank	36%	36%	

The study identified good potential for energy savings in commercial dishwashers with least-cost (LLLC) savings of 12 – 36%. Energy savings for the best available technologies were higher in the case of conveyor one-tank dishwashers, but at a higher lifecycle cost. In all other categories the best technology has the lowest life-cycle cost. No BNAT technologies were identified.

A1.6 Innovation in the sector

Innovations are continually occurring in the catering equipment industry. While there are some key suppliers with strong positions in individual markets, the barriers to entry are relatively low, and a new supplier can enter the market relatively easily. Established suppliers will continually innovate to remain in the lead in their particular category. Suppliers may also broaden their product offerings to expand into related categories. Innovations are also coming into the sector from related industries, for example the Refrigeration Industry, and the Fast-Food sector.

Potential innovations and trends apparent within the industry include:-

A1.6.1 Refrigeration

- Central chiller units using Glycol as a refrigerant.
- Innovation coming from the broader refrigeration industry, e.g. Magnetic refrigeration.
- E-cube - this technology has been trialled by caterers regarding food safety, but there has so far not been a definitive study on energy saving potential.

A1.6.2 Cooking

- Integration of technologies:-
  - Microwave / combination ovens (Merrychef) – from Fast-food sector.
  - Induction / microwave grill (Electrolux).
- Controls
  - Combi-ovens with sensors to switch off if a cavity is empty
  - Low-temperature cooking – Combi-ovens with a time/temperature profile to cook a roast slowly at a low temperature.
- Maturing technologies
  - Induction Hobs are thought to have about 5% penetration, but this is growing rapidly, especially in education, where chefs are becoming trained to use it.
  - Induction Hobs. There may be more gains in terms of heat transfer efficiency, such as tuning the hob to the cookware.
  - Microwave cookers still have limited capacity. Can they go further?
  - Accelerated cooking. An example is the Manitowoc Merrychef high impingement cooker which uses microwave heating plus air impingement to achieve short cooking times suitable for cook-to-order service.
  - Use of Combi-Ovens for frying and grilling as well as their traditional functions of roasting and steaming.
- Fuel choice

- Some electrically-powered cooking technologies such as Induction and Microwave have high energy transfer efficiencies, and short warm-up times, and are already more carbon-efficient than gas alternatives.
- Potentially the current advantage of Gas appliances in other categories in terms of carbon emissions would be reduced as the electricity supply becomes decarbonised.
- The all-electric kitchen (Lanesborough Hotel) also has the advantage of removing the need for extraction of gas combustion fumes.
- Electrical appliances also find favour for providing catering facilities in buildings that were not designed for the purpose, e.g. offices, or where it is costly or difficult to install a gas supply.

A1.6.3 Dishwashers

- Water efficiency. Reduction in water use has been a priority for many years, and there is now thought to be little further scope for this. Water use is closely related to energy use as most dishwashing energy use if for water heating.
- Heat recovery. There is still potential for greater penetration of heat-recovery technologies from both steam and waste water.
- Hot feed/cold feed – some models take cold-water feed and recover heat from waste water to pre-heat it, reducing electric heating demand. Others take hot feed water from a central gas-fired boiler to reduce electric heating demand. Where a heat recovery unit is fitted then heat transfer efficiency will be maximised if the difference in temperature is greater, i.e. with cold feed.
- Low temperature machines which use chemical sanitising, rather than high temperature rinse water.
- Ultrasound. Some manufacturers have produced demonstration models using Ultrasound as a cleaning method, but there are no commercially available products.

A1.6.4 Systems thinking

- Energy modulation between appliances to manage peak demand.
- Customised suites of cooking equipment tailored to menus, not the other way round.
- Centralised energy recovery from fridges, extractors, dishwashers for water pre-heating.

A1.6.5 Measuring equipment performance

EFCEM (European Federation of Catering Equipment Manufacturers) has been working on performance measuring standards for a range of equipment (Table A1-8). These standards identify the industry's views on how to measure the energy performance of catering equipment, and are mostly based on the best available EU local standards (for example German DIN standard for Combi-Ovens, and Italian UNI standard for dishwashers).

It is anticipated that these standards will inform the work on the Eco-design directive, the Market Transformation Programme, and the Energy Technology List.

Table A1-8 Forthcoming EFCEM Energy Performance Standards

Forthcoming EFCEM Energy Performance Standards	
Open topped hobs	Refrigeration
Boiling pans	Pre-rinse spray heads (for pot wash)
Bratt pans	Fry tops and griddles
Fryers	Coffee machines
Combi ovens	Water boilers
Convection ovens	Induction equipment
Dishwashers	Rethermalisation equipment
	Solid top hobs
See http://www.efcem.org/viewDirective.asp?directiveURN=75	

In the USA the ASTM (American Society of Testing and Materials) has published a series of standards for measuring performance of catering equipment. See http://www.fishnick.com/testing/testmethods/.

A1.7 International Perspective

A1.7.1 US product standards

In the USA the 1992 EPA (Energy Policy Act) mandated the DOE (Department of Energy) to develop Minimum Energy Performance Standards (MEPS) for many categories of equipment.

Within the catering sector MEPS have been implemented for:-

- Refrigerators.
- Walk in Refrigerators.
- Walk in Freezers.

See http://www1.eere.energy.gov/buildings/appliance_standards/commercial_products.html

A1.7.2 Energy Star

The US Environmental Protection Agency (EPA) introduced the ENERGY STAR™label in 1992 to recognize energy-efficient computers. Since then, the label has grown to identify efficient products across more than 40 product categories.

The ENERGY STAR label appears only on equipment that meets strict energy use guidelines, and assures the buyer an appliance is among the top energy performers in its class.

Appliances in the following Catering categories may earn the ENERGY STAR:

- Dishwashers (new version in development).
- Fryers (new version in development).
- Griddles.
- Hot Food Holding Cabinets (new version in development).
- Ice Machines.
- Ovens.
- Refrigerators & Freezers.
- Steam Cookers.
- Pre-rinse Sprayheads (new category in development).

See http://www.energystar.gov

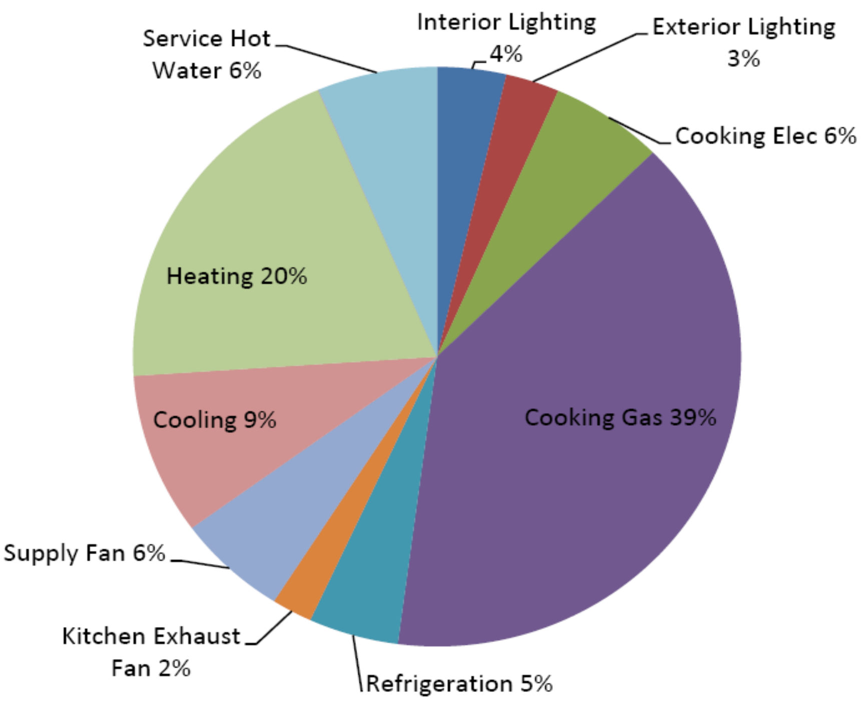
A1.7.3 Fast-food case study

The US Department of Energy commissioned a feasibility study into the scope for 50% reduction in the energy consumption of the Quick Service Restaurant (QSR) sector, through Energy Efficiency Measures (EEMs) which produced a payback period of less than 5 years. The feasibility study was carried by the Pacific Northwest National Laboratory in collaboration with two key industrial partners, the Halton Company and the Pacific Gas & Electric Food Service Technology Centre. The findings of this study were published in September 2010.

A 2500ft^2 testing model based on actual floor plans in prototypical QSR design drawings was used, together with a state-of-the-art simulation software programme (EnergyPlus), to determine the scope for energy savings. The average energy saving demonstrated by the simulation was 45% (the savings ranged from 45%-52% across the different climatic zones simulated).

Intensive process loads resulting from food preparation and storage typically constitute 45-65% of the total energy consumption for a QSR. Significant savings are possible through optimising kitchen ventilation systems and utilising innovative food preparation and storage technologies.

Figure A1-3 Proportion of energy savings from different end use categories (US EPA fast food study)



In the EPA study, 39% of the energy savings in the study came from choice of efficient gas cooking appliances, specifically replacement of the griddles and fryers with best-in class ENERGY STAR rated equipment (Figure A1-3 above).

The key recommendations of this study were the implementation of the following EEMs:

- Enhanced building opaque insulation.
- High performance window glazing.
- Cool roofs.
- Reduced interior lighting power density to 0.85 w/ft^2.

- Reduced power allowance for exterior lighting and photocell controls.
- Daylight dimming controls in dining areas.
- Ultra-efficient cooking appliances.
- Electronically Commutated Motors (ECM) for walk in coolers/freezers.
- Additional refrigeration insulation.
- Waste heat recovery from refrigerant to preheat hot water.
- Air-conditioning with premium cooling efficiency.
- Reduced exhaust flow rate for ultra-efficient cooking appliances and efficient exhaust hoods.
- Demand controlled exhaust, based on cooking appliance schedules.
- Runaround coil heat recovery to preheat outdoor air with waste heat from kitchen exhaust hoods.
- Broader use of air-side economisers and extended cooling capacity to cover 5 ton air units.
- Gas fired condensing water heaters with 95% thermal efficiency.

Source: http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19809.pdf

These measures would be applicable in many of the catering kitchens we visited during this study. Waste heat recovery from refrigerant to preheat hot water requires local water heating rather than centralised water heating which is the norm in the catering kitchens we visited.

Appendix 2 – Methodology

The aim of this project was to investigate sector specific manufacturing processes in order to build a detailed picture of process energy use and identify practical, cost-effective carbon saving opportunities.

Four sites were visited during Stage 1 of the Contract Catering IEEA. The sites were selected to provide coverage of the four major segments (MOD, Healthcare, Education and Business and Industry). The sites also acted as reference points for energy efficiency opportunities and metering plans to be explored further. For the purposes of this report, the sites visited have been anonymised.

Collectively, the participating sites represent a tiny proportion of overall energy use in the sector but were determined by the industry to be as 'representative' as possible for the purposes of the identification of energy saving opportunities and development of a metering plan.

Our methodology was based on the following key elements:

- Project kick off meeting
  - A meeting was held with the British Hospitality Association (BHA) in August 2010 to reiterate the aims of the project and outline our plans, what they could expect from us and what we required from them in return.
  - Contract catering companies that showed interest in the project were invited to actively participate.

- Initial information gathering phase
  - An intensive period of site visits, desk based research and consultation with the BHA, CESA and contract catering companies to build a thorough appreciation of the sector and define the programme of work for the rest of the project
  - Development of a relationship with the contract caterers to determine a representative sample of sites to visit. Relationships were also developed with their respective clients whose sites we had selected for visits.
  - Desk based research of current and future standards in contract catering equipment
  - Desk based research of potential energy efficiency opportunities
  - Desk based research of innovative opportunities in other countries and sectors that may be transferable to the UK contract catering sector
  - A questionnaire distributed to contract caterers on priorities, barriers, progress to date and their ideas
  - Search for and attempts to obtain historical data

- Development of Monitoring Plans
  - Metering plans developed for four representative Contract catering sites.

- Site monitoring – see Appendix 3 for details

- Site data analysis, implication, opportunities and reporting

We worked with a representative sample of sites from the sector; key considerations were:

- Representation from the four major 'host' site business segments
- Typical quantity of meals served and type
- Potential for involving client
- Differing hours of operation
- A range of equipment type

However, the contract catering sector is especially diverse in terms of number of outlets and it should be noted that variation will exist at all contract catering outlets.

A2.1 Engagement with the sector

The British Hospitality Association (BHA) were key to engaging with the sector - we are grateful to them for facilitating initial contact with host sites, distributing communications and the questionnaire and providing insight, guidance and feedback throughout the project. The four Contract caterers involved in the study were key to gaining access to the workings of the sector. It is unfortunate that circumstances beyond our control within the Contract Catering sector resulted in significant time delays and this coincided with a funding review of the entire IEEA programme, leading to the inability to initially complete Stage 1 as originally anticipated though subsequent funding by Defra enabled full completion of Stage 1.

Our strategy for engaging with the sector included the following key elements:

- Visits to host sites.
- Telephone and email communication with the host sites.
- Regular emails and telephone calls with the key contacts.
- A questionnaire distributed to the wider sector via the key company contacts.
- Project ‘briefing’ documents including site selection criteria, information for hosts and information for equipment suppliers.

Throughout the project we fostered close working relationships with key contacts from the host sites and the client.

A2.2 Understanding drivers and barriers

In addition to our meetings and discussions with the host sites and the BHA, a survey was conducted to help us engage with the wider sector and understand key drivers and barriers to the deployment of energy efficiency opportunities.

We received 10 completed questionnaires relating to 10 separate sites managed by two contract caterers. These responses were selected to be representative of the contract catering sector.

A2.3 Host site profiles

Four sites were visited during Stage 1 of the Contract Catering IEEA. The sites were selected to provide coverage of the four major segments (MOD, Healthcare, Education and Business and Industry). The sites also acted as reference points for energy efficiency opportunities and metering plans to be explored further with three of them participating in on-site metering and measurement activity. The site not involved in the detailed metering and observation activity was the MOD site. For the purposes of this report, the sites visited have been anonymised.

A2.4 Business and Industry

A prestigious city-centre office, the building was constructed in 2007 and occupied in 2008, and houses about 850 staff.

The client has a Corporate Responsibility policy which aims for continual reduction in its carbon footprint through energy use, travel and waste reduction. The company has committed to a target of 20% improvement in energy efficiency by 2020 versus a 2008/09 baseline, has achieved the Carbon Trust Standard, and has an EMS certified to ISO14001 for its UK offices. The site has invested in energy metering, and has over 100 sub-meters installed so far.

The catering operation serves approximately 40-50,000 meals per year, defined as a main course or buffet or sandwich lunch, and comprises three main services, a cafeteria, a staff canteen/restaurant, and hospitality services for meetings, entertainment and functions.

The operation is spread across six areas within the building.

- Ground floor cafeteria.
- Main kitchen with servery, and staff restaurant.
- Satellite kitchen and three pantries which service the hospitality operation.

Prime cooking for the hospitality service can take place in the satellite kitchen when insufficient capacity is available in the main kitchen.

The equipment is all owned by the client and utility bills are paid by them. Any equipment purchases are made by the client as requested by the caterer to fulfil a service requirement. For example, a beer pump and pizza oven were purchased to provide evening pizza service in the Cafeteria. As the equipment is relatively new, none of it is due for replacement.

There are gas and electricity meters for the main kitchen, but not for the cafeteria or other satellite operations. Catering energy use is estimated to be approximately 3% of the total building energy use.

A2.5 Healthcare

An 85 bed specialist hospital which is part of an NHS Foundation Trust. The building has previously been a hotel, and a private hospital, and was converted to its current use 10 years ago. There are four patient wards.

The catering operation comprises a coffee shop, cafeteria and patient feeding, all served from an on-site kitchen. A total of approximately 120,000 meals, defined as a restaurant cover, patient meal or main course are served on the site per year. On-site cooking of patient meals is becoming less common in the healthcare sector as pressure on hospital site space leads to cooking moving off site into industrial-scale food production units.

The client has signed up to the 10:10 campaign, and has pledged to cut carbon emissions by 10% over the next year. The client has a sustainability manager and a Facilities Director who directs carbon reduction efforts across the NHS trust. The NHS trust is accredited to the Carbon Trust Standard.

The site recently won an award for developing a cost-effective low carbon meal, fish steamed over vegetables.

Current energy saving projects at the hospital include: HVAC projects, a recent upgrade to the laundry which featured energy-efficient dryers and an energy monitoring system which is designed to relay live energy consumption data to a screen in reception.

The catering operation is spread across seven areas within the building. There are gas, electricity and hot water meters for the main kitchen, but not for the other parts of the operation.

- Coffee shop.
- Restaurant serving meals for staff and visitors and a kitchen where food is prepared. There is a small pantry behind the kitchen used for refrigerated storage and dishwashing.
- Main kitchen – prepares food for the restaurant and patient feeding. The site is fresh cook, rather than cook chill. Meals are prepared for a large variety of patient diets, depending on medical and dietary preferences.
- 3 Ward pantries. Used for serving meals to patients on the wards. They are used for traying meals for service, serving hot drinks, dishwashing and heating meals for the out-of-hours service. Catering staff work closely with nursing staff to supervise patient feeding and identify any missed meals.

- Out-of-hours service. A selection of meals is held in a small freezer in the main kitchen for the out-of-hours service. These can be requested for ward service at any time of day or night.

The equipment is all owned by the client and energy bills are paid by them, not by the caterer. The caterer maintains most of the equipment under a maintenance contract. The equipment is of various ages, and from various manufacturers and some is due for replacement. Any equipment purchases are made by the client as requested by the caterer.

The caterer is contracted to provide a minimum number of patient meals. Any meals over the target number are subject to a profit share with the client. The revenue from the restaurant and coffee shop is retained by the caterer. Staff meals are sold in the restaurant at a subsidised price.

The caterer has an energy manager who works within their hospital client portfolio, mainly on building energy projects within the facilities management operations of the caterer, and not specifically on catering energy use.

A2.6 Ministry of Defence

An MOD base which was brought back into use in May 2010 after a vacant period. When at full strength site population is 1,600, but this varies considerably with deployments overseas. The base has a higher proportion of officers than many other bases due to its strategic function.

The catering operation comprises the Officer's Mess (OM), Sergeant's Mess (SM), Junior Ranks Mess (JRM), a Costa Coffee shop, a Social club, and a retail shop. This is a typical Mess structure for MOD sites.

The caterer liaises with the Station Staff Officer. The facilities on site are managed by Defence Estates, and they have a separate hard facilities subcontractor.

Each mess has its own building and kitchen facilities and is a stand-alone operation. The equipment is all owned by MOD and maintained by their subcontractor. Energy bills are paid by MOD.

The site operates a "Pay as you Dine" service. The caterer provides a "Core" menu at a subsidised price, and a "Retail" menu at commercial prices. This replaces the previous DMR (Daily Messing Rate) where a daily amount was deducted from wages.

The switch to Pay as you Dine has created opportunities for the caterer to up sell, but the amount of subsidy has been reduced due to the loss of the DMR. The caterer estimates a 70:30 split of Retail to Core menu.

Some of the chefs working in the kitchens are MOD chefs with the balance supplied by the caterer. These chefs report to both the caterer's Mess Managers and their military commanders and are available for deployment overseas if required.

- Officer's Mess (OM). Provides three meals a day on weekdays and a brunch/dinner service at weekends. The OM includes accommodation, meeting rooms, bars and function rooms. It has the largest kitchen on the base with the oldest equipment. It is estimated that there are 15,000 meals served per year, plus functions.
- Sergeant's Mess (SM). Provides three meals a day on weekdays and a brunch/dinner service at weekends. This is a smaller mess than the OM, with a newly refitted kitchen. It is estimated that there are 20,000 meals served per year, plus functions.
- Junior Rank's Mess (JRM). Provides three meals a day on weekdays and a brunch/dinner service at weekends. The kitchen and serving area have been refitted recently. It is estimated that there are 50,000 meals served per year.

All the messes have electricity and gas metering, including some electrical sub-metering. The gas meter includes space heating in the OM and SM.

The OM and SM both produced relatively low volumes of meals from fully-equipped kitchens, leading to high specific energy use.

In the JRM there are separate gas meters for heating and catering – for this reason the JRM was identified as the target operation within the MOD host site.

A2.7 Education

A grant-aided mixed-sex secondary school with 1,500 pupils. The school has expanded considerably over the last 10 years and the catering operation has grown with it, though the kitchen retains the same level of equipment it had previously.

There are three main services per day, Monday-Friday, for 39 weeks of the school year:-

- 08.15 - 08.40 Breakfast service, about 15/day.
- 10.15 - 10.30 Mid-morning snack ~ 500 /day. Service includes sausage rolls, bacon rolls and freshly baked cakes.
- 12.20 - 13.40 Lunch 500 – 700/day, hot meals, pasta bar, sandwiches and snacks.

The equipment is owned and maintained by the school. Total estimated meal production is 60,000 / year.

There is no electrical sub-metering. The gas meter also supplies the science labs and home economics kitchen, but not space heating which is oil-fired.

The kitchen prepares much of the food from fresh ingredients, and enjoys daily deliveries.

Appendix 3 – Energy metering details

Data collected in the study

Table A3-1 Equipment metered as part of the on site study.

Type	Appliance	Gas	Electricity	Activity (temp)
Kitchen	Whole kitchen	2	2	
Cookers	Hobs/ovens	3		4
	Grills			2
	Combi ovens	1	6	7
	Fryers			3
	Bratt pan			1
	Griddle			1
	Microwave		1	
	Flat-top			1
Extraction	Extractors		5	
	Air supply		1	
Dishwashers	Hood-type dishwashers		3	
	Conveyor type dishwasher		1	
Refrigeration	Walk-in fridge		2	
	Walk-in freezer		2	
	Double fridge		1	
	Double freezer		1	
	Dairy deck		1	
	Chilled well		1	
	Blast chiller		1	
Total	**55**	**7**	**28**	**20**

The site data collection included 55 metering points on 3 sites. The data from the meters was collected at 2 minute intervals by dataloggers and accessed using a desktop application. The metering period used for analysis was the five week period from 31st Jan to 2nd March 2012. The study included a wide range of equipment as shown in Table A 3-1 above.

The data was annualised assuming a 52 week year for three sites and a 39 week year for the school site (except refrigeration equipment which was assumed to operate for 52 weeks at the school). No attempt was made to adjust the data for any seasonal changes. There may be some changes in refrigeration demand relating to the external temperature which were not accounted for.

Figure A3-1 – Proportion of energy consumption metered

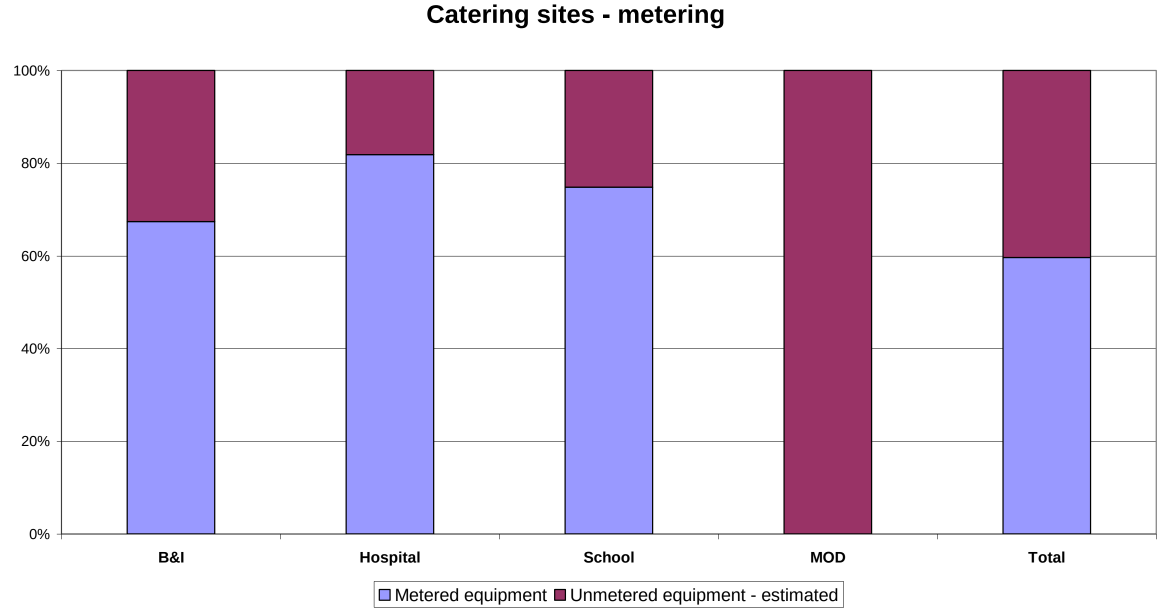


Figure A 3-2 shows the extent of coverage of the metered equipment. On three sites an average of 75% of the equipment was metered and good estimates were made for the remaining equipment. On the fourth site all the equipment was itemised and individual estimates were made for each piece of equipment based on operating hours, plate ratings and duty cycles. Where appropriate usage data from similar metered equipment was used. Overall 59% of the energy used on the four sites was directly measured.

Figure A3-2 – Proportion of energy consumption metered by type

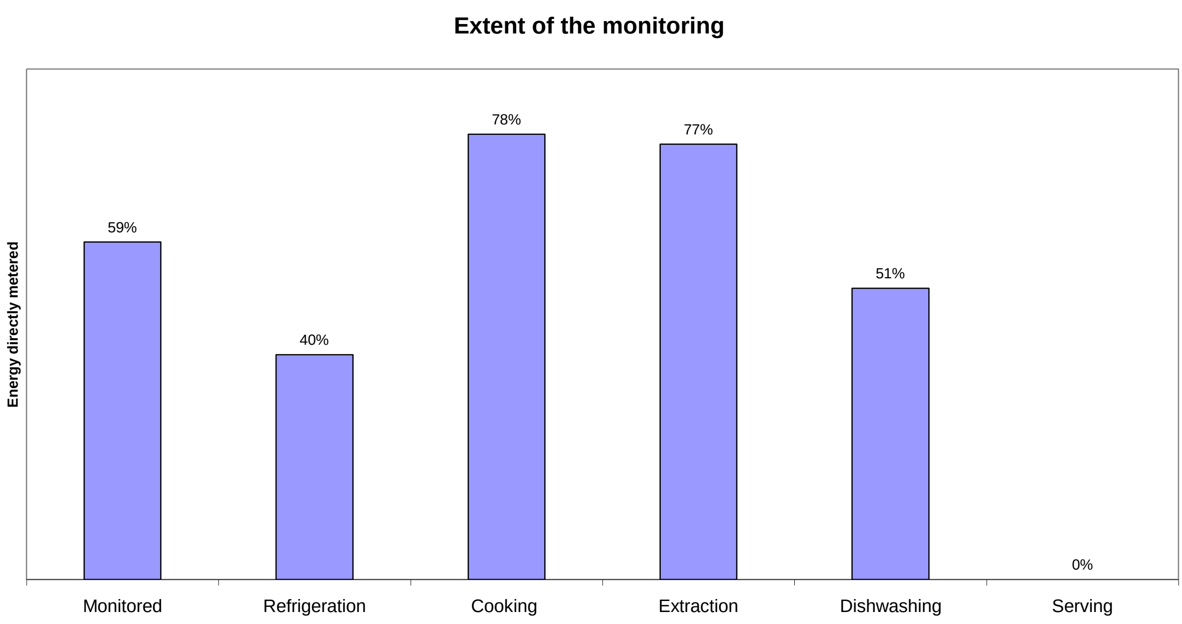


Figure A3-3 shows that cooking and extraction were the most intensively monitored areas, with dishwashing and refrigeration receiving less coverage. Serving equipment was not metered directly. The difference in extent is largely due to the concentration on the main kitchen at each site for practical reasons, meaning that equipment in satellite locations such as serveries, cafes, and pantries could not be directly metered.

At each site operational data was collected including:-

- Number of meals served.
- Temperature records from fridges and freezers.

Hot water data was collected from existing meters at one site but the data was unreliable.

At two sites a day was spent observing how equipment was used including:-

- Hobs – no of burners lit, no of pans.
- Other cookers – settings, no of uses.
- Ovens – settings, door openings, no of pans.
- Fridges and freezers – door openings.
- Dishwashers – cycles.
- Choice of equipment, how it was used.

This activity was logged every 4 minutes and compared with the energy use and temperature data from the simultaneous monitoring.

Appendix 4 – List of stakeholders

Maggie Charnley – Defra

Stephanie Boulos – MTP

Al-Karim Govindji – The Carbon Trust

John Dyson - BHA

Robin McKnight – CEDA

Peter Kay – CEDA

Keith Warren – CESA

Vic Laws & Kate Gould – FCSI

Val Carter & Sue Lightfoot - Aramark

Debbie Martin – Caterlink

Grazia Dal Fara – Elior

Paul Bracegirdle – Sodexo

Appendix 5 – Workshop summary

A5.1 Overview

There were two workshops with industry participants undertaken the study. The first occurred before metering started and focuses on initial analyses of sector energy use.

The summary presented here focuses on the second workshop held on the 29th March 2012 at which results from the metering and on-site observations were presented prior to producing this final report. This was an opportunity to get industry comment on the gathered data and preliminary analysis.

A5.2 Agenda for 29th March 2012 workshop

The agenda for this workshop was as follows:

Agenda – IEEA Contract Catering project – 2nd workshop

Central Hall (www.c-h-w.com), Westminster, London, SW1H 9NH – Maurice Barnett Room

09:30 – 10:00 Arrival

10:00 – 10:15 Introduction / Housekeeping messages: Mike Savage

10:15 – 11:15 Study overview: James Diamond
- Site profiles
- Data collected / Extent of metering
- Operational data / Site observations
- Site energy usage / Carbon footprint
- Factors driving energy use
- Sector estimates
- Questions / discussion

11:15 – 11:30 Morning Tea/Coffee break

11:30 – 12:30 Study results – Cooking and Extraction: James Diamond
- Patterns of use
- Comparisons of equipment performance across sites
- Observation findings
- Equipment benchmarking findings
- Opportunities for savings
- Questions / discussion

12:30 – 13:30 Lunch

13:30 – 14:30 Study results - Refrigeration and Dishwashing: James Diamond / Jan Bastiaans
- Patterns of use
- Comparisons of equipment performance across sites
- Observation findings
- Equipment benchmarking findings
- Opportunities for savings
- Questions / discussion

(E-Cube Trial)

14:30 - 15:00 Summary of Saving Opportunities / Best practice

15:00 - 15:15 Afternoon Tea/Coffee break

15:15 - 15:45 Industry presentations – opportunities for innovation
- Fryers: Scott Dackombe (Jestic Foodservice Equipment)
- Refrigeration: Glenn Roberts (Gram (Uk) Ltd)
- Possible third presentation

15:45 - 16:00 Key points round up / closing remarks – Mike Savage (AEA) / Al-Karim Govindji (The Carbon Trust)

16:00 - 17:00 Departure

A5.3 Key points from the workshop

The project was able to provide information such as energy use/meal which has never been collated in the past, but might be useful for a contractor to interest prospective client to invest in more energy efficient equipment, as the main issue is the fact that the end user is not the purchaser of equipment, and generally will have no input into choosing the equipment for the kitchen.

The MOD site and the B&I site had the most recent equipment (less than five years), yet the estimated energy used at the MOD was the highest. The data showed that the equipment is key rather than the number of meal/week served.

It was also noted that menu complexity and the type of ingredient used to prepare dishes will have a major impact into storage and cooking capacity requirement. This is why B&I and MOD are likely to have much higher impact per meal than a school or hospital. The more complex the menus are, the more ingredients per dish will be required, which in turn will results in higher storage and cooking capacity required. This was supported by the relevant stakeholders during the session.

A participant asked whether there were any other drivers that influence energy consumption.

It was discussed that manufacturers are now looking at idle mode on ovens (all types) once they have a reached a certain temperature that would be acceptable and from which an oven can go back up to high temperature rapidly.

Someone asked if the comparison was made between pre prepared food and food prepared from scratch. This was not possible as all the sites monitored prepared food from scratch.

No staff training was taking place at the sites monitored, however on the day that behaviour was monitored it can't be ruled out that the site visit influenced how staff behaved on that day.

There was a lengthy discussion around the impact of weather on energy requirements for compressor depending where the compressor is located. The load requirement of a compressor is influenced by hot/cold ambient air around it.

Ambient air temperature was not recorded as part of the metering exercise. A manufacturer commented that ambient air temperature is very important and will impact on the energy used by the equipment.

Fridge capacity varied widely between the sites and was not linked to the number of meals served/year.

In the following subsections there are questions and comments from workshop delegates grouped by type of equipment.

A5.3.1 Extraction - Comments / Questions:

- What type of filtration was installed at each sites (no further details were available)? It was discussed that for example a carbon filtration system would increase energy consumption noticeably.
- It was mentioned that secondary filtration can make up to a 5 kW/hour difference.
- Were maintenance logs were reviewed? They were not, though it was noted that on some sites the filtration system could have been cleaner. The maintenance regime will again impact on energy consumption.
- It was noted that the cleaning regime is more important on a mesh filter rather than a stainless steel open filter.

A5.3.2 Ovens – Comments / Questions:

- It was commented that smaller ovens were the best overall option.
- It was commented that a gas combi-oven required 25% more extraction capacity than an electric one.
- Combi-oven: There are currently no standard tests as they can be used quite differently by using the programming function.
- There was a long conversation around the US Energy Star programme and how equipment manufacturers that trade on the US market all have it as it helps sells. There is an Energy Star label for commercial ovens.
- Low carbon cooking and the link between this and healthy eating were discussed (e.g. fished steamed over vegetables).

A5.3.3 Fridges Comments made/ questions asked

- From the data it was noted that new technologies in fridges/freezers were more responsive to the impact of opening doors.
- B&I site had the most efficient fridges, because their coolant is CO_2 (most efficient on market currently).
- The location of fridge/freezer's compressor was again discussed at length as it should be placed into a cool environment to ensure max energy efficiency.
- It was noted that there is an opportunity to use blast chilling for food waste reduction.

A5.4 Other points raised

- How do catering contractors influence their clients in the equipment they purchase? The short cycle of contract mean that the relationships are rather precarious.
- The sector would welcome KPIs that they can use to show/illustrate the cost/meal to prospective clients based on how meals are designed and equipment available to the kitchen.
- In terms of behaviour, there are currently no incentives for a contractor to reduce kitchen energy use as it is not responsible for paying the energy bills, and currently the relationship between contractor and client does not allow for a "bonus" type of payment for lower energy bills.

Customer:

Defra and Carbon Trust

Customer reference:

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